ANNEX to GB decision of 14 December 2017

FUEL CELLS and HYDROGEN 2 JOINT UNDERTAKING (FCH 2 JU)

2018

ANNUAL WORK PLAN and BUDGET

In accordance with the Statutes of the FCH2 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 fifth 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 2018.

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, leverage private investment, 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fuels, an economy where energy is based on a centralised, supply-side approach and which relies on old technologies and outdated business models.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 that *"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. As a follow-up, on 16 November 2016 the Marrakech climate conference (COP22) concluded with concrete results to put the Paris Agreement on climate change into action.

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;

[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

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

- 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%;
- 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. As part of the Clean Energy Package, the EC adopted a revised Renewable Energy Directive. The role of renewable gas including green hydrogen is explicitly mentioned which would leave the door open for green hydrogen to contribute to Member States renewable energy and transport targets. In addition, a new 30% energy efficiency target for 2030 has been proposed in the EC proposals for the updated Energy Efficiency Directive.

More recently 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, outlined 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.

The development of hydrogen storage solutions, furthermore, 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 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. The European Union is therefore committed to transforming its transport and energy systems as part of low-carbon economy by 2050, whilst decoupling economic growth from resource and energy use, reducing GHG emissions, increasing energy security and maintaining a strong competitive global position. Fuel Cell and Hydrogen (FCH) technologies hold great promise for energy and transport applications from the perspective of meeting Europe's energy, environmental and economic challenges. It is recognised that FCH technologies have an important role in this transformation and are part of the Strategic Energy Technologies Plan (SET) Plan, adopted by the European Council. Furthermore the importance of supporting European Research and Innovation, for which Horizon 2020 represents its largest-to-date implementation tool, has been highlighted by Commissioner Carlos Moedas[7].

[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] See for example: https://ec.europa.eu/commission/2014-2019/moedas/announcements/european-research-and-innovation-global-challenges_en

Finally, 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. At the same time as the international climate conference in Bonn (COP23 – 6-17 November 2017), the Commission is showing that the EU is leading by example. In this respect, Commission President Jean-Claude Juncker outlined in the State of the European Union speech in September: *"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 is 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 is 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.

Against the policy developments described above, the present Annual Work Plan 2018 of the Fuel Cells and Hydrogen 2 Joint Undertaking, outlining the scope and details of its fifth year operational and horizontal activities, intends to address all these concerns and proposes a list of actions, 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 2018

3.1. Executive Summary

The Annual Work Plan 2018 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 2018, a call for proposals with an indicative budget of EUR 73.2 M will be launched in January 2018 (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 20 topics will be part of the call for proposals, including 7 for Transport, 8 for Energy, 1 for Overarching and 4 for Cross-Cutting. They will be grouped into 5 Innovation Actions (IA), 14 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[8] are addressed in the 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-01-1-2018: Large Scale Demonstration of H2 fueled HD Trucks with High Capacity Hydrogen Refueling Stations (HRS) FCH-01-2-2018: Demonstration of Fuel Cell applications for mid-size passenger ships or inland freight FCH-01-3-2018: Strengthening of the European supply chain for compressed storage systems for transport applications FCH-01-4-2018: Fuel cell systems for the propulsion of aerial passenger vehicle FCH-01-5-2018: Next generation automotive MEA development FCH-01-6-2018: Game changer fuel cell stack for automotive applications FCH-01-7-2018: Improvement of innovative compression concepts for large scale transport 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-02-3-2018: Robust, efficient long term remote power supply FCH-02-6-2018: Cost-effective novel architectures of interconnects FCH-02-7-2018: Efficient and cost-optimised biogas-based co-generation by high-temperature fuel cells FCH-02-8-2018: Waste-stream based power balancing plants with high efficiency, high flexibility and power-to-X capability FCH-04-3-2018: Accelerated Stress Testing (AST) protocols for Solid Oxide Fuel Cells (SOFC)
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	FCH-02-4-2018: Thermochemical Hydrogen Production from Concentrated Sunlight FCH-02-6-2018: Cost-effective novel architectures of interconnects

