ANNEX to GB decision no FCH-GB-2018-18 of 17/12/2018.

FUEL CELLS and HYDROGEN 2 JOINT UNDERTAKING

(FCH 2 JU)

2019

ANNUAL WORK PLAN and BUDGET

NOTICE

Please note that until the UK leaves the EU, EU law continues to apply to and within the UK, when it comes to rights and obligations; this includes the eligibility of UK legal entities to fully participate and receive funding in Horizon 2020 actions such as those called for in this work plan. Please be aware however that the eligibility criteria must be complied with for the entire duration of the grant. If the UK withdraws from the EU during the grant period without concluding an agreement with the EU ensuring in particular that British applicants continue to be eligible, they will no longer be eligible to receive EU funding and their participation may be terminated on the basis of Article 50 of the grant agreement.

In accordance with the Statutes of the FCH 2 JU annexed to Council Regulation (EU) No 559/2014 and with Article 31 of the Financial Rules of the FCH 2 JU.

The annual work plan will be made publicly available after its adoption by the Governing Board.

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2. INTRODUCTION

This document establishes the sixth Annual Work Plan (AWP) of the Fuel Cell and Hydrogen 2 Joint Undertaking (FCH 2 JU), outlining the scope and details of its operational and horizontal activities for the year 2019.

FCH 2 JU is a public-private partnership focusing on the objective of accelerating the commercialization of fuel cell and hydrogen technologies. FCH 2 JU was setup, within the Horizon 2020 Framework programme, as a Joint Undertaking by Council Regulation N° 559/2014[1]. Its aim is to contribute to the Union's wider competitiveness goals and leverage private investment by means of an industry-led implementation structure.

Conscious of its extreme dependence on oil and gas imports, largely from unstable countries, the EU has set targets to reduce the related risks. This is voiced in the European Commission's (EC) 2014 Energy Security Strategy[2], which again puts the focus on the need for improved energy efficiency but also on the necessity to increase EU's own energy production, to diversify supply sources and routes, to consolidate its internal energy system and to protect its critical infrastructure.

On 25 February 2015, Commissioner Miguel Arias Cañete insisted on the fact that *"Our path to real energy security and climate protection begins here at home. That is why I will focus on building our common energy market, saving more energy, expanding renewables and diversifying our energy supply".* He launched the Energy Union Framework Strategy[3], one of the 10 Commission priorities, with the following statement: *"We have to move away from an economy driven by fossil fuels, an economy where energy is based on a centralised, supply-side approach and which relies on old technologies and outdated business models. We have to empower consumers providing them with information, choice and creating flexibility to manage demand as well as supply."*

He was supported in his approach by Commissioner Maroš Šefčovič who said on 21 June 2015 *"We would like to provide Europeans with energy which is secure, competitive and sustainable".*

Few months later, at 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".* The EU has been at the forefront of international efforts towards a global climate deal and was the first major economy to submit its intended contribution to the new agreement in March 2015. It is already taking steps to implement its target to reduce emissions by at least domestic 40% by 2030. On 5 October 2016, the EU formally ratified the Paris Agreement, thus enabling its entry into force on 4 November 2016

Underpinning this, the Communication from the European Commission[4] on 'A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy' contains among all lines of action the following:

- Energy security, solidarity and trust;
- Energy efficiency;
- Decarbonizing the economy;
- Research, innovation and competitiveness.

At the EU level, the long-term objective is to achieve 80% to 95% reduction in greenhouse gases compared to 1990 levels by 2050, with a specific target for transport of a 60% reduction in Greenhouse Gases (GHG)

[1] OJ L 169/108 of 7.6.2014
[2] European Energy Security Strategy. {SWD(2014) 330 final}
[3] http://ec.europa.eu/priorities/energy-union/index_en.htm
[4] COM(2015)80, Energy Union Package

emissions. Specific short and medium term climate, energy and transport targets are set-up in the 2020 and 2030 Climate and Energy frameworks. Issued in 2015 the 2030 Energy Strategy[5] sets the following targets:

- A binding EU target of at least a 40% reduction in greenhouse gas emissions by 2030, compared to 1990;
- A binding target of at least 27% of renewable energy in the EU;
- An energy efficiency increase of at least 27% (compared to projections), to be reviewed by 2020 (with an EU level of 30% in mind);
- The completion of the internal energy market by reaching an electricity interconnection target of 15% between EU countries by 2030, and pushing forward important infrastructure projects.

In November 2016, the EC adopted the "Clean Energy for All Europeans Package"[6], which includes revised legislative proposals covering energy efficiency, energy performance in buildings, renewable energy, the design of the electricity market, security of electricity supply and governance rules for the Energy Union. On 14 June 2018 the Commission, the Parliament and the Council reached a political agreement[7] which includes a binding renewable energy target for the EU for 2030 of 32%, with a clause for an upwards revision by 2023. The role of renewable gas including green hydrogen is explicitly mentioned which would open the door for green hydrogen to contribute to Member States renewable energy and transport targets. During the same political agreement, a more ambitious energy efficiency target for the EU for 2030 of 32.5% with an upwards revision clause by 2023 has been set.

In addition, the European Commission Staff Working Document (SWD) on Energy storage published as part of the "Second Report on the State of the Energy Union' on 01 February 2017[8], outlines the role of energy storage in relation to electricity, presents the advantages of different technologies and innovative solutions in different contexts, and discusses further possible policy approaches. It is acknowledged that energy storage, including hydrogen storage based solutions, has not yet developed its full potential in the energy markets. Developing affordable and integrated energy storage solutions is highlighted as a priority to facilitate and enable the transition to a low carbon energy system based largely on renewables. A High Level Roundtable on Energy Storage and Sectoral Integration[9] was organised by the Commission on 1st March 2018 and brought together representatives from industry, research and the European Commission to discuss the role that energy storage and sectoral integration can play in the transition to a low carbon economy. Sectoral integration is the linking of energy (electricity, gas and heat), transport and industrial infrastructure with the aim of boosting use of energy from renewable sources and decarbonising the economy. Together with energy storage, it has the potential to make the clean energy transition – which needs to cover all sectors of the economy – faster and more cost-effective.

On 8th November 2017, the European Commission has also proposed to update the EU Gas Directive[10], in order to ensure that all major gas pipelines entering EU territory comply with EU rules, are operated with the same levels of transparency, are accessible to other operators, and are operated in an efficient way. The proposal aims to improve the functioning of the EU internal gas market, increase competition between suppliers, and boost Europe's energy security. The role of hydrogen is also mentioned as one of the solutions to decarbonise the EU gas network and increase security of supply.

It has become even clearer during 2018 that the development of hydrogen storage solutions will serve the strategic purpose of strengthening links between the energy and the transport sectors and facilitate the transition of the EU toward a low-carbon society. As highlighted in the EC SWD "Towards clean, competitive

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[5] EU 2030 Energy Strategy https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2030-energy-strategy

[6] Clean Energy for All Europeans Package: https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition

[7] http://europa.eu/rapid/press-release_STATEMENT-18-4155_en.htm

[8] https://ec.europa.eu/energy/sites/ener/files/documents/swd2017_61_document_travail_service_part1_v6.pdf

[9] https://ec.europa.eu/info/events/high-level-roundtable-energy-storage-and-sectoral-integration-2018-mar-01_en

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

and connected mobility: the contribution of Transport Research and Innovation to the Mobility package", the expected increase in renewable hydrogen production will help the EU to address its decarbonisation and quality of air challenges linked to the transport system.

On 8th November 2017, the European Commission has adopted and published the so-called 'Clean Mobility package' which takes action to reinforce EU's global leadership in clean vehicles by proposing new targets for the EU fleet wide average CO2 emissions of new passenger cars and vans to help accelerate the transition to low- and zero emission vehicles. In this respect, Commission President Jean-Claude Juncker outlined in the State of the European Union speech in September 2017: *"I want Europe to be the leader when it comes to the fight against climate change. Last year, we set the global rules of the game with the Paris Agreement ratified here, in this very House. Set against the collapse of ambition in the United States, Europe must ensure we make our planet great again. It is the shared heritage of all of humanity."* As part of the package, an action plan and investment solutions for the trans-European deployment of Alternative Fuels Infrastructure was proposed, which includes hydrogen as one of the clean fuel for transport. The aim is to increase the level of ambition of national plans, to increase investment, and improve consumer acceptance. In addition, proposal was made to amend the Clean Vehicles Directive to promote clean mobility solutions in public procurement tenders and thereby provide a solid boost to the demand and to the further deployment of clean mobility solutions, including fuel cells vehicles. On 17 May 2018, the European Commission presented a new Mobility Package entitled 'Sustainable Mobility for Europe' with which it seeks to promote safe, connected and clean mobility across the EU. This third and last Mobility Package[11] by the Juncker Commission contains various legislative and non-legislative proposals for the EU automobile industry.

Furthermore, in 2018 there was a global agreement for the first time within International Maritime Organisation, IMO on targets to reduce the GHG emissions of the maritime transport by a minimum of 50% by 2050 and phase-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 is increasingly being considered.

On 18 September 2018 the use of hydrogen as a future-oriented energy form was among the items on the agenda of the informal meeting of EU energy ministers[12]. *"The Austrian Presidency of the Council of the European Union proposed a Hydrogen Initiative that many member states approved of and signed"*, said Elisabeth Köstinger, current chair of the EU energy minister meetings. *"Under this initiative, the signatory states commit themselves to continue research and investment in the production and use of hydrogen as a future-oriented technology"*, Elisabeth Köstinger added. In Linz, where the informal meeting of energy ministers took place on 17 and 18 September, one of the most modern European hydrogen production plants is currently being built (mentioning FCH 2 JU project 'H2-FUTURE'[13]).

"In order to achieve the European-wide 2030 climate and energy goals, renewable energy forms have to be strengthened and better integrated", Elisabeth Köstinger emphasised. *"A big challenge is also being able to use renewable energy at those times when the sun is not shining, the water level is low or the wind is not blowing. Therefore, energy storage solutions are crucial in order to stock energy and to store it in the case of overproduction."* According to Elisabeth Köstinger, renewable hydrogen could, in future, play an important role in this area. Moreover, she said, hydrogen constituted not only a potential future-oriented technology for storing energy but its use as a vehicle fuel would also add to reducing the role of fossil energy sources in mobility. *"With the Hydrogen Initiative we want to send out a strong signal for renewable hydrogen and a European-wide cooperation",* Elisabeth Köstinger said.

EU Commissioner Miguel Arias Cañete also welcomed the initiative of the Austrian Presidency of the Council of the European Union: *"Green hydrogen offers significant potential for the decarbonisation of the European economy. The Commission warmly welcomes the Hydrogen Initiative as it will further harness the innovative drive across the EU."*

[11] https://ec.europa.eu/transport/modes/road/news/2018-05-17-europe-on-the-move-3_en

[12] https://www.eu2018.at/latest-news/news/09-18-Informal-meeting-of-energy-ministers.html

[13] https://www.fch.europa.eu/project/hydrogen-meeting-future-needs-low-carbon-manufacturing-value-chains

In line with the policy developments described above, it is crucial that the FCH 2 JU continues to develop technology solutions that will help materialise the benefits of hydrogen and fuel cell technologies in support of the high level EU policy agenda. The present Annual Work Plan 2019 of the Fuel Cells and Hydrogen 2 Joint Undertaking proposes a list of research and demonstration activities in line with the above-mentioned EU-wide objectives and with at least one of the FCH 2 JU objectives as listed in Council Regulation 559/2014 of 6 May 2014:

1. Reduce the production cost of fuel cell systems to be used in transport applications, while increasing their lifetime to levels which can compete with conventional technologies;
2. Increase the electrical efficiency and the durability of the different fuel cells used for power production to levels which can compete with conventional technologies, while reducing costs;
3. Increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using fuel cell system can compete with the alternatives for electricity production available on the market;
4. Demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems, including through its use as a competitive energy storage medium for electricity produced from renewable energy sources;
5. Reduce the use of the EU defined ‘Critical raw materials”, for instance through low-platinum or platinum-free resources and through recycling or reducing or avoiding the use of rare earth elements.

3. ANNUAL WORK PLAN YEAR 2019

3.1 Executive Summary

The Annual Work Plan 2019 for the FCH 2 JU continues the work initiated in previous years concerning the development of a research and innovation programme aligned with the objectives set in Council Regulation 559/2014 of 6 May 2014.

During 2019, a call for proposals with an indicative budget of EUR 80.8 million will be launched in January 2019 (see chapter 3.2, Conditions for the Call), addressing key challenges as identified by the stakeholders in the Joint Undertaking. These challenges encompass different areas of research and innovation for each of the Transport and Energy pillars, as well as Overarching and Crosscutting activities. A total of 17 topics will be part of the call for proposals, including 5 for Transport, 8 for Energy, 1 for Overarching and 3 for Cross-Cutting. They will be grouped into 7 Innovation Actions (IA), 9 Research and Innovation Actions (RIA) and 1 Coordination and Support Action (CSA).

The Call for Proposals will be subject to independent evaluation and will follow the H2020 rules on calls for proposals. Upon selection, the Partners (the 'consortium') will sign a Grant Agreement with the JU.

In addition, work will continue on the different operational activities along the call and to ensure that the support activities to operations provided by the Programme Office facilitates the proper management of H2020 and FP7 funds, according to the principles laid out in the financial guidelines.

Communication and outreach activities will ensure that stakeholders are duly informed about the activities and results of the FCH 2 JU, raising the FCH 2 JU Programme's profile and highlighting technology potential and market readiness.

3.2 Operations

Objectives & indicators - Risks & mitigations

Techno-economic objectives

The techno-economic objectives laid out in the Multi-Annual Work Plan (MAWP) 2014-2020[14] are addressed in this AWP through the call topics. The correspondence of topics into the techno-operational objectives is shown below:

Objective	Topic
Techno-economic objective 1: reduce the production cost of fuel cell systems to be used in transport applications, while increasing their lifetime to levels competitive with conventional technologies	FCH-01-1-2019: Demonstrating the blueprint for a zero-emission logistics ecosystem FCH-01-2-2019: Scaling up and demonstration of a multi-MW Fuel Cell system for shipping FCH-01-3-2019: Cyber-physical platform for hybrid Fuel Cell systems FCH-01-4-2019: Towards a better understanding of charge, mass and heat transports in new generation PEMFC MEA for automotive applications
Techno-economic objective 2: increase the electrical efficiency and the durability of the different fuel cells used for CHP and power only production, while reducing costs, to levels competitive with conventional technologies	FCH-02-3-2019: Continuous supply of green or low carbon H2 and CHP via Solid Oxide Cell based Polygeneration FCH-02-6-2019: New materials, architectures and manufacturing processes for Solid Oxide Cells FCH-02-7-2019: Development of highly efficient and flexible mini CHP fuel cell system based on HTPEMFCs FCH-02-8-2019: Enhancement of durability and reliability of stationary PEM and SOFC systems by implementation and integration of advanced diagnostic and control tools
Techno-economic objective 3: increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system is competitive with the alternatives available in the marketplace	FCH-02-1-2019: Combined electrolyser-HRS and Power-to-Gas system FCH-02-2-2019: Multi megawatt high-temperature electrolyser for valorisation as energy vector in energy intensive industry FCH-02-4-2019: New Anion Exchange Membrane Electrolysers FCH-02-6-2019: New materials, architectures and manufacturing processes for Solid Oxide Cells
Techno-economic objective 4: demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems, including through its use as a	FCH-01-5-2019: Underground storage HRS FCH-02-1-2019: Combined electrolyser-HRS and Power-to-Gas system FCH-02-5-2019: Systematic validation of the ability to inject hydrogen at various admixture level into high-pressure gas networks in operational conditions

[14] http://www.fch.europa.eu/page/multi-annual-work-plan

competitive energy storage medium for electricity produced from renewable energy sources	FCH-03-1-2019: H2 Valley FCH-04-3-2019: Hydrogen admixtures in natural gas domestic and commercial end uses
Techno-economic objective 5: reduce the use of the EU defined "Critical raw materials", for example via low platinum resources, and through recycling or reducing or avoiding the use of rare earth elements	FCH-02-4-2019: New Anion Exchange Membrane Electrolysers FCH-02-6-2019: New materials, architectures and manufacturing processes for Solid Oxide Cells

One topic is addressing techno-economic objectives related to both transport and energy pillars (so called **'overarching activities'**) while also addressing mainly the 'cross-sectorial' aspects of the Techno-economic objective 4:

- Topic FCH-03-1-2019: H2 Valley;

While two topics are addressing **crosscutting issues (mainly training aspects and pre-normative/contribution to standards aspects),** related to all techno-economic objectives:

- Topic FCH-04-1-2019: Training of Responders;
- Topic FCH-04-2-2019: Refueling Protocols for Medium and Heavy-Duty Vehicles.

Key Performance Indicators (KPIs):

FCH 2 JU follows the objectives and technical targets defined in the MAWP. These are integrated in the call topics.

A list of indicators (see Annex) was developed by the European Commission services; the indicators are grouped into 3 categories as follows:

- Horizon 2020 Key Performance Indicators[15] common to all JUs;
- Indicators for monitoring H2020 Cross-Cutting Issues [16] common to all JUs;
- Key Performance Indicators specific to FCH 2 JU;

Risk Assessment

In the annual risk assessment exercise, conducted in October 2018, the following significant risks & responses to those risks in terms of action plans were identified:

	Risk Identified	Action Plan
HIGH	Due to BREXIT, participation of UK entities in the programme (currently representing significant part of FCH 2 JU funding) at the state of application and during projects execution can be adversely affected, including fluctuations of project budgets, and commitments from the UK based companies.	Follow up closely on the developments; maintain active dialogue with the EC.

[15] Based on Annex II - Council Decision 2013/743/EU
[16] Based on Annex III - Council Decision 2013/743/EU

	Risk Identified	Action Plan
MEDIUM	Business continuity risk in case of key staff turnover due to the lean structure of the JU.	In case of absence of key staff, FCH 2 JU ensures appropriate back-up solutions in the short–term. For medium-term, FCH 2 JU is prepared to hire short-term temporary contract people (e.g. interims) to ensure full business continuity. Other potential measures should be explored.
MEDIUM	Timely execution and closure of the ex-post audits for H2020 (including less amount of control over H2020 ex-post audit process due to transfer of the responsibility to Central Support Service, CSC at EC) which could weaken the assurance of the Executive Director.	For H2020 audits, an active dialogue via regular participation on joint (CLAR) meetings has been established with the Common Audit Service of the CSC. JUs' horizontal issues are addressed by cooperation with other JUs. Timely monitoring and actions are ensured via regular dialogue between the Executive Director and Internal Control and Audit management function of the H2020 audits should be further enhanced via SYGMA/COMPASS workflows.
MEDIUM	Representative error rate may increase due to the simplified ex-ante controls under H2020 agreed horizontally for the Research family. Significant representative error rates in H2020 due to decreased ex-ante controls. Consequently, risk of obtaining a qualified opinion and of not getting the discharge from the European Parliament due to fact that the Court of Auditors' threshold for representative error rate stays at the level of 2%	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 on ex-ante controls. Reinforcement of communication campaign with introduction of financial webinars.
MEDIUM	Leak of confidential data from projects to public and breach of confidentiality clauses signed by the Authorising Officer with the FCH 2 JU beneficiaries due to lack of assurance coming from the Common Support Centre (CSC) in the implementation of the Dissemination Strategy (especially due to improper design of IT tools, which is supposed to handle confidential data in H2020).	Close follow up on recent developments in the IT tools via participation in the dedicated DiEEP working groups. Continuous dialogue with the CSC in order to reach an agreement on the treatment of confidential data and related liabilities.
MEDIUM	Disruption of the operations due to improper functionality of the IT tools, their continuous development and failure of the IT equipment.	Back-up systems are in place to mitigate loss of data. Regular follow up on the IT tickets issues raised via tickets is performed. Participation on the trainings for new software and tools introduced via CSC / locally. Ensure backup and proper documentation for the tools developed internally.

The FCH 2 JU monitors closely the fulfilment of the action plan and reports on it in its Annual Activity Report.

Scientific priorities & challenges

In order to achieve its objectives, the FCH 2 JU should provide financial support mainly in the form of grants to participants following open and competitive calls for proposals.

The 2019 Call for Proposals is the result of a joint effort by the major stakeholders, namely Hydrogen Europe, Hydrogen Europe Research and the European Commission. It represents a set of prioritised actions, consistent with the objectives of the FCH 2 JU, and is divided primarily into the Pillars identified in the MAWP: Transport, Energy and Crosscutting activities. In addition, Overarching activities, combining the entire supply chain from production of hydrogen all the way to its use in different applications and addressing the sectoral integration aspect through 'Hydrogen Valleys' were identified as priority for this year.

The emphasis given to different actions in different pillars reflects the industry and research partners' assessment of the state of the technological maturity of the applications and their estimated importance to achieve critical objectives of the FCH 2 JU.

In line with the activities started already in 2017, the FCH 2 JU will continue to work to reinforce the European supply and value chain of critical key components e.g. a higher range of common/standardised parts to be produced in the EU and H2020 Associated Countries, and to enable initial investments in production facilities for further ramp-up in these markets.

In May 2018 the Renewable and Clean Hydrogen Challenge[17] was created under Mission Innovation (Accelerating the Clean Energy Revolution), co-led by Australia, the European Commission and Germany, and currently consisting of 14 member countries. This Innovation Challenge aims to accelerate the development of a global hydrogen market at gigawatt scale by overcoming key technology barriers to renewable and clean hydrogen production, distribution, storage and use. As the associated work has a strong potential to also benefit the EU hydrogen and fuel cell stakeholders in both maturing their products and expanding their markets, cooperation with member countries of the Renewable and Clean Hydrogen Challenge is strongly encouraged under this Call (see section 3.2.G. International Cooperation) in order to improve access to global talent, innovation networks and value chains, and to leverage the relevant expertise of other regions of the world in regard of hydrogen and fuel cell technologies. The relevant entities might benefit from the general H2020 Rules for participation provision (see Article 10(2)(a) of H2020 Rules for Participation) whereby a participating legal entity established in a third country, which is not eligible for funding under Part A of the General Annexes to the Commission Work Programme, may receive JU funding if, in particular, its participation is deemed essential by the FCH 2 JU for carrying out the action.

International collaboration with countries participating in the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)[18] is also encouraged for all topics of the call, as well as collaboration with developing world countries supported by the Climate Technology Centre & Network (CTCN) under the UN Environment Programme[19].

In addition, continued openness towards EU13 countries is expected and integration of participants from those countries in consortia, to facilitate cross-fertilisation of knowledge is highly encouraged.

For proper technology monitoring and progress against state-of-art, but also to identify how each of the projects contribute to reaching the targets and indicators set by the MAWP, supported projects will report on an annual basis in the FCH 2 JU secure online data collection platform (TRUST), according to template questionnaire(s) relevant to the project content (and the technology development and TRL). This should be integrated as a specific annual deliverable in the grant agreement. The template questionnaires can be consulted online (http://www.fch.europa.eu/projects/knowledge-management), subject to modifications due to technology development and/or change in projects portfolio.

[17] http://mission-innovation.net/our-work/innovation-challenges/hydrogen-challenge/
[18] https://www.iphe.net/
[19] https://www.ctc-n.org/

For all topics and related successful projects, any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

For all topics, Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

1. Transport related activities:

PEM technology is the main enabling technology for all transport applications. Specifically the understanding of the performance limitations for MEA is a challenge that has to be tackled continuously and over several product generations, fostering the EU supply chain. In this call, one topic will address this challenge (as already started in 2017-2018) focusing on the understanding of heat, mass and charge transport limitations in a MEA and proposing breakthroughs in component design, operation strategies and performance prediction evolution of MEA technology.

Another key aspect of durability and performance of PEM technology for transport applications is the requirement for high dynamic performance and both production and development cost will influence a fast market penetration significantly. To reach these goals, one topic of this call will look at drivetrains optimisation for hybrid system composed of a fuel cell system and a battery.

In order to decarbonize industrial and logistic environments, there is a need to consider the big picture of the whole ecosystem: trucks, loaders, vans, and other specialized vehicles yet to be decarbonized. Tackling successfully this challenge presents an enormous opportunity for the technology: once industry customers are convinced of the environmental and economic benefits of a FC based solution, the ecosystem can be easily replicated in production plants worldwide. One topic this year will demonstrate (at least 250 vehicles in 1-2 locations) that the environmental and operational benefits do materialize in a real industrial or logistic ecosystem, thus paving the way to replication.

Similarly, fuel cell technology using hydrogen or another alternative carbon neutral fuel can enable shipping applications to achieve a very large reduction (>90%) in both GHG and pollutant emissions. There are however several challenges associated with taking larger fuel cells into use in shipping e.g. fuel cell systems need to be scaled up to the desired MW scale while simultaneously addressing durability, compatibility with maritime conditions and refueling facilities and high-volume fuel bunkering systems are required, particularly for larger vessels. One topic this year will adapt, scale up and demonstrate a 2 MW fuel cell (FC) system for shipping, capable of reducing GHG emissions by at least 70 % and NOX, SOX and particulate matter by at least 80% compared to conventional diesel-based systems for the selected mode(s) of operation.

Finally and addressing the main barriers to the successful rollout of hydrogen infrastructure in urban environments, one topic will look at improving hydrogen refueling station design, focusing on its largest component, the storage tanks. The development of low-cost, underground storage concepts for compressed gaseous hydrogen will be addressed, in order to enable rollout of a HRS network dense enough to meet customer requirements by 2020.

2. Energy related activities:

Electrolysis as the key enabling technology for increased renewables sources in the EU energy system while decarbonizing the gas sector remains in the focus of the FCH 2 JU during 2019. It is continued the activity started in 2018 on steam electrolysers increased scale; the related topic will aim to demonstrate at multi-megawatt scale how high-temperature electrolyser (HTE) technology is well suited for EII and how the availability of low-grade heat sources helps to improve the process efficiency and hence the production costs.

In addition, a separate research topic will look to new material breakthroughs and design concepts for Anion exchange membrane (AEM) electrolysis, to potentially combine the beneficial features of the PEM and alkaline electrolyser technologies.

A similar research topic will look at next generation of cells and stacks for the various SOC related applications, including new materials, architectures and associated manufacturing processes. It would consider several operating modes, SOE and rSOC modes being mandatory and co-SOE or any other operating modes optional.

Beside work on different electrolyser technologies, in 2019 the programme will concentrate some of its activities on the ability to inject hydrogen into the European gas infrastructure via the power-to-gas approach. One topic will demonstrate how to overcome the issue of low HRS utilisation (when coupled with an electrolyser) through the selling of surplus hydrogen as green gas to natural gas distribution networks. A complementary topic will explore how to enable injection of hydrogen into the high-pressure gas transmission network safely at industrial scale, addressing both the issue of scalability (ability to decarbonize the gas usages in all their aspects), and marketability/bankability of projects. A third topic (as cross-cutting activity and effect into standardisation) will ask for prenormative research to identify and verify the impacts of continuous and time-varying supplies of hydrogen-natural gas mixtures (H2NG) blends on the combustion characteristics (flame speed and shape, temperature, emissivity, emissions) of appliances together with the potential impacts on appliance safety, efficiency, lifetime and environmental performance (e.g. NOx emissions).

As regards the stationary fuel cells (for CHP solutions), the exploitation of the strengths of solid oxide cells will be demonstrated in a polygeneration system to prove the ability to provide hydrogen from electricity in the electrolysis (SOE) mode or from methane when no electricity is available (SOFC mode). In addition, a research topic will further explore the integration of available monitoring and diagnostic techniques along with the development of both prognostic algorithms and advanced control techniques for enhancement of durability and reliability of stationary PEM and SOFC systems. Finally, continuing the effort to address HTPEMFC technology for mini-CHP devices in the range of 5-10 kWe as a promising technology to satisfy local demands for heat and electricity, and their permanent availability, but also as an addition to intermittent RES power production, one topic is in particular looking at improving the electrical efficiency and performance on the stack level.

3. <u>Overarching activities:</u>

Building on the Regions Initiative[20] (signature of the MoU by a total 91 regional and local authorities representing 22 countries in Europe), a topic was introduced as the next logical step towards market introduction of FCH technologies at regional scale. The topic will target building up of local/regional H2 value chains and integrated use of FCH technologies across different sectors and applications, and therefore aiming to establish a 'Hydrogen Valley'.

4. <u>Cross-Cutting activities:</u>

These activities are included in the AWP in order to both support and enable activities undertaken within the Energy and Transport Pillars, and also to facilitate the transition to market for fuel cell and hydrogen technologies. Within AWP2019, these activities will be implemented through three separate topics.

Pre-normative research is more and more necessary to establish standardised fuelling protocols for any medium or heavy-duty vehicle to enable the short-term uptake of these hydrogen vehicles based on modelling, experimental validation and field tests. Similarly, it is considered strategic to start looking at the hydrogen admixture in the natural gas grid and the impact during Europe energy transition (see above under Energy activities).

Public awareness and acceptance regarding fuel cells and hydrogen technologies have essential impacts on the market implementation and stabilization of FCH applications, especially regarding safety aspects. Professional knowledge and skills are needed by first and second responders to tackle situations involving hydrogen systems and infrastructure. One topic will therefore explore the 'train the trainer' approach and establishment of pan-European integrated training resources.

[20] https://fch.europa.eu/page/about-initiative

List of actions

For the implementation of the Work Plan, the following actions will be taken in 2019:

A. Call for proposals 2019

Topic descriptions are detailed starting from the next page.

TRANSPORT PILLAR

FCH-01-1-2019: Demonstrating the blueprint for a zero-emission logistics ecosystem

Specific challenge:

Regulations for indoor operations of vehicles and the intensified discussion on air quality for industrial areas (harbours, chemical sites, wholesale markets) demand zero emission drive trains for various kinds of vehicles. Electric vehicles are commonly regarded as the suitable answer. Considering that most operators are procuring battery electric vehicles to meet air quality regulations, the challenge for fuel cell logistic and production vehicles will be to demonstrate the distinct operating advantages of those in comparison to battery solutions. For example, battery-based solutions are often lacking a sufficient operating time in industrial applications (especially in sites with 3 working shifts or 14 hours of operation per day), need relatively long time for recharging, require precious space for the recharging infrastructure or for the storage of replaceable batteries, are unable to work in refrigerated areas and are therefore, not suitable as a replacement of conventionally propelled vehicles.

Previous EU/FCH 2 JU projects[21] on FC based Material Handling Vehicles (MHV) like HAWL, HyLIFT-DEMO and HyLIFT-Europe and especially the success of FC forklifts in the USA (more than 20,000 units in operation) have shown the general technical feasibility on one hand and a realistic potential of an economic operation on the other. However, costs for both FC based logistic vehicles and the necessary infrastructure are still too high in comparison to battery or combustion engine-based solutions. Likewise, beyond forklifts (<3.5t) other logistic vehicles have still to be decarbonized and/or their market is not yet activated. The availability and cost argument are also the main reason why potential customers are still hesitating with procurement of FCVs. These projects have also shown that besides the cost topic there are also hurdles on the end user side e.g. when applying for the permission to install hydrogen refuelling infrastructure in buildings and training of the personnel. In order to decarbonize industrial and logistic environments, there is the need of going beyond MHVs and consider the big picture of the whole ecosystem: trucks, loaders, vans, and other specialized vehicles yet to be decarbonized. End users are also still missing certain types of FC logistic vehicles for their specific demands (max. load, outdoor suitability).

Tackling successfully this challenge presents an enormous advantage for the technology: once industry customers are convinced of the environmental and economic benefits of a FC based solution, the ecosystem can be quickly replicated in plants worldwide as typical for these manufacturing or logistic companies.

The challenge of this topic is to demonstrate that the environmental and operational benefits do materialize in a real industrial or logistic ecosystem, thus paving the way to its replication.

The project should therefore not only focus on removing existing hurdles on the cost side of the vehicles and infrastructure (Total Cost of Ownership perspective) but also on regulatory, financial and operational (e.g. availability) aspects. The following specific challenges have to be met:

1. A further reduction of the capital cost of the fuel cell logistic vehicles in line with increased volume (total and per site) by:
    - Eliminating technological barriers identified in previous projects such as availability and reliability;
    - Fully developing the necessary supply chain with focus on a healthy and diversified European value chains (e.g. drivetrain, FC stacks and systems, tanks among others) and second sources for related services, including availability of trained personnel, spare parts etc. in order to bring this technology on a parity with conventional technologies;
    - Designing modular and standardized systems allowing an integration to various vehicles.
2. Reduction of the operational costs, including fuel, infrastructure, down times, production shift optimization or maintenance cost;

[21] https://www.fch.europa.eu/page/all-our-projects

3. Identification and quantification of the remaining barriers to market, with a special focus to the user side: permitting procedures, safety aspects (ATEX[22]), training of operators and creation of a higher acceptance of this technology;
4. Enlarging the variety of FC based MHV for special purposes which are able to operate in challenging conditions like outdoor (both in cold and very hot conditions), refrigerated warehouses, paper/cement industry (heavy loads and dusty environment) while highlighting the use cases in which FC vehicles are advantageous compared to existing battery solutions;
5. Creation of a basis for future larger procurements like common specifications and standards for both vehicles and infrastructures, establishment of cross-border procurement groups etc.;
6. Creating synergies with already existing green hydrogen production facilities or development and demonstration of an onsite-production of green hydrogen, which is commercially feasible also for SMEs. Operators could also benefit from the existing supply chain of green hydrogen.

Scope:

Projects should demonstrate at least 250 fuel cell logistic vehicles such as forklifts, trucks, vans, loaders or other relevant industrial vehicle at two end-user sites with a minimum of 50 vehicles per site. The sites should be chosen such that different operational scenarios (e.g. type of goods produced, indoors/outdoors, cold/hot climate, dusty environment, etc) are demonstrated. One single site for the demonstration could also be considered to demonstrate the impact of a higher critical mass of vehicles in one location. Reasons for the choice of site(s) should be explained by the applicants/consortium.

The project should be open to different industries such as and not limited to logistic hubs, car industry, ports and airports, refrigerated warehouses, heavy industry or ceramic industry. The vehicles can also operate outside the site grounds but should be connected to the logistic process of that site.

The demonstration should include necessary and relevant support of cost-efficient hydrogen supply infrastructure and the hydrogen generated should be green hydrogen (i.e. from biomass or from electrolysis based on renewable energy) at least in one of the locations.

It is expected that the vehicles to be deployed in all sites fulfil the following conditions:

- Vehicle type A: trucks (gross vehicle mass >3.5t) or tow tractors (load carriers) for net loads >3t - minimum of 10 units and at least 3 units per site;
- Vehicle type B: vans, small trucks (gross vehicle mass <3.5t) or tow tractors (load carriers) for net loads <3t - minimum of 10 units and at least 3 units per site;
- Vehicle type C: logistic vehicles, of all weight classes, which either a) have not yet been previously converted to zero-emission or b) work currently with batteries but whose operation with fuel cells is deemed more advantageous and where the conversion is required (forklifts for net loads >3.5t could be also included) - minimum of 10 units and at least one unit per site;
- Vehicle type D: forklifts for net loads <3.5t - minimum of 30 units and at least 3 units per site.

Although the proposed topic includes the powertrain integration of FC systems in vehicles in which a fuel cell system has not yet been integrated, it should not include however the development of the powertrain components. The technology to be installed in the vehicles should reflect and go beyond the achievements from the previous FCH 2 JU supported projects (HyLift-Demo[23], HyLift-Europe[24], HAWL[25] etc) and should represent the newest state-of-the-art from the EU supply chain. Development of further FC logistic vehicle

[22] The term "ATEX" applies to atmospheres that are potentially explosive due to the possible presence of dusts vapours or gases that are likely to ignite or explode (https://www.hsa.ie/eng/Topics/ATEX_and_Electrical_Apparatus/Atex_Regulations_-_Frequently_Asked_Questions/)
[23] https://www.fch.europa.eu/project/european-demonstration-hydrogen-powered-fuel-cell-forklifts
[24] https://www.fch.europa.eu/project/hylift-europe-%E2%80%93-large-scale-demonstration-fuel-cell-powered-material-handling-vehicles
[25] https://www.fch.europa.eu/project/large-scale-demonstration-substitution-battery-electric-forklifts-hydrogen-fuel-cell-forklif

platforms and the adaptation to certain ambient condition could be also in scope of this topic. In order to assess the reliability, performance and availability of HRSs, vehicles and the overall operation, a data monitoring and analysis system should be put in place. This data should extract value for the next technology generation as well as for the logistic operation itself.

The project is expected to reach the following requirements in terms of performance and safety:

- Operation under application specific indoor/outdoor environmental conditions including cold/freezing ambient conditions, freeze start capability at -20°C on system level. Data monitoring and evaluation should be installed to evaluate the influence of different operation conditions on the performance;
- 1, 2 and 3 shift or 14 hours daily operation scenarios should be demonstrated;
- LCA *('cradle to grave')* of environmental performance of vehicles, infrastructure and energy source. Assessment should be carried out according to the requirements of the FC-HyGuide guidance document available at http://www.fc-hyguide.eu;
- The required hydrogen refuelling station should be designed and operate in high utilization scenarios under strict availability requirements (> 98% from planned operation time);
- FC systems eligible for funding should address specific European safety standards such as EN 62282-2:2012 Fuel cell technologies - Part 2: Fuel cell modules and EN 62282-4-101:2014 FC Systems Industrial Trucks Safety or EC79/2009 Hydrogen-powered Motor Vehicles as well as have to be CE marked or certified according to applicable EU directives for off-road and on-road vehicles.

The competitiveness (on TCO basis) in comparison with incumbent technology or state-of-the-art technologies (ICE, LA/LI battery) at the fleet level for a specific site, should include investment, maintenance and service expenses, hydrogen consumption, other operational costs and disposal/recycling. "CertifHy Green H_2"guarantees of origin should be used through the CertifHy platform[26] to ensure that the hydrogen consumption is of renewable nature.

As regards harmonization of regulatory framework:

- In case two sites are chosen, it would be advantageous to be selected from two EU countries in order to be able to evaluate differences in the regulatory framework for both the permitting of the operation of hydrogen-propelled vehicles and of the installation of a hydrogen-refuelling infrastructure in buildings;
- Differences and hurdles should be identified, safety criteria and concepts for indoor operation and refuelling of trucks, vans or MHVs as basis for standardization shall be developed and proposals for an EU wide harmonization be made.

The minimum operational period for any vehicle demonstrated in the project should be at least:

- Vehicle type A: 24 months and 30,000 km (trucks); 24 months and 2,500 hours of operation (tow tractors);
- Vehicle type B: 24 months and 30,000 km (vans and small trucks; in particular, 36 months should be considered for vans); 24 months and 2,500 hours of operation (tow tractors);
- Vehicle type C: 12 months and 1,000 hours of operation;
- Vehicle type D: 36 months and 4,000 hours of operation.

Refuelling infrastructure (new installation or upgrade of existing one and/or optimized refuelling procedure, e.g. through robot) as well as green hydrogen generation capabilities should be also in scope of the project.

FC systems should be analysed for power degradation and efficiency over the operation period.

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[26] https://fch.europa.eu/page/certifhy-designing-first-eu-wide-green-hydrogen-guarantee-origin-new-hydrogen-market

The project results should be presented to at least two relevant international events raising the awareness of potential customers and/or policy makers for this technology.

It is expected that consortium comprises end users at each site committing themselves to demonstrate a minimum of 50 MHV and industrial vehicles at the start of the project and at least two vehicle manufacturers and hydrogen infrastructure suppliers. The commitment should be secured by at least Letter Of Intent (LOI) in the proposal and by way of pre-orders or similar before signature of the Grant Agreement. The participation of a research organisation or academia is also recommended.

TRL at the start of the project:

- Vehicle type A: 5-6
- Vehicle type B: 5-6
- Vehicle type C: 4-5
- Vehicle type D: 7-8

TRL at the end of the project:

- Vehicle type A: 6-7
- Vehicle type B: 6-7
- Vehicle type C: 6
- Vehicle type D: 8-9

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The maximum FCH 2 JU contribution that may be requested is EUR 10 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

In order to increase the leverage effect of the FCH 2 JU contribution, the possibility of co-funding from national/regional initiatives could be considered.

Expected duration: 4 - 5 years.

Expected impact:

- Demonstrate the blueprint for a zero-emission logistics ecosystem and asses its replication potential for other industrial sites, drawing a rollout roadmap with a risk mitigation strategy;
- Confirmation and promotion of economic value proposition of fuel cell and hydrogen technology in the logistic and industrial vehicles sector;
- Demonstrate that the availability, reliability and performance of logistic vehicles and infrastructure is compatible with industrial operation scenarios;
- Creation and stabilization of EU-based component and system production, suppliers' network and value chain; specifically demonstrate that the technology used for the FC system components and H2 tanks is easily migrated to other transport applications;
- Enlargement of the variety of FC based logistic vehicles;

- Demonstration of the environmental benefits by using green hydrogen generated from renewable energy and reduction of hazardous materials and waste compared to state of art battery technology also with electricity from renewable sources;
- Demonstration of the environmental benefits of the FC technology in comparison with incumbent technology regarding recycling;
- Proposals regarding harmonization of regulatory framework for the indoor operation of H2 propelled vehicles as well as HRS within industrial sites;
- Ensure EU competitiveness and manufacturing.
- The following technical KPI should be achieved:
    - Vehicle type A – trucks only: initial lifetime ≥ 20,000 h (operational time might differ) and 25,000 h lifetime as project target, FC mean time between failures (MTBF) > 2,500 km, availability ≥ 90% (to be measured in available operation time), tank-to-wheel efficiency ≥ 42%, for trucks measured in real cycles;
    - Vehicle type B – vans only: FC system durability ≥ 6,000h (operational time might differ), availability ≥98%, FC system cost < 50EUR/kW at mass production;
    - Tow tractors (Vehicle type A and B) and MHVs (Type C): lifetime ≥ 5,000 h (operational time might differ), availability ≥95%, FC mean time between failures (MTBF) >500 hours;
    - Forklifts (Vehicle type D): lifetime ≥ 20,000 h (operational time might differ), hydrogen consumption ≤6.3 kg/h, system electrical efficiency ≥ 53%, availability ≥98%, FC mean time between failures (MTBF) >1,000 hours, cost of spare parts ≤7 EUR/h, fuel cell system cost (10 kW) ≤ 1,250 EUR/kW at mass production.

Type of action: Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018-2020 which apply mutatis mutandis.

FCH-01-2-2019: Scaling up and demonstration of a multi-MW Fuel Cell system for shipping

Specific challenge:

In 2018 the International Maritime Organization (IMO) adopted a global strategy to reduce greenhouse gas (GHG) emissions from international shipping by at least 50% by 2050 (compared to 2008). Given the long lifetime of ships (typically 25-30 years) and the strong reliance of the sector on fossil fuels, meeting the IMO's ambition will require a rapid introduction of both alternative fuels and electrification of the powertrains. Moreover, EU transport GHG emission reduction targets for 2030 along with policies that aim at boosting inter-modality underline the urgency of introducing ultra-low and zero-emission solutions for shipping. There is an increasing trend to electrify ships using diesel-electric propulsion systems. Such systems offer the possibility to incorporate a range of fuels, energy management systems and batteries to provide peak power shaving for the main engines to reduce GHG emissions and improve efficiency. Fossil based Liquefied Natural Gas (LNG) can also be deployed as a commercially available solution to reduce air pollutants (SOx, NOx, PM), but it is less effective at reducing GHG emissions and would not be able to contribute substantially towards achieving the aforementioned IMO GHG reduction target. Several pure battery-electric ships have also been introduced in recent years, but the amount of battery storage capacity required and the very high electrical demands when charging make such solutions unsuitable for long-distance shipping.

Fuel cell technology using hydrogen or another alternative carbon neutral fuel can enable shipping to achieve a very large reduction (>90%) in both GHG and pollutant emissions. However, so far only several small, low speed vessels have implemented fuel cells (of up to a few hundred kW) for demonstration purposes.

There are several challenges associated with taking larger fuel cells into use in shipping. First, fuel cell systems need to be scaled up to the desired MW scale while simultaneously addressing durability, compatibility with maritime conditions (saline air, shock, rolling & vibration). Second, refuelling facilities and high-volume fuel bunkering systems will be required, particularly for larger vessels and this poses a significant challenge for the less mature fuel options. Moreover, the total propulsion system's energy and power density as well as redundancy should be adequately secured for the specific applications. Third, immature regulations, codes and standards (RCS), apply to hydrogen in particular, but also alternative fuels and FC technologies. The time consuming Alternative Design process may exhibit an unavoidable challenge, as IMO rules are not yet in place. Fourth, market deployment, cost reduction strategies (including maintenance for marine environments) leading to viable business models need to be developed. Last, but not least, the public domain needs to be addressed, ensuring the acceptance of these new propulsion systems.

Scope:

The scope of this topic is to adapt, scale up and demonstrate a fuel cell (FC) system for shipping with a total minimum nominal power output of 2 MW, capable of reducing GHG emissions by at least 70 % (both local and on a well-to-wake basis) and NO_X, SO_X and particulate matter by at least 80% compared to conventional diesel-based systems for the selected mode(s) of operation. A pathway towards zero-emission operation should also be outlined to ensure compatibility with longer-term IMO objectives. The topic is open to all types of FC technologies and all types of fuels, as long as the new system can meet the expected emissions reduction. The FC system may be used for propulsion and/or auxiliary loads or for port and pilotage operations on ships (e.g., a ferry, freight carrier, cruise ship, passenger boat etc.). Retrofit of a vessel, where the FC system replaces conventional fossil-fuelled engines is also allowed. The ship should be used for commercial services to gain relevant operational experience. The FC system can be built of smaller units (modules) but no lower than 500 kW with a total on board installed power within each vessel of at least 2MW.

The project should address the following key issues:

Fuel cell system issues:

- Adapt and validate the FC module/system for reliable operation under maritime conditions for the selected fuel in line with prevailing technical (i.e., durability, power density) and regulatory (RCS, redundancy etc.) requirements;

- Assess how the FC module/system may be further up scaled to 20 MW power systems for larger ships;
- Particularly, if other fuels than hydrogen are chosen, maximise system efficiency to achieve a substantial improvement over current maritime combustion engine technology.

Fuel storage and supply chain:

- For the selected fuel, identify the required refuelling facility for the FC-powered ship and the fuel supply arrangements required to meet the stated CO_2 emission reduction targets. Consideration should be given to system weight, volume, required time for and operation time between bunkering, energy penalties and implications for larger ship designs (with regards to safety and potential loss of useful space);
- Define the fuel supply chain in volumes sufficient for short-range vessels and for long-range ocean-going vessels;
- For hydrogen as fuel:
    - an interim refuelling solution (e.g., containers) in relevant scale for the demonstrations is foreseen and
    - a study on a bunkering concept with the potential for scaling up (for compatibility with a 20 MW FC system) is required, ensuring minimization of hydrogen loss/leakages/boil-off (if relevant);
- For other fuels:
    - the bunkering solution is considered an integral part of the project.

System integration and operation:

- Define vessel integration requirements and develop adequate maintenance procedures, in line with approval requirements;
- Adapt/design the multi-MW fuel cell system/power generating unit to vessel application;
- Physical integration of the fuel cell, the fuel system and power management system into the vessel and vessel systems;
- Define any additional battery storage systems that may be needed for load levelling.

Regulatory, economic and societal issues:

- Contribute to the establishment and further development of maritime rules and guidelines for selected FC powered vessel design(s) and the alternative fuel to be utilized (i.e. explosion safety levels) in line with class/flag/port approval requirements;
- Assess and propose suitable business models, to foster further commercialisation of technical FCH solutions both on board the vessel and bunkering/refuelling;
- Quantify the potential for cost reductions as the FC and alternative fuel technologies mature and define the roadmap to get there;
- Assess the advantages of using FC systems in combination with the selected alternative fuel option in terms of emission reduction during operation, noise reduction, availability and reliability;
- Discuss /share experiences with the shipping industry to contribute to raise awareness of the potential of FC propulsion technology;
- Define training requirements for operator and crews.

With regard to the regulatory, economic and societal issues, it is expected that the project will contribute towards the objectives and activities of the Hydrogen Innovation Challenge (as detailed under section 3.2.G.

International cooperation). Promoting international collaboration beyond EU Member States and H2020 Associated Countries is therefore strongly encouraged.

The project should closely follow the developments in the IGF Code Correspondence Group at the IMO, works of the European Sustainable Shipping Forum (Sub-group on alternative fuels) and relevant work of the certification bodies. The project should moreover take into account and seek synergies with other ongoing activities such as research projects arising from the 2019 *Horizon 2020 topic LC-MG-1-8-2019: Retrofit Solutions and Next Generation Propulsion for Waterborne Transport*[27] addressing high power FC passenger ship concept.

The project should include an operational period of at least 12 months (including both winter and summer season) and a minimum of 3,000 operational hours demonstrating the TRL of the FC system and vessel. The ship should be used on a regular basis in order to gain relevant operational experience. Bunkering to sustain the normal operational profile of the vessel(s) is considered within the scope of this topic. Exploitation of synergies with refuelling infrastructure for other applications is considered advantageous. Excess fuel expenses during the demonstration compared to diesel is considered eligible costs.

If the selected fuel is hydrogen, “CertifHy Green H_2“ guarantees of origin should be used through the CertifHy platform[28] to ensure that the hydrogen consumption is of renewable nature.

The project consortium should include at least one of each of the following: vessel owners or operators, fuel cell system providers, shipbuilders or shipyards; cooperation with Classification Societies is also encouraged.

The construction of the demonstration vessels' hull, superstructure and other components unrelated to the FC propulsion system, as well as operational costs such as crew are not considered eligible costs.

For the various FC types and fuels (storage and bunkering solution) which are eligible (as described above), the TRL varies widely, so no TRLs at project start and end are included here. The proposals should nevertheless clearly describe the targeted TRL advancements.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The maximum FCH 2 JU contribution that may be requested is EUR 10 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

Expected duration: 4 - 6 years.

Expected impact:

The total minimum of 2 MW FC installed power is expected to be an early stepping-stone towards meeting larger vessels' power requirements of typically 20 MW or more for environmentally sound, safe and reliable operation. It provides a significant step towards the implementation of multi-MW FCs and their zero-emission fuels in shipping as the main energy source. The project should also strengthen the EU supply chain both for FCs and identify the steps that are needed in order to develop sustainable low-emission bunkering solutions for FC powered vessels. If other fuels than hydrogen are chosen, should demonstrate a significant improvement in fuel efficiency over the current state of the art. Additionally, the project should identify viable business models for large vessel applications. It will moreover provide for increased visibility of the potential of FCH technologies as a means for de-carbonising shipping. The demonstration will also provide important

[27] http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-transport_en.pdf
[28] https://fch.europa.eu/page/certifhy-designing-first-eu-wide-green-hydrogen-guarantee-origin-new-hydrogen-market

empirical evidence to IMO, Classification Societies, Flags Administration and the whole community for the development of underlying regulations, codes and standards, best practices, business cases, and so on.

More specifically, the expected impact include:

- Successful demonstration of MW-scale FC system(s), alternative fuel storage, bunkering and refuelling for shipping that, compared to current state of the art diesel engine technology, reduces GHG emissions by >70% and each atmospheric pollutant (NOx, SOx and particulates including ultrafine particulates) by >80% for the selected modes of operation;
- Identification of a route for scalability to 20 MW FC power, associated bunkering and system integration for large long-range vessels;
- FC Module durability of at least 25,000 h;
- Tank to propeller electrical efficiency of >48% (LHV) for relevant operation profile(s);
- FC system availability of at least 95 %, and operational strategies for meeting commercial ship requirements for propulsion, auxiliary load or port/pilotage operation;
- Technical solutions that meet all local safety requirements concerning refuelling, fuel storage and bunkering within the operational environment;
- Systems design life of at least 7 years to fit service intervals between major vessel overhauls (servicing allowed) in line with the typical 25-30 years vessel lifetime;
- Provision of empirical evidence and lessons learnt from implementing and operating FC ships and use of alternative fuels, identification of bottlenecks – technical, organisational, structural, financial including RCS and formulation of recommendations on how to address these;
- Increased public awareness about zero emission initiatives in the marine segment;
- De-risking further commercialisation of FC and alternative fuels technologies;
- Contribute to significant further capital cost reduction of fuel cells and refuelling infrastructure.

Type of action: Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018-2020 which apply mutatis mutandis.

FCH-01-3-2019: Cyber-physical platform for hybrid Fuel Cell systems

Specific challenge:

One of the most important objectives of FCH 2 JU is the support of the industrialization of fuel cell technology and systems for all kinds of applications, mobile and stationary. In many of these applications, fuel cell technology is and will be competing with other well-established technologies. The market price, durability and performance of the established technologies (internal combustion engines, gas turbines, partly batteries) have been optimized over many years, so that it is hard to compete with for the rather new fuel cell technology, which is a complex and highly integrated mechatronic and chemical system of systems.

Durability and performance, especially for transport applications with high dynamic performance requirements are 'must-haves' for fuel cells, and both production and development cost will influence a fast market penetration significantly. To reach these goals, drivetrains are usually an optimized hybrid system composed of a fuel cell system and a battery.

The way and the degree of coupling between batteries and fuel cells is the result of trade-off between autonomy range, weight and costs, and up to now limited analysis/development of hybridization strategies has been performed (see example of project SWARM[29]). The development of a model-based tool and its experimental validation for designing a hybrid system in early phases is of particular importance to accelerate the understanding and development of new products. This environment needs to be available soon to enable the European fuel cell industry, in particular the SMEs to develop and optimize fully functional, highly reliable and cost-effective products. Such highly integrated product design and development environment should combine virtual (i.e. simulation based) and physical (i.e. experiment based) aspects seamlessly over the whole development process. For example, numerical/physical models used in the first phase of fuel cell system development have to be continuously replaced by emulators for physical components that do not yet exist and combined with already available real hardware. This versatile mixed virtual / real development environment serves as a basis for control development, pre-calibration, functional and performance optimization and validation, sensitivity analysis etc. throughout the entire development process.

Scope:

The overall objective of the topic is to develop a validated fuel cell system model and its hybridization, and use it to assess design-point, part-load, dynamic performance and customized energy management strategies for automotive applications (also using results and data of previous research activities in this area). The proposal should address both numerical development (design and validation of an open-access modelling tool) and technological development (design, achievement and validation of the physical platform) with the following possible and successive steps:

- Design of a multi-application physical platform consistent with a wide variety of applications and hybridized architectures;
- Building and qualification of such a platform and validation of coupling with the open access software to be developed in parallel;
- Testing and validation of the platform with a real example (e.g. hybridized bus, truck, ship etc.) to validate the robustness of the platform. This step should produce optimised components of the FC system from the preliminary dimensioning steps and then should test them on the platform with operating conditions as close as possible to real operation conditions; some adjustments of both numerical and physical components of the platform might be foreseen.

In a first step and with the support/feed-back of an end-user, the most critical issues related to hybridization (e.g. energy management, system and component lifetime etc.) should be identified. The impact of system design and energy demand profile on the system performance, reliability and the durability should also be assessed. This should rely on two aspects:

[29] https://www.fch.europa.eu/project/demonstration-small-4-wheel-fuel-cell-passenger-vehicle-applications-regional-and-municipal-

- An open, seamless and highly integrated development platform for fast prototyping described as X-in-the-Loop (XiL) where X stands for model, software or hardware (MiL, SiL or HiL) of complex hybrid FC systems which goes far beyond existing specific simulation and experimental tools. Such a development platform should enable the combination and utilization of best in class or specialized tools, integrate XiL and real-time systems, allow massively parallel simulations and experimental tools for optimization and complex multi-scenario validation, fully support high performance and cloud computing as well as cross-company product validation, based on technologies like co-simulation and experimental testing as a service;
- Creating a common simulation, experimental and validation platform to exchange code libraries, models and best practices; UML 2.0 standard[30] should be used. Physical based model for lifetime prediction should also be included as well as an off-line (based on on-field data provided by end-users) or on-line (experimental characterisation at approx. 1kWe scale) study of different strategies on the system behaviour.

The system definition should start from the stack level to optimize the operating conditions of the fuel cell and to minimize the degradation of the MEAs. Therefore, a hybrid fuel cell system could be developed with a reduced time comparable to development time frames of today's conventional powertrains and taking into consideration the aspects from the material performance and durability (using experimental and model-based development approaches) and up to the assembly process and control strategies development. The integration and validation of advanced control including physical or signal treatment-based models, specifically for lifetime optimization (as state observers), should be validated both experimentally and in a modular mixed virtual/physical XiL platform. The modularity of this platform should allow the continuously and seamlessly integration of already developed components of the fuel cell system, including controllers, Balance of Plant (BoP) components, power electronics, etc. with the stack, even with different fuel cell system architectures.

Finally, the environment should also allow the consideration and investigation of hybrid systems to optimize the sizing of fuel cell and battery hybrid systems simultaneously within their constraints, including on-line power management strategies.

Real time capability of emulators and related numerical models for the components and the entire environment should be a prerequisite to validate the different algorithms (fuel cell system control and power management) and control strategies.

The increasing complexity of models on various levels (from subcomponent to system-of-systems level) should be approached with automated parameterization functionalities and algorithms, and a seamless switching between real and emulated parts.

Fuel cell technology would profit from such a development platform significantly, as product development and optimization could be performed here "ab initio" on these new standards rather than needing to replace existing classical development routes and in development time frames suitable for typical industrial product cycles in the range of 36 to 60 months.

The XiL platform should be open regarding the interfaces to other third party simulation and testing modules and tools (including co-simulation etc.). The XiL platform should also consider interfaces for future web-based services and data exchange.

It is expected that at least several end-users or vehicle manufacturers to be part of the consortium.

TRL at start: 4-5 and TRL at end: 6.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

[30] UML = Unified Modelling Language

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 1.8 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

A maximum of 1 project may be funded under this topic.

Expected duration: 3 years.

Expected impact:

Expected impacts of the project should include:

- Significant reduction of development times from >60 months down to 36 months for new fuel cell – battery hybrid systems;
- A better understanding of hybridization strategies on the performance, reliability and durability, for reference cases representing typical transport industrial applications. This includes a benchmark of current optimization algorithms (off-line and on-line);
- The expected tool/platform will be not only a software but an optimized and versatile combination of real or emulated components of the complete FCEV propulsion system (stack and BOP, battery pack, power electronics, electric engine…) associated with XiL open to any users of the value chain from component suppliers to Original Equipment Manufacturers (OEMs) for different transport applications (land, air, water etc.);
- Development of high-performant real-time BoP-emulators surrogating and realistically emulating the highly dynamic behaviour of real components or sub-systems needed for transport applications;
- Create a modular open development platform (SiL, MiL, HiL) for hybrid fuel cell systems with integration capabilities for BoP components, controllers, energy management strategies, etc. and corresponding simulation models along with analytical tools and advanced instrumentation to validate the different methodologies developed;
- Enable multi-tool combinations with massive parallel computing;
- Exchanging best practicing and harmonizing models and algorithms to optimize hybrid fuel cell system architecture and power management strategies and validation in a XiL platform in order to achieve at least 5,000 h durability, a hydrogen consumption lower than 1.15 kg/100km for fuel cell light duty vehicles and at least 20,000 h durability, a hydrogen consumption lower than 8 kg/100km for large vehicles (bus, trucks, ships, trains);
- Promote the exchanges and create sound links between software development, software implementation as well as experimental tools and FC industry along the entire supply chain;
- Enable the establishment of a EU based supply industry for hybrid FC system simulation and experimental tool environment (XiL platform) to order to boost the competitiveness of EU FC industry. At the end of the project, open and free access to the platform it is expected for EU industry, in particular SMEs with limited costs to the operational costs.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

FCH-01-4-2019: Towards a better understanding of charge, mass and heat transports in new generation PEMFC MEA for automotive applications

Specific challenge:

Automotive application requests next generation PEMFC operating at high current densities (>2.7A/cm²), low noble catalyst loading (<0.08 mg/cm²), high power densities (>1.8W/cm², 9.3 kW/l), with high durability (>6,000h) and low cost (<50€/kW), as defined for horizon 2024 in the MAWP. The current status (for instance AutoStackCore project[31]) is still far from these targets reaching approx. 1.13 W/cm², 4.1kW/l for approx. 0.4 mg/cm² during 3,500 hours. It is obvious that a disruptive approach is mandatory to reach these targets, including new materials and associated processes, new components design, and new stack architecture. Consequently, such next generation MEA (Membrane Electrode Assembly) shall deliver much higher power densities than the current ones and the SRU (Single Repeat Unit) of the stack will be much thinner and lighter, and based on ultra-thin MEA with ultra-low catalyst loadings. Based on this, two sets of questions can be highlighted i) what kind of new or exacerbated phenomena can occur with these next generation MEA, and ii) how can power density be increased when reducing catalyst loading at the same time? A common issue is to better understand the performance limitations for such MEA to propose new design and materials to overcome these issues.

Until now, the mechanisms inducing these limitations in performance are still under discussion and the relationship between the structure/design of the materials and the performance is not understood enough despite some recent progress. It is thus very difficult to define how far the performance could be increased by modifying the MEA. To better understand heat, mass and charge transport limitations in a MEA will allow proposing reliable breakthroughs in component design, operation strategies and performance prediction.

Scope:

This topic is focused on the basic understanding of promising MEAs and MEAs components to meet the target of high-power density PEMFC single repeat unit. Only MEAs and MEA components showing performance greater than all of 0.79W/cm2 and 2,450hrs (which are approx. 70% of the current State of the Art (SoA) status quoted above) and at Platinum loading less than 0.50 mg/cm² (total loading) proven in automotive testing condition (as defined in JRC99115[32]) are eligible as reference materials for this topic

The project should include all of the following issues:

- Transport mechanisms, properties and limitations in the components (protons, electrons, liquid water, gases, heat) of the catalyst layer and microporous layer and at the interfaces, e.g. between catalyst layer and membrane, and between catalyst/layer and transport media in coupling with the electrochemical mechanisms. This includes the mechanisms and kinetics of the oxygen reduction reaction as a function of local conditions (temperature, partial pressure of reactants and products) in relation with catalyst surface structure and composition (e.g. oxides, hydroxides coverages). The Gas Diffusion Layer (GDL) and the interface between GDL and flow channels could be also considered if clearly justified as major issue. Project should be focused on MEA targeting ultra-low Pt loading (< 0.08 mg/cm²), high power density (> 1.8 W/cm²) and compact design (ultra-thin materials and designs, typically two to three-times thinner than today). The type of MEA should be proposed by the consortium while the project should account as much as possible for 'generic' situations applicable to SoA MEA and next generation MEA;
- The MEA should present reasonable durability, e.g. performance decay less than 50 µV/h. Durability is also an issue for such low catalyst loadings. As this topic is focused on understanding the performance limitations to increase power densities, the understanding of durability issues is not part of the topic. Nevertheless, it will be highly appreciated to check durability of the MEA tested and

[31] https://www.fch.europa.eu/project/automotive-fuel-cell-stack-cluster-initiative-europe-ii
[32] http://publications.jrc.ec.europa.eu/repository/bitstream/JRC99115/ldna27632enn.pdf

especially to test how durability is modified by using MEA with increased power densities due to better heat and mass transports inside the MEA;

- Combine experiments and modelling to predict the overall performance of a Single Repeat Unit (SRU) in a real stack geometry. It is expected to give the most accurate phenomenological description of the major limiting phenomena and their coupling thanks to specific experiments and the associated validated models. This should be assessed thanks to an accurate characterization, description and simulation of the local conditions and components structure and composition from 1-10 µm down to the 5-50 nm scale, considering the SRU design and real operating conditions. These measurements of the local conditions in a real stack design (MEA surface representative of a full-scale stack geometry) will also be established from the beginning of the project on the last state-of-the-art selected stack design and ultrathin MEA. The main idea is to bridge the gap between the local composition, structure and properties of the components, from the 'micro'-scale, their effective properties at the 'meso'-scale and their performance for different operating conditions when assembled in a SRU[33]. Mechanistic models for the description of the basic phenomena are highly desirable and then could be upscaled to be included in ones usable at the 'macro-scale'. Model components and systems could be used for easier model validation in addition to dedicated validation experiments. The experiments must be conducted in conditions as close as possible to the ones of real operating PEMFC stack. Operando characterisation are recommended but ex-situ characterisation mimicking real conditions are also acceptable. At least, transport phenomena with phase change and two-phase flow must be addressed in the proposal.

The implementation of original methods or approaches is preferable, either in addition to or in coupling with improved conventional ones, both for experimental or modelling aspects.

In order to demonstrate the progress beyond the state-of-art in MEA development, the consortium should cooperate with the ongoing or finished projects (not only FCH 2 JU supported) in order to make consistent technical choices based on preliminary results from these former projects and target materials that have already proven certain performance.

The consortium is expected to contain at least one OEM partner that should take part in the technical work.

It is expected that the project will contribute towards the objectives and activities of the Hydrogen Innovation Challenge (as detailed under section 3.2.G. International cooperation). Promoting international collaboration beyond EU Member States and H2020 Associated Countries is therefore strongly encouraged.

TRL at start: 2 and TRL at end: 3-4.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 2 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

More than 1 project may be funded under this topic for complementary approaches.

Expected duration: 3-4 years.

[33] Local properties and composition can include for instance 3D solid phase and composition at the pore scale (also called the 'micro'-scale), effective properties refer to an average of the local properties over a heterogeneous system which can then be used to describe the system as a homogeneous one (also called the 'meso'-scale), for instance effective electrical conductivity.

Expected impact:

The project should result in:

- Justifying and characterizing the performance limitations and the effective properties of the MEA;
- Quantifying and predicting the local operating conditions inside a MEA;
- Designing recommendations for components to increase performance of MEA ;
- Preliminary orientations for future studies and development to reach the durability targets.

The main KPIs to be reached are the following:

- Power density > 1.8 W/cm2 at 0.66 V;
- Max operating temperature of 105 °C;
- Durability projected for 6,000 h;
- Pt efficiency up to 15 A/mg @0.66 V;
- Overall Pt loading < 0.08g/kW;
- Cell Volumetric power < 9.3 KW/l.