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

conversion using the fuel cell system is competitive with the alternatives available in the marketplace	
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 competitive energy storage medium for electricity produced from renewable energy sources	FCH-02-1-2018: Demonstration of a large scale (min. 20MW) electrolyser for converting renewable energy to hydrogen FCH-02-2-2018: Demonstration of large scale steam electrolyser system in industrial market FCH-02-5-2018: Hydrogen carriers for stationary storage of excess renewable energy FCH-04-2-2018: Hydrogen admixtures in the natural gas grid
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-01-5-2018: Next generation automotive MEA development FCH-01-6-2018: Game changer fuel cell stack for automotive applications FCH-01-7-2018: Improvement of innovative compression concepts for large scale transport applications

One topic is addressing techno-economic objectives related to both transport and energy pillars (so called **'overarching activities'**):

- Topic FCH-03-1-2018: *Developing Fuel Cell applications for port/harbor ecosystems*;

While two topics are addressing **crosscutting issues,** related to all techno-economic objectives:

- Topic FCH-04-1-2018: *PNR for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces*;
- Topic FCH-04-4-2018: *Strengthening public acceptance and awareness of FCH-technologies by educating pupils at schools*;

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[9] common to all JUs;
- Indicators for monitoring H2020 Cross-Cutting Issues [10] common to all JUs;
- Key Performance Indicators specific to FCH 2 JU;

[9] Based on Annex II - Council Decision 2013/743/EU
[10] Based on Annex III - Council Decision 2013/743/EU

Risk Assessment

In the annual risk assessment exercise, conducted in October 2017, the following significant risks & responses to those risks in terms of action plans were identified:

#	Risk Identified	Action Plan
MEDIUM	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.
MEDIUM	Due to the lean structure of the JU, turnover and/or lack of key staff may cause business continuity issues.	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.
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 in his Annual Activity Report in 2017.	For H2020 audits, an active dialogue via regular participation on joint (CLAR) meetings has been established with the Common Audit Support unit 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.
MEDIUM	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% (despite of the change in the overall H2020 ex-ante control strategy for the whole research family).	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 AO with the FCH 2 JU beneficiaries due to lack of assurance coming from the 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.

#	Risk Identified	Action Plan
MEDIUM	Disruption of the operations due to improper functionality of the IT tools and IT equipment.	Ensure that proper testing of the new functionalities in the IT tools is done prior to introduction of the changes in the life environment. Back-up systems are in place to mitigate loss of data. Regular follow up on the IT tickets raised is performed. Participation on the trainings for new SW and tools introduced via CSC / locally.

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

Scientific priorities & challenges (including implementation of the SRA/SRIA)

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 2018 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. In addition, Overarching projects, combining the entire supply chain from production of hydrogen all the way to its use in transport applications for port/harbour applications 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 in 2017, the FCH 2 JU will continue to work to reinforce the European supply chain of critical key components by e.g. a higher range of common/standardised parts to be produced in EU and H2020 Associated Countries, and to enable start investments in production facilities for further ramp-up in these markets.

International collaboration with countries under International Partnership of Hydrogen into the Economy (IPHE)[11] is encouraged for all topics of the call (see section 3.2.G below). Collaboration with developing world countries supported by the Climate Technology Centre & Network (CTCN)[12] is also encouraged. Moreover, cooperation with dedicated innovation challenges under Mission Innovation (Accelerating the Clean Energy Revolution)[13] should be explored.

In addition, further openness towards markets in the EU13 countries should be continued and integration of participants from those countries in consortia 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 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.

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.

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 2018" below), in order to benchmark performance of components and allow for comparison across different projects.

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[11] http://www.iphe.net/
[12] https://www.ctc-n.org/
[13] http://mission-innovation.net/

1. Transport related activities:

PEM technology is the main enabling technology for all transport applications. Specifically the cost reduction, increased power density and durability are challenges that have to be tackled continuously and over several product generations, fostering the EU supply chain. In this call, two topics address these challenges, albeit at different technical readiness levels (TRL): one focusing on the evolution of MEA technology and the other asking for a more radical approach to automotive stack technology.

Another key transport enabling technology is compressed hydrogen storage. The challenge asked in this call lies specifically in the strengthening of the European supply chain by driving competition among various players, which should lead to cost reduction and improved technical performance.

Heavy-duty trucks are an application of strategic value since it is foreseen to take the best value of the advantages of fuel cell systems for transport compared with other zero-emission technologies: long range and reduced refuel time. These aspects should translate in monetary value for its operators as well. A demonstration of this application aims to pinpoint the ideal conditions for its operation, including all relevant stakeholders such as customers, OEMs, suppliers, operators, and experimenting various business models.