These KPIs should be reached under automotive operating conditions (as defined in the harmonised EU test procedure) and at single cell level: JRC99115.

Type of action: Research and Innovation.

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

FCH-01-5-2019: Underground storage HRS

Specific Challenge:

Two main barriers to the successful rollout of hydrogen retail infrastructure are still the high cost and the large footprint of hydrogen equipment. In particular, in urban environments, the space available at retail stations is often too small to add hydrogen refueling technology. The problem might become soon a large impediment once hydrogen has been added to the few available spacious sites in a region and only compact sites remain.

Improved station design has also reduced the space needed for hydrogen equipment, making the storage the largest component on hydrogen stations. Storage of conventional fuels, like gasoline, is usually underground, leaving space on the surface for the other components. The development of low-cost, underground storage concepts for compressed gaseous hydrogen is therefore required to enable rollout of a hydrogen refueling network dense enough to meet customer requirements in the 2020's.

Scope:

The objective of the topic is to design, certify, build and operate for at least 6 months a hydrogen retail station with underground storage of hydrogen, whereby:

- The usable amount of hydrogen stored underground is at least 150 kg with a system volume of maximum 0.14 m3/kg;
- The pressure of the hydrogen released from the underground storage system is ~ 30 bar;
- The system is designed to be refilled from a compressed hydrogen trailer in less than an hour or from an on-site hydrogen generator;
- The system can be installed similarly to underground gasoline tanks, without the need for significant (concrete) construction (ideally gasoline tanks should be replaced with hydrogen containing tanks without further need for fortification);
- The space above the storage can to a large extent be used for activities necessary on a forecourt (e.g. placement of the hydrogen dispensing equipment, high pressure storage, roads and car parking);
- No additional equipment needs to be installed above ground to store or process the hydrogen (apart from normal hydrogen station operations);
- The cost of the buffer storage system should be below 750 EUR/kg usable hydrogen and the installation cost below 250 EUR/kg;
- The lifetime of the system should be at least 20 years, assuming it is refilled from minimum to maximum (or 'empty to full') three times a week.

The hydrogen storage facility should be integrated into a multi-fuel refueling station that dispenses gasoline, diesel, and preferably also LPG and/or CNG to ensure realistic conditions for the safety assessment, certifications and regular inspections. The underground storage may be installed at an existing, planned or new HRS site.

The scope should also include developing recommended procedures for safety assessment and permitting process steps, including co-location of hydrogen storage with other liquid and gaseous fuels. Associated learnings should be documented as case study examples for typical site layouts, as well as for the specific implementation site. The resulting procedures should be made publicly available. Similarly, solutions relevant to the underground storage developed during the project should also be made publicly available, including drawings pictures and/or videos.

The demonstration site should include a minimum of one hydrogen dispenser capable of refueling 350 and 700 bar FCEV. All relevant hydrogen equipment closely associated with the underground storage facility are eligible (e.g. storage vessels, sensors, pipework, civil works, modification costs, planning and permitting costs), while the other components of the station (e.g. dispenser, high pressure storage, compressor or electrolyser) are not eligible costs for the project. "CertifHy Green H_2" guarantees of origin should be used through the CertifHy platform[34] to ensure that the hydrogen dispensed is of renewable nature.

TRL at start: 6 and TRL at end: 8.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu, which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The FCH 2 JU considers that proposals requesting a contribution of EUR 1.5 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

A maximum of 1 project may be funded under this topic.

Expected duration: 3 years.

Expected impact:

The project should become a blueprint for the further rollout of underground hydrogen storage at retail stations. It is therefore expected to:

- Demonstrate that underground storage of hydrogen is feasible (regarding safety and permitting) and practical (regarding space requirement, lifetime and full cost);
- Provide a framework for safety assessment and permitting of future hydrogen stations with underground storage;
- Make recommendations as to how such hydrogen stations can be incorporated into harmonised EU standards;
- Identify how the hydrogen refueling infrastructure across the EU can be expanded via the demonstrated approach compared with not having underground hydrogen tanks;
- Provide ample publicly available material for use in future projects.

Type of action: Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

[34] https://fch.europa.eu/page/certifhy-designing-first-eu-wide-green-hydrogen-guarantee-origin-new-hydrogen-market

ENERGY PILLAR

FCH-02-1-2019: Combined electrolyser-HRS and Power-to-Gas system

Specific challenge:

The business case for renewable hydrogen projects is frequently hindered by low utilisation of the equipment. This is caused by the combination of a variable renewable energy supply and a still emerging demand for renewable hydrogen in the mobility sector (e.g. from fuel cell vehicles). Projects are thus often limited to specific niches where non-monetary benefits compensate for idle excess capacity. New business models are therefore required to facilitate the future rollout of hydrogen infrastructure.

The ability to inject hydrogen into the European gas infrastructure via the power-to-gas approach would allow selling surplus hydrogen as a green gas to natural gas distribution networks and reduce the variability on the demand side. This will create a supplementary revenue stream from the gas market, improve electrolyser readiness for providing electricity grid services on demand, and reduce the investment risk by overcoming low plant/HRS utilisation.

The challenge for this topic is to reduce the financial risk of hydrogen supply at a refuelling station by optimising the operating condition of the electrolyser under varying power prices, grid services regimes and changing customer demand, using the low pressure gas distribution network as a hydrogen sink for achieving a secondary income stream, and electricity grid services as a tertiary income stream.

Scope:

This topic calls for assessment and demonstration of an electrolyser and gas network injection equipment at a refuelling station where hydrogen demand for mobility is expected to increase over time. The mobility demand may come from passenger cars, or any other type of hydrogen vehicle including buses, trucks and trains. Although co-location of a station with the gas distribution network is not a conventional siting criterion, it is a pre-requisite for achieving a combined electrolyser-HRS and Power-to-Gas system.

The following equipment could be used for the project and be directly connected at a single site:

- A hydrogen refuelling station with a capacity of dispensing at least 200 kg/day that is expected to experience under-utilisation during most (or all) of the demonstration period (demand build-up period);
- An electrolyser of at least 600 kg/day generation capacity, with sufficient flexibility to optimise hydrogen production cost as a function of electricity prices, grid balancing activities and gas network feed-in tariffs;
- A gas grid admixture and injection system, including the development of appropriate mixing and concentration monitoring technology, which is capable of injecting hydrogen admixtures at flow rates of up to 100% of the electrolyser capacity while maintaining the transient concentration at the grid injection point within specified limits.

It is expected that potential project would:

- Create and publish a model that optimises for total cost of ownership the operation of the components above as a function of power prices, grid services payments, hydrogen mobility revenue and hydrogen injection revenue (including injection fee where applicable). Consideration should be given to diurnal and seasonal variations in operating strategy, to the expected transition from low to high numbers of hydrogen vehicles using the station and to any variations in the value of hydrogen to gas networks as they decarbonise. It is important that any costs for the gas network in a regulatory context (e.g. regulatory sandbox) are included in the analysis and the model should consider existing, planned and new stations that are in close proximity to gas distribution pipelines. Preferred operating strategies should be identified by the project, which must be comprehensive enough that others can repeat the work and adopt the identified business models;

- Build and operate the equipment to validate the model with real life data, including comparing the Total Cost of Ownership (TCO) of the refuelling station without gas grid injection (no CAPEX, OPEX or revenue from the injection system) to that with a grid injection facility. Hydrogen cost targets for stations with and without gas grid injection should be compared for a range of operating variables and rates of HRS deployment across the period 2020-2030. The demonstration should last for at least 2 years, with the expectation that all of the equipment remains in use afterwards. The duration of need for the network injection facility is a key parameter (demand build-up period);
- Liaise with the similar topics of this call (topic *FCH-02-5-2019: Systematic validation of the ability to inject hydrogen at various admixture level into high-pressure gas networks in operational conditions* and topic *FCH-04-3-2019: Hydrogen admixtures in natural gas domestic and commercial end uses*) to ensure the latest understanding of the impacts of admixtures upon end use equipment and any variations across EU inform the chosen concentration limit and concentration ranges to be applied at the HRS site;
- Obtain an exemption from existing regulations and a permit as required from the gas network regulating authority to inject admixtures at the site of the refuelling station. Because flow rates in gas distribution networks tend to be low outside of the heating season, especially overnight, it is important for the system to be able to inject admixtures of up to the highest acceptable concentration if the annual electrolyser utilisation is to be maximised, rather than remain within the limits of existing regulations;
- Assess the challenges and propose solutions for injecting hydrogen admixtures into gas distribution networks with respect to: identifying appropriate sites where refuelling stations can feasibly be located close to gas distribution pipelines while ensuring all downstream gas applications are compatible with the admixture concentration under consideration; obtaining any required permits and exemptions; network connection costs and hydrogen concentration measurement at the entry point; and the associated impacts on HRS footprint and site maintenance;
- Report any differences with initial assumptions, for example related (but not limited) to electrolyser hydrogen yield, product losses, switching times, injection curtailment due to low gas grid flow rates or transient situations, the primary/secondary/tertiary revenue streams, and the cost and regulatory context for the grid injection equipment;
- Provide a conclusion around the impact of hydrogen admixture injection into the gas distribution grid upon the business case of an electrolyser-HRS and identify the cost reduction potential of adding gas grid injection to an electrolyser-HRS.

TRL at start: 6 and TRL at end: 8.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The HRS, electrolyser, gas mixing and injection equipment, and related activities are considered within the scope of the project, while consortium is encouraged to make use of existing infrastructure or equipment where possible and focus on the demonstration, generating and communicating learnings.

"CertifHy Green H_2" guarantees of origin should be used through the CertifHy platform[35] to ensure that the hydrogen produced, dispensed at the HRS and injected in the natural gas grid is of renewable nature.

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[35] https://fch.europa.eu/page/certifhy-designing-first-eu-wide-green-hydrogen-guarantee-origin-new-hydrogen-market

The maximum FCH 2 JU contribution that may be requested is EUR 5 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

A maximum of 1 project may be funded under this topic.

Expected duration: 4 years.

Expected impact:

The project should deliver substantiated information on the optimisation potential and optimisation schemes for electrolysers at HRS operated on variably priced power and receiving revenues from FCEV refuelling, the gas market thanks to admixture injection, and the delivery of electricity grid services.

Via a validated model, the results should be applicable to different settings where the actual demonstration takes place, for example other EU countries.

It is expected that the project would:

- Combine a hydrogen refuelling station and a power-to-gas system compactly at one site using one electrolyser;
- Ensure more efficient use of renewable power and increase the amount of renewable gas in the gas grid;
- Enable lower cost on-site hydrogen supply from renewable power sources, reducing the hydrogen price at the pump. This would also increase the amount of decentralised hydrogen production and thus decrease distribution requirements;
- Provide a blueprint for HRS bankability at initial stages of operation when vehicle concentration is low, facilitating a more economic and faster roll-out of an HRS network across Europe;
- Demonstrate efficient sectoral integration between the electricity, gas and mobility sectors;
- Improve understanding of the impacts of admixtures upon grid and end use equipment, in collaboration with the other two relevant topics of the call (see above under Scope).

Type of action: Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

FCH-02-2-2019: Multi megawatt high-temperature electrolyser for valorisation as energy vector in energy intensive industry

Specific Challenge:

Energy intensive industries (EII) including food, pulp and paper, basic chemicals, refining, iron and steel, nonferrous metals (primarily aluminum), and nonmetallic minerals (primarily cement) consume around one quarter of the energy in Europe[36] and are a large contributor to GHG emissions. The majority of the energy currently comes from hydrocarbons such as coal, natural gas and oil.

Hydrogen is often the only solution to substitute carbon-based reducing agents, gases, and fuels that brings significant GHG emission reductions, especially if the hydrogen is produced from renewable energy sources. The reason why renewable hydrogen has not yet been rolled-out at a significant scale in EII is due to the high production costs of hydrogen, as well as a slow adaptation rate to emerging technologies in EII such as electrolysis.

The high-temperature electrolyser (HTE) technology is well suited for EII as the availability of low-grade heat sources helps to improve the process efficiency and hence the production costs compared to low-temperature electrolysers (PEM, AEL). The project aims to scale HTE to a level that starts to have recognition in EII while simultaneously presenting the world's largest HTE. Current HTE technologies have not yet demonstrated the MAWP 2020 targets for efficiency, durability and costs at (i) megawatt scale and (ii) over a relevant period of time. In order to show that these targets can be met in short-term and to increase industrial awareness and confidence, at least 24-month demonstration at an industrial site is needed. Significant efficiency gains should be achieved by fully integrating the HTE into the specific EII processes.

As durability is one of key hurdles to market penetration, it is important and urgent to address degradation effects and robustness of auxiliary equipment such as steam supplies or hydrogen compression and purification. Here, former system projects have shown that combining HTE with compression and hydrogen purification is a special challenge.

Only few HTE stack technologies have been demonstrated on an intermediate scale so far to offer a fast path to scale-up based on full system experience. To ensure the longer-term take-up of the most efficient stack technology, at least 2 different stacks are to be physically benchmarked in a relevant system environment (hotbox test) at 10 kW_{SOE} level and economically evaluated within the project in order to identify the available stack options for further upscaling.

Scope:

This topic calls for a large-scale multi-megawatt high-temperature electrolyser to be demonstrated in EII under realistic market conditions by using renewable electricity. Steam should be provided, at least partially, from an external source (e.g. from waste heat) in order to illustrate the superior efficiencies of HTE compared to low-temperature electrolyser systems.

The demonstration should prove an economical business case for HTE by generating hydrogen at competitive prices. Prospects for the business case should be solid and well justified. The valorization of any side product (e.g. oxygen or power management) within the industrial environment should be considered too.

It is expected that the project would:

- Address a particular EII and propose the integration of an HTE. The HTE should be benchmarked against alternative solutions and the advantages of the selected process route for further development under the proposed project should be explained;
- Manufacture, integrate and operate an HTE at the level of a large pilot (>60 kg/h hydrogen) over a period of at least 36 months;
- Provide a benchmark stack test of at least 10 kWel with at least 2 different stack technologies;

[36] https://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy

- Perform long term operation under realistic operation including cycles for at least 16,000 h (long-term testing);
- Provide information on integrated process efficiency, electricity and steam consumption, and hydrogen consumption;
- Evaluate the expected environmental performance – at the very least GHG emissions reduction potential (at the level of the full process route, including production of hydrogen),
- Minimize the use of any critical raw materials and other major environmental burdens;

Special importance should be given to degradation effects resulting from contaminations either from steam supplies or from the materials that are used inside the system; efficiency degradation rates lower than 0.5%/1000 h at constant hydrogen should be achieved.

The system should consist of a number of HTE modules to enable larger flexibility in operation. Industrial applications typically require different hydrogen qualities up to 5.0 as large differences exist and need to be investigated individually for every application. The project should address whether a pre-treatment of e.g. water/steam, constructional changes in the electrolyser or an after-treatment of hydrogen is the most economical solution in terms of CAPEX, OPEX and achievable hydrogen quality. Furthermore, the project should prove high availability, low maintenance requirements and high efficiency of compression and hydrogen purification systems in combination with rigid requirements of HTE systems in terms of pressure and load fluctuations.

The project should propose future strategies to tackle the issue of constant hydrogen demand of the EII processes and the intermittent availability of renewable energies for the production of renewable hydrogen (e.g. through hybrid power purchasing models, polygeneration or small Steam Methane Reforming (SMR) with renewable gas, large scale hydrogen storage). Therefore, "CertifHy Green H_2" guarantees of origin should be issued through the CertifHy platform[37] to ensure that the hydrogen production is of renewable nature.

A higher thermal and chemical integration of the electrolyser into downstream processes can increase overall efficiency and complexity. Likewise, the utilization of the oxygen produced via HTE has an impact on overall efficiency. Any other auxiliary systems necessary for the specific EII process should be assessed for trade-offs in terms of added value gained against CAPEX and OPEX expenditures to ensure optimal integration of the HTE modules in the plant.

TRL at start: 7 and TRL at end: 8.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The maximum FCH 2 JU contribution that may be requested is EUR 7 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

A maximum of 1 project may be funded under this topic.

Expected duration: 4 - 5 years.

Expected Impact:

One of the main impact would be building of the world's largest HTE in EU and demonstration thereby of its both technological and industrial leadership in SOC technology. The demonstration of an HTE as a chemical energy supply for energy intensive industry processes significantly lower the carbon footprint in a specific

[37] https://fch.europa.eu/page/certifhy-designing-first-eu-wide-green-hydrogen-guarantee-origin-new-hydrogen-market

showcase, integrated in an industrial environment, using renewable electricity. Thanks to the superior efficiencies of HTE, with electricity consumptions of ≤ 40 kWh/kg H2 if operated with steam from exhaust heat, competitive hydrogen prices can be achieved in many industries.

A successful validation of HTE module(s) on multi-megawatt scale and achievement of the KPIs listed below will increase maturity and credibility of the technology. The direct comparative benchmarking of various stacks will favor the emergence of a more specialized/structured supply chain, offering system integrators qualified options for system developments in their specific context.

The project should also reduce the gap between HTE and low-temperature electrolysis such as PEMEL and AEL. The stack benchmarking should also identify the available stack options for further scaling and prepare the path for large cost reductions due to increased production volumes.

A technology comparison will improve the credibility and competitiveness of multiple players in this field. Together with very large potential market, a successful product launch will strengthen the EU industry's position globally and creates prospects for future jobs.

The target KPIs according to MAWP 2024 (Annex 2) have to be met on the electrolyser system level:

- Electricity consumption @nominal capacity: ≤ 39 kWh / kg (of hydrogen)
- Availability: ≥ 98 %
- Capital Cost: ≤ 2,400 € / (kg/d)
- Stack production loss rate: ≤ 1.2 %/1,000 h
- Operations & Maintenance cost ≤ 120 €/(kg/d)/year

The project should present a commercially acceptable service and maintenance concept that shows that O&M cost of ≤ 120 €/(kg/d)/year can be achieved.

Type of action: Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

FCH-02-3-2019: Continuous supply of green or low carbon H2 and CHP via Solid Oxide Cell based Polygeneration

Specific Challenge:

There is increased penetration of various intermittent (electric) power generation sources in combination with a shift towards fossil-free hydrogen from power. This combination requires back-up solutions during dark doldrums, for a reliable continuous supply of electric power as well as renewable hydrogen.

Tackling this challenge by coupling the industrial, power, heat and mobility sectors by using reversible Solid Oxide Cell (SOC) technology integrated into existing infrastructures allows to achieve this with high flexibility at low cost. SOC have the ability to provide adequate energy transformation processes as required by the overall energy system situation, both storing or generating electricity while assuring continuous hydrogen supply, e.g. for critical processes. For example, a polygeneration system has the ability to provide hydrogen from electricity in the electrolysis (SOE) mode or from methane when no electricity is available (SOFC mode). In the latter case, the system also provides electricity and heat, usually adequately with demand.

Various projects such as GrInHy[38] and CH2P[39] are already addressing the constitutive basic blocks to build polygeneration systems such as the Solid Oxide membrane reactor, reformers, and shift reactors. Within these projects, the systems demonstrate different sub-sets of a polygeneration system but not the entire scope. In order to achieve reversible polygeneration for continuous hydrogen supply, the thermal integration, fast and save mode changes as well as a lower cost and efficient gas downstream processing present the main challenges. A high system efficiency in the various modes is required to deliver economical attractive solutions and needs to be balanced with proper component dimensioning to avoid excessive costs.

The challenge also includes the identification of specific use cases where an appropriate payback on the investment cost can be expected associated to a sufficient market volume to allow adequate cost reduction. Such cases are expected to be found in mobility applications with seasonality of renewable electricity supply (hydro, solar) and for chemical processes but might be found also in other domains. Setup of business models that allow demand driven secured supply of low-carbon hydrogen and power from distributed specific points, such as in transport or grid serving, especially pathways allowing stepping forward quickly on the market with limited or no subsidies.

Scope:

The project should develop, engineer, build a polygeneration system and test/operate it for 5,000 hours in a real industrial or mobility environment. It is expected that every mode should be operated for at least 20% of the total operating time. The polygeneration system should also meet the following criteria:

- Electrolysis output > 20 kg/day;
- LHV-based efficiency in electrolysis mode > 75%;
- LHV-based efficiency in fuel cell mode >75% accounting H2 LHV, electricity and useful heat or 70% accounting H2 LHV and electricity;
- Part load operation capability as low as 30% for hydrogen production;
- Transient operation capability and reverse cycle time of <30 minutes;
- Degradation <0.5%/khrs on H2 production and electricity efficiency, including mode and thermal cycling at constant hydrogen output (or equivalent as adequate to the specific use case).

The system design and construction should be based on component modelling and testing to better understand and enhance degradation and performance in different operational modes.

[38] https://www.fch.europa.eu/project/green-industrial-hydrogen-reversible-high-temperature-electrolysis

[39] https://www.fch.europa.eu/project/cogeneration-hydrogen-and-power-using-solid-oxide-based-system-fed-methane-rich-gas

The project should also cover the development of a demand and operational model, ensuring that "CertifHy Green H_2" or "CertifHy Low-Carbon H2" guarantees of origin are issued through the CertifHy platform[40] to ensure that the hydrogen production is renewable or low-carbon depending on the operation mode. The flexibility of polygeneration should ensure that the demand side for hydrogen does not have to follow the supply side of renewable electricity.

The operational model should consider the market constraints such as electricity and 'grey' hydrogen prices, access to capacity markets etc. and lead into a profitable business model. If a profitable business model is not possible, the obstacles towards profitability should be identified and communicated.

Depending on the environment, syngas (CO + H2) can be an alternative to pure H2.

TRL at start: 4-5 and TRL at end: 6.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The maximum FCH 2 JU contribution that may be requested is EUR 3 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

A maximum of 1 project may be funded under this topic.

Expected duration: 3 - 4 years.

Expected Impact:

Polygeneration systems will provide continuous renewable and low carbon hydrogen and ensure a fast and reliable path for the deployment of hydrogen use. The project should therefore expected to have the following impacts:

1. Demonstration of secure year-round green or low carbon H_2 availability of over 90% for hydrogen dependent processes, also during dark doldrums;
2. Year round hydrogen availability and polygeneration assuring maximum annual capacity utilization reducing thereby the specific CAPEX (i.e., CAPEX per kg of H2 or kWh electricity) is reduced to <5,000 €/(kg H2/day) at an annual system manufacturing volume corresponding to 40,000 kg/day;
3. Replacement of carbon intensive steam reformers and hydrogen-logistics with reduction of >60% in CO_2 emission per kg of produced hydrogen;
4. Cost effectiveness with targets of 3.50 €/kg H2 (@40 €/MWhel) and 5.00 €/kg (@80 €/MWhel);
5. Offer lower cost and low carbon foot print system for distributed supply of hydrogen accelerating the rollout of hydrogen infrastructure in transport;
6. Removal of the need for expensive back-up systems for hydrogen supply for the generation of hydrogen from renewable sources, allowing the highly flexible system to couple the different sectors of electricity, industry, mobility and heat; this flattens peak prices caused by the compensation of fluctuation/intermittency, a major bottleneck as of today;
7. Providing additional volumes of stack manufacturing in this application and supporting the volume-driven cost reduction path in further fields of application such as SOE and cogeneration.
8. The project offers the opportunity for new operational and business models, showing profitability or identifying the hurdles to profitability.

[40] https://fch.europa.eu/page/certifhy-designing-first-eu-wide-green-hydrogen-guarantee-origin-new-hydrogen-market

Type of action: Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

FCH-02-4-2019: New Anion Exchange Membrane Electrolysers

Specific challenge:

Hydrogen is an important raw material for chemical syntheses (ammonia, methanol etc.), metallurgical reduction reactions and oil refining. Nowadays, it is mostly generated by reforming hydrocarbons, which is associated with a significant carbon footprint.

Proton exchange membrane (PEM) electrolysis has evolved into a mature technology with promising perspectives to play a key role for production of green hydrogen in the future energy landscape. However, the use of PEM electrolysers for producing a meaningful percentage of the annual hydrogen production rate in Europe would require the installations at gigawatt scale. The electrodes of state-of-the-art PEM electrolysers require a significant loading of platinum-group metals (PGMs), particularly iridium. Hence, such a large-scale deployment of PEM electrolysers raises major concerns about the availability and price of these raw materials. On the other hand, the electrodes of alkaline water electrolysers do not require PGMs. However, at present alkaline electrolysers operate at low current densities due to the high resistance of the relatively thick separators.

Anion exchange membrane (AEM) electrolysis can potentially combine the beneficial features of the PEM and alkaline electrolyser technologies, *i.e.* a low cost, raw materials that do not raise concerns in terms of supply bottlenecks (electrodes that do not include PGMs, stainless steel current collectors), a compact design, the adoption of feeds based on non-corrosive liquids (low concentration alkali or DI water), and differential pressure operation. However, as of today AEM electrolysis is limited by AEMs exhibiting an insufficient ionic conductivity as well as a poor chemical and thermal stability. Moreover, most non-PGM electrocatalysts, in addition to poor electrical conductivity mentioned, are only stable above pH 12, and really active at pH 14. Therefore, new material breakthroughs and design concepts are needed before AEM technology can challenge PEM electrolysers. These include:

- Increase in membrane and ionomer conductivity and stability;
- Decrease in membrane thickness while retaining good gas separation;
- Improve mechanical stability;
- Optimize chemical composition and activity of non-PGM electrocatalysts;
- Optimize electrocatalyst conductivity, dispersion and utilization in the electrode;
- Improved cell design.

Scope:

The potential proposal should:

- Develop and redefine new components for AEM electrolysers, including membrane, ionomers, PGM-free electrode packages, porous interconnectors and separators;
- Implement the newly developed components in a 1 kW stack with a minimum of 5 cells;
- Achieve current PEM electrolysis performances as defined by the MAWP, with diluted circulation of electrolytes but gradually move to pure DI water circulation (< 20 µS cm-1), reaching single-cell voltages of 2 V at 1 A cm-2 at 45°C and maintain stable performance at constant current for 2,000 h with a degradation gap of less than 50 mV;
- Make a clear correlation between the developed materials/components and the achieved cell performance and durability;
- Provide cost assessment for the developed technology and scale-up. The technology should clearly demonstrate component cost reduction compared to current PEM electrolysis technology.

It is expected that the consortium include industrial companies capable of scaling up and commercializing the technology developed. The focus of the project should be clear on the combination between materials research and performance testing.

It is expected that the project will contribute towards the objectives and activities of the Hydrogen Innovation Challenge (as detailed under section 3.2.G. International cooperation). Promoting international collaboration beyond EU Member States and H2020 Associated Countries is therefore strongly encouraged.

The technology should start at TRL 2 and reach TRL 4 at the end of the project.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The FCH 2 JU considers that proposals requesting a contribution of EUR 2 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected duration: 3 years.

Expected impact:

The AEM electrolyser short stack including the newly developed components will offer a promising and cost-effective alternative to PEM electrolysis technology paving the way for larger systems. The expected impacts are:

- Stable and cost-effective components for AEM water electrolysers that will reduce substantially the risk to incur in supply bottlenecks, the investment costs and thus the total €/kg H2;
- New knowledge with respect to the design and operation of an AEM electrolyser stack including the new components;
- Understanding of the correlation between degradation processes in materials and the operation conditions such as temperature and current density;
- Increased EU competitiveness in production of green hydrogen from renewable sources at large scale.

The expected KPI to be achieved by AEMs are:

1) Area specific resistance (ASR): $\leq 0.07\ \Omega\ cm^2$ (room temperature);
2) OH^- conductivity of membrane: 50 mS cm^{-1} (room temperature);
3) Swelling ratio (dry/wet): [dimensional stability]
    - Machine Direction (MD): ≤ 1 %;
    - Transverse Direction (TD): ≤ 4 %;
4) Mechanical strength: 15 MPa; elongation at break: 100 %;
5) Ionomer conductivity: 20 mS cm^{-1}
6) Stability: 2,000 h, ASR remains.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

FCH-02-5-2019: Systematic validation of the ability to inject hydrogen at various admixture level into high-pressure gas networks in operational conditions

Specific challenge:

Hydrogen can play a pivotal role, either being produced by electrolysis as a service to the electricity grid (sector coupling) or produced on purpose for decarbonization of hard-to-electrify sectors (e.g. individual heat, and long-range mobility).

There is presently no harmonized and systematic approach across EU regarding the ability to inject hydrogen into the high-pressure gas network, and various European operators display non-consistent hydrogen admission rates. This un-clarity strongly hinders the ability of projects promoters to de-risk their project using the option to evaluate their excess hydrogen production into the organized Integrated Energy gas Market (IEM), and hinders policy makers when trying to properly assess the potential role of hydrogen for sector coupling and in the energy transition at large.

The topic aims at establishing and documenting that hydrogen injection into the EU wide high-pressure gas infrastructure is a long-term sustainable solution, supporting not only sector coupling between electricity and gas, but also opening the role of hydrogen as a cost-efficient decarbonization mean for gas usages[41]; this is in line with the European Commission proposal to update the EU Gas Directive to improve the functioning of the EU internal gas market, increase competition between suppliers, and boost Europe's energy security[42].

In existing power-to-gas demonstration projects, hydrogen is injected locally into the low-pressure distribution grid or in very specific higher-pressure locations. This solution, although necessary in the short run and appropriate for projects of a limited injection rate, cannot address a scale up of hydrogen production. In particular, injection of hydrogen in the low-pressure grid as a mix is limited by the limited size of demand in summer and the acceptable methane/hydrogen ratio. This has been already documented as a challenge e.g. for biomethane injection.
Conversely, a total conversion of a low-pressure grid to pure hydrogen usage requires a replacement of almost all end-users' appliances, and is conditioned by the vicinity of specific geological formations (salt caverns) to address the swing in production and demand[43].

The challenge for this topic is to enable injection of hydrogen into the high-pressure gas transmission network safely at industrial scale, addressing both the issue of scalability (ability to decarbonize the gas usages in all their aspects), and marketability/bankability of projects (accessing the IEM for excess hydrogen). In the absence of an answer to the CH_4/H_2 admixture possibility, hydrogen use will be restricted to limited niches, leading to a market fragmentation and inefficiency of energy use.

The ability to operate the gas system in a mixed hydrogen/methane environment relies on assessing systematically and in an EU harmonized way the technical adaptions, which have to be made in the operating and maintenance processes, materials, admixture steering etc. across the whole system. In this respect, the technical and legal framework is lacunar, and has to be specified and harmonized across EU. Technical specifications on the network and components of the network should be defined based on facts established through scientific knowledge, lab and larger scale test.

Scope:

The potential project should address the development, and subsequent operation of a research and development platform reproducing all the components of a high-pressure network and allowing testing of various accessories and appliances for various H_2/CH_4 admixtures:

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[41] At EU level, gas usage is presently representing 22% of Final Energy Consumption (20% electricity), and various studies have proven that a 100% electricity FEC solution would be unnecessarily costly

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

[43] See Leeds H21 CityGate project (http://futureofgas.uk/documents/h21-leeds-citygate-project/)

- It should validate levels of admixtures compatible with the technical elements of the existing high-pressure gas grid (approx. 40 to 80 bars), and high-pressure industrial users equipment (not addressed by the topic *FCH-04-3-2019: Hydrogen admixtures in natural gas domestic and commercial end uses*). In particular it should provide knowledge to support the adaption of maintenance procedure for a safe operation of the high-pressure gas network with regards to different levels of H2/CH4 admixture;
- It should validate the industrialization of innovations necessary to make the whole existing gas system (pipeline, fittings, but also industrial end users' equipment) compatible with these admixtures (e.g. gas quality steering through the mixing equipment, inspection tools etc.).

The project should fill the technical gaps identified by several stakeholders, in particular for high-pressure grid. The scope of the research and development platform should be based on the gap analysis of the main barriers in the state-of-the-art technology and standardisation identified by the Working Group Hydrogen from the Sector Forum Energy Management (SFEM)[44].

It is therefore expected that the project would deliver:

- An impact assessment concerning the use of H2 in various percentage mixed with natural gas (up to 100% H2); this should also embrace the associated fittings and other components for all of the technologies within the high-pressure gas networks;
- A fact-based assessment of the roles of these technologies in integrating H2 and CH4 energy systems at EU level thanks to economic modelling and identification of legal aspects on inter-operability and cross-border regulatory issues;
- Pre-normative research actions leading to standardisation at EU level.

Moreover, it is also expected that the admixture facility would:

- Have a capacity of injecting equal or greater than 5 kg/h of hydrogen at full load into the test loop;
- Operate with concentrations from 0 to 100% hydrogen with various ramp rates, response times and pressure cycles;
- Operate with transient gas characteristics and flow rate (depending on sources - natural gas, new generation biomethane etc.);
- Have precise measurement and control of the hydrogen concentration in the injected gas, whereby the solution must be scalable and easily applied at high pressure level and for various concentration limits;
- Be able to accommodate various tests or certification programs, including on network equipment, appliances and coatings.

While the test loop should be used to:

- Test (high pressure > 40 bar) gas network equipment that could be impacted by the presence of hydrogen, as identified by the consortium, and present necessary changes to equipment and/or maintenance procedures;
- Define principles and improve the design of hydrogen injection and mixing system in line with network behaviour. An optimum design should be published to establish a solid basis for hydrogen injection systems across EU;
- Test separation systems to meet cases where some users' process cannot accommodate the presence of hydrogen. Focus should be placed on streams where hydrogen is present in small concentrations (lower than 15%), since for high concentrations present Pressure swing adsorption (PSA) technology is already optimized.

[44] http://publications.jrc.ec.europa.eu/repository/bitstream/JRC99525/sfem%20wg%20hydrogen_final%20report%20(online).pdf

From the regulatory perspective, it is expected that the potential project would also:

- Identify the legal aspects, cross-border regulatory issues and support schemes and European green certificates schemes that hinder or enable the adoption of various H2NG blends across Europe and give recommendations for alterations where needed;
- Identify issues related to managing the energy system (both physical and commercial, including use of certificates) across Member States and identify the necessary roles in system management;
- Develop and publish a pathway for a stepwise integration of hydrogen in the EU gas network.

Safety of the whole hydrogen chain, from the injection in gas network, to the gas metering, leakage detection, pipeline inspection should be the main technical objective and goal of the platform. For example, technical specifications on the use of components of the network, based on tests performed in the platform will allow the injection of hydrogen in gas network while improving safety. Better knowledge of hydrogen impact on pipeline integrity is needed to know or insure the compatibility of existing gas network with hydrogen transmission and adaptions of gas network control and maintenance procedures.

TRL at start: 4 and TRL at the end of the project: 6.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The FCH 2 JU considers that proposals requesting a contribution of EUR 2 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

A maximum of 1 project may be funded under this topic.

Expected duration: 3 years.

Expected impact:

The project is expected to support acceleration for the implementation of power-to-gas systems by solving technical barriers and initiating the removal of legal and regulatory barriers to injection of hydrogen in the gas transmission network. This will enable hydrogen produced at sites during periods of excess renewable power to be sold in countries with lower availability of renewable power, even if these places are in a different EU country. As a consequence, it will be supportive of renewable electricity production integration, but also of a deep decarbonisation of the gas usages.

The platform developed by the project will validate the technical, legal, regulatory conditions for safe operation of the gas transmission system, supporting the integration of hydrogen “at scale” in the EU-wide gas system, and therefore in the Integrated Energy Market. Operators’ and market-players’ responsibilities, and mechanisms for dealing and managing the energy system across at least two EU Member States will be identified, and help develop transnational knowledge exchange towards an optimal (stepwise) integration of H2 and CH4.

The project should aim to improve the understanding of the impacts of admixtures on the high pressure transmission grid and related equipment, complementing the knowledge produced by the other two related topics of this call (topic *FCH-02-1-2019: Combined electrolyser-HRS and Power-to-Gas system* and topic *FCH-04-3-2019: Hydrogen admixtures in natural gas domestic and commercial end uses*).

It is further expected that the equipment installed during the project will remain available for long-term R&D work into gas grid injection, and made available free to EU stakeholders outside the consortium, as a basis for further development while hydrogen production gets traction across Europe.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

FCH-02-6-2019: New materials, architectures and manufacturing processes for Solid Oxide Cells

Specific challenge:

Solid Oxide Cells (SOC) have historically been developed for the conversion of gas into power, known as Solid Oxide Fuel Cell (SOFC). In the context of the energy transition with more intermittent renewable energy sources and efforts to decarbonise entire industry sectors such as steel and the chemical industry, Solid Oxide Cells see potential applications in a much wider scope. The same base set of materials can cover Solid Oxide Electrolysers (SOE) for hydrogen production or for the production of syngas (co-electrolysis of steam and CO2, co-SOE), or for renewable energies storage (reversible electrolysis/fuel cell mode, rSOC), and further operating modes are envisioned in the context of sector coupling in the energy field.

Today's set of materials has been optimised for the historically longest-standing application, the SOFC. The additional use modes challenge the current material and microstructural sets, opening the door for new materials and processes not commonly applied in the SOC industry. The challenge is to address a large scope of materials, appropriate microstructures and manufacturing processes for SOC and to integrate them into stacks to reach an optimum (trade-off) in terms of performance, durability, reliability and cost.

Scope:

The objective of the topic is to propose the next generation of cells and stacks for the various SOC related applications, including new materials, architectures and associated manufacturing processes. It should consider several operating modes, SOE and rSOC modes being mandatory and co-SOE or any other operating modes optional.

The potential proposal should focus on the development of new concepts of cells (electrodes, interfaces, architectures) in terms of innovative materials and related production processes for their integration into stacks, targeting the following improvements without compromising the other targets included in the MAWP:

- Improvement of cell/stack long-term stability and reliability while maintaining their performance for SOE, co-SOE or rSOC operation, potentially for pressurized operation or at lower operating temperatures. To this respect particular attention should be given to the development of manufacturing processes able to control microstructural properties of electrodes and interfaces;
- Allowing, thermal and load cycling as required for the aforementioned applications; in particular the possibility of recovery or self-healing options as well as increased resilience strategies should be considered;
- Decreasing the use of high cost and critical raw materials (CRM), promoting environmentally friendly processes: smart use of raw materials, e.g. aqueous solutions rather than organic based solvents, use of non-toxic organic additives, zero or low amount of wastes in the process, recycling and/or based on eco-designed manufacturing processes, reducing the energy intensity of the whole process;
- Selecting at least 10 concepts, materials, and the related processes suitably controlling their microstructure able to cope with future industrial needs (e.g. should be industrially scalable for mass production, at low cost, compatible with the size requested for stacks). The new materials that can be considered in the project should have already proven a performance and stability not lower than 70% of the reference state of the art materials in at least one relevant testing conditions (SOE/rSOC/Co-SOE operation).

The potential project should address:

- Validation of the developments on cells with > 50 cm² of active area and at short stack scale (≥ 5 cells) considering a stack design already available;
- Durability improvement, demonstrated with tests above 2,000h for single cells, above 1,000h for short-stacks in conditions representative of the application;

- For the most promising solutions developed in the present project, a long-term durability test at stack level above 5,000h should be performed;
- An environmental assessment of the proposed cell designs as compared to the state-of-the-art cell design. This assessment should be carried out according to the requirements in the FC-HyGuide guidance document (http://www.fc-hyguide.eu/guidance-document.html).

The project should rely mainly on existing test-infrastructure, while additional support in test infrastructure could only cover new operating modes. Investment in new test facilities needs to be justified by additional requirements for specific operating mode, not covered by the conventional equipment. The advanced characterisations and analyses, as well as the modelling activities, if needed, should also be performed between partners having the appropriate background and knowledge in the field.

Modelling activities could be performed to support the understanding of the link between performance, durability and microstructures and guide the improvements proposed. Those activities should be based on previously elaborated models by FCH 2 JU supported projects such as Endurance[45], Sophia[46], Eco[47], Pro-SOFC[48] or other similar work.

It is expected that the technology starts at TRL2 and reaches TRL4 at the end of the project.

The consortium should include at least three cell or stack manufacturers involved in SOE, co-SOE or rSOC developments as well as research institutions and academic groups working in these field(s).

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The maximum FCH 2 JU contribution that may be requested is EUR 5 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

A maximum of 1 project may be funded under this topic.

Expected duration: 3 years.

Expected impact:

The project should provide the industry with a choice of materials and the related manufacturing processes to be implemented into the next generation of SOC cells and stacks, in order to improve the performance, durability and cost of cells and stacks and to make them ready to be scaled up to industrial production. The main impact would be then that industrial partners will have identified and validated most promising next generation materials, processes and components for their products.

In order to achieve this, the project should achieve the following performances:

- Current densities above 0.75 A/cm² in electrolysis mode, for the three usages (SOE, co-SOE, rSOC modes);
- With a corresponding ASR value of 0.5 Ohm.cm² or below 750°C in electrolysis mode, for the three usages (SOE, co-SOE, rSOC modes);

[45] https://www.fch.europa.eu/project/enhanced-durability-materials-advanced-stacks-new-solid-oxide-fuel-cells
[46] https://www.fch.europa.eu/project/solar-integrated-pressurized-high-temperature-electrolysis
[47] https://www.fch.europa.eu/project/efficient-co-electrolyser-efficient-renewable-energy-storage-eco
[48] https://www.fch.europa.eu/project/production-and-reliability-oriented-sofc-cell-and-stack-design

- Degradation rate below (voltage increase for a given current density) 1%/1,000h in SOE, co-SOE or rSOC mode, for a level of performance similar as the one achieved with state-of-the-art cells, measured for durations above 2000h at single cell level, and above 1000h in stack environment;
- Stability upon SOFC/SOE cycling for rSOC mode: similar as compared to individual SOFC or SOE modes, that is to say degradation rate upon SOFC/SOE cycling of 1%/1,000h or below in each mode;
- Stability upon load cycling: similar as compared to steady state operation, that is to say degradation rate upon load cycling of 1%/1,000h or below;
- Stability upon thermal cycling: 50 cycles performed in representative stack environment with less than 0.2 mV lost per cycle, in the operating mode selected;
- Cell manufacturing cost acceptable as compared to standard cells considering the improvements achieved;
- Reduction by at least 25% of use of toxic organics or materials as compared to reference processes;
- For cells developments: cells with > 50cm2 of active area and validated at the short-stack scale (≥ 5 cells) in industrial stack design environment.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

FCH-02-7-2019: Development of highly efficient and flexible mini CHP fuel cell system based on HTPEMFCs

Specific challenge:

Mini combined heat and power fuel cell systems (mini-CHP) are energy conversion devices in the range of 5-10 kW_e and constitute a promising technology to satisfy local demands for heat and electricity. Their permanent availability can play a key role for the development of smart grid power systems, providing efficient power quickly and efficiently on demand. A significant market lies in intermediate to large scale residential or commercial scale applications, not only for primary power but also for heating. Such system must be able to offer an addition to intermittent RES power production with high electrical efficiency, fast start up and fast dynamic response to provide power even under extreme environmental temperatures. Requirements that other fuel cell technologies, such as SOFCs struggle to meet.
Prior projects on HTPEMFCs focused on the increase of electrical efficiency and performance on the stack level. This topic requests to tackle the performance and efficiency of the CHP system and focuses on both the electrical and thermal efficiency of the system as well as on fast start up and dynamic response. A significant effort must be devoted to integrate thermally the fuel cell with the fuel processor in order to recover the maximum amount of the fuel cell's wasted heat thus, aiming to system's level electrical efficiencies up to 55% (LHV). Furthermore, the design and construction of compact systems with high volumetric power density needs to be achieved to fit in residential and commercial environments with space constraints.

Scope:
The overall objective of this topic is to develop, manufacture and validate in a relevant environment mini-CHP energy conversion device using HTPEMFCs technology at 5 kWe. The development activities should build on existing material and stack knowledge and validated designs of HT-PEMFC systems. The improvements targeted on the system design levels should enhance the system's electrical efficiency, shorten start up time and improve the dynamic response, the volume power density, and simplify the Balance of Plant, as well to increase the durability of a mini-CHP system. Activities on materials and stack design should be limited to adaptation required for proper system integration or improving the thermal management, influencing also on lifetime and efficiency. Reliable data of the operation and stability will be generated in relevant environment. If possible, it is encouraged to reach TRL6 by the end of the project.

The project should aim at both high electrical efficiency and performance as well as high volumetric power density of the mini-CHP system. The topic should therefore aim at the following:

- Validation of system's 50-55% (LHV) DC electrical efficiency depending on fuel (NG, LPG or MeOH) and more than 90% overall efficiency and volumetric power density 10-20 W/l. To achieve these the following should at least be considered:
  - Improvements or design innovations of the fuel processor and/or the HTPEM stack so that their effective thermal coupling into the system's BoP will reach DC electrical efficiencies on system level up to 55% (LHV);
  - Improved BoP design through new concepts for the efficient use of the high temperature heat produced with focus on heating, cooling or additional electricity production;
- The mini CHP unit should be compact with high volumetric power density, according to the KPIs mentioned below. The robustness of the system should be proven with accelerated stress test, including fast start/stop cycles (15min), endurance in thermal cycling and fast dynamic response (<10 s) upon change of power. The accelerated test will be carried out for a period of 6 months and for at least 2,000 h of operation.

The projects should increase the state of the technology from TRL3 to TRL5.

The consortium should include at least two industrial partners comprising fuel cell system-core component suppliers (MEA, stack or reformer) and a system integrator with clear perspectives and commitment to exploit the results commercially as access to mini-CHP market is a key element.

Activities should build on past experience and achievements, for example, from earlier FCH 2 JU funded projects[49] (e.g. DeMStack, IRMFC, CISTEM, etc.)

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The maximum FCH 2 JU contribution that may be requested is EUR 1.5 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

A maximum of 1 project may be funded under this topic.

Expected duration: 3 - 4 years.

Expected impact:

The project should:

- Prove the scalability of the components, systems and processes cost reduction for systems up to 50 kW;
- Strengthen the EU knowledge on the CHP technology and result in strong synergies or joint ventures including beyond the consortium for the manufacturing of viable and competitive products;
- Show that can produce cheap and secure electricity with low carbon footprint according to the KPIs mentioned below;
- Support the RES system with an always available, highly efficient and flexible power source (fast start up in less than 15 min and dynamic adaptation during variable power demand within few seconds).

Additional specific KPIs include the following:

- CAPEX 10,000 €/kW according to the target set for 2024 in the MAWP;
- On the fuel cell stack level electrical efficiency 55% (LHV) at performance exceeding 0.2 W/cm2;
- On the system level Volume Power density 10-20 W/l should be achieved at an electrical efficiency of 50-55% (LHV) depending on the fuel, LPG, natural gas or methanol;
- Projected degradation of the system < 0.4 % per 1,000h on the electrical efficiency at constant power output;
- No less than 85 % fuel processor efficiency at the Begin of Life (BoL);
- Reference test conditions can be realized with reformate gas originating from methanol, bio-gas, LPG/NG or NG blended with H2 admixtures with composition H2 (55-70 %), H2O (7-20 %) CO2 (20-30 %), CO (1-3 %) with fuel utilization exceeding 95 % or λ<1.05. Other renewable fuels can also be used.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

[49] https://fch.europa.eu/page/all-our-projects

FCH-02-8-2019: Enhancement of durability and reliability of stationary PEM and SOFC systems by implementation and integration of advanced diagnostic and control tools

Specific challenge:

PEM and SOFC systems for stationary applications have reached a maturity level that guarantees their field operation for micro-Combined Heat and Power (µ-CHP) and energy generation (e.g. remote/isolated areas, backup). However, a step forward is needed to improve their availability, reliability and durability together with a reduction in operational cost.

Some EU/FCH 2 JU funded projects[50] have already successfully carried out research and innovation activities focusing on monitoring and diagnostics of PEMFCs (e.g., D-CODE, SAPPHIRE, HEALTH-CODE, GIANTLEAP) and SOFCs (e.g., GENIUS, DESIGN, DIAMOND, INSIGHT) with a preliminary attention to stack lifetime and prognostics, paving the way towards advanced control. Each of these projects proposed monitoring and diagnostic solutions for either balance-of-plant (BOP) or stack. Conventional techniques have been implemented for BOP components of SOFC that may be easily extended to PEM systems. On the other hand, several approaches have been effectively tested for field monitoring and diagnostics of both PEM and SOFC stacks, they range from simple methodologies up to advanced ones, such as Electrochemical Impedance Spectroscopy (EIS), Total Harmonic Distortion (THD) and Pseudo-Random Binary Signals (PRBS).

A wide expertise has been built and is available among a large research and industrial community, with a well-recognized EU leadership in the field. Nevertheless, a comprehensive tool that could embed all these functions, as derived from the research carried on PEM and SOFC stacks and systems, is not available yet.

Today the state-of-the-health (SOH) of both stack and system can be effectively monitored, whereas prognostic and control actions are not yet considered in a holistic and integrated manner. Indeed, the combination of expected lifetime (RUL) information and adaptive control would help to maintain performance, keep durability and availability in the planned maintenance timeframe or even support its intelligent scheduling (i.e. predictive maintenance). Moreover, a generalized approach applicable equally to both technologies is still missing along with a dedicated experimental campaign, able to prove its validity and reliability during systems long and real operation.

The challenge of this topic is the integration of available monitoring and diagnostic techniques along with the development of both prognostic algorithms and advanced control techniques to be all implemented for enhancement of durability and reliability of stationary PEM and SOFC systems.

Scope:

The project should develop and demonstrate a new generation of robust, general and cost-effective prognostic and control tool for both PEMFC and SOFC systems primarily for µ-CHP and energy generation (e.g. remote/isolated areas, backup). The integration of advanced monitoring and diagnostic algorithms for BOP and stack should be considered as the starting point for the assessment of the state-of-the-health of the whole FC system. The challenge of developing and integrating advanced prognostic and control algorithms ensuring high accuracy, reliability and generalizability for both technologies should be clearly addressed.

The project should address the following actions:

- Develop an advanced monitoring, diagnostic, prognostic and control (MDPC) tool, which should embed all the functionalities required for proper integration with both stack and BOP components;
- Guarantee high flexibility and generalizability to apply the tool on both PEMFC and SOFC, with limited effort in terms of time and costs;
- Apply optimal sensor placement techniques to solve the trade-off between costs (i.e., number of sensors) and effective on-line monitoring, thus maximizing the information level on running systems (stack and BOP);

[50] https://fch.europa.eu/page/all-our-projects

- Implement approaches that suitably combine conventional measurements with more advanced techniques (e.g. EIS, THD, PRBS) able to improve performance and durability by detecting BOP malfunctions and stack faults and applying suitable control counteraction;
- Developed monitoring and control tools with functions that could be used for future integration of FC systems with smart grids and application for remote management in the frame of VPP;
- Test PEMFC and SOFC systems with embedded prototypes of MDPC tool for field operation, aiming at validation by means of dedicated experimental campaigns in operational environment.

The project should implement hardware solutions already available along with conventional sensors and actuators; therefore, the research of new hardware for monitoring, diagnostic, prognostic and control is not in scope of this topic. The implementation of the MDPC tool should be independent from SOFC or PEMFC system configuration, with little effort for adaptation.

The project should start with TRL 4 and conclude at TRL 7 for prognostic and control algorithms. Although, some components, solutions and algorithms have already achieved TRL above 5 or 6, their integration should lead to an overall TRL of 7 as first step towards certification and industrialization for commercialization.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The FCH 2 JU considers that proposals requesting a contribution of EUR 3 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

A maximum of 1 project may be funded under this topic.

Expected duration of the project is 4 years with at least 1 year of experimental campaign in operational environment, to test the MDPC tool on both technologies. Testing should be conducted for at least two PEM and two SOFC systems. The cost of the systems for the testing are not in scope of the topic.

Expected impact:

A proper integration of MDPC functions within PEM and SOFC products will improve performance reproducibility and reliability, and overall leading to more profitable fuel cell systems by reducing the TCO and accelerating its market penetration.

It is expected that such a tool, once implemented in the embedded control of the units, could improve the field performance in terms of extending useful lifetime in real environment by at least 25%, keeping an average efficiency of 35% until the end of life.

Similar to lifetime, two further positive impacts are expected in terms of increased of power availability (≥98%) and reliability (MTBF < 45,000 h) of both stack and BOP components to target 15 years of operation.

The MDPC functionality should not increase the overall system manufacturing cost by more than 3%.

The tool will allow to implement centralized monitoring and predictive maintenance strategies to optimize service costs and support continuous reduction of service costs. The tool shall contribute to the performance improvement of the next generation of stationary FC with enhanced functions, which could be easily integrated with smart grids.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

OVERARCHING ACTIVITIES

FCH-03-1-2019: H2 Valley

Specific challenge:

Hydrogen and fuel cell technologies have been identified as key solutions for a significant reduction of greenhouse-gas emissions and energy consumption in the European Union. Hydrogen and fuel cells may also play an important role in sector coupling and sectorial integration. Within the context of a market-entry process for hydrogen technologies, the demonstration at large scale of sector coupling and sectorial integration is key to make a significant contribution to decarbonising the current energy system.

Since the beginning of the FCH JU in 2008, mainly individual demonstration projects have successfully shown the maturity and benefits of isolated FCH technologies, such as FCEVs, FC-buses and HRS. It is now necessary to introduce the next logical step towards market introduction, the building up of local and regional H2 value chains and integrated use of FCH technologies across different sectors and applications and so establish a 'Hydrogen Valley'. A Hydrogen Valley is a defined geographical area, city, region or industrial area where several hydrogen applications are combined together and integrated within an FCH ecosystem. By linking individual projects and developing local H2 infrastructure, establishing H2 Valleys represents the next development stage towards a local H2 economy in the long term.

Sector coupling via hydrogen allows green energy from the electricity sector to be used for the decarbonisation of other sectors such as transport, building or industry by integrating several different hydrogen technologies within this ecosystem. Such an integration helps to simultaneously increase the share of renewables in the local energy mix, while providing power grid balancing. However, it is still not always and everywhere possible to provide sufficient amounts of renewable electricity at reasonable cost. Thus, H2 valley might need to use also hydrogen from fossil sources, such as hydrogen from natural gas reforming, to a certain extent. In that case, methods of producing hydrogen from fossil energy sources without emitting CO2 should be used. Another possibility could be the use of byproduct hydrogen. An increase of the portion of renewable hydrogen, especially from renewable electricity is one of the challenges the projects should find an answer.

Another challenge is the availability and sustainability of the solutions deployed in funded projects. Consortia should substantiate that the installed devices and applications (like FCEVs) will continue to be operated after the end of project funding. As a consequence, the operations are expected to remain economically viable after the end of the funded project, with a goal to continue the operation. The setup of a large-scale hydrogen hub and thus, reach the critical size where renewable hydrogen price and prices for applications can become more competitive is not easy to achieve.

Scope:

The main H2 valley principles to be covered in the project are:

1. Coverage of entire value chain: establish a complete local H2 ecosystem covering production, storage, distribution, refuelling and final use of H2;
2. Demonstration of sector coupling: show how the use of H2 can enable sector coupling and in turn help large penetration of variable renewable power;
3. Different FCH use cases: demonstrate different FCH use cases together in one coherent project;
4. Integrated approach: link individual sub-projects to each other, show their systemic interaction in a distinct regional or local setup.

A significant portion of the hydrogen used in the project should be produced from renewable sources. The amount of renewable hydrogen can be lower at the start of the project, at least 75% of the volumes produced, but needs to target a level of 100% at the end of the project. The project shall aim at reducing by at least 50% the GHG emissions, as compared with the incumbent technologies[51].

[51] Incumbent technologies meaning fossil-based solutions widely spread in present economy.

Hydrogen should be produced out of low carbon and/or renewable electricity via electrolysis. Other industrial source and by-product could be also mixed as long as the carbon footprint meets the targets of the project.

“CertifHy Green H_2“ guarantees of origin should be issued and cancelled through the CertifHy platform[52] to ensure that the hydrogen production and consumption is of renewable nature.

At least three FCH applications from at least two different sectors should be part of the project. The following sectors and applications can be considered:

1. Transport sector: Buses, cars (private cars and / or captive fleets such as taxis), delivery vans and small trucks, medium and heavy-duty trucks (also for long haul trips), specialty vehicles (like garbage trucks and sweepers), trains, waterborne applications (like boats/ships and port logistics), airborne applications (small and medium airplanes, drones and UAVs), material handling vehicles. Other transport applications are not excluded;

2. Energy sector: Building heat and power, commercial/residential applications using FC-based CHP units, backup-power and electricity supply of critical infrastructure;

3. Industrial applications: Industrial application valorizing low CO2 hydrogen, like refineries, steel industry, metallurgy, glass industry, ammonia or methanol production.

The volumes produced and distributed for the different applications should be consistent with the amount of investment considered. For the size of the project, it is expected that at least 1,500 tons per year or 5,000 kg/day hydrogen capacity is deployed. Similarly, each application should involve and consume at least 20% of the whole volumes or a minimum of 300 tons per year or 1 ton/day hydrogen.

Elements of already existing projects could be used to support the new H2-valley project, without being accounted as financial leverage of the project; however, it is requested that the coverage of three applications from two sectors should be shown with new installations.

The aim is developing, deploying and demonstrating replicable, balanced and integrated fuel cell and hydrogen-overarching solutions in both energy and transport fields, with the option of providing a hydrogen feedstock for industry through strong partnerships between municipalities, industries and academia. The project should be implemented in EU.

The replicability of the project is fundamental to facilitate further future deployments of H2 Valleys. The proposals should therefore address efforts to provide learnings how to best scale-up and transfer FCH solutions investigated within the H2 valley to other interested areas and regions. This should comprise also RCS issues.

To increase impact beyond the demonstration part of the project, the consortium should develop a long-term vision (roadmap) how to serve all energy needs from H2 and RES based on a local/regional H2 economy until 2050.

The TRL of the applications in the project should be at least 6 at the beginning of the project while the overall concept should target a TRL 8 at the end of the project.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

[52] https://fch.europa.eu/page/certifhy-designing-first-eu-wide-green-hydrogen-guarantee-origin-new-hydrogen-market

The maximum FCH 2 JU contribution that may be requested is EUR 20 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

The consortium is strongly encouraged to identify and secure additional funding sources. Commitment of local authorities (Member States, Regions, Cities) is considered necessary and should be evidenced in the proposal in a form of letter of Interests (LOIs), to be followed by firm commitment before signature of the Grant Agreement. The proposal should therefore include a financing scheme describing the sources of co-funding/co-financing.

Applicants should demonstrate a clear and targeted business model. The funding requested shall be consistent with the economical gap to incumbent technologies.

A maximum of 1 project may be funded under this topic.

Expected duration: 6 years with at least 2-3 years of operation per application.

Expected impact:

Depending on the chosen applications, KPIs for each application should be defined and aligned with the MAWP targets[53].

The project should address the techno-economic objectives as defined in the Multi Annual Working Plan (MAWP) and in particular:

- Showcase the versatility of hydrogen in the frame of the energy transition, the sectorial integration and the Local Hydrogen Economy based on multi and interconnected hydrogen usages within a given geographic area;
- Show evidence of the GHG reduction potential of the H2-Valley via a Life Cycle Analysis; Identify the contribution of such concept in the EU 2030 GHG reduction targets;
- Boost the introduction of hydrogen hubs based on large electrolysis or other CO_2 neutral H_2 production technologies, through the development of viable business models which in turn shall drive significantly the future development of FCH markets;
- Increase/improve the integration and/or utilisation of renewable energy sources in the region and demonstrate savings by 'doing with the existing' infrastructure rather than expensive major upgrades;
- Identify potential barriers, including RCS to creating a viable business model for implementing such a Hydrogen Valley across all regions of Europe and recommend possible solutions;
- Create close links between all parties (technology providers, owners, operators, end-users, local authorities) with long-term ambitions and strategies;
- Develop public awareness and acceptance of hydrogen technologies and create a ground for skills development;
- Demonstrate the role of electrolysis for grid balancing services and local energy storage at a meaningful scale for the grid operator;
- Show case at an unprecedented scale in EU, the concept of H2-valley and demonstrate the sustainability of the solution and of the business model associated.

Type of action: Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

[53] https://fch.europa.eu/page/multi-annual-work-plan

CROSS-CUTTING ACTIVITIES

FCH-04-1-2019: Training of Responders

Specific challenge:

Professional knowledge and skills are needed by first and second responders[54] to tackle situations involving hydrogen systems and infrastructure. This is essential to inform their participation in the initial permitting process, improving resilience and preparedness through enhanced emergency planning, and ensuring appropriate accident management and recovery. Providing technically accurate and up to date hydrogen safety information to responders is essential to underpin inherently safer deployment of hydrogen technologies and its public acceptance.

The foundations to training of first responders have been already laid by the HyResponse project[55] which has established the first European Hydrogen Safety Training Platform (EHSTP) to train first responders through threefold comprehensive training: *educational* training with the state-of-the-art knowledge in hydrogen safety, including tools for characterisation of hazards and associated risks from hydrogen applications, operational training on mock-up real scale transport and hydrogen stationary installations, and innovative *virtual reality* training reproducing the entire accident scenarios, intervention strategies and tactics, including the whole chain of command and communications between all members of the first responders team, facility managers, and public.

The uniqueness and importance of EHSTP and its European Emergency Response Guide (EERG) has been validated by the feedback from EU, USA and Japanese firefighters and experts in hydrogen safety. It is now important to capitalise upon the HyResponse investment and draw on wider experience by engaging further stakeholders both across EU and beyond. The establishment of pan-European integrated training resources is however a challenge. This would require consistent and continuous approach across regions, whilst accounting for local level projects, national level requirements, and languages. A 'train the trainer' approach will assist in meeting this challenge but first an appropriate network should be established.

Scope:

Training of responders has been identified as a priority beyond EU with programmes, for example, in the USA. The experience gained globally should be analysed and utilised through efficient collaboration with EU and global/international organisations in areas of hydrogen safety, emergency and rescue services, emergency planning, etc.

Projects should seek to:

- Establish a pan-European network of trainers for first and second responders, supported by stakeholders from EU and beyond, to facilitate dissemination of knowledge and experience generated within the HyResponse project and relevant follow-up projects from EU to national level;
- Update and expand the threefold training programme of EHSTP, through further development of emergency scenarios to reflect the latest state of the art (e.g. develop intervention strategies and tactics for liquid hydrogen (LH2) applications, tools for assessment of hazards and risks for LH2);
- Create tailored local training allowing for local language, country specific national regulations and established practices, simplifying and facilitating local approval of hydrogen projects, improving further safety of first responders at the accident scene, etc;
- Educate and train tomorrow's responder trainers through established and regularly updated comprehensive educational, operational and virtual reality training. These trainers should replicate this European hydrogen safety training in their own country and in their own language to facilitate

[54] **First responders** typically include any person(s) first appeared at accident scene, firefighters, hazmat officers, police officers, paramedics, other emergency and rescue services while **second responders** refer to workers who support first responders in their emergency preparedness, response and recovery;

[55] FCH 2 JU HyResponse project "European hydrogen emergency response training programme for first responders", No. 325348, 2013-2016, www.hyresponse.eu.

and improve efficiency of the local training process, to underpin the introduction of the technology and its public acceptance;

- Integrate this hydrogen safety training into broader national training programmes where available, e.g. through the provision of emergency response training for hydrogen-powered vehicles along training for other electrical vehicles, LPG and CNG vehicles, etc;
- Establish an International Forum of First Responders in Hydrogen Safety Training to facilitate sharing of best practice globally;
- Establish links with ongoing FCH 2 JU projects, e.g. sharing of training materials through educational platform(s) to maximise outreach, dissemination and impact;
- Establish stronger links between first responders' activities and FCH 2 JU research and educational projects; Valuing the responders' experience and their feedback to enrich and harmonise harm criteria, models for hazards and risk assessment from the point of view of hydrogen system designers, expand communications to other stakeholders, including but not limited to legislators, technology experts, insurance companies, etc to underpin a massive and inherently safer deployment of hydrogen systems and infrastructure.

The consortium should include fire service institution(s), partner(s) experienced in application of virtual reality for training of fire and rescue services, academic partner(s) specialising in research-led education and training in the field of hydrogen safety, representative(s) of hydrogen industry. Stakeholder(s) beyond past HyResponse project should be now part of the consortium. Participation of non-EU stakeholders should be sought, e.g. through an Advisory Board engagement.

It is expected that the project will contribute towards the objectives and activities of the Hydrogen Innovation Challenge (as detailed under section 3.2.G. International cooperation). Promoting international collaboration beyond EU Member States and H2020 Associated Countries is therefore strongly encouraged.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The FCH 2 JU considers that proposals requesting a contribution of EUR 1 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

A maximum of 1 project may be funded under this topic.

Expected duration: 3 years.

Expected impact:

- First and second responders will have educational background to permit/approve hydrogen projects at a local level and will be stronger integrated into hydrogen safety community to underpin the activities in deployment of hydrogen systems and infrastructure;
- Emergency planning and preparedness relating to hydrogen technologies and infrastructure will be enhanced;
- Risk of incidents/accidents relating to hydrogen infrastructure will be reduced through improved knowledge and training of first and second responders with at least a training session in 10 EU countries;
- Pan-European Network of Responder Trainers should be founded for at least 10 EU countries;
- Coherent up-to-date training programmes for responders will be available in at least 7 different languages;

- Translated educational materials will be available to all stakeholders, e.g. through the NET-Tools Educational Platform[56];
- European cadres of trained first responder trainers will be available including new tools for assessment of hazard and associated risks for first responders from hydrogen-powered transport and stationary applications;
- Updated European Emergency Response Guide, including intervention strategies and tactics for LH2 applications, will be available online for all responders;
- Finally, an International Forum of Responders in Hydrogen Safety Training should be founded.