Similarly, long distance maritime applications such as mid-size passenger ships or inland freight will be demonstrated in order to better understand the market potential (and business cases/feasibility) and regulatory issues.

The quest for the commercial offer of fuel cell aeronautic applications continues with concrete steps in modularization and certification process. Both UAV and small maned planes alike could benefit from the result of successful projects focusing on the FC system components.

Further research to reduce cost and increase HRS performance, specifically on the compression process will also be addressed in this call. The cost and reliability of the HRS infrastructure remain the key challenges for OEMs, operators and customers alike.

2. Energy related activities:

Electrolysis as key enabling technology for increased renewables sources remains in the focus of the FCH 2 JU. As regards more mature water electrolyser technologies, a further increase in hydrogen production respectively power transformation capacity is aimed at, with a 20 MW water electrolyser integrated, connected to renewable energy sources and for greening the industry (e.g. fertilizers, food industry etc). Less mature steam electrolysers should also progress in scale; the related topic will aim to demonstrate a 15 kg/hr hydrogen electrolyser, using renewable electricity only and making use of heat resources directly available within an industrial context for the steam generation. While the demonstration should allow for cost reduction by increasing the volume, a separate research topic aims to reduce the cost by establishing a supply chain for the major stack cost item, the metallic interconnects. By integrating results from several projects into an industrially manufactured component, new, more competitive value chains for solid-oxide stack manufacturing should be enabled. Solid oxide fuel cell manufacturers should also benefit from this topic, as they use very similar or identical components in their fuel cells stacks.

Besides electrolysis, the more long-term option of direct hydrogen production from concentrated solar sources will be explored. Transformation efficiency to hydrogen is here in focus.

The storage and distribution of hydrogen for stationary applications faces some challenges. Low pressure solution with hydrogen carriers have been shown feasible and the aim now is to transform this in engineered solutions, showing the expected lower cost and higher energy efficiency of such solutions.

As regards the stationary fuel cells (for CHP solutions), the exploitation of the strengths of solid oxide fuel cells in different context will be demonstrated. One topic aims at simplifying the purification of biogas, while exploiting the biogas contained CO2 in fuel cells to achieve high electrical efficiencies. Another topic will demonstrate the robustness of the fuel cell systems with respect to hostile environmental conditions (temperature, humidity) that are encountered in remote areas, such as for the protection of gas pipelines. Today, low efficient or maintenance intensive products are used, which offers the technology a market niche of significant size on the global level. Finally, solid oxide membrane reactors present the ability to operate reversibly in electrolysis and fuel cell mode. Their high operating temperature and the use of an oxygen membrane present many technical options for an optimised exploitation of various carbon-containing waste streams that likely will be transformed by gasification processes in a first step. Those new technical options for thermal and energetical integration for such power balancing plants will be first engineered, before proceeding further in this direction.

3. Overarching activities:

These activities look at synergies between transport and energy applications. For this call, the topic will investigate fuel cell applications (stationary and mobile) in port environments, as these have been identified as areas where high reductions of emissions can be achieved[14].

4. Cross-Cutting activities:

As with previous years, Crosscutting 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 AWP2018, these activities will be implemented through four separate topics. Pre-normative research is more and more necessary for safety of road applications in confined structures, including tunnels; the results should contribute to related standards.

It is considered strategic to start looking at the hydrogen admixture in the natural gas grid and the impact on Europe energy transition; 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, therefore in order to establish a European understanding of an acceptable hydrogen concentration in the natural gas system, one topic will identify and start looking at different knowledge gaps.

Identifying degradation mechanisms in stack components for SOFC technology continues on the similar topic published in 2017, where only PEMFC technology has been covered.

Public awareness and acceptance regarding fuel cells and hydrogen technologies have essential impacts on the market implementation and stabilization of FCH applications. To address this most efficiently, a bottom up approach focusing on pupils (primary and secondary education) appears as most promising to transfer essential knowledge to the public.

[14] See outcome of workshop on maritime and port applications, Valencia (May 2017), http://www.fch.europa.eu/event/workshop-maritime-and-port-applications

List of actions

For the implementation of the Work Plan, the following actions will be taken in 2018:

A. Call for proposals 2018

Topic descriptions are detailed starting from the next page.