Type of action: Coordination and Support Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

[56] https://www.fch.europa.eu/project/novel-education-and-training-tools-based-digital-applications-related-hydrogen-and-fuel-cell

FCH-04-2-2019: Refueling Protocols for Medium and Heavy-Duty Vehicles

Specific challenge:

The lack of standardised fuelling protocols that can be used for any medium or heavy-duty vehicle is a significant barrier preventing larger hydrogen fuel cell vehicles from progressing past the back-to-base philosophy and is a major hurdle for both infrastructure players and vehicle manufacturers to develop and deploy standard products. With an increasing number of zero emission buses and trucks expected to be deployed in EU, a validated refuelling protocol (or set of protocols) for vehicles with Compressed Hydrogen Storage System (CHSS) of capacities >250 litres, or >10 kg storage, is needed. This is a prerequisite for meeting the increasing end-user demand for a) hydrogen fuel and b) short refuelling times; it is the key to opening the commercial market for such vehicles and ensuring HRS are able to safely refuel them.

Furthermore, industry consensus needs to be achieved around the storage technology to be used for capacities of >50 kg on-board a vehicle, because long haul heavy-duty vehicles will most likely not be able to make use of 350 bar CHSS (as currently used by municipal vehicles and city buses) due to the large volumes of hydrogen required.

Currently the majority of HRS for compressed hydrogen serve only "light duty" vehicles, i.e. those with CHSS capacities <250 litres. These typically use the SAE J2601 standards[57] for fuelling protocols, or alternatively fuelling protocols based on these, such as the Clean Energy Partnership (CEP)[58] protocol(s). These are typically unsuitable for the CHSS capacities used for medium and heavy-duty vehicles, and often the dispensers are also physically inaccessible to larger vehicles.

SAE J2601-2:2014 includes some information for fuelling vehicles with >10kg of storage and provides boundary conditions for safe refuelling, but it leaves much of the fuelling protocol up to the reader. Whilst this is reasonable for return-to-base applications for fleet vehicles (e.g. buses) known to the refuelling station operator, it is not appropriate for the wider application of vehicles that would require >250 litre storage using different stations, as the current SAE J2601-2 lacks the practical level of detail required for a full standard.

In general, the technical challenge can be grouped into : (a) vehicles with a storage capacity of up to approx. 50 kg hydrogen, some of which are already in existence, and (b) vehicles requiring capacities of over 50 kg hydrogen, which are under development. There is currently no agreed solution available for both of these groups. Whilst the dispenser and refuelling station for different transport sectors may differ, a fuelling protocol for road vehicles, or trains, or boats, with the same capacity of CHSS should be able to utilise a similar fuelling protocol.

Scope:

There are two overarching objectives to be addressed by this topic:

1. Fuelling protocol(s) should be developed to enable the short-term uptake of hydrogen vehicles based on modelling, experimental validation and field tests. These should be able to be used to fill any compressed hydrogen vehicle of >250 litre CHSS capacity, rather than be protocols specific to particular vehicles (for instance captive fleets of a certain vehicle design). Such vehicles include, but are not limited to vans, buses, trucks, coaches, lorries, trains, ferries, boats and other appropriate mobile hydrogen fuelled applications. This should preferably include fuelling to Nominal Working Pressures (NWP) of both 350 bar and 700 bar, but this does not preclude considering other possible NWPs (e.g. 500 bar).

   It is possible that one fuelling protocol would not cater effectively for all sizes of CHSS >250 litres, so it is expected that a small number of protocols, relevant to identified CHSS capacities, could be required (for instance from 250 litres to 500 litres, and 500 litres to 1000 litres), if it is not feasible to

[57] https://www.sae.org/standards/content/j2601_201407/

[58] https://cleanenergypartnership.de/en/home/

use a single protocol. If so, appropriate break points for the size of CHSS capacities should be identified for vehicles that would typically use a Heavy Goods Vehicle (HGV) specific refuelling station.

The protocol(s) should cater for fuelling in a wide of range of ambient conditions (e.g. from -40 °C to +50 °C). It should prevent over pressurisation or overheating of the CHSS above 125% NWP, and above +85 °C, to match the capabilities of the on-board storage vessels currently available. This short-term protocol(s) could use 120 g/s as a maximum hydrogen flow rate to avoid inconsistency with current standards, although it would be considered advantageous to explore higher flow rates.

This work should be carried out in conjunction with SAE J2601-2 and other relevant standards organisations (for example ISO TC 197[59]). Where possible, it should further develop and make available publically the protocols developed in previous hydrogen bus projects (e.g. HyFleet-CUTE[60]) or other applicable work (e.g. HyTransfer[61]).

2. A feasibility study should be undertaken into the needs of future protocols, which should include storage technologies for capacities over 50 kg hydrogen. Whilst "light duty" gaseous hydrogen vehicle fuelling protocols are limited to 60 g/s, and currently some "heavy duty" gaseous hydrogen vehicle fuelling protocols are limited to 120 g/s, there is an anticipated need for greater refuelling rates for vehicles with large CHSS capacities.

   The suitability of the current maximum limit of 120 g/s proposed in SAE J2601-2 should be investigated, to identify what components limit the refuelling rate, including but not limited to, the nozzle, receptacle, on-board storage vessel(s) and associated valve(s). Design options for enabling larger flow rates to be used should be identified.

   A thorough technology review and benchmarking should be performed for both gaseous and liquefied hydrogen dispensing, keeping practicability and technical constraints in mind to identify the most suitable storage technology for applications such as long haul trucks, coaches, trains, sea-going ships, inland barges, hydrogen transport systems, mobile gensets, etc. Careful consideration is needed to ensure acceptability for all vehicle and systems manufacturers as well as HRS equipment manufacturers and infrastructure operators. Whilst not part of the scope of this work, it should be borne in mind that the technology will then need to be able to be standardized with globally defined boundary conditions that do not pose a restriction to safety of operation, speed of fill and suitability for purpose.

   This part of the project should also look into appropriate boundary conditions for the fuelling, and make recommendations on whether different conditions to those currently used for vehicles (in SAE J2601, EN 17127 or ISO 19880-1 for example) can be reassessed to enable faster fuelling.

A workshop(s) might be held at the start of the project to, where possible, identify the current approaches being taken or being anticipated for the fuelling vehicles with >250 litre storage.

The outcome of both objectives should be disseminated to the hydrogen mobility and hydrogen refuelling infrastructure sectors in workshop(s) at the end of the project. Findings and recommendations should also be disseminated to the SAE FCEV Interface Taskforce, and ISO TC 197 WG24 as a minimum, and other standardization committees in the field of hydrogen fuelled heavy goods vehicles, boats and trains.

The consortium should comprise partners from the following sectors: HRS suppliers / HRS operators, medium / heavy-duty vehicle manufacturers (not limited to road vehicles) and component suppliers (e.g. tank, nozzle/receptacle) as appropriate, and organisations able to model fuelling events, in order to scope and validate the practical testing. In addition, the participation of Notified Bodies / hydrogen refuelling station authorisers is also recommended.

[59] https://www.iso.org/committee/54560.html

[60] https://cordis.europa.eu/project/rcn/85636_en.html

[61] https://www.fch.europa.eu/project/pre-normative-research-thermodynamic-optimization-fast-hydrogen-transfer

A suitable medium and heavy duty hydrogen vehicle refuelling station(s) should be made available for this work by one or more of the project partners and should be evidenced at a proposal stage – either existing, or expected to exist before the project starts. Building of a new hydrogen station is not an eligible cost, while the costs toward fitting an existing station with the necessary hardware, for instance to enable precooling of the hydrogen dispensed, to enable a light duty fuelling station with flow limitations of 60 g/s to deliver up to 120 g/s, or, if applicable, to permit fuelling at 500 bar etc. Are considered eligible. A sufficiently instrumented and controllable dispensing system is required, that is capable of dispensing hydrogen at a range of appropriate flow rates, temperatures and pressures for vehicles with various on-board storage capacities.

Links with other relevant FCH 2 JU funded projects should be established, in particular with the trucks or maritime projects when considering where the future for on-board storage solutions for these applications may lie.

It is expected that the project will contribute towards the objectives and activities of the Hydrogen Innovation Challenge (as detailed under section 3.2.G. International cooperation). Promoting international collaboration beyond EU Member States and H2020 Associated Countries is therefore strongly encouraged.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The FCH 2 JU considers that proposals requesting a contribution of EUR 1.5 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

A maximum of 1 project may be funded under this topic.

Expected duration: 2 years.

Expected impact:

A proven protocol or series of protocols, suitable for any hydrogen vehicle with a larger quantity of on-board storage than those of typical light duty vehicles should be developed as part of this project, with the aim of preparing this protocol(s) for acceptance into relevant international standards.

Consensus on the storage technology and specification to be used for large quantities of hydrogen, which will enable the development of refuelling infrastructure and allow free movement of hydrogen powered medium and heavy-duty vehicles, which would otherwise be limited to prohibitively short ranges if required to fill from the same dispensers as light duty vehicles. A feasibility study into, and development of industry consensus on, storage methods, dispensing protocols and the infrastructure-vehicle-interface (e.g. an ultra-high flow nozzle, capable of approx. 500 g/s) will lay the 'ground stone' for the development in the heavy duty long haul area, where significantly greater than 50 kg storage can be expected to be needed.

Key benefits of suitable fuelling protocols that the project delivers include:

- Shorter refuelling times for end-users, resulting in more competitive products (product attractiveness);
- Non-proprietary protocols over proprietary protocols opens up the EU market for HRS developers and influences the world market heavy-duty segment (competitive markets);
- Competence development for protocols for important early markets (EU leadership);
- One common approach to fuelling of large storage systems for different applications (e.g. long-haul trucks, coaches, trains, inland barges, transport systems, etc.) also offers the possibility to create a

large enough market for component manufacturers to be able to develop and offer components at attractive prices, something the industry is currently struggling with.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

FCH-04-3-2019: Hydrogen admixtures in natural gas domestic and commercial end uses

Specific Challenge:

Injecting hydrogen admixtures into the natural gas network can contribute significantly to solving the problem of transporting and storing surplus electricity generated from renewable resources. There are, however, a number of challenges to operate safely with hydrogen admixtures (H2NG blends) for the existing gas infrastructure and end use equipment. In order to establish a European understanding of an acceptable hydrogen concentration in the natural gas system, a number of knowledge gaps need to be filled. The addition of hydrogen to natural gas influences gas properties and therefore the performance and safe operation of existing applications (including industrial gas turbines, industrial burners and residential burners). Domestic and commercial users are generally “passive” users of their gas appliances and they are not able themselves to intervene with the appliance (e.g. to counterbalance the effect of a gas change). Conversely, industrial users have more possibilities to intervene and retrofit/develop integrated mitigation solutions. Therefore, domestic and commercial users need to be addressed differently from industrial ones and this topic focuses exclusively on domestic and commercial applications.

Power-to-gas systems injecting admixtures of 2 vol% have been widely demonstrated, further demonstrations of up to 20 vol% (e.g. GRHYD[62], HyDeploy[63]) are underway and have already shown that such systems can operate to provide grid services and absorb surplus renewables: already 10 vol% is permissible in some parts of the natural gas system, while a 2 vol% limit must be applied close to CNG refuelling stations. There is however a need to define a clear vision at EU level of the admissible hydrogen percentage for use in domestic and commercial applications. In addition, there is a need to identify the RCS needs for progressively enhancing the admissible hydrogen concentration in the gas system. CEN/TC 238[64], which is in charge of test gases for gas appliances and of defining gas appliance categories, has expressed the need for this PreNormative Research, PNR in view of the revision of EN 437[65] (the key transverse standard used for the testing required for the regulatory certification of gas appliances).

Scope:

Research is required to identify and verify the impacts of continuous and time-varying supplies of H2NG blends on the combustion characteristics (flame speed and shape, temperature, emissivity, emissions) of appliances together with the potential impacts on appliance safety, efficiency, lifetime and environmental performance (e.g. NOx emissions). Results from previous and ongoing national and EU projects should be included (e.g. NaturalHy[66], GASQUAL[67], HIPS-NET[68], DOMHYDRO[69], GRHYD, HyDeploy, etc.) and their transferability evaluated.

Low, medium and high hydrogen concentrations in natural gas should be investigated:

- Low = <10% Vol.
- Medium = 10-30% Vol.
- High = 30-60% Vol.

The following activities should be undertaken, by means of desk research supported by an integrated experimental programme, and consider a wide range of appliances and hydrogen concentrations:

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[62] https://www.engie.com/en/innovation-energy-transition/digital-control-energy-efficiency/power-to-gas/the-grhyd-demonstration-project/
[63] https://hydeploy.co.uk/
[64] https://www.cen.eu/Pages/default.aspx
[65] http://www.sarm.am/docs/437.pdf
[66] https://cordis.europa.eu/project/rcn/73964_en.html
[67] http://www.gasqual.eu/copy_of_documents-link
[68] https://www.dbi-gruppe.de/hips-net.html
[69] http://www.gerg.eu/public/uploads/files/publications/GERGpapers/P2G_TUV_Nord_2_web.pdf

- Evaluate the existing end-use stock and new appliances with respect to their sensitivity to hydrogen concentration. Existing knowledge should be collated, testing procedures defined and testing undertaken both in relation to the existing EU stock of installed (domestic and commercial) appliances and to new gas technologies (e.g. micro-cogeneration, gas heat pumps, space heaters, fuel cells). The experimental procedures should be chosen to represent as far as possible real operative conditions (e.g. full components should be preferred to downsized laboratory prototypes). Validated accelerated stress testing should be performed, considering gas quality fluctuations and changes in environmental conditions. In some cases, in order to reduce testing costs, testing at the highest hydrogen concentration values may be ignored provided that a reasonable assessment can be made by modelling;
- Evaluate mitigation solutions to widen the acceptance of appliances to higher hydrogen concentrations. Existing combustion controls designed for natural gas quality variation are not necessarily suited for working with H2NG blends, so mitigation solutions should be determined and their technical feasibility verified. The work involving testing and/or modelling should cover hardware (combustions controls) for new or existing appliances (retrofit) and if relevant on site adjustment procedures. Burner modifications and other design changes should be identified, including possible simple actions to remedy any problems preventing the adoption of higher hydrogen concentrations. Tests should cover the main segment of the domestic and commercial appliance market and give priority to appliances that have been shown to be sensitive to hydrogen concentration and include long term testing. Where possible, appliance manufacturers should be involved;
- Identify new test methods /test gases for the certification of domestic and commercial appliances (falling under the Gas Appliances Regulation[70]). In the future, gas burning appliances will have to be tested with H2NG specific test procedures and test gases to enable their certification, a prerequisite for the use of H2NG blends.

The tests should cover the impact on safety, efficiency, reliability, lifetime (for small domestic appliances only), CO, NOx and other possible impacts.

The combustion parameters Wobbe index, methane number, laminar flame speed and flame temperature are among the main parameters that should be considered in the investigation. Testing should be performed with different compositions of natural gas combined with different hydrogen concentrations. Temporal fluctuations in the concentration of hydrogen should also be studied. Gas of lower calorific value (L gas) is not considered in scope (due to its declining use).

It is expected that the consortium will interact with manufacturers, gas consumers and gas industry .

It is expected that the project will contribute towards the objectives and activities of the Hydrogen Innovation Challenge (as detailed under section 3.2.G. International cooperation). Promoting international collaboration beyond EU Member States and H2020 Associated Countries is therefore strongly encouraged.

Any safety-related event that may occur during execution of the project shall be reported to the European Commission's Joint Research Centre (JRC) dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu , which manages the European hydrogen safety reference database, HIAD and the Hydrogen Event and Lessons LEarNed database, HELLEN.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2019"), in order to benchmark performance of components and allow for comparison across different projects.

The FCH 2 JU considers that proposals requesting a contribution of EUR 2.5 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

A maximum of 1 project may be funded under this topic.

[70] https://ec.europa.eu/growth/sectors/pressure-gas/gas-appliances/regulation_en

Expected duration: 3 years.

Expected Impact:

The project will ensure that the safe operation of existing and future gas appliances and applications is not jeopardized by the supply of H2NG instead of the natural gas composition range for which they have been designed and certified, and identify categories of existing appliances and equipment that would need to be replaced as the hydrogen concentration is increased. The expected impacts of the project include:

- Establishing what concentration hydrogen admixture can be implemented in the domestic and commercial sector without changing the existing certification of appliances;
- Establishing how the existing certification shall be modified to allow higher concentrations, including the related additional costs and the required changes to common gas burners;
- Recommendations for revision of EN or ISO standards or drafting of new standards based on PNR results and a review of the existing testing methods;
- Improved knowledge on the effect of H2NG on common burner types including necessary adjustments and design changes. This will help the industry to bring on the market appliances that will accept H2NG.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.3 and in the General Annexes to the Horizon 2020 Work Programme 2018– 2020 which apply mutatis mutandis.

B. Collaboration with JRC – Rolling Plan 2019

The JRC undertakes high quality research in the field of fuel cells and hydrogen that is of considerable relevance to the implementation of the FCH 2 JU activities. During the FP7 period, cooperation between the JRC and FCH JU was structured under a Framework Agreement that covered support activities that JRC provided in-kind to FCH JU, as well as possible funded JRC participation to FCH JU projects.

For the Horizon 2020 period, a Framework Contract between FCH 2 JU and JRC was approved by the Governing Board on 23/12/2015 and signed by both parties on 18/02/2016. Contrary to the situation under FP7, involvement of JRC in FCH 2 JU funded projects outside the Horizon 2020 Rules for Participation is not possible. The scope of the Framework Contract therefore covers the activities that JRC will provide at the level of the FCH 2 JU programme free of charge and against payment from the FCH 2 JU operational budget. In line with the JRC mission, these support activities will primarily contribute to formulation and implementation of the FCH 2 JU strategy and activities in the areas of RCS, safety, technology monitoring and assessment. In addition, the Programme Office may call upon JRC to perform testing as a service to FCH 2 JU, providing added value to programme objectives by complementing activities of FCH 2 JU funded projects.

For the year 2019, a provisional budget of EUR 865,000 (up to a maximum budget of EUR 1 million) from the FCH2 JU operational budget is foreseen.

The JRC support activities to the FCH 2 JU programme covered by the Framework Contract are discussed and agreed on an annual basis between the JRC and the Program Office, with involvement of representatives of Hydrogen Europe and Hydrogen Europe Research.

The annual Rolling Plan 2019 (based on the similar plans approved and executed between 2016 and 2018), constitutes part of this Work Plan and describes the annual activities and their related deliverables provided against payment by JRC to FCH 2 JU (heading B of Article 2 in the Framework Contract). Additional activities that JRC performs without payment (heading A of Article 2) are not listed in this document. They consist of international collaborations as well as support to programme definition and implementation.

B.1 JRC support to formulation and implementation of RCS strategy

Section 4.1 of the MAWP requires the set-up and operation of a Regulations, Codes and Standards (RCS) Strategy Coordination (RCS SC) group led by industry and specifies that "... *JRC will assist the RCS Group and the PO in their RCS task*". In 2019 JRC will continue in its role as coordinator of the group[71], supporting the secretariat and chair. JRC will also deliver data and gap analysis as done in the past 3 years. The JRC will participate to international standardisation bodies upon request of RCS SC to ensure that PNR results generated within FCH JU projects are exploited as effectively as possible. Among the set of activities identified in Section 4.1 of the MAWP, JRC will deliver the following contributions to the RCS strategy coordination of the future AWP:

Annual deliverables:

B.1.0 RCS SCG work plan 2019 (strategy implementation, timeline, methodological approach) (January 2019)

B.1.1 Updated mapping of programme PNR progress and its link to the international and European standardisation activities (November 2019)

B.1.2 Report from a workshop with FCH 2 JU demonstration projects regarding their findings and recommendations on PNR and RCS priorities (June 2019)

B.1.3 Annual report on RCS SCG activities, as input to the Annual Activity Report (December 2019)

[71] Decision taken at the RCS SC meeting of 28th September 2017

B.2. JRC direct contribution to implementing RCS strategy

To provide inter-project comparable results and to facilitate assessment of technology progress without compromising on intellectual property rights (IPR) issues, JRC formed a working group on harmonisation through which industry-consented harmonised test approaches for automotive applications were achieved. It resulted in testing protocols and reference test cell hardware.

In 2016 and 2017, this effort has been extended to harmonised test approaches for low temperature water electrolysis (LTWE) applications regarding terminology and testing procedures. For 2019 it is planned to establish testing protocols for LTWE applications. This will be carried out in collaboration with the harmonisation working group to which the relevant projects are invited to contribute. It is also intended to kick-off harmonisation efforts for high temperature electrolysis (HTE) applications which should focus in 2019 updating the existing LTWE terminology document in respect of HTE requirements. The work on HTE aspects will closely involve stakeholders from both HE and HER, similar to LTWE. The results of the harmonisation efforts will be utilized by drafting New Work Item Proposals (NWIP) at ISO TC 197 and IEC TC105, as appropriate.

In addition, upon request and within the limits of its own resources, JRC foresees validation testing for performance assessment using the EU reference test cell hardware and harmonised testing protocols and procedures as part of the testing harmonisation multi-annual plan.

The following known deliverables are foreseen for 2019:

B.2.1 Harmonisation of LTWE Testing protocols:

Draft for public stakeholder consultation (Q1 2019)

Final report (Q2 2019)

B.2.2 Harmonisation of HTE Terminology:

Draft for public stakeholder consultation (Q1 2019)

Final report (Q2 2019)

B.2.3 Harmonised Electrolysis Testing:

Testing protocols for High Temperature Water Electrolysis (to be determined by the HTE working group, at latest Q4 2019)

B.3 JRC contribution to programme monitoring and assessment

Technology benchmarking. To allow for an assessment of European achievement against the international best-in-class, data related to the international state of the art, the so-called 'reference data' need also to be collected. In the past few years, JRC has delivered the reference data related to some priority sub-technologies. In 2019, JRC will gather information on the international state-of-the-art for selected sub-technologies. In addition, the JRC will track the evolution of selected key performance indicators throughout the running time of the FCH JU programme.

B.3.1 Support to knowledge management through technology monitoring and assessment of FCH JU project portfolio. (December 2019)

B.3.2 Reporting on international technology status according to the agreed priority ranking. (November 2019)[72]

Support to Programme Monitoring and Assessment by means of JRC tools: JRC.I.3 will develop and adapt to the needs of the FCH 2 JU two JRC general monitoring and analysis tools.

[72] More detailed plan for each of the sub-technology will be agreed with the KM of the PO. The final deadline of November relates to the requirement to be ready for the PRD 2019

- The JRC Tools for Innovation Monitoring (TIM) is is a tool gathering scientific literature, patent data, news articles and data from R&D projects funded by the EU, aiming at monitoring and analyzing thematic or technological areas, tracking currently used or emerging technologies. The JRC is developing a FCH2JU-specific version of TIM to provide the FCH2JU with a system customised with features related specifically to its programme, such as tagging functions of FCH beneficiaries. Three technology areas have been mapped so far: solid oxide fuel cell, alkaline fuel cell and polymer electrolyte membrane fuel cells. In 2019 the development work will be extended to the remaining technologies. The final TIM tool will be publicly available.
- The European Media Monitor (EMM) is a system for monitoring open source news information. The main purpose of EMM is to provide monitoring of a large set of electronic media, reducing the information flow to manageable proportions by clustering related news and categorising articles to derive further metadata. In 2018 JRC has tailored its generic EMM tool to the FCH2JU needs, by defining categories and developing ad-hoc filters. This customised EMM system is hosted and maintained at JRC Data Centre in Ispra and enables custom newsletter template and connection with the FCH-JU Web Portal to send it to the list of FCH subscribers. In 2019 system validation will be completed and used.

B.3.3 Customized FCH media monitoring system European Media Monitor FCH EMM (December 2019)

B.3.4 Maintenance, operation and extension of FCH Technology Innovation Monitoring System FCH TIM (December 2019)

Programme Annual Review as in 2017 and 2018, JRC will perform a full programme review cycle for the year 2019, in the form of a report.

B.3.5 Update of methodology for the PRD, if needed, submitted for approval by PO (April 2019). This will consider the lessons learned from the 2018 PRD.

B.3.6 Draft report delivered before the PRD2019 (October 2019)

B.3.7 Final JRC report delivered for finalization & publication by PO (February 2020)

Sustainability aspects: one of the overarching objectives of the FCH 2 JU, as laid down in the MAWP, is to reduce the use of EU defined 'critical raw materials'. More in general, this objective relates to the development of a circular economy. As tool supporting progress related to this, the FCH JU has defined a Life-Cycle Assessment (LCA) methodology to be applied to its projects and products[73]. LCA are part of the FCH 2 JU strategy: "*it is expected that LCAs will be performed at both project and programme levels. The resulting Life Cycle Inventory (LCI) data sets will form a database, published as part of the ILCD Data Network, and maintained by the industry partners of the FCH 2 JU. The FCH 2 JU shall also establish an international exchange thus providing for a globally consistent framework*."

In 2018 JRC has provided an inventory and gap analysis of the work performed in the various projects to the FCH 2 JU, focussing on LCA methodology. Based on the outcome of this analysis, a harmonisation effort in the approach to LCA is proposed. The JRC will also start to assess critical raw materials aspects of relevant project results.

B.3.8 A workshop with selected experts in the field of LCA will be organized by JRC in collaboration with the FCH 2 JU: the goal of the workshop will be a refinement and updating of the current guidelines addressed in the "Guidance document for performing LCAs on Fuel Cells and H_2 Technologies" (HyGuide deliverable D3.3) (June 2019); the recommendations and the suggestions from the workshop will be collected and elaborated in a report (December 2019).

[73] See project FC-HyGuide (http://www.fc-hyguide.eu/)

B.4 JRC contribution to safety dimension and safety awareness

In the frame of the FCH2 JU strategy on safety aspects at program level, the database Hydrogen Events and Lesson LEarNed (HELLEN) is a multi-purpose tool for a repository of safety information generated by projects, for lessons learned and safety improvement recommendations. In 2016 the structure and interface of the database has been revamped, and in 2017 the modus operandi and the communication channels with the projects have been agreed and designed.

In 2018 The FCH 2 JU launched the European Hydrogen Safety Panel (EHSP) initiative with the mission to assist the FCH 2 JU in assuring that hydrogen safety is adequately managed both at programme and at project level; that also included the assessment and lessons learned from HIAD 2.0 (i.e. the public available version of the Hydrogen Incident and Accident Database). JRC is supporting the EHSP in their work as requested by FCH 2 JU.

B.4.1 HELLEN operation: HELLEN population with the events delivered by projects and annual report[74] (December 2019)

B4.2 Support on data collection on hydrogen safety related events; this is a task by EHSP on assessment and lessons learned from HIAD 2.0, HELLEN or other available databases. (December 2019).

B4.3 Contribution to a report on 2019 research progress in the field of hydrogen safety. This report by the EHSP will be based as usual on a broad range of sources and serve also the prioritization work linked to deliverable B.1.1 (December 2019).

B.5. JRC support to FCH Smart Specialisation.

No particular/dedicated activities foreseen in 2019; however, as part of Regions Initiative, FCH 2 JU will explore with JRC creation of a dedicated 'FCH Platform' under a new potential Energy Partnership.

B.6 JRC testing activities in support to specific part of the programme.

This deliverable consists of providing testing services by means of JRC reference facilities and reference hardware, mainly to implement the harmonisation efforts mentioned sub B.2 above and to guarantee programme-level harmonisation of performance assessment. The type and the quantity of the testing service will depend on the execution of AWP's and PO requests. In the previous three years this deliverable was not activated.

[74] This includes also assessment of HELLEN functions and (if needed) an improvement plan for the following year.

Enclosure I – RESOURCES REQUIRED FOR THE SUPPORT AT PROGRAMME LEVEL

(these are values reflecting approximately the true figures from the Cost Evaluation Form of the Framework Contract)

Deliverable number	Deliverable title	Effort [PM]	Costs [k€]
B.1	**Support to formulation and implementation of RCS strategy (RCS SC group)**	4	-
B.2	**Direct contribution to implementing RCS strategy (Harmonisation)**	12	-
B.3	**Contribution to programme monitoring and assessment**	24	-
B.4	**Support to safety aspects**	6	-
B.6	*Testing in support to specific activities of the FCH2JU programme*	*Max 6*	-
	Manpower Totals [PM]	**52**	

	Overview indicative costs (with overhead) [k€]
Manpower	**600.0**
Missions	**40.0**
Consumables	**50.0**
Subcontract (for TIM and EMM, deliverables B.4)	**175.0**
Total indicative cost for 2019	**865.0**
Max amount per year	*1000*

Costs includes overhead costs = 25%

JRC will report on a regular basis (every month) on deliverables progress and meet the Programme Office every three months.

C. Regulations, Codes and Standards Strategy Coordination (RCS SC) Group

The establishment and implementation of a multi-annual Regulations, Codes and Standards strategy is crucial for the market deployment of FCH systems. The development of common regulations and codes, the harmonisation of standards, also carrying out Pre-normative Research (PNR) to address RCS knowledge gaps at EU (and world) level is recognised as something that would greatly facilitate the commercialization of FCH products. Inconsistent and conflicting regulations and standards will hinder the development of FCH technologies through lack of confidence from stakeholders (customers, authorities) and impair the reduction of costs linked to experience gained and economies of scale.

The overall goal of the RCS Strategy is to enable the development and application of any necessary safety and harmonized performance-based standards for FCH appliances and systems for energy and transport applications so that these standards can be referred to in legislation.

The RCS Strategy therefore aims to facilitate activities which will enable European industry interests to be met, e.g. establishing compliance/certification criteria within the EC and United Nations (UN) regulatory framework; developing international and European standards that provide the technical requirements to achieve safety and build confidence; as well as to guide authorities and other stakeholders in their application.

The FCH 2 JU tackles RCS-related issues mainly through the Crosscutting activities and for the RCS Strategy, an industry-led RCS SC Group[75] was created in 2015 with the aim of addressing the needs of the European FCH sector.

The RCS SC Group, consisting of representatives of organisations in the Hydrogen Europe and Hydrogen Europe Research groupings, supported by the European Commission's Joint Research Centre (JRC) and the FCH 2 JU Programme Office (PO), coordinates the strategy on RCS. The four main tasks of the RCS SC Group are to:

1. Identify and prioritise RCS needs of strategic importance for the EU, through following RCS developments, and updating and prioritizing RCS needs of the sector through a continuous global watch function;
2. Identify PNR activities to support the RCS priorities, tailor PNR and other RCS-related activities in the FCH 2 JU programme to ensure that safety issues and needs for standardization and regulation are appropriately addressed and validated;
3. Transfer and ensure application of the projects' PNR results into RCS development;
4. Define a strategy to pursue the priority RCS issues.

The activities include interfacing with regulatory bodies (e.g. EC, UN), and international organizations for standardization (e.g. ISO, IEC, CEN, CENELEC) for development/amendment of international standards and regulations. To progress these tasks, through its members, the SCG interacts with standardisation and regulatory bodies particularly by introducing European interests into these bodies, and coordinating the attendance of European representatives.

Since 2016, the RCS SC Group has identified and prioritised the main RCS needs of strategic importance for the EU and based on them, has provided recommendations of topics to be considered for incorporation into AWP 17 and 18. Meanwhile, a strategy implementation plan has been developed and adopted to further define the tasks of the RCS SC Group.

In 2018, the RCS SC Group has developed and executed a work plan that covers the activities in support of the AWP and input towards the Annual Union Work Programme for Standardisation as well as the coordination of identified RCS needs and gaps towards appropriate standardisation platforms (such as Technical Committees and the Sector Fora) and regulatory bodies.

In 2019 the RCS SC Group will continue these activities, as laid out in its annual work plan.

[75] https://fch.europa.eu/page/rcs-strategy-coordination-group

D. European Hydrogen Safety Panel (EHSP)

The FCH 2 JU launched the European Hydrogen Safety Panel (EHSP) initiative in 2017. The mission of the EHSP is to assist the FCH 2 JU both at programme and at project level in assuring that hydrogen safety is adequately managed, and to promote and disseminate H2 safety culture within and outside of the FCH 2 JU programme.

Composed of a multidisciplinary pool of experts – 17 experts in 2018 - the EHSP is grouped in small ad-hoc working groups (task forces) according to the tasks to be performed and to their expertise. Collectively, the members of the EHSP have the necessary scientific competencies and expertise covering the technical domain needed to make science-based recommendations to the FCH 2 JU.

Over 2018, four task forces were launched and a safety guidance document for hydrogen and fuel cell projects was published. Besides, the EHSP supported the FCH 2 JU in identifying safety issues and researching that still might require support within the programme, and performed a comprehensive assessment of the safety data and events contained in the European Hydrogen Safety Reference Database, and on the contribution of the FCH JU programme on research progress in the field of hydrogen safety.

Building on the results and activities from last year, in 2019 the EHSP will continue working on the same four main areas.

D.1 Support at project level

The EHSP activities under this category aim at coordinating a package of measures to avoid any accident by integrating safety learnings, 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.

Building on the safety guidance document for hydrogen and fuel cell projects published last year, in 2019, a practical-fit-for-purpose document tailored for the FCH 2 JU projects will be produced. Envisaged as an early warning system that will support the FCH 2 JU programme in identifying projects that potentially might require a greater attention on safety aspects, the ultimate aim of this document is to verify that all funded projects address safety-related aspects and follow a set of safety measures based on the EHSP recommendations and expertise.

D.2 Support at programme level

Besides the support at project level, which represents a significant share of the FCH 2 JU activities, the EHSP works under this category include a set of activities with a broader and cross-cutting dimension focused on the FCH 2 JU programme itself and how safety aspects can be enhanced within the overall programme. Activities include also support in specific occasions for answering urgent questions related to hydrogen safety, acting as representative of the FCH 2 JU on safety aspects, or the provision of specific guidelines for safe use of hydrogen in the public domain.

Over 2018, the EHSP supported the FCH 2 JU in identifying safety issues and researching that still might require support within the programme. Based on this first exercise, and taking into consideration the expected activities and results coming up from the different task forces, in 2019 with the support of JRC a broader strategy will be developed, paving the way to develop a Multi-annual work plan for the EHSP.

D.3 Data collection and assessment

In 2018, the EHSP tasks under this category have encompassed the analysis of safety data and events contained in the revamped European Hydrogen Safety Reference Database (HIAD 2.0) operated by JRC (Joint Research Centre of the European Commission) and supported by the FCH 2 JU. In close collaboration with JRC, the EHSP members have systematically reviewed more than 250 events and the lessons learned stemmed from this assessment will be summarised in a report that will provide a clear view about the current situation concerning the Hydrogen Safety Reference Database, while providing the foundations for future research in this field. Moreover, and related to the activities of the previous task force, a dedicated set of activities over 2018 have also been focused on reviewing the contribution of the FCH JU programme on safety aspects so far, providing as a clear base line for drafting the envisaged multi-annual work plan.

In 2019, the EHSP with the support of JRC will continue the activities started and the EHSP will expand the HIAD 2.0 database with further accidental cases uncovered by the panellists as well as of new information from relevant mishaps, incidents or accidents. Based on the lessons learned from the new and past events, recommendations to all stakeholders will be provided. Moreover, a final report on research progress in the field of hydrogen safety from FCH 2 JU funded projects as well as other major progress internationally will be completed.

D.4 Public outreach

Framed within the context of the intended broad information exchange, in 2018, a dedicated webpage about the EHSP initiative was created on the FCH 2 JU website and potential communication channels for maximising the effectiveness of the outreach of the EHSP activities have been discussed.

In 2019, besides updating on a regular basis the EHSP webpage and providing an annual activity report about the EHSP activities, a comprehensive and practical communication strategy will be finalised and put in place in accordance with the overall communication activities of the FCH 2 JU.

E. Knowledge management. Dissemination and communication on projects results

Knowledge Management:

Technology monitoring will continue with the annual data collection exercise from projects, in the internally developed data collection platform TRUST (Technology Reporting Using Structured Templates)[76]. Following its successful development and use during the last two years and considering data generated the year(s) before (e.g. for 2018 data from 2017 were requested), projects will be invited similarly to provide their data in 2019 concerning results generated in 2018. Data collected, will allow to benchmark project progress against State of the Art (SoA) and FCH 2 JU targets as defined in the MAWP 2014-2020 (and its Addendum) and related AWPs.

In that respect, each project active in the year 2018 (previous year to the exercise) will be asked to complete one or several questionnaires concerning the data obtained within the activities foreseen in the description of action/work. The questionnaires are assigned to the projects according to the type of technologies concerned and the activities carried out. In 2018, 23 different questionnaires were used (so called "templates")[77]. Within each questionnaire, several parameters either descriptive or operational should be filled and each of them can individually be tagged as public or confidential. The FCH 2 JU is committed to respect data confidentiality (according to the conditions setup by the Grant Agreement) and will only use them in the respect of this attribute: confidential data will not be disclosed as such, but only in aggregated form (following a clean-room approach), and in a manner that ensures anonymity of their origin.

An annual iteration of the data collection exercise will enable the development of a time-dependent database of FCH 2 JU project results. Progress and findings that can be shown will be made public (normally associated to the Programme Review exercise – see below). This year further developments will take place on the TRUST tool to offer efficient use of the tool and the database. Developments will improve the interface of the tool as well as functions related to input and export of data/databases. Recommendations for further improvements derive from the feedback collected from the FCH 2 JU project beneficiaries who experienced the tool and the FCH 2 JU programme office.

In parallel to this, JRC (see section B above) will support the PO by updating international state-of-the art, SoA figures with the so called 'reference data' for the various technologies, in order to allow a benchmarking of the FCH 2 JU activities and results of its projects within the global setting. This year, JRC will further expand their analysis on the evolution of MAWP/MAWP Addendum and AWP KPI's, both in terms of targets and achievements.

JRC has delivered in 2018 the requested developments (datasets) in TIM[78] (Tools for Innovation Monitoring) tool, related to the following FCH technologies: Polymer Exchange Membrane (PEM), Solid Oxide (SO) and Alkaline. The tool has mapped scientific publications, contributions to literature patents, patents and participations to EU funded projects according to the authors' organisations. FCH 2 JU beneficiaries and relevant activities have been tagged and the users will be able to filter data related to FCH 2 JU projects. This should allow tracking developments in the FCH technologies and related impact of FCH 2 JU funding. In this context, FCH 2 JU will create a dedicated webpage to host the TIM tool and will continue cooperation with JRC for further adaptation, maintenance and operation of the tool.

An internal database was started to be developed in 2017 containing overall plans and deployments in Europe; it will continue to be maintained and updated by the FCH 2 JU. This database is fed with information from projects and from general/specific press concerning plans and deployments of FCH technologies, such as electrolysers, vehicles, hydrogen refuelling stations and stationary units, including detailed information on country, size, technology etc. Information for other parts of the

[76] https://www.fch.europa.eu/sites/default/files/TRUST_ExplanationFile_Draft_2018%20%28ID%203366054%29%20%28ID%203366108%29.pdf

[77] https://www.fch.europa.eu/projects/knowledge-management

[78] http://www.timanalytics.eu/

world may also be included for benchmarking. The development of the European Media Monitoring (EMM)[79] for FCH technologies with support of JRC (mainly for communication purposes), should provide a more comprehensive press screening mechanism and allow a more thorough capture of the relevant information in the future.

In particular, for cars, this should be complemented with reference to fuel cell car deployment figures (passenger car data only) from the European Automobile Manufacturers Association (ACEA) recorded on a quarterly basis, as obtained from ACEA directly. Vehicle sales figures are also captured every 6 months from the vehicle manufacturers themselves, if possible. These data will be harmonised and then transferred to the *'Fuel cells and hydrogen market and policy observatory'*, which will eventually become the main reference point for data related to the FCH sector; it is expected that the Fuel Cells and Hydrogen Observatory will start its activities in December 2018 with a duration of 40 months. The observatory shall gather data in the following domains: technology and markets, socio-economic, policy & regulation, codes and standards (RCS), financial support and incentives. The observatory shall present the data in a user friendly way so that policy-makers, general audience as well as FCH stakeholders can easily retrieve information of their interest reinforcing the role of the FCH 2 JU as a reference source of fuel cells and hydrogen related information.

Dissemination and communication on projects results:

The FCH 2 JU is also part of the Horizon 2020 Dissemination and Exploitation Network (D&E-Net) (previous DiEPP) which is established under the H2020 Strategy for common dissemination and exploitation of research and innovation data and results for the remaining period of 2018-2020. In 2019 the D&E-Net activities will mainly involve participation in the main working group and in six subgroups established by the European Commission DG RTD: (1) D&E practices across the R&I family & capacity building, (2) Data sharing and visualisation, (3) Activating multipliers & synergies, (4) Virtual marketplace & go-to-market tool, (5) Strengthening policy feedback, (6) Exploitation and impact in FPs.

In close relationship with daily knowledge management activities, relevant actions will continue as part of the European Commission initiatives in the field, such as invitation to projects to participate in the second EC Common Exploitation Booster (CEB) and Common Dissemination Booster (CDB) (to be launched in Q1-2019), the currently ongoing service of SSERR (Support Services for Exploitation of Research Results), whereby projects can receive consultancy-type advice such as training and coaching on exploitation aspects and the World Alliance for 1000 Efficient Solutions initiative[80].

In 2018, the FCH2 JU began its participation in the Innovation radar pilot and by the end of 2018 the exercise will have been conducted for 21 projects. The Innovation Radar pilot exercise has so far been conducted in project mid-term reviews where a dedicated expert is mandated to identify potential innovations and is required fill out a questionnaire with the aim of providing information in a structured and quantified way. With the learnings provided by this pilot, the FCH 2 JU will have collected valuable feedback that will be provided to its liaisons in DG RTD and DG CONNECT in order to see how the initiative can be further improved. Furthermore, the identified innovations/innovators will be supported for further exploitation of their results (e.g. pitching to possible investors etc).

Finally, the FCH 2 JU will perform monitoring of any activity of FCH 2 JU projects within these initiatives to provide dedicated assistance in either exploitation or dissemination of results.

In continuation of efforts of 2018, FCH 2 JU will continue to contribute to the IRIS/OSIRIS initiative concerning text mining for EU policy purposes of project documents (proposals, grant agreements, amendments, reports, deliverables, etc).

Continuing the good experience and practice so far, the 9th annual Programme Review Days will be organised in autumn 2019 (Q4 of 2019). The review will be carried out with the support of JRC (see section B above). Initiated in 2011, this annual exercise, managed by the FCH 2 JU initially with the

[79] http://emm.newsbrief.eu/overview.html

[80] https://solarimpulse.com/world-alliance

input of independent experts and lately JRC, provides feedback on the progress of the portfolio of FCH 2 JU funded projects identifying key achievements but also potential areas to be addressed or reinforced in subsequent years. The exercise also provides an excellent visibility platform for projects and technological developments achieved in the sector, as well as networking and pitching opportunities for project participants (please section F below).

F. Support to policies and funding/financial engineering

<u>Support and input to EU policies:</u>

The FCH 2 JU is contributing to the activities of a number of services in the EC. Contributions vary in content and format, but they all share the common goal of providing fact-based information on the state of art of fuel cells and hydrogen technologies and their contribution to the EU initiatives and policies especially in the energy, transport and industry sectors as well as to competitiveness and growth.

In practical terms, this means taking part in a number of technical groups organised by the EC and other international bodies, active participation in the meetings, providing written technical input and ensuring that fuel cells and hydrogen technologies are properly represented. It includes also feedback from project to the EC in contribution to relevant energy, transport and clean air policy files.

The FCH 2 JU is actively following and contributing to the European Strategic Energy Technology Plan (SET-Plan)[81] activities, in particular Action 5 "Energy Efficiency in Buildings", Action 6 "Energy Efficiency for Industry" and Action 8 on "Renewable Fuels". The FCH 2 JU is also taking part as an observer in several of the sub-groups of the ART Fuels Forum[82] established under the project "Support for alternative and renewable liquid and gaseous fuels forum (policy and market issues)". Still in the domain of transport, the FCH 2 JU participates in the "Sustainable Transport Forum"[83] and the "Clean Bus Expert Group"[84]. The latter group is dedicated to work on specific policy recommendations (funding and financing topics included) related with clean buses' deployment to be delivered before end-2018. As the Clean Bus Expert Group will split, the FCH 2 JU input for the year 2019 is expected to shift to the setting up of the Clean Bus Deployment Platform, providing insights regarding the pipeline of projects to deploy FCEB in Europe.

Worth mentioning is the on-going collaboration of DG MOVE, DG RTD, JRC, EMSA[85] and FCH 2 JU on regulatory aspects (safety, standardisation, regulation) related to hydrogen as a maritime fuel. In addition, FCH 2 JU participates to the HIA Task 39 "Hydrogen in maritime transport" and together with DG RTD it has presented the technical progress of hydrogen powered ships projects at the International Maritime Organisation (IMO). Support to EC DGs will continue throughout 2019 and the FCH 2 JU will also support DG ENV while working on the 'Clean Air policy' file or DG GROW files on supply/value-chain aspects of the FCH technologies (e.g. the FCH 2 JU Study on Value Chain and Manufacturing Competitiveness Analysis for Hydrogen and Fuel Cells Technologies will be concluded in 2018 and will provide an evidence based analysis of the value added that the FCH sector can bring to Europe, including how fuel cells and hydrogen sector could contribute to strengthening and reinforcing the competiveness of EU industry).

The FCH 2 JU is also facilitating the set-up of a Stakeholder's Platform for the establishment of a Guarantees of Origin (GO) Scheme for Hydrogen based on the current CertifHy[86] initiative. This activity is expected to continue in 2019 (see chapter 3.2.H. Public Procurements) as it is essential to setup a broadly accepted and fully operational hydrogen GO scheme. The continuation of the initiative in 2019 is planned to, among others, act as a catalyst for convergence within the stakeholder community, to give input and influence RCS as well as the standard that is currently under preparation by CEN/CENELEC/TC6/WG2. This will also help enable the potential adaptation of the CertifHy scheme to new regulatory requirements from the RED2 and other interactions with the regulatory system (e.g. anticipated recast of the Gas Directive).

Exchanges of the FCH 2 JU extend also to the Executive Agencies in charge of managing other parts of Horizon 2020 in areas relevant to fuel cells and hydrogen technologies. On the transport sector, the

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[81] https://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan
[82] http://artfuelsforum.eu/
[83] https://ec.europa.eu/transport/themes/urban/cpt/stf_en
[84] https://ec.europa.eu/transport/themes/urban/cleanbus_en
[85] European Maritime Safety Agency (http://www.emsa.europa.eu/)
[86] https://fch.europa.eu/page/certifhy-designing-first-eu-wide-green-hydrogen-guarantee-origin-new-hydrogen-market

FCH 2 JU continues collaborating with INEA[87] (under both H2020 programme but also CEF programme[88]) on activities related to fuel cell buses and Hydrogen Refuelling Stations (HRS) and partially the energy sector activities, mainly energy storage. The FCH 2 JU has also liaised closely with the EASME[89]. The activities of the FCH 2 JU in transport and energy have also been presented lately to the European Defence Agency (EDA). As a result, the FCH 2 JU is now attending regularly the bi-annual Consultation Forum for Sustainable Energy in the Defence and Security Sectors bringing together European Ministries of Defence and organised by the EDA[90].

Some exchanges have also taken place with other European Technology Platforms. For instance, the results of the demonstration projects supported by the FCH 2 JU looking at fuel cells as heat and power solutions for buildings were presented to the European Construction Technology Platform Steering Committee.

The above are just examples of some of the activities the FCH 2 JU is involved. In 2019 the FCH 2 JU Programme Office will continue to reinforce the collaboration with policy makers in the European Commission.

Funding and Financial Engineering:

As noted by the Independent Experts Group during the Interim Evaluation of the FCH 2 JU[91], funding/financial engineering activities have been integrated into the Programme Office in order to work closely with the Industry, Academia and Research, the European Commission, Member States, Regions and Cities, other EU bodies and Financial Institutions to create synergies between different funding and financing sources. The aim is to accelerate the market introduction and deployment of the technologies stemming from the projects that FCH 2 JU supports.

There are several funding and financing schemes complimentary to the ones directly supported by the FCH 2 JU. Reaching out to alternative funding and financing sources has the potential to leverage the impact of FCH 2 JU projects and enhances the achievement of their objectives.

Although the FCH 2 JU has already successfully enabled the blending of different EU funds into a few projects under its portfolio[92], it is now important to ensure a systematic approach towards leveraging FCH 2 JU budget and activities through other EU funds not centrally managed by the EC. By combining or opening access to new funding streams for the projects, it is expected that both the time to market of R&D supported under FCH 2 JU operations and its cost premium compared with incumbent technologies will be reduced.

To better exploit synergies among funding programmes the FCH 2 JU will seek to engage with Executive Agencies and Managing Authorities in two distinct areas: (1) the funding of R&D, infrastructure and deployment of FCH applications and (2) the sharing of risk involved in product development. The FCH 2 JU is now providing advice and support to prospective or past beneficiaries of FCH 2 JU projects in order to combine funding from various programmes and optimise structured finance operations.

Acknowledging that in terms of funding structure there is no one-size-fits-all approach, the FCH 2 JU has launched a dedicated webpage on Funding and Financing[93] to harmonise and aggregate the sources of information and lessons learnt. It includes the lessons learnt from already supported projects benefiting from the combination of funds, highlighting specific requirements that potential beneficiaries must address to ensure EU funds' blending is fully compatibility with EU rules (e.g. compliance with the non-cumulative principle and the co-financing principle). The site is set to be

[87] Innovation & Networks Energy Agency (https://ec.europa.eu/inea/en/welcome-to-innovation-networks-executive-agency)
[88] Connecting Europe Facility (CEF)
[89] Executive Agency for SMEs (EASME)
[90] European Defence Agency (https://www.eda.europa.eu/)
[91] http://www.fch.europa.eu/news/publication-fch2-ju-interim-report
[92] Example combined projects JIVE/MEHRLIN
[93] http://www.fch.europa.eu/page/funding-financing

further consolidated in 2019 to become a repository of IT tools[94] and studies that (1) raise awareness on the technology, (2) provide clarity on the viability of investments and (3) reveal the funding and financing available to support the deployment of FCH technologies . The webpage is now an entry door for new project promoters but also a market enabler for beneficiaries of the FCH JU calls, providing them with the guidance and initial support towards materialisation of investments.

Following the completion and conclusions of the study “Fuel Cells and Hydrogen for Green Energy in European Cities and Regions”[95] in 2018, the FCH 2 JU will implement a number of measures in particular the continuation of the collaboration through a platform, which is being formalised as an Energy Partnership under the Smart Specialisation Platform in collaboration with the JRC and Project Development Assistance (PDA) as a procurement service.

The Regions and Cities Initiative bottom-up approach have encouraged local and regional governments to include fuel cells and hydrogen within their regional priorities when managing certain European Structural and Investment Funds (ESIF). It is thus necessary to establish strong links and relationships with countries and regions managing EU Funds

In the context of the topic *FCH-03-1-2019: H2 Valley* to which project applications are expected to be led by the regions, the Programme Office will explore the possibility to provide a Seal of Excellence[96] and assistance to any project that will pass the evaluation but will not be funded, due to budget constraints (projects in reserve lists).

The FCH 2 JU will remain 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 of these collaborations are the common study with S2R[97] to identify where fuel cell technologies best fit in the rail sector, the linked project JIVE-MERLHYN on the deployment of fuel cell buses with CEF or the complementary programs with CleanSky2 for the use of fuel cells in the aeronautic sector. The FCH 2 JU will continue to collaborate with executive agencies and other JUs (under the leadership of the policy DGs in the EC) in view of improving the exchange of information and generating synergies between different initiatives, thus reducing the risk of duplication within areas that are of common interest.

The FCH 2 JU will also continue to work together with the EIB and the industry in view of facilitating access to Financial Instruments like the InnovFin EDP or others being used for de-risking projects having access to the European Fund for Strategic Investments (EFSI).

It is essential that the finance community remains and becomes even fully aware of the state of the art in terms of FCH technology solutions (through the results of FCH 2 JU projects), their market readiness, the benefits they bring and the impacts they may achieve through the provision of private sector funding and financing support (across the spectrum of new entrants, start-ups, SMEs and established firms in the FCH marketplace). The FCH 2 JU will continue to raise awareness of projects’ results within the finance community. It will therefore address the private sector funding and financing challenge that acts as a market barrier for deployment of FCH technologies and wider FCH integrated solutions. To this end as mentioned in the previous section, the FCH 2 JU together with DG RTD and their Support Services for Exploitation of Research Results (SSERR) initiated a pilot Brokerage Event that culminated with the pitching of results by trained representatives of the beneficiaries of our projects during the PRD2018 event. A follow-up of this exercise is intended in 2019, including during PRD2019.

[94] E.g. “funding and financing navigation tool”, “mobility business case tool’’

[95] More information at http://www.fch.europa.eu/page/about-regions

[96] The Seal of Excellence is the high-quality label awarded to projects submitted to Horizon 2020 which were deemed to deserve funding but did not receive it due to budget limits. It recognises the value of the proposal and supports the search for alternative funding (https://ec.europa.eu/research/soe/index.cfm)

[97] Shift2Rail (https://shift2rail.org/)

G. International Cooperation

The importance of international cooperation in science and technology is explicitly recognized in the European Union's Innovation Union flagship initiative and the Horizon 2020 programme. This is described in the communication entitled "Enhancing and focusing EU international cooperation in research and innovation: a strategic approach"[98]. Following this principle, in order to align with, facilitate and accelerate worldwide market introduction of fuel cell and hydrogen technologies the FCH 2 JU continuously tries to identify priority areas, at policy and technology level, where coordinated and collaborative international activities are of interest.

As the deployment of fuel cells and hydrogen technology is carried out globally and key stakeholders of the FCH 2 JU are involved in these developments, establishment of links with other major FCH related programmes globally is deemed important. This is particularly valid during 2019 in areas of cross cutting nature such as regulatory and policy frameworks (for example issues with harmonisation of regulations for maritime applications), codes, standards (for example pre-normative research on refueling protocols or impact of hydrogen admixtures in the natural gas networks), safety or education (for example training of responders). These areas play a very important role in early market activation and where intellectual property rights are less of an issue.

On a more general level, the relevant international activities of interest include in particular those carried out by the International Energy Agency (IEA) under the Hydrogen Implementing Agreement (IEA Hydrogen)[99], Advanced Fuel Cell Implementing Agreement and the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)[100]. The FCH 2 JU will hence continue in 2019 to collaborate closely with the EC representatives in the steering committees of these international agreements/associations, in particular within the working-groups on power-to-X and maritime applications of the IEA.

Synergies will continue to be explored with the Climate Technology Centre & Network (CTCN)[101], which is the implementing body to the COP[102], making sure developing countries adopt the right climate technologies to reach the 2°C target.

Following the launch in May 2018 (Malmö, Sweden) of a new Hydrogen Innovation Challenge[103] to accelerate the development of technologies needed for a global hydrogen market, FCH 2 JU will foster the collaboration and support to the Mission Innovation[104] activities, especially through projects collaboration with similar worldwide activities but also through dedicated activities (see section 3.2.H on Public Procurements). Within this context, European Commission (as co-leader of this Hydrogen Innovation Challenge) pushes the acceleration of hydrogen innovation and this work-plan includes a number of specific actions, which directly target an increased international cooperation of EU Member States and Associated Countries in the context of Mission Innovation.

In recognition of this committed collaboration within Mission Innovation, proposals are expected to contribute towards the objectives and activities of the Hydrogen Innovation Challenge by promoting international collaboration beyond EU Member States and H2020 Associated Countries.

Consortia are strongly encouraged to include legal entities established in the countries members/participant[1] in the Hydrogen Innovation Challenge under the following topics:

[98] COM(2012)497
[99] http://ieahydrogen.org/
[100] http://www.iphe.net/
[101] https://www.ctc-n.org/
[102] http://unfccc.int/bodies/body/6383.php
[103] http://mission-innovation.net/our-work/innovation-challenges/hydrogen-challenge/
[104] http://mission-innovation.net/about/
[1] For the list of countries which are members/participant to Hydrogen Innovation Challenge, please see: http://mission-innovation.net/our-work/innovation-challenges/

FCH-01-4-2019: Towards a better understanding of charge, mass and heat transports in new generation PEMFC MEA for automotive applications

FCH-02-4-2019: New Anion Exchange Membrane Electrolysers

FCH-04-1-2019: Training of Responders

FCH-04-2-2019: Refuelling Protocols for Medium and Heavy-Duty Vehicles

FCH-04-3-2019: Hydrogen admixtures in natural gas domestic and commercial end uses

FCH-01-2-2019: Scaling up and demonstration of a multi-MW Fuel Cell system for shipping – in particular activities related to 'Regulatory, economic and societal issues' of the topic.

The relevant entities might benefit from the general H2020 Rules for participation provision (see Article 10(2)(a) of H2020 Rules for Participation) whereby a participating legal entity established in a third country, which is not eligible for funding under Part A of the General Annexes to the Commission Work Programme, may receive JU funding if, in particular, its participation is deemed essential by the FCH 2 JU for carrying out the action.

H. Public Procurements

In 2019, the FCH 2 Joint Undertaking will carry out a number of activities via calls for tenders (i.e. public procurement) for an indicative amount of **EUR 3.35 million**. Recourse to existing Framework Contracts will be envisaged where possible. The procurement activities are covering subjects of a strategic nature for the FCH 2 JU, providing input to R&I priority setting and supporting further financing, deployment and commercialisation of green hydrogen and fuel cells.

For each of the procurements, detailed Terms of Reference will be drafted with European Commission participation. The following indicative list of procurements is currently foreseen:

Subject (Indicative title)	Indicative budget (EUR)	Expected type of procedure	Schedule Indicative
Support to Mission Innovation – H2 Challenge *Develop a platform for exchanges between different worldwide initiatives on H2 valleys; within the same budget, particular attention will be given to addressing the logistics (hydrogen carriers) aspects (at a global level).*	500,000.00	Open procedure	Q1
Certification of green H2 *Further development and continuation of implementation of guarantees of origin certificates for green and clean H2, including establishment of physical platform for certificates exchanges and link to regulators.*	1,500,000.00	Open procedure	Q3
Project Development Assistance (PDA) for regions, in particular from Central-East European Countries *Follow-up action on the Regions Initiative, in particular for less developed plans in the regions with strong potential to introduce H2 in their decarbonisation strategy..*	750,000.00	Open procedure	Q1
European business cases for FCH trucks and technology development roadmap *Seen as high-potential technology on short-term, there is an urgent need to identify the R&I priorities (including synergies with other heavy-duty applications on the core modular FC technology).*	300,000.00	Open procedure	Q2
Role of power-to-gas (P2G) in contributing to Member States meeting their Energy & Climate targets *Based on national plans, examine for every country how P2G (hydrogen produced from renewable electricity) could contribute in reaching these targets for the sectors of industry, transport and the gas grid.*	300,000.00	Open procedure	Q2

The final budgets awarded to actions implemented through procurement procedures may vary by up to 20% of the total value of the indicative budget.

Conditions for the Call

Call identifier: **H2020-JTI-FCH-2019-1**

Total budget[105]: EUR million 80.8

Estimated opening date[106]: **15 of January 2019**

Estimated deadline[107]: **23 of April 2019**

Indicative budgets:

Topic	Type of action	Indicative budget (million EUR)
1. TRANSPORT PILLAR		
FCH-01-1-2019: Demonstrating the blueprint for a zero-emission logistics ecosystem	Innovation Action	10
FCH-01-2-2019: Scaling up and demonstration of a multi-MW Fuel Cell system for shipping	Innovation Action	10
FCH-01-3-2019: Cyber-physical platform for hybrid Fuel Cell systems	Research and Innovation Action	5.8
FCH-01-4-2019: Towards a better understanding of charge, mass and heat transports in new generation PEMFC MEA for automotive applications	Research and Innovation Action	
FCH-01-5-2019: Underground storage HRS	Innovation Action	1.5
2. ENERGY PILLAR		
FCH-02-1-2019: Combined electrolyser-HRS and Power-to-Gas system	Innovation Action	15
FCH-02-2-2019: Multi megawatt high-temperature electrolyser for valorisation as energy vector in energy intensive industry	Innovation Action	
FCH-02-3-2019: Continuous supply of green or low carbon H2 and CHP via Solid Oxide Cell based Polygeneration	Innovation Action	

[105] The final budgets awarded to actions implemented through the Call for Proposals may vary by up to 20% of the total value of the indicative budget for each action.
[106] The Executive Director may decide to open the call up to one month prior to or after the envisaged date of opening.
[107] The Executive Director may delay the deadline by up to two months. The deadline is at 17.00.00 Brussels local time.

FCH-02-4-2019: New Anion Exchange Membrane Electrolysers	Research and Innovation Action	2
FCH-02-5-2019: Systematic validation of the ability to inject hydrogen at various admixture level into high-pressure gas networks in operational conditions	Research and Innovation Action	11.5
FCH-02-6-2019: New materials, architectures and manufacturing processes for Solid Oxide Cells	Research and Innovation Action	
FCH-02-7-2019: Development of highly efficient and flexible mini CHP fuel cell system based on HTPEMFCs	Research and Innovation Action	
FCH-02-8-2019: Enhancement of durability and reliability of stationary PEM and SOFC systems by implementation and integration of advanced diagnostic and control tools	Research and Innovation Action	
3. OVERARCHING ACTIVITIES		
FCH-03-1-2019: H2 Valley	Innovation Action	20
4. CROSS-CUTTING ACTIVITIES		
FCH-04-1-2019: Training of Responders	Coordination and Support Action	1
FCH-04-2-2019: Refueling Protocols for Medium and Heavy-Duty Vehicles	Research and Innovation Action	4
FCH-04-3-2019: Hydrogen admixtures in natural gas domestic and commercial end uses	Research and Innovation Action	
TOTAL		80.8

Through their participation in projects funded under this call and in accordance with point (b) of Article 13(3) of the FCH 2 JU Statutes, it is estimated that an additional 6 million EUR in-kind contributions will be provided by the constituent entities of the Members, other than the Union or their affiliated entities participating in the indirect actions published in this call.

In accordance with Article 4 (2)(b) of Council Regulation (EU) No 559/2014 the estimated value of the costs incurred by the constituent entities of the Members other than the Union or their affiliated entities them in implementing additional activities outside the work plan of the FCH 2 Joint Undertaking contributing to the objectives of the FCH Joint Technology Initiative (referred to as In-Kind in Additional Activities (IKAA)) is set in the 2019 Additional Activities Plan, subject of a separate document to be submitted to the FCH 2 JU GB for approval.

Indicative timetable for evaluation and grant agreement signature:

Information on the outcome of the evaluation: Maximum 5 months from the date for submission;

Indicative date for the signing of grant agreements: Maximum 8 months from the date for submission.

Consortium agreement: Members of consortium are required to conclude a consortium agreement, in principle prior to the signature of the grant agreement.

Proposals are required to provide a draft plan for exploitation and dissemination of results.

3.3 Call management rules

The call will be managed and the proposals should comply with the Call conditions above (chapter 3.2) and with the General Annexes to the Horizon 2020 Work Programme 2018–2020[108] that shall apply mutatis mutandis to the actions covered in this Work Plan (with the exceptions introduced below). There is no derogation from the H2020 Rules for Participation.

Countries eligible for funding: The list of countries eligible for funding is described in Part A of the General Annexes to the Horizon 2020 Work Programme 2018–2020 which shall apply mutatis mutandis to the actions covered in this Work Plan.

Eligibility and admissibility conditions: The conditions are described in parts B and C of the General Annexes to the Horizon 2020 Work Programme 2018–2020 which shall apply *mutatis mutandis* to the actions covered in this Work Plan.

For some actions, an **additional eligibility criterion** has been introduced to limit the FCH 2 JU requested contribution, as follows:

FCH-01-1-2019: Demonstrating the blueprint for a zero-emission logistics ecosystem

The maximum FCH 2 JU contribution that may be requested is EUR 10 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-01-2-2019: Scaling up and demonstration of a multi-MW Fuel Cell system for shipping

The maximum FCH 2 JU contribution that may be requested is EUR 10 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-02-1-2019: Combined electrolyser-HRS and Power-to-Gas system

The maximum FCH 2 JU contribution that may be requested is EUR 5 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-02-2-2019: Multi megawatt high-temperature electrolyser for valorisation as energy vector in energy intensive industry

The maximum FCH 2 JU contribution that may be requested is EUR 7 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-02-3-2019: Continuous supply of green or low carbon H2 and CHP via Solid Oxide Cell based Polygeneration

The maximum FCH 2 JU contribution that may be requested is EUR 3 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-02-6-2019: New materials, architectures and manufacturing processes for Solid Oxide Cells

The maximum FCH 2 JU contribution that may be requested is EUR 5 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-02-7-2019: Development of highly efficient and flexible mini CHP fuel cell system based on HTPEMFCs

The maximum FCH 2 JU contribution that may be requested is EUR 1.5 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

[108] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

FCH-03-1-2019: H2 Valley

The maximum FCH 2 JU contribution that may be requested is EUR 20 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

For all actions of the call, the FCH 2 JU will activate the option for EU grants indicated under Article 30.3 of the Model Grant Agreement, regarding the FCH 2 JU's right to object to transfers or licensing of results.

Types of Action: The definitions of the types of actions, specific provisions and funding rates are described in Part D of the General Annexes to the Horizon 2020 Work Programme 2018–2020 which shall apply *mutatis mutandis* to the actions covered in this Work Plan.

Technology Readiness Levels (TRL): The definitions for technology readiness levels are provided in Part G of the General Annexes to the Horizon 2020 Work Programme 2018–2020. In addition, for topics focused or partially addressing manufacturing issues, as the topics and related activities are not ultimately contributing to the progress of the technology but mainly to the manufacturing level of the technology, Manufacturing Readiness Levels (MRL)[109] requirements have been also introduced.

Evaluation procedure: The entire evaluation procedure including criteria, scoring and threshold(s) but also the procedure for setting a priority order for proposals with the same score are described in part H of the General Annexes to the Horizon 2020 Work Programme 2018–2020 which shall apply *mutatis mutandis* to the actions covered in this Work Plan [110].

Budget flexibility is described in Part I of the General Annexes to the Horizon 2020 Work Programme 2018–2020 which shall apply *mutatis mutandis* to the actions covered in this Work Plan.