Topics' Descriptions

TRANSPORT PILLAR

FCH-01-1-2018: Large Scale Demonstration of H2 fueled HD Trucks with High Capacity Hydrogen Refueling Stations (HRS)

Specific challenge:

In the context of a global reduction of emissions from the transportation sector, the decarbonization of the mid and heavy-duty (HD) truck fleets, such as those used for the transportation of goods from logistic centers to urban-based retail outlets but also those used in long-haul services represents a major challenge.

For the various needs linked to payloads and urban/suburban access requirements, the 19 to 44 (gross weight) tons range is meeting the expectations of the truck market.

Furthermore, urban areas are increasingly facing air quality degradation through, amongst other contributors, delivery trucks equipped with ICE technologies and emitting local pollutants, e.g. particulates, NOx and noise. Consequently, an increasing number of cities across Europe have decided or are in the process of deciding, to restrict access to urban areas of diesel fueled HD vehicles.

Alternative truck technologies such as battery and fuel cell technology offering adequate performance must therefore be developed and implemented to replace the diesel trucks and alleviate the emissions problems. For the required daily ranges and payloads in question, hydrogen can offer a very promising zero emission alternative. Opening the scope to 19 tons class allows the vehicles to enter the most restricted urban areas.

Scope:

The project aims at demonstrating at least 15 mid or heavy-duty (19+ tons) trucks in total, used for long-haul traffic and in interurban areas.

The trucks should fulfill the following requirements:

- The powertrain should be based on hydrogen fuel cells and electric motors;
- The truck should integrate a fuel cell system from 85 to 300 kW (net power), depending on the truck size and type of use;
- Availability > 90% of the operation time (excluding preventive maintenance time);
- The truck consumption target in kg of H2 / 100 km should be defined in the proposal;
- The expected Gross Vehicle Weight Rating (GVWR) should address the 19 to 44 tons Gross Combined Weight Rating (GCWR) truck segment;
- The FCE truck should be designed to meet end-users' needs and therefore should be able to perform the same tasks as the equivalent diesel truck, notably assure a one-day operation with one refueling or two refueling when a mid-day refueling is feasible;
- For standardization reasons, the hydrogen tanks should be based on an existing standard (e.g. 350 and/or 700 bar, liquid hydrogen storage systems;
- The range of the trucks should be sized according to the end-users' needs; it is however, typically expected to be in the range of 400 to 1000 km autonomy between refuelings;

- The hydrogen consumption should be provided and monitored according to the delivery routes profile.

Each site should demonstrate a fleet of minimum 4 FCE trucks and each of the related refueling station should have the adequate capacity to supply the hydrogen. Existing stations, or upgrades thereof, would be prioritized. In addition, the hydrogen production and delivery to the refueling station should reduce the FCE trucks CO_2 emissions by at least 50%, as compared to the emissions of the equivalent diesel trucks, calculated on a well-to-wheel basis. The necessary trucks refueling protocol put in place should be made available to the FC and H_2 community in order to log and share the experience gained.

The proposal is expected to contain minimum three different demonstration sites in at least two different countries, with a minimum of 15 trucks in operation during the project. As the focus is on long-haul, the number of trucks >26 tons should represent minimum 80% of the total.

The trucks should be operated for minimum two years (minimum of 30 000 kilometers per truck and per year), including the time to maintain and repair the trucks.

The TRL for trucks at the start of the project should be 6 and the project should aim to reach a TRL of 8 at completion.

While the operation costs that are specific to the FCE technology are considered eligible, the costs incurred by the operation, similar to the ones for the equivalent diesel solution (typically driver costs or non FCE-specific maintenance), are not eligible.

Some actors are positioning themselves to develop FCE trucks, whether being in the USA or in Europe (eg. Scania/ASKO, COOP/Swiss Hydrogen, VDL/Colruyt). In the USA we can mention the Project Portal from Toyota, Nikola trucks, Kenworth or Loop Energy. It is thus of outmost importance that Europe moves also quickly on this and the consortium should demonstrate how the proposed solution is competitive with regards to solutions mentioned here above, but also identify in which conditions the operation of the trucks could be continued after the end of this publicly funded 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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 12 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: 4-6 years

Expected impact:

The project should contribute to developing a new business model on FCE trucks that has never been demonstrated beforehand, therefore specific dissemination actions should be foreseen to promote the project, share the experience gained and present the lessons learned.

The final target is to operate zero CO2 emissions, long distance transportation truck fleet, together with the refueling infrastructure and the delivery of significantly decarbonised hydrogen (according to CertifHy project recommendations[15]).