In order to optimise the use of possible leftover call budget (or in case any additional budget becomes available), notwithstanding the provisions of Parts I and H of the General Annexes to the Horizon 2020 Work Programme 2018–2020 which apply mutatis mutandis to the actions covered in this Work Plan, the following criteria shall be used, in the order of priority mentioned below and if sufficient additional budget is available:

1. Selecting the proposal(s) having the highest total score among the next proposals from all ranked lists (and repeating this until the budget is spent);
   Where there are two or more proposals from different ranked lists having equal total score, the proposal having the highest score in "Excellence" shall be selected (and repeating this until the budget is spent); if still equal, the proposal having highest score in 'Impact' shall be selected;
2. Selecting the proposal(s) from the ranked list(s) having the highest oversubscription.

As a general approach, complementarity between approaches/solutions of different proposals in the same ranked list should be sought; this should be checked by experts evaluating the proposals.

As regards **open access to research data**, part L of the General Annexes to the Horizon 2020 Work Programme 2018–2020 shall apply mutatis mutandis to the actions covered in this Work Plan.

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[109] D. Wheeler and M. Ulsh (February 2010). "Manufacturing Readiness Assessment for Fuel Cell Stacks and Systems for the Back-up Power and Material Handling Equipment Emerging Markets", National Renewable Energy Laboratory, United States Department of Energy, available at http://www.nrel.gov/hydrogen/pdfs/45406.pdf

[110] The full evaluation procedure is described in the relevant **H2020 guide for participants** as published on the Participant Portal: http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/pse/h2020-guide-pse_en.pdf

3.4 Support to Operations

Communication and events

In 2019, communication will continue to promote FCH 2 JU Joint Undertaking activities and objectives, building on the programme success stories to demonstrate the benefit of the instrument and the impact of its results. The stories about the technology, the journey and the successes are a powerful tool, which can have a wide outreach.

Communication will support the priorities identified in the current AWP and will ensure that stakeholders are informed about the activities and results of the FCH 2 JU.

Throughout the communication, FCH 2 JU will build on the growing momentum created during 2018 for the FCH technology: Hydrogen as the missing link in the energy transition, commitment towards Hydrogen through various initiatives at local, national and regional level. In this respect, in addition to concrete achievements and benefits, it is essential to highlight and raise awareness about the market readiness of the technology.

In addition, FCH 2 JU will continue to create synergies with the projects communication to strengthen the impact and increase outreach.

Last but not least, it will enhance efforts for raising awareness beyond the hydrogen and fuel cell community in order to reach out to more audiences.

The activities outlined below will form the basis for the annual communication plan 2019.

Communication objectives

The objectives for 2019 will continue to include the general objectives identified in the communication strategy, with a focus on: raising the programme profile overall, while highlighting the potential of the technology and its market readiness. FCH 2 JU has identified, in addition, some specific objectives to further guide communication efforts.

General objectives

- **Raise the FCH 2 JU Programme's profile (among all target groups identified) by:**
  - Increasing political and public awareness of the FCH 2 JU;
  - Highlighting the programme's contribution to the Energy Union (and other relevant policy initiatives);
  - Mobilising strongly committed applicants in order to broaden participation in the programme;
  - Increase synergies with additional funding programmes and instruments.

- **Highlight technology potential and market readiness by:**
  - Increasing visibility around projects findings and outcomes;
  - Communicating the benefits of the technology with real-life examples and projects 'results;
  - Gathering and production significant material attesting of the programme's progress and benefits in several areas;
  - Reach-out activities and project results will stay closely linked in order to tap into the FCH 2 JU most successful projects' outcomes.

Specific objectives 2019

- Build on the growing momentum created throughout 2018 for the FCH technology by targeting key stakeholders;
- Trigger interest in fuel cells and hydrogen technologies beyond the programme stakeholders, reaching out to new audiences;

- Leverage project communication and promote successful projects' outcomes, building on the increasing number of finished projects.

Target audiences

The target audiences identified by the FCH 2 JU Communication Strategy are:

- Policy-makers: 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.);
- FCH 2 JU current beneficiaries;
- FCH 2 JU potential beneficiaries;
- Financial actors;
- General public;
- Decision supporters / multipliers (Civil society, Associations, NGOs).

Main communication themes

Throughout all communications, we need to deliver clear and consistent messages that resonate with all audiences, from policymakers to the wider public and raise awareness and excitement around fuel cells and hydrogen.

Communication themes will include, amongst others:

- Most advanced FCH technologies and applications areas: transport (buses, cars and HRS infrastructure) and energy (electrolysers and micro CHP) as identified through FCH 2 JU projects' results and success stories; FCH 2 JU will focus on innovations, research breakthroughs, etc.;
- Market readiness of the technology and the need to support the development of the market conditions;
- Projects' results and success stories: concrete benefits for the European citizens, socio-economic benefits, benefits and involvement of Small and Medium Enterprises etc.;
- Successful collaboration between the EU, research and industry, to deliver green transport and green energy: 'a long-standing cooperation that bears fruit';
- Growing momentum for the FCH technology;
- Specific, target messages for both transport and energy sectors.

Communication and outreach activities

Awareness-raising campaigns

Several "pilot" communication initiatives have been launched in the last quarter of 2018. More specifically, the FCH 2 JU has launched a pilot campaign to promote both the technology and the instrument to a general audience in Brussels – focusing on the benefits of technology (hydrogen for green transport and energy) and FCH 2 JU as a public-private partnership making this possible. FCH 2 JU will closely monitor the impact of the campaign in order to assess its effectiveness and potential for renewal in 2019. Furthermore, the first edition of FCH 2 JU Awards is taking place in November 2018 to recognise success stories and breakthroughs that demonstrate the value of the technology when applied to the energy, industrial and transport sectors and beyond.

Media relations

In order to develop media outreach, the following activities are foreseen throughout 2019:

- Development of a press and social media strategy around relevant initiatives / events will help raising the profile of the programme;
- Developing a media contacts database will allow for reaching out to journalists through press releases and other media tools;

- Media Monitoring through the European Media Monitoring (EMM) for FCH technologies (developed with the support of JRC will provide for a more comprehensive press screening mechanism and allow a more thorough and regular capture of the relevant information. It will also serve as a source of information for the development of an external e-newsletter of the FCH 2 JU. The tool has been finalised and practical aspects of its usage will be further defined;
- Publication of news articles and op-eds in both specialised and general publications (online and print);
- Paid advertising will be used as a last resort, only in combination with earned media.

Website

As the main communication tool of the programme, the website https://www.fch.europa.eu/ is in need of continuous updating and editing. New developments are needed to improve user friendliness and allow for a better presentation of the information, in line with recent trends. These will be addressed throughout the year.

e-Newsletter

Programme highlights will be distributed to a subscribers database through a monthly external e-newsletter, which will complement the existing news-alert system. New subscribers will be targeted actively, via social media and during events, while ensuring compliance with GDPR rules.

Social media

By creating an editorial calendar around the main events and initiatives, social media will be more coordinated and pro-active.

The FCH 2 JU twitter account is one of the main tools for distributing content to a wider audience. Communication activities will continue leveraging this channel to relay news information, drive traffic to the FCH JU website and reach out to new audiences.

In addition, LinkedIn will continue to support communication targeting the professional community interested in both technical and general information, while the YouTube channel will support the distribution of the programme and project videos.

Events

The FCH 2 JU will continue to contribute to different events (conferences, workshops, project events, exhibitions etc.) to keep informing on the organisation's achievements, work and funding opportunities.

A detailed events calendar will be developed at beginning of 2019 and updated throughout the year. It will guide the communication around these events, including news publication and will include the types of communication actions required on each occasion and the involvement of the FCH 2 JU.

The following main events have been already identified (list to be updated during the year):

- FCH 2 JU Stakeholder Forum (SF) and Programme Review Days (PRD): provisional date 18 - 22 November 2019 (topics and concept to be determined during the year);
- Hannover Messe 2019: Apr 1, 2019 – Apr 5, 2019;
- The EU Sustainable Energy Week (EUSEW): 17 to 21 June 2019 as being the biggest event dedicated to renewables and efficient energy use in Europe;
- Events organised by / around the EU presidencies (Romania and Finland).

The FCH 2 JU will closely work with projects' communication and dissemination teams for other project-related events. For further information about projects results' dissemination, please refer to section 3.2.E. Knowledge management. Dissemination and information about projects results.

Publications

Several publications will be published and promoted throughout 2019, among which the H2 EU roadmap Study (planned to be launched at COP 24 in December 2018) and all final reports of procurement/studies contracted by the FCH 2 JU.

In addition, FCH 2 JU will continue to develop success stories, to continue the initiative started in 2018 with the success stories brochure (if possible, to be updated).

Brand visibility and development

The FCH 2 JU visual identity will be reinforced throughout all communication channels; in 2019 all FCH 2 JU studies and reports will have an updated, coherent design, which will help brand stability. All publications will follow the overall programme brand style.

FCH 2 JU will incorporate the EU funding reference and logo throughout all the materials developed by the programme itself as well as by project beneficiaries. The dedicated webpage[111] on communication and dissemination activities contains already important information on this topic. Furthermore, the specific guidelines will be presented at the meetings with the current / future beneficiaries and reinforced whenever needed.

Collaboration with EC

Collaboration with EC communication services and other relevant DGs entails:

- Regular meetings of the Joint Communication Taskforce;
- Participation in the Communication Research and Innovation Group (CRIG) group;
- Participation in joint events;
- Contributions to the EC websites and publications (including Horizon Europe, CORDIS, etc.);
- Cross-communication and contribution to campaigns in line with the FCH 2 JU's objectives;
- Publications around specific stories will continue to follow also, when possible, EC communication calendar in order to drag attention on specific results at strategic timings.

External communication support

The FCH 2 JU will contract out to external services providing web support, and design event organisation, proofreading and editorial tasks, media relations and the design and production of promotional material, as appropriate. Participation in communication framework contracts will be assessed according to the needs and context. The following procedures are currently under consideration:

- Interinstitutional Call for Tender for the provision of professional audio, video and photographic equipment and accessories;
- Interinstitutional Tender for Strategic Communication Services (to be launched by the ETF).

[111] https://fch.europa.eu/page/fchju-projects-communication-dissemination

Procurement and contracts

Besides procurement funded by the operational budget as described in section 3.2.H above, FCH 2 JU allocates part of the administrative budget to procure the necessary services and supplies needed to support its operations and infrastructures.

With a view to make tendering and contract management as effective and cost-efficient as possible, FCH 2 JU has a policy to join inter-institutional tenders either launched by the EC or in agreement with other Joint Undertakings.

The focus of procurement in 2019 will be to further modernize and improve efficiency and effectiveness of procurement procedures and contract management by implementing eProcurement solutions initiated in 2018: eSubmission and eInvoices. For the latter an assessment of efficiency gains will be done in 2019 in order to decide on its possible extension to a broader range of suppliers. Developments on eProcurement will be closely followed up so that the Programme Office is ready to implement the soonest possible corporate solutions offered by the EC.

FCH 2 JU is expected to be invited in the following procedures in 2019:

- Provision for interim staff with DG HR as the leading contracting authority
- CLOUD II - Public and Private IaaS, cloud on premises & services
- Datacentre solutions (NESTOR II)
- External Network Services (ENS III) and Internet Access Services (INAS)
- Acquisition channel for networking, telecom and videoconferencing equipment (NATACHA III)
- Training on financial IT systems (ABAC, SAM, SAP) to succeed procedure BUDG15/PO/02
- Audits and control services to succeed procedure BUDG15/PO/03. This framework contract with reopening of competition was used for contracting firms to perform audits on the final accounts
- Consultancy services to support the learning and development to succeed procedure HR/R3/PR/2015/003
- Acquisition of SAP licenses (BO & ERP) and the provision of associated services to succeed procedure DI/07450
- Organisational development consultancy services to succeed procedure HR/R3/PO/2015/005
- Trans European Services for Telematics between Administrations (TESTA ng III)
- Provision for professional audio, video and photographic equipment and accessories
- Strategic Communication Services

In addition, the table below summarizes the tenders that FCH 2 JU plans to launch in 2019 for communication activities. These procedures will lead to the signature of framework contracts; therefore the indicative budget covers a 4-year period:

Subject	**Indicative budget (EUR)**	**Expected type of procedure**	**Indicative plan for launching the procedure**
PR relations, media planning and consulting services *The contract will cover press relations services and media planning activities. Current framework contract expires in May 2019*	143,000	Negotiated procedure for middle value contract	Q1 2019

Subject	**Indicative budget (EUR)**	**Expected type of procedure**	**Indicative plan for launching the procedure**
Event organization *Current budget under the inter-institutional framework contract is consumed* *The indicative budget covers the period until November 2020 when the inter-institutional framework contract expires, after which FCH will seek to join the succeeding procedure*	300,000	Open procedure	Q1 2019
Editing and proofreading services *FCH 2 JU will procure editing and proofreading services for a number of texts and reports drafted by the FCH 2 JU (PRD, AAR etc.)* *The current contract expired in October 2018*	143,000	Negotiated procedure for middle value contract	Q1 2019
Publicity campaigns *Follow-up of initiative first introduced in the context of the PRD/AAR 2018*	143,000	Negotiated procedure for middle value contract	Q2 2019

IT and logistics

The FCH 2 JU strategic objective in the field of IT is to deliver applications and infrastructure to support the implementation of the business objectives. The priority objectives are to ensure a stable and secure IT system, provide IT support to staff in the use of IT applications and equipment and to cooperate with the other JUs to ensure synergy and efficient use of resources.

In 2019 special focus will be put on the following:

1) Infrastructure and office automation:

FCH shares IT infrastructure, related IT operations and office automation support with other JUs that are also located in the same premises. In the context of the common infrastructure, the following activities are foreseen:

- Follow-up on the migration of the infrastructure-as-a-service (IaaS) solution initiated in 2018 to the CANCOM contracted through the inter-agency framework contract available to the JU;
- Implementation of the new Framework Contract for common JU IT services and monitoring of the related specific contract to ensure a continuous maintenance of the common infrastructure and networks as well as end-user office-automation support covering incidents, service requests and improvements;
- In the context of further improvement of the office automation environment , analysis of alternative technologies and solutions such as Software-as-a-service solution (SaaS) providing fully functional applications to end users running on cloud infrastructure (such as Microsoft Office 365);
- Enhancement of the applications regarding performance, usability and user interface in order to improve the end-user experience and facilitate FCH staff work through (1) the reinforcement of teleworking capabilities using the windows VPN solution available with windows 10 and (2) the redesign of the local area and Wi-Fi networks.

2) Information systems for operational and administrative activities:

- Enhancement of the FCH 2 JU website aiming to improve visibility of success stories, improve and streamline access to project related information, improve user friendlines;
- Preparation for the adoption of the EC application SYSPER II (for personnel time management, career management and possibly other modules such as appraisal and reclassifications) in accordance with the 2 years roadmap defined by DG HR;
- Implementation of the e-procurement platform provided by DIGIT and enabling a paperless procurement cycle that simplifies manual interactions, saves time and reduces payment delays.
- A common JU business continuity and disaster recovery plan has been adopted in 2018, providing guidance and establishing procedures in case of interruption of activities or unforeseen situations. The plans will be subject to a full test in 2019.

In addition, **logistical support** is provided in the context of General Administration. It encompasses the management of supply and maintenance of equipment namely stationery, goods and services for administration and includes monitoring of services provided in particular through the OIB, the translation centre and the publication office.

Further to the preparation made in 2018 a joint JU meeting room will be equipped for the necessary audio-visual & web conferences services. It is also planned to upgrade the internal telecommunication network, with special focus on the Wi-Fi capacity, using recent framework contracts available to the JU for purchase of modern equipment.

JU Executive Team – HR matters

JU Executive Team

The Executive Director is the legal representative of the FCH 2 JU and the chief executive responsible for the day-to-day management. He is supported by the Programme Office (PO), composed of temporary and contract agents.

The PO implements all the decisions adopted by the GB; provides support in managing an appropriate accounting system; manages the calls for proposals; provides to the Members and the other bodies of the FCH 2 JU all relevant information and support necessary for them to perform their duties as well as responding to their specific requests; acts as the secretariat of the bodies of the FCH 2 JU and provides support to any advisory group set up by the GB.

HR matters

The priority objectives in the field of Human Resources are to ensure that the Staff Establishment Plan is filled, to ensure an efficient management of staff resources and to ensure an optimal working environment.

This is achieved mainly through efficient selection procedures, staff performance appraisals and reclassifications, learning and development opportunities, promotion of open communication and inter-JU cooperation.

In 2019 special focus will be put on the following:

- Follow-up on learning and development plan to ensure adaptation of staff skills and competences to efficiently implement the Programme office mission and tasks, provide training opportunities on topics of common interest, such as anti-fraud, personal effectiveness, communication skills; provide the Management team with quarterly status reports;
- Revise HR policies and procedures as necessary to align them to the new legal environment; prepare a compendium “code of conduct” for staff of rules and procedures related to conduct and behaviour;
- Follow-up on the implementing rules of the revised staff regulations that cannot be adopted by analogy in liaison with the Standing Working Group of agencies and the Commission (DG HR) and where draft model decisions are under discussion, such as: engagement of CAs, conduct of administrative inquiries and disciplinary procedures, type of post and post titles, absences as a result of sickness or accident. Present the newly adopted rules to staff;
- Support the launch of the staff survey;
- Organise the teambuilding activity;
- Launch the appraisal and reclassification exercises;
- Follow up on the call for trainees for year 2019;
- Follow up on the call for Seconded National Experts (SNE);
- Contribute to the preliminary phase of SYSPER implementation project starting in January 2019.

Administrative budget and finance

The main objective for Finance and Budget is to ensure a sound financial management of the Programme Office resources.

This is mainly achieved though the alignment of planned activities with budgeted resources, the establishment of commitments for respecting legal obligations, the payment execution for goods and services delivered and the monitoring of the budget execution.

In 2019 activities will focus on the following:

- Ensure efficient budget forecast and maintaining a high level of accuracy in budgetary forecasting; to this perspective the spending pace of the grants with the highest budget will be closely monitored and checked against the forecast that their consortia has been provided;
- Prepare 2020 budget in liaison with DG RTD and DG BUDG;
- Report on 2018 budget execution and financial management;
- Prepare monthly reports containing key elements to budget execution and sound financial management (payment delays, budget execution);
- Ensure transactions are financially and procedurally correct, that is, in conformity with the contracts and respecting the Financial Regulations and other relevant rules in operations; timely handling of all types of transactions.

These activities will be monitored through targeted KPIs, such as budget execution and Time-To-Pay.

Data protection

It is expected that the new data protection legislation regarding the processing of personal data by the Union institutions, bodies, offices and agencies[112] will be applicable as from December 2018. The FCH 2 JU, under the supervision and guidance of the Data Protection Officer (DPO), will continue to ensure an effective application the data protection legal framework, encompassing all the legislative changes as well as the guidance documentation issued on this matter by the European Data Protection Supervisor.

In 2018, the following actions will be taken:

- Update of the data protection framework with any other measures required by the new legislation after its adoption, which are adjacent to the update of the data protection framework undertaken during the year 2018;
- Awareness raising for staff in internal meetings with regard to new legislation and to their own rights, as well as in relation to the implementation of the accountability principle as codified by the new legislation; aside from the ad-hoc awareness raising session, bi-annual training sessions will be organised by the DPO for all staff members;
- General and ad-hoc advice to the controller in fulfilling its obligations;
- The DPO will provide support for the preparation of any new records and corresponding privacy statements, for any new processing operations;
- The DPO will oversee the maintenance of the FCH 2 JU register of procession operations;
- Continue to participate in the data protection working groups of the EU institutions and bodies for continuing the preparation of the necessary documentation relating to data protection in the framework of Horizon 2020, and, where necessary, further customise it for the FCH 2 JU specificities;
- Ensure follow-up with guidelines provided by the EDPS, the European Data Protection Board, CJEU decisions affecting the field of data protection in the context of FCH 2 JU's activities.

[112] Currently available as a *Proposal for a regulation of the European Parliament and of the Council on the protection of individuals 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.* The last version available at the time of the preparation of this document is available here: http://www.europarl.europa.eu/RegData/seance_pleniere/textes_adoptes/provisoire/2018/09-13/0348/P8_TA-PROV(2018)0348_EN.pdf (site accessed on 22/10/2018)

3.5 Governance

The **Governing Board (GB)** is the main decision-making body of the FCH 2 JU. It shall have overall responsibility for the strategic orientation and the operations of the FCH 2 JU and shall supervise the implementation of its activities in accordance with Article 7 of the Statutes. The GB is composed of 3 representatives of the European Commission on behalf of the EU, 6 representatives of the Industry Grouping (Hydrogen Europe) and 1 representative of the Research Grouping (Hydrogen Europe Research). The GB is planning to hold three meetings during 2019.

The indicative key decision of the GB in the year 2019 are listed below:

Key decisions in 2019 – timetable	
Approve the AAR 2018 and adopt its assessment	Q2
Deliver an opinion on the Final Accounts 2018	Q2
Approve the independent assessment of the level of in-kind contributions (related to FP7) as at 31 December 2018	Q2
Approve the lists of actions for funding (main and reserve lists and the list of rejected proposals)	Q3
Adopt the Annual Work Plan and Budget for 2020 including the staff establishment plan	Q4
Approve the Additional Activities plan for 2020	Q4

The States Representatives Group (SRG) is an advisory body to the GB. It consists of one representative of each Member State and of each country associated to the Horizon 2020 Framework Programme. The SRG shall be consulted and, in particular review information and provide opinions on the following matters: (a) programme progress in the FCH 2 JU and achievement of its targets; (b) updating of strategic orientation; (c) links to the Horizon 2020; (d) annual work plans; (e) involvement of SMEs. The GB shall inform without undue delay the SRG of the follow up it has given to recommendations or proposals provided by the SRG, including the reasoning if they are not followed up. The Chairperson of the SRG shall have the right to attend the meetings of the GB and take part of its deliberations but without voting rights.

The SRG will hold at least two meetings in 2019, in Q2 (tentatively around May) and Q4 (in November around the Stakeholder Forum). There are no major changes or decisions foreseen for 2019. Issues that are likely to be covered include:

- Input to AWP2020;
- Input from Member States on potential support of hydrogen and fuel cells under the upcoming Horizon Europe programme.

Furthermore, measures to enhance the role of the SRG will be further discussed.

The **Scientific Committee (SC)** is an advisory body to the GB and shall consist of no more than 9 members. The members shall reflect a balanced representation of worldwide-recognized expertise from academia, industry and regulatory bodies. The SC role is to provide (a) advice on scientific priorities to be addressed in the annual work plans; (b) advice on scientific achievements described in the Annual Activity Report. The Chairperson of the SC shall have the right to attend the meetings of the GB and take part of its deliberations, but without voting rights. The SC will hold at least two meetings in 2019.

The **Stakeholder Forum (SF)** is an advisory body to the GB. It is an important communication channel to ensure transparency and openness of the FCH 2 JU programme. It provides an overview of the major developments in the past year and seeks to outline a vision for the way the sector will unfold in the coming years. It shall be convened once a year and shall be open to all public and private stakeholders, international interest groups from Member States, Associated Countries as well as from other countries. The SF shall be informed of the activities of the FCH 2 JU and shall be invited to provide comments. The 12th edition of the SF will take place in Q4 2019 (see also communication section above).

3.6 Internal Control framework

FCH 2 JU has aligned its Internal Control Framework (ICF) to the revised control framework adopted by the European Commission on 19 April 2017[113]. FCH 2 JU revised Internal Control Framework was adopted by the GB on 14 August 2018[114]. The new IFC moves away from a compliance-based to a principle-based system and provides the necessary flexibility to adapt to specific characteristics and circumstances while ensuring a robust internal control with a consistent assessment throughout the FCH 2 JU.

The priority objective remains to implement and maintain an effective internal control system so that reasonable assurance can be given that (1) resources assigned to the activities are used according to the principles of sound financial management and (2) the control procedures in place give the necessary guarantees concerning the legality and regularity of transactions.

This is mainly achieved through assessing the effectiveness and efficiency of operations and the compliance with the applicable rules and regulations as well as through the periodic review of risks.

A thorough assessment in internal control systems accompanied by a gap analysis was carried out in 2018. This exercise revealed where focus should be placed in 2019:

- ✓ Regarding the **control environment component**:
  1) Systematic presentation on implementing rules and procedures after their adoption by the GB (eg. implementing rules on outside activities)
  2) Adoption of code of good administrative behavior by the ED
  3) Preparation of a compendium that includes the code of conduct for all procedures and ethical values
- ✓ Regarding the **component of the control activities:**
  1) A training JU session on Business Continuity Plan (BCP) will be organized
  2) A common JU exercise on BCP will be conducted
- ✓ Regarding the **information and communication component:**
  1) The document management and registration policy will be finalized for adoption by the ED
  2) The action plan of new data protection regulation will be fully implemented in 2019
  3) A procedure on website rights and uploading information will be adopted by the ED

Financial procedures

Financial procedures guide FCH 2 JU operations and lay out how the JU uses and manages its funds and resources.

In 2019, focus will be out in revising the FCH 2 JU Financial Rules following the revision of the Model Financial Regulation for Public Private Partnership bodies, expected to be adopted by EC by year-end 2018.

Ex-ante and ex-post controls

Ex-ante controls are essential to prevent errors and avoid the need for ex-post corrective actions. In accordance with Article 74 of the Financial Regulation 2018/1046[115], "each operation shall be subject at least to an ex ante control relating to the operational and financial aspects of the operation, on the basis of a multiannual control strategy which takes risk into account.". Therefore, the main objective of ex ante controls is to ascertain that the principle of sound financial management has been applied.

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[113] Communication on the revision of the Internal Control Framework (ICF) – C(2017)2373

[114] Ares(2018)4420458

[115] OJ L193, 30.7.2018 p.66

An ex-ante control can take the form of checking grant agreements, initiating, checking and verifying invoices and cost claims, carrying out desk reviews (performed by FCH 2 JU project, finance and legal officers); mid-term reviews carried out by external experts and ad-hoc technical reviews (when deemed necessary).

FCH 2 JU has developed elaborated procedures defining the controls to be performed by project and finance officers for every cost claim, invoice, commitment and payment taking into account risk-based and cost-effectiveness considerations.

In 2019, specific attention will be put to the following elements of ex-ante control:

- Increased financial checks during the Grant Agreement Preparation (GAP) phase;
- Participation of project and finance officers at H2020 project kick-off meetings in order to clearly communicate the financial reporting requirements;
- Setting-up webinars with consortia to clarify financial issues before claiming costs;
- Introduction of the targeted workshops and reviews for beneficiaries and projects with higher identified inherent risk, especially for smaller SMEs;
- Application of the feedback from ex-post audits and lessons learnt on ex-ante controls, e.g. identification and red-flags for most frequent H2020 errors identified by ex-post audits.

Ex-post controls are defined as the controls executed to verify financial and operational aspects of finalised budgetary transactions in accordance with Article 19 of FCH 2 JU Financial Rules. The main objectives of the ex-post controls are to ensure that legality, regularity and sound financial management (economy, efficiency and effectiveness) have been respected and to provide the basis for corrective and recovery activities, if necessary. FCH 2 JU ex post controls of FCH grants include financial audits. The complete lifecycle of FCH-FP7 audits is managed and monitored by FCH 2 JU and audits are carried out by external audit firms. For FCH- H2020 grants are monitored by the Common Audit Service (CAS– Unit J2) of the CSC, in close cooperation with the FCH 2 JU, except for implementation which remains fully with the FCH 2 JU. CAS may also outsource the audit work to external audit firms for the FCH-H2020 grants.

In 2019, focus will be put on the following:

- Launch and monitor of a new batch of financial audits of FCH-FP7 grants;
- Liaise with CSC on the improvements of the methodology for the H2020 audit strategy (simplification of the indicative model audit programme, coordinated sampling exercise with other stakeholders to enhance efficiency of number of participations per one audit, etc.) to ensure coherence and consistency and make sure that the needs of the FCH 2 JU are taken into account;
- Contribute, in cooperation with the CAS, to the successful implementation of H2020 working arrangements for the effective management of H2020 ex-post audits;
- In cooperation with CAS, and in line with H2020 Working Arrangements, ensure launching and monitoring of timely completion of the H2020 audits in the new Sygma-Compass workflows for FCH 2 JU according to annual plan as part of Annex 1 to the H2020 Audit Strategy.

FCH 2 JU implements the common Research **Anti-Fraud Strategy** adopted in July 2012, updated in March 2015 and to be revised following the review by OLAF and the special report of the European Court of Auditors "Fighting fraud in EU spending: action needed". It includes an action plan which implementation is monitored through regular meetings of the Fraud and irregularity Committee (FAIR) and was revised in 2018.

In 2019, FCH 2 JU will:

- continue to apply harmonized preventive measures for fraud detection, e.g. via enhanced-monitoring tool available as a new feature in Sygma-Compass workflow;

- participate to FAIR meetings organized by DG RTD;
- follow-up on the revision of the common research anti-fraud strategy and action plan;
- develop its own anti-fraud strategy for elements which are not covered via a common RTD-anti-fraud strategy;
- ensure completion of introductory ethics and anti-fraud training by all FCH personnel by end of 2019;

Audits

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

In 2019, focus will be put on the following:

- Finalization and feedback of the new risk assessment carried out by the IAS in October 2018 in view of their strategic internal audit plan for 2019 – 2021;
- Coordination of the new annual IAS audit under a new strategic internal audit plan (fieldwork estimated to take place in Q1 – Q2 of 2019);

As regards **ECA audits**, the FCH 2 JU will:

- Liaise with an independent auditor (contracted in 2018 based on the results of the reopening of competition under EC (DG BUDG) FWC) to audit FCH 2 JU accounts as required by the FCH 2 JU Financial Rules);
- Follow up and implement the recommendations made in ECA reports on the FCH 2 JU annual accounts;
- Provide the necessary information and support for ECA audit on 2018 and 2019 accounts and possibly on the Performance audit of PPPs.

4.BUDGET YEAR 2019

4.1 Budget information

The draft budget 2019 is in line with the preliminary budget presented in the Fiche Financière and with the draft budget sent to GB members on 5 February 2018. The following changes are noted:

1) Due to the impact from the adjustment of the EFTA contribution from 2.33 % (initial assumption in the Fiche Financière) to 2.38 % (confirmed EFTA rate for 2019), there is an increase of:

> i) EUR 42,535 in commitment appropriations (EUR 39,912 for operational expenditure and EUR 2,623 for administrative expenditure) and
>
> ii) EUR 54,205 in payment appropriations (EUR 51,582 for operational expenditure of H2020 and EUR 2,623 for administrative expenditure).

2) Removal of anticipated internal assigned revenues of EUR 18,432. As it is not clear whether they will be cashed in 2019 or 2020, these expected revenues are removed from the 2019 budget.

3) Reactivation of EUR 269,954.09 (instead of EUR 217,640.25) unused commitment appropriations from administrative costs, coming from year 2017, stemming from de-commitments

4) Reactivation in operational commitment appropriations of EUR 3,529,221 as follows:

- ✓ EUR 545,842.95 from H2020 operational decommitments done this year
- ✓ EUR 562,038.33 from H2020 recoveries cashed in 2018
- ✓ EUR 2,421,340.08 from H2020 unused commitment appropriations in 2018 resulting from the outcome of the call 2018 evaluations and 3 studies initially included in AWP 2018 (Hydrogen for Decarbonising Heat, European Economic Fuel Cell Bus by 2020, FCH Market potential in Central and Eastern Europe)

It is noted that the budget of the FCH 2 JU shall be adapted to take into account the amount of the Union contribution as laid down in the budget of the Union.

The estimated revenue of FCH 2 JU for the year 2019 include contributions to the administrative costs from Industry Grouping and Research Grouping as well as the contribution of the Union for administrative costs and operational activities.

Title Chapter Article Item	Heading	Budget 2017 CA (executed)	Budget 2017 PA (executed)	Budget 2018 CA	Budget 2018 PA	Budget 2019 CA	Budget 2019 PA	Remarks
2001	***European Commission subsidy for operational expenditure (FP 7)***	0	20,364,173		15,586,390		4,750,000	Council Regulation 559/2014 of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking
2002	***European Commission subsidy for administrative expenditure***	1,801,377	1,801,377[116]	2,341,923	2,341,923	2,684,775	2,684,775	Council Regulation 559/2014 of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking includes EFTA (2.44% in 2017, 2.33% in 2018 and 2.38% in 2019)
2003	***Industry Grouping contribution for administrative expenditure***	2,058,391	2,058,391	2,014,054	2,014,054	2,308,907	2,308,907	Council Regulation 559/2014 of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking
2004	***Research Grouping contribution for administrative expenditure***	342,877	342,877	327,869	327,869	375,869	375,869	Council Regulation 559/2014 of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking
2005	***European Commission subsidy for operational expenditure (H 2020)***	94,234,786	154,747,416[117]	75,099,696	82,096,147	81,723,069	105,618,082	Council Regulation 559/2014 of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking includes EFTA (2.44% in 2017, 2.33% in 2018 and 2.38% in 2019)
2006	***JTI revenues***	486,591	486,591					Interest, income from liquidated damages & others
	sub total title revenues	98,924,022	179,800,826	79,783,542	102,366,383	87,092,620	115,737,633	
3008	***C2 reactivation of appropriations for administrative expenditure (2015)***	912,443	912,443					FCH 2 JU Financial rules article 6 - unused PA for administrative costs re-entered to be used for administrative costs
3009	***C2 reactivation of appropriations for operational expenditure (2015)***	25,861,251	0					FCH 2 JU Financial rules article 6 - de-committed CA for operational activities re-entered to be used for operational activities
3010	***C2 reactivation of appropriations for administrative expenditure (2016)***	20,000	825,269	734,699	734,699			FCH 2 JU Financial rules article 6 - unused PA for administrative costs re-entered to be used for administrative costs
3011	***C2 reactivation of appropriations for operational expenditure (2016)***	2,108,756	17,050,367	1,847,044				FCH 2 JU Financial rules article 6 - de-committed CA for operational activities re-entered to be used for operational activities
3012	***C2 reactivation of appropriations for administrative expenditure (2017)***			243,355	1,043,471	269,954	269,954	FCH 2 JU Financial rules article 6 - unused PA for administrative costs re-entered to be used for administrative costs
3013	***C2 reactivation of appropriations for operational expenditure (2017)***			640,499	20,126,737			FCH 2 JU Financial rules article 6 - de-committed CA for operational activities re-entered to be used for operational activities
3014	***C2 reactivation of appropriations for administrative expenditure (2018)***							FCH 2 JU Financial rules article 6 - unused PA for administrative costs re-entered to be used for administrative costs
3015	***C2 reactivation of appropriations for operational expenditure (2018)***					3,529,221		FCH 2 JU Financial rules article 6 - de-committed CA for operational activities re-entered to be used for operational activities
	sub total reactivation	28,902,450	18,788,078	3,465,597	21,904,907	3,799,175	269,954	
	TOTAL REVENUES	**127,826,472**	**198,588,904**	**83,249,140**	**124,271,290**	**90,891,795**	**116,007,587**	

[116] Of which EUR 56,758 are 2018 credits (including EFTA) related to H2020 and EUR 1,744,619 are from an amount made available in 2013 for the EU contribution to the administrative costs for the period 2014-2017 related to FP7

[117] The difference of 1,005 € with the commission budget lines is due to 2 items: (1)2015 EU adopted budget reduced our administrative PA by 1,152. FCH budget was amended to align to the EU budget. RTD offset the decrease in their administrative budget line (08 02 07 37) with an increase in the operational one (08 02 07 38). In 2017, we agreed with RTD to request this RAL from their administrative line (where the cut was done) and book it to our operational line, as RTD did in 2015, (2)In 2017, RTD advised FCH to request 147 € more from their H2020 budget line and reduce accordingly our FP7 claim (under BL 08 02 51). However this request came late in the year and since we have our own budgetary constraints -thus cannot request more than what we have in the budget, we booked the extra amount that originated from their H2020 line to our FP7 and vice versa, as it was in our budget.

The FCH 2 JU 2019 budget amounts to a total of EUR 90,891,795 in CA and EUR 116,007,587 in PA with the following breakdown:

Title Chapter Article Item	Heading	Executed 2017		Financial year 2018		Financial year 2019		*Ratio 2017/2019*	*Ratio 2017/2019*	Comments
		Commitment appropriations (committed)	Payment appropriations (paid)	Commitment appropriations (CA)	Payment appropriations (PA)	Commitment appropriations (CA)	Payment appropriations (PA)	*Commitment appropriations (CA)*	*Payment appropriations (PA)*	
1	**STAFF EXPENDITURE**									
1 1	STAFF IN ACTIVE EMPLOYMENT	2,887,221	2,863,914	3,326,600	3,326,600	3,218,000	3,218,000	90%	89%	Salaries for temporary staff and contract agents, family allowances, expatriation and foreign residence allowances, unemployment insurance, insurance against accidents and occupational disease, annual travel costs
1 2	EXPENDITURE RELATED TO RECRUITMENT	4,258	2,858	46,400	48,400	137,000	137,000	3%	2%	Miscellaneous expenditure on staff recruitment: installation and travel expenses
1 3	MISSION AND TRAVEL	135,000	116,435	137,700	168,946	145,000	145,000	93%	80%	Mission expenses
1 4	SOCIOMEDICAL INFRASTRUCTURE	36,791	30,390	45,000	45,000	42,000	42,000	88%	72%	Training, medical service and mobility costs
1 5	ENTERTAINMENT AND REPRESENTATION EXPENSES	4,100	2,333	5,600	8,249	5,600	5,600	73%	42%	Representation and receptions
	TOTAL TITLE 1	**3,067,370**	**3,015,930**	**3,561,300**	**3,667,420**	**3,547,600**	**3,547,600**	**86%**	**85%**	
2	**INFRASTRUCTURE**									
2 0	INVESTMENTS IN IMMOVABLE PROPERTY RENTAL OF BUILDINGS AND ASSOCIATED COST	436,571	421,136	353,800	374,234	360,000	360,000	121%	117%	Rent, works, insurance, common charges (water/gas/electricity), maintenance, security and surveillance
2 1	INFORMATION TECHNOLOGY	189,917	231,908	289,800	392,595	230,000	230,000	83%	101%	IT purchases, software licences, software development
2 2	MOVABLE PROPERTY AND ASSOCIATED COSTS	0	1,886	13,000	13,000	5,000	5,000	0%	38%	Purchases and rental of office equipment, maintenance and repair
2 3	CURRENT ADMINISTRATIVE EXPENDITURE	5,596	10,076	7,000	7,529	10,000	10,000	56%	101%	Office supplies, library, translation service, bank charges and miscellaneous office expenditure
2 4	CORRESPONDENCE, POSTAGE AND TELECOMMUNICATIONS	11,000	8,476	12,000	20,738	9,000	9,000	122%	94%	Telephones, video conferences and postal services
2 5	EXPENDITURE ON FORMAL AND OTHER MEETINGS	80,289	73,056	90,000	104,436	90,000	90,000	89%	81%	Official meetings such as SRG, Scientific Committee, Governing Board
2 6	COMMUNICATION COSTS	430,802	206,490	535,000	869,046	583,705	583,705	74%	35%	External communication and events
2 7	SERVICE CONTRACTS	233,094	441,038	372,000	515,917	400,000	400,000	58%	110%	Studies and audits
2 8	EXPERT CONTRACTS AND MEETINGS	390,484	357,187	428,000	497,102	404,200	404,200	97%	88%	Costs related to expert contracts (evaluations, mid-term reviews)
	TOTAL TITLE 2	**1,777,753**	**1,751,254**	**2,100,600**	**2,794,597**	**2,091,905**	**2,091,905**	**85%**	**84%**	
	TOTAL TITLE 1+2 (ADMINISTRATIVE EXPENDITURE)	**4,845,122**	**4,767,184**	**5,661,900**	**6,462,016**	**5,639,505**	**5,639,505**	**86%**	**85%**	
3	**OPERATIONAL EXPENDITURE**									
3 0 0 1	Implementing the research agenda of FCH JU: FP7	91,167	27,127,621	367,891	25,239,847		4,750,000	N/A	156%	This appropriation shall cover the operational costs of the JU regarding FP7 grants (pre-financings, interim and final payments) and studies.
3 0 0 2	Implementing the research agenda of FCH JU: H2020	118,072,567	145,253,937	77,219,349	92,569,427	85,252,290	105,618,082	138%	138%	This appropriation shall cover the operational costs of the JU regarding H2020 grants (pre-financings, interim and final payments), studies and JRC contribution.
	TOTAL TITLE 3 (OPERATIONAL EXPENDITURE)	**118,163,734**	**172,381,558**	**77,587,240**	**117,809,274**	**85,252,290**	**110,368,082**	**139%**	**156%**	
	TOTAL EXPENDITURE	**123,008,857**	**177,148,742**	**83,249,140**	**124,271,290**	**90,891,795**	**116,007,587**	**135%**	**153%**	

Revenues

The members' contribution to administrative costs in the 2019 budget refers only to H2020.

As per article 13.2 of the Statutes annexed to the Council Regulation No 559/2014 of 06/05/2014, the Union shall contribute 50%, the Industry Grouping 43% and the Research Grouping 7% to the administrative budget.

The 2019 administrative budget is boosted by EUR 269,954 from 2017 unused administrative appropriations.

Expenditure

Overall the administrative budget (Titles 1 and 2) will remain at the same level as in 2018 (taking into account amendments), with a marginal decrease of EUR 22,395.

In more details:

Title 1 – Staff

Title 1 (staff costs) represents 63 % of the administrative costs in the 2019 budget. It mainly covers salaries (91%) whereas other budget lines cover missions, training & socio-medical costs, recruitment costs and representation expenses.

Title 1 will show a marginal decrease (-0.38% amounting to EUR 13,700) compared to 2018 costs. This is due to:

- A decrease by EUR 108,600 in staff in active employment

This is due to the decreased number of interims needed in 2019 compared to 2018, as the operational needs will be covered by the SNEs. In addition, in the beginning of 2018, certain assumptions for the entitlements of new recruitments were made that are not valid anymore. In addition, other costs such as the contribution to the European Schools costs will be lowered in 2019.

- A decrease of 3,000 in sociomedical infrastructure as less contribution to mobility costs is foreseen in 2019

On the other side, the following budget lines will show increase compared to 2018:

- Expenditure related to recruitment (+EUR 90,600) due to the assumption that 2 SNEs will be employed as of the beginning of 2019.
- Mission expenses (+EUR 7,300) which are regularised to the increased needs as recorded in 2018

Title 2 – Infrastructure

Title 2 represents 37 % of the administrative costs in 2019. Title 2 will show a marginal increase of 0.32%, amounting to EUR 6,800 compared to the 2018 budget as it stands after 1 amendment and 3 transfers. This is due to:

- An increase in communication costs by EUR 48,705. The year 2018 showed already an increase due to the participation in and organisation of more events, public relation activities and publicity campaign and these efforts will be further continued in 2019. It is also planned to enhance the website to improve user friendliness and visibility of project related information and events;
- An increase in service contracts by EUR 28,000. This reflects the assumption that as of 2019 FCH JU will pay for H2020 audits carried out by Common Audit Service (CAS). It is noted however that discussions are currently ongoing and there might be an agreement with CAS that audits will be paid by FCH only after 2019.

On the other side:

- IT costs will show a decrease by EUR 59,800. In 2018, there were a number of one-time migration fees (eg. ARES, eSubmission) as well as the Internet as a Service migration that will not be repeated in 2019. In addition, TESTA-ng costs will be halved.

- Costs related to expert contracts will be lowered by EUR 23,800 as the cost for evaluations is adjusted to historical trends.

Title 3 – Operational

Commitment appropriations correspond to H2020 programme and will be increased by 10%. They will include new commitment appropriations of EUR 81,723,069 and re-activations as detailed under the 3rd bullet point of "Budget Information" amounting to EUR 3,529,221. The appropriations will cover the call 2019, procurement plan as detailed in section 3.2 of the document and the annual contribution to JRC.

Payment appropriations correspond to estimated needs to cover:

- Payment appropriations under FP7 projects (interim & mainly final payments) for EUR 4,750,000, which constitutes a significant decrease by 81% compared to 2018 level since only a handful of reports are expected to be paid in 2019.
- Payment appropriations under H2020 projects for EUR 105,618,082, increased by 14% compared to the 2018 level. The 2019 payment appropriations will cover mainly interim and final payments of H2020 projects, the majority of the pre-financing for call 2019, the payments in line with the JRC agreed rolling plan and payments of studies procured under the operational budget as described in section 3.2 (H).

Summary Statement of Schedule of Payments

The FCH 2 JU Schedule of payments represents a summary statement of the schedule of payments due in subsequent financial years (2018-2021 and following years) to meet budget commitments entered into earlier financial years (before 2018) as well as in 2018 and 2019.

SUMMARY SCHEDULE OF PAYMENTS (Operational)

2017 Outturn		2018 Budget		2019 Budget		Difference (2019/2017)	
Committed	Paid	CA	PA	CA	PA	CA	PA
18,163,734	172,381,558	77,219,349	117,809,274	85,252,290	110,368,082	10%	-6%

DETAILS OF PAYMENT SCHEDULE (Operational)

FP7

		Payments					
Commitments		2018	2019	2020	2021	Outstanding amount	**Total**
Pre-2014 commitments still outstanding (RAL)	**51,424,707**	9,912,912	9,623,088	7,340,415	918,019	23,630,273	**51,424,707**
TOTAL	**51,424,707**	9,912,912	9,623,088	7,340,415	918,019	23,630,273	**51,424,707**

H2020

		Payments					
Commitments		2018	2019	2020	2021	Outstanding amount	**Total**
Pre-2018 commitments still outstanding (RAL)	**159,377,136**	24,328,081	51,104,748	25,166,111	41,471,623	17,306,573	**159,377,136**
2018 commitment appropriations still outstanding (RAL)	**72,360,139**	36,762,008	7,300,000	7,264,797	10,149,377	10,883,957	**72,360,139**
2019 commitment appropriations	**85,252,290**	0	50,000,000	9,761,666	7,761,666	17,728,958	**85,252,290**
TOTAL	**316,989,565**	61,090,089	108,404,748	42,192,574	59,382,666	45,919,488	**316,989,565**

State of play on 17/10/2018: RAL refers to open commitments on 17/10 - payments for 2018 refer to foreseen payments from 17/10/2017 until the end of the year

FP7: payments in 2019 include the payments initially foreseen and included as payment appropriations (PA) in the budget (4,750,000) and additional needs due to delays in project implementation (4,873,088). To meet the latter payment requirements, any unused PA will be re-activated in the 2019 budget

H2020: from the available 2019 commitment appropriations, an amount of 2,400,000 will still have to be committed for the studies in AWP 2018
Regarding 2019 payments, they include the initially foreseen as in the budget (105,618,082) and additional needs due to delays in project implementation (2,786,666). To meet the latter payment requirements, any unused PA will be re-activated in the 2019 budget

4.2 Staff Establishment Plan

The JU team of statutory staff consists of 27 positions (24 TA and 3 CA).

In addition, staff resources include 2 Seconded National Experts (SNE).

The 2019 Staff Establishment Plan is shown below:

Grade	**2018 budget**	**2018 filled**	**2019 budget**
AD 14	1	1	1
AD 13	-	-	-
AD 12	-	-	-
AD 11	2	2	2
AD 10	-	-	-
AD 9	2	2	2
AD 8	6	6	6
AD 7	-	-	-
AD 6	3	3	4
AD 5	1	1	0
Total AD[118]	**15**	**15**	**15**
AST 8	2	2	2
AST 7	1	1	1
AST 6	1	1	1
AST 5	1	1	1
AST 4	4	4	4
Total *AST*[119]	**9**	**9**	**9**

118 AD stands for Administrator
119 AST stands for Assistant

Function Group IV	1	1	1
Function Group III	1	1	1
Function Group II	1	1	1
Total Contract Agents	**3**	**3**	**3**
Total Seconded National Experts	**2**	**0**	**2**

5. LIST OF ACRONYMS

Term	Definition
AAR	Annual Activity Report
AEL	Alkaline Electrolysis
AEM	Anion Exchange Membrane
ASR	Area Specific Resistance
AWP	Annual Work Plan
BoP	Balance of Plant
CA	Contract Agent
CAPEX	Capital Expenditure
CAS	Common Audit Service
CEN-CENELEC	European Committee for Standardisation and European Committee for Electrotechnical Standardisation
CHP	Combined Heat Power
CHSS	Compressed Hydrogen Storage System
CEF	Connecting Europe Facility funding instrument
COP	Conference of the Parties (yearly conferences in the framework of the United Nations Framework Convention on Climate Change)
CNG	Compressed Natural Gas
CSC	Common Support Centre
DG BUDG	Directorate-General for Budget
DG GROW	Directorate-General for Internal Market
DG HR	Directorate-General for Human Resources and Security
DG MOVE	Directorate-General for Mobility and Transport
DG RTD	Directorate-General for Research and Innovation
DPO	Data Protection Officer
ED	Executive Director
EC	European Commission
ECA	European Court of Auditors
EHSTP	European Hydrogen Safety Training Platform
EHSP	European Hydrogen Safety Panel
EII	Energy Intensive Industries
EMM	European Media Monitoring
EMSA	European Maritime Safety Agency
EFTA	European Free Trade Area
EU	European Union
EUSEW	EU Sustainable Energy Week
FCEV	Fuel Cell Electric Vehicle
FCH JU, FCH 2 JU	The Fuel Cells and Hydrogen 2 Joint Undertaking: name used to refer to the legal entity established as the public & private partnership.
FP7	EU's Seventh Framework Programme for Research and Technological Development (2007 - 2013)
GB	Governing Board
GHG	Greenhouse Gases
H2020	Horizon 2020 – EU's Framework Programme for Research and Innovation programme (2014 - 2020)

H2GN	Hydrogen Natural Gas Mixtures
HE	Hydrogen Europe
HELLEN	Hydrogen Event and Lessons LEarNed database
HER	Hydrogen Europe Research
HIAD	Hydrogen Incident and Accident Database
HRS	Hydrogen Refuelling Station
HTE	High Temperature Electrolysers
HTPEM	High Temperature Proton Exchange Membrane
IAS	Internal Audit Service
ICF	Internal Control Framework
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IMO	International Maritime Organisation
IPHE	International Partnership for Hydrogen into the Economy
ISO	International Standards Organization
JRC	Joint Research Centre of the European Commission
KPI	Key Performance Indicator
LCA	Life-Cycle Assessment
LH2	Liquid Hydrogen
LHV	Lower Heating Value
LPG	Liquefied Petroleum Gas
LTWE	Low Temperature Water Electrolysis
MAWP	Multi-Annual Work Plan
MDPC	Monitoring, Diagnostic, Prognostic and Control
MHV	Material Handling Vehicles
MEA	Membrane Electrode Assembly
MTBF	Mean Time Between Failures
MW	Megawatt
NG	Natural Gas
NGO	Non-governmental organisation
NWP	Nominal Working Pressure
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
PEM/PEMFC	Proton Exchange Membrane Fuel Cell
PEMEL	PEM Electrolysis
PGM	Platinum-Group metals
PO	FCH 2 JU Programme Office
PPP	Public Private Partnership
PRD	Programme Review Days
PNR	Pre-normative Research
RCS	Regulations, Codes and Standards
rSOC	Reversible Solid Oxide Cell
R&D	Research and Development
SAE	Society of Automotive Engineers association and standards developing organisation

SET-plan	Strategic Energy Technology plan
SME	Small and Medium Enterprises
SoA	State of the Art
SOC/SOFC	Solid Oxide (Fuel) Cell
SOE	Solid Oxide Electrolysis
SRG	States Representative Group, advisory body of the FCH JU gathering representatives from Member States and Associated Countries
SRU	Single Repeat Unit
SWD	Staff Working Document of the European Commission
TA	Temporary Agent
TCO	Total Cost of Ownership
TIM	Tools for Innovation Monitoring
TRL	Technology Readiness Level
TRUST	Technology Reporting Using Structured Templates (Data collection platform)
UN	United Nations
XiL	X-in-the-Loop development platform, where X stands for model, software or hardware (MiL, SiL or HiL) of complex hybrid FC systems

6. Annex: Horizon 2020 INDICATORS FOR JOINT UNDERTAKINGS

- Table I shows the Horizon 2020 KPIs which apply to JUs, both under Industrial Leadership and Societal Challenges (Horizon 2020 Key Performance Indicators (Annex II - Council Decision 2013/743/EU)).

- Table II presents all indicators for monitoring of cross-cutting issues which apply to JUs (Annex III - Council Decision 2013/743/EU).

- In tables I and II, the numbers attributed to the indicators correspond with those in the Horizon 2020 indicators approved by the RTD Director-General and agreed by all the Research family DGs (according to Annexes II and III - Council Decision 2013/743/EU). The missing numbers correspond to KPIs not applicable to the JUs.

- KPIs and Indicators that correspond to those approved by the RTD Director-General are presented with a white background in the tables. They are aligned to what has been discussed between the Common Support Centre and the JUs. KPIs and monitoring indicators in tables I and II, which do not correspond to those approved by the RTD Director-General, are presented with a green background in the tables.

- Table III presents the KPI specific for FCH 2 JU.

TABLE I: Horizon 2020 Key Performance Indicators[120] common to all JUs

		Key Performance Indicator	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Baseline at the Start of Horizon 2020 (latest available)	Target at the End of Horizon 2020	Automated
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);	Based on Community Innovation Survey (?). Number and % of participating SMEs that have introduced innovations to the company or to the market;	Number of SMEs that have introduced innovations;	HORIZON 2020 beneficiaries through project reporting	n.a. [new approach under Horizon 2020]	50%	Yes
	13	SME - Growth and job creation in participating SMEs	Turnover of company, number of employees	Turnover of company, number of employees;	Horizon 2020 beneficiaries through project reporting	n.a. [new approach under Horizon 2020]	To be developed based on FP7 ex-post evaluation and /or first Horizon 2020 project results	Yes
SOCIETAL CHALLENGES	14	Publications in peer-reviewed high impact journals	The percentage of papers published in the top 10% impact ranked journals by subject category.	Publications from relevant funded projects (DOI: Digital Object Identifiers); Journal impact benchmark (ranking) data to be collected by commercially available bibliometric databases.	Horizon 2020 beneficiaries through project reporting; Responsible Directorate/Service (via access to appropriate bibliometric databases)	n.a. [new approach under Horizon 2020]	[On average, 20 publications per €10 million funding (for all societal challenges)]	Yes

[120] (based on Annex II to Council Decision 2013/743/EU)

		Key Performance Indicator	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Baseline at the Start of Horizon 2020 (latest available)	Target at the End of Horizon 2020	Automated
	15	Patent applications and patents awarded in the area of the JTI	Number of patent applications by theme; Number of awarded patents by theme	Patent application number	Horizon 2020 beneficiaries through project reporting; Responsible Directorate/Service (via worldwide search engines such as ESPACENET, WOPI)	n.a. [new approach under Horizon 2020]	On average, 2 per €10 million funding (2014 - 2020) RTD A6	Yes
	16	Number of prototypes testing activities and clinical trials[121]	Number of prototypes, testing (feasibility/demo) activities, clinical trials	Reports on prototypes, and testing activities, clinical trials	Horizon 2020 beneficiaries through project reporting	n.a. [new approach under Horizon 2020]	[To be developed on the basis of first Horizon 2020 results]	Yes
	17	Number of joint public-private publications in projects	Number and share of joint public-private publications out of all relevant publications.	Properly flagged publications data (DOI) from relevant funded projects	Horizon 2020 beneficiaries through project reporting; Responsible Directorate/Service (via DOI and manual data input-flags)	n.a. [new approach under H202]	[To be developed on the basis of first Horizon 2020 results]	Yes
	18*	New products, processes, and methods launched into the market	Number of projects with new innovative products, processes, and methods,	Project count and drop down list allowing to choose the type processes, products, methods,	Horizon 2020 beneficiaries through project reporting	n.a. [new approach under Horizon 2020]	[To be developed on the basis of first Horizon 2020 results]	Yes

[121] Clinical trials are IMI specific

		Key Performance Indicator	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Baseline at the Start of Horizon 2020 (latest available)	Target at the End of Horizon 2020	Automated
EVALUATION	NA	Time to inform (TTI) all applicants of the outcome of the evaluation of their application from the final date for submission of completed proposals	To provide applicants with high quality and timely evaluation results and feedback after each evaluation step by implementing and monitoring a high scientific level peer reviewed process	Number and % of information letters sent to applicants within target Average TTI (calendar days) Maximum TTI (calendar days)	Joint Undertaking	FP7 latest know results?	153 calendar days	Yes
	NA	Redress after evaluations	To provide applicants with high quality and timely evaluation results and feedback after each evaluation step by implementing and monitoring a high scientific level peer reviewed process	Number of redresses requested	Joint Undertaking	FP7 latest know results?		
GRANTS	NA	Time to grant (TTG) measured (average) from call deadline to signature of grants	To minimise the duration of the granting process aiming at ensuring a prompt implementation of the Grant Agreements through a simple and transparent grant preparation process	Number and % of grants signed within target Average TTG in calendar days Maximum TTG in calendar days	Joint Undertaking	n.a. [new approach under Horizon 2020]	TTG < 243 days (as %of GAs signed)	Yes
	NA	Time to sign (TTS) grant agreements from the date of informing successful applicants (information letters)		Number and % of grants signed within target Average TTG in calendar days Maximum TTG in calendar days	Joint Undertaking	n.a. [new approach under Horizon 2020]	TTS 92 calendar days	Yes

		Key Performance Indicator	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Baseline at the Start of Horizon 2020 (latest available)	Target at the End of Horizon 2020	Automated
PAYMENTS	NA	Time to pay (TTP) (% made on time) -pre-financing - interim payment -final payment	To optimize the payments circuits, both operational and administrative, including payments to experts	Average number of days for Grants pre-financing, interim payments and final payments; Average number of days for administrative payments; Number of experts appointed	Joint Undertaking	FP7 latest know results?	-pre-financing (30 days) - interim payment (90 days) -final payment ((90days)	Yes
HR	NA	Vacancy rate (%)		% of post filled in, composition of the JU staff [122]	Joint Undertaking	n.a. [new approach under Horizon 2020]		
JU EFFICIENCY	NA	Budget implementation/execution: 1. % CA to total budget 2. % PA to total budget	Realistic yearly budget proposal, possibility to monitor and report on its execution, both in commitment (CA) and payments (PA), in line with sound financial management principle	% of CA and PA	Joint Undertaking		100% in CA and PA	Yes
	NA	Administrative Budget: Number and % of total of late payments	Realistic yearly budget proposal, possibility to monitor and report on its execution in line with sound financial management principle	Number of delayed payments % of delayed payments (of the total)	Joint Undertaking			Yes

NOTES:

18* This indicator is not a legally compulsory one, but it covers several additional specific indicators requested for more societal challenges by the services i n charge.

[122] Additional indicators can be proposed/discussed with R.1 and/or DG HR

TABLE II: Indicators for monitoring Horizon 2020 Cross-Cutting Issues[123] common to all JUs

	Cross-cutting issue	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Data to be Provided in/to	Direct Contribution to ERA	Automated
2	Widening the participation	2.1 Total number of participations by EU-28 Member State	Nationality of Horizon 2020 applicants & beneficiaries (number of)	Horizon 2020 applicants & beneficiaries at the submission and grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
		2.2 Total amount of EU financial contribution by EU-28 Member State (EUR millions)	Nationality of Horizon 2020 beneficiaries and corresponding EU financial contribution	Horizon 2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
NA		Total number of participations by Associated Countries	Nationality of Horizon 2020 applicants & beneficiaries (number of)	Horizon 2020 applicants & beneficiaries at the submission and grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
NA		Total amount of EU financial contribution by Associated Country (EUR millions)	Nationality of Horizon 2020 beneficiaries and corresponding EU financial contribution	Horizon 2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
3	SMEs participation	3.1 Share of EU financial contribution going to SMEs (Enabling & industrial tech and Part III of Horizon 2020)	Number of Horizon 2020 beneficiaries flagged as SME; % of EU contribution going to beneficiaries flagged as SME	Horizon 2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes
6	Gender	6.1 Percentage of women participants in Horizon 2020 projects	Gender of participants in Horizon 2020 projects	Horizon 2020 Beneficiaries through project reporting	JU AAR	YES	Yes

[123] (based on Annex III to Council Decision 2013/743/EU)

	Cross-cutting issue	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Data to be Provided in/to	Direct Contribution to ERA	Automated
		6.2 Percentage of women project coordinators in Horizon 2020	Gender of MSC fellows, ERC principle investigators and scientific coordinators in other Horizon 2020 activities	Horizon 2020 beneficiaries at the grant agreement signature stage	JU AAR	YES	Yes
		6.3 Percentage of women in EC advisory groups, expert groups, evaluation panels, individual experts, etc.	Gender of memberships in advisory groups, panels, etc.	Compiled by Responsible Directorate/ Service/Joint Undertaking based on existing administrative data made available by the CSC	JU AAR	YES	
7	International cooperation	7.1 Share of third-country participants in Horizon 2020	Nationality of Horizon 2020 beneficiaries	Horizon 2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
		7.2 Percentage of EU financial contribution attributed to third country participants	Nationality of Horizon 2020 beneficiaries and corresponding EU financial contribution	Horizon 2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
9	Bridging from discovery to market [124]	9.1 Share of projects and EU financial contribution allocated to Innovation Actions (IAs)	Number of IA proposals and projects properly flagged in the WP; follow up at grant level.	Project Office – at GA signature stage he/she will be required to flag on SYGMA. Responsible Directorate/Service (WP coordinator)/Joint Undertaking - via tool CCM2	JU AAR RTD Monitoring Report		Yes
		9.2 Within the innovation actions, share of EU financial contribution focussed on demonstration and first-of-a-kind activities	Topics properly flagged in the WP; follow-up at grant level	Responsible Directorate/Service (WP coordinator)/Joint Undertaking - via tool CCM2	JU AAR RTD Monitoring Report		Yes

[124] This indicator (9.2) is initially intended to monitor the Digital Agenda (its applicability could be only partial)

	Cross-cutting issue	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Data to be Provided in/to	Direct Contribution to ERA	Automated
NA		Scale of impact of projects (High Technology Readiness Level)	Number of projects addressing TRL[125] between ...(4-6, 5-7)?	Joint Undertaking	JU AAR RTD Monitoring Report		
11	Private sector participation	11.1 Percentage of Horizon 2020 beneficiaries from the private for profit sector	Number of and % of the total Horizon 2020 beneficiaries classified by type of activity and legal status	Horizon 2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes
		11.2 Share of EU financial contribution going to private for profit entities (Enabling & industrial tech and Part III of Horizon 2020)	Horizon 2020 beneficiaries classified by type of activity; corresponding EU contribution	Horizon 2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes
12	Funding for PPPs	12.1 EU financial contribution for PPP (Art 187)	EU contribution to PPP (Art 187)	Responsible Directorate/Service/	JU AAR		Yes
		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 project selected for funding - additional activities (i.e. research expenditures/investment of industry in the sector, compared to previous year)	Joint Undertaking Services	JU AAR RTD Monitoring Report JU annual accounts (part of)		

[125] TRL: Technology Readiness Level

	Cross-cutting issue	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Data to be Provided in/to	Direct Contribution to ERA	Automated
13	Communication and dissemination	13.3 Dissemination and outreach activities other than peer-reviewed publications - [Conferences, workshops, press releases, publications, flyers, exhibitions, trainings, social media, web-sites, communication campaigns (e.g. radio, TV)]	A drop down list allows to choose the type of dissemination activity. Number of events, funding amount and number of persons reached thanks to the dissemination activities	Horizon 2020 Beneficiaries through project reporting	JU AAR RTD Monitoring Report	YES	Yes
14	Participation patterns of independent experts	14.2 Proposal evaluators by country	Nationality of proposal evaluators	Responsible Directorate/Service/Joint Undertaking in charge with the management of proposal evaluation	JU AAR		
		14.3 Proposal evaluators by organisations' type of activity	Type of activity of evaluators' organisations	Responsible Directorate/Service/Joint Undertaking in charge with the management of proposal evaluation	JU AAR	YES	
NA	Participation of RTOs and Universities	Participation of RTO[126]s and Universities in PPPs (Art 187 initiatives)	Number of participations of RTOs to funded projects and % of the total Number of participations of Universities to funded projects and % of the total % of budget allocated to RTOs and to Universities	Horizon 2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
NA	Ethics	The objective is ensuring that research projects funded are compliant with provisions on ethics efficiently	% of proposals not granted because non-compliance with ethical rules/proposals invited to grant (target 0%); time to ethics clearance (target 45 days)[127]	Responsible Directorate/Service/Joint Undertaking	JU AAR RTD Monitoring Report		

[126] RTO: Research and Technology Organisation
[127] Data relates to pre-granting ethics review. This time span runs in parallel to granting process.

	Cross-cutting issue	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Data to be Provided in/to	Direct Contribution to ERA	Automated
NA	Audit	Error rate	% of common representative error; % residual error	CAS	JU AAR RTD Monitoring Report		Yes
NA		Implementation of ex-post audit results	Number of cases implemented; in total €million; ´of cases implemented/total cases	CAS	JU AAR RTD Monitoring Report		Yes

Notes:

* Horizon 2020 applicants - all those who submitted Horizon 2020 proposals

* Horizon 2020 beneficiaries - all those who have signed a Horizon 2020 Grant Agreement

*Responsible Directorate - DG RTD Directorates and R&I DGs family in charge with management of Horizon 2020 activities

*Services -Executive Agencies and other external bodies in charge with Horizon 2020 activities

*Project officer - is in charge of managing Horizon 2020 projects in Responsible Directorate/Service including Executive Agencies

TABLE III: Key Performance Indicators specific to FCH 2 JU

Key Performance Indicator	Objective	Data to be Provided by	Baseline at the Start of Horizon 2020	Target at the End of Horizon 2020	Automated
Share of the fund allocated to the following research activities: - renewable energy - end user energy-efficiency - smart grids - storage		JU	Result of FP7		
Demonstrator projects hosted in MSs and regions benefiting from EU structural funds		JU	Result of FP7		