As the technology is just being implemented for the first demonstration projects, the costs associated are expected to be still important. The funding in the frame of this project is meant to fill this gap with the state of the art solution. In the frame of the project, the consortium should demonstrate how this gap is filled, based on a TCO analysis.

Existing and/or new hydrogen refueling stations will be heavily utilized thanks to the large hydrogen consumption expected for the type of truck (30 to 50 kg H2 estimated per refueling) and therefore generate a quicker learning curve that will help the deployment of the hydrogen 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.

[15] http://www.fch.europa.eu/project/developing-european-framework-generation-guarantees-origin-green-hydrogen

FCH-01-2-2018: Demonstration of Fuel Cell applications for mid-size passenger ships or inland freight

Specific challenge:

While emission regulations have been enforced in road transport for more than 2 decades, maritime transport is still, largely, utilising heavy fuel oil and high sulphur containing diesel. In cities with major harbours, maritime transport is today contributing significantly to air pollution.

Emission Control Areas (ECAs) are defined in the North and Baltic Sea (requiring the use of low-sulphur diesel) and along the North American coastline. ECA regulations have been proposed also for e.g., the Mediterranean Sea, and the coastlines of Australia, Japan and Norway. To comply with these more stringent local emission regulations, conventional propulsion systems based on internal combustion engines (ICEs) are subject to installing costly exhaust cleaning technologies.

Moreover, European GHG emission targets for 2030 along with the ambitions of shifting especially freight from road to rail and sea underlines the urgency of introducing low and 0-emission solutions also for maritime transport. Some European cities (e.g., Amsterdam) have already announced 0-emission requirements for cruise-ships in harbour within 2025. Environmental legislation designed to reduce emissions across the maritime industry is hence placing higher demands for compliance upon ship owners and operators.

Consequently, conventional ICE-based drivelines are currently being hybridized with batteries for reducing fuel consumption and the high local emission from ICE drivelines operating at part load. Liquefied Natural Gas (LNG) as a marine fuel constitutes a commercially available solution, which is almost eliminating local emissions (SOx, NOx, PM). Replacing diesel with LNG may reduce CO2-emissions by 15-20%, but this is not compliant with the 40 % GHG reduction ambitions for 2030.

A first generation of pure battery-electric ships have been introduced in recent years. The largest to date is the 1 MW ferry boat Ampere which has been in operation since early 2015 in Norway. However, battery-electric ships have limited range, long charging time and require a high capacity grid connection. In that respect hydrogen and FC technology represents a promising option.

FCs have been demonstrated for propulsion in several smaller slow speed vessels. PEMFCs and hydrogen as fuel is dominating and the power range is typically up to 100 kW. Lately, several initiatives have been taken for utilising FCs at higher power ranges and in high-speed vessels. Leading FC suppliers are now adapting MW-scale FC systems for maritime use. For wide deployment of FC technologies in maritime transport there is, however, still a series of specific challenges which needs to be addressed, including durability, system power density for high speed vessels, compatibility with maritime conditions (saline air, shock, rolling & vibration), high volume bunkering, regulations, codes and standards (incl. redundancy), and public acceptance.

Scope:

The scope of this topic is the development and demonstration of at least 2 mid-size FC powered ships each with a minimum nominal FC system power of 400 kW, for inland/coastal freight or transportation of more than 100 passengers. A total minimum nominal FC system power of 1MW should be installed in the ships. The ships should be used on a daily basis in order to gain relevant operational experience. Refuelling (bunkering) to sustain the normal operational profile of the vessels is considered within the scope of this topic. Exploitation of synergies with refuelling infrastructure for other applications are considered however advantageous.

To assess different operational scenarios the ships shall operate at 2 different locations. The demonstrations should highlight the superior energy density and short refuelling time of hydrogen vs pure battery solutions. Batteries may however be included in a FC hybrid configuration to reduce fuel consumption and smoothen power demands on the FC unit. Retrofit of FC systems to replace conventional fossil-fuelled propulsion is also within the scope of the topic. An averaged minimum of 50 % renewable based hydrogen is required during the demonstration. Access cost of hydrogen compared to diesel is eligible.
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.
The project should address the following key issues:

- Development of a FC system suitable for integration in new and existing ships, complying with maritime requirements regarding safety, redundancy and operational conditions ;
- Adaption and certification/approval of a new or retrofit of an existing vessel (i.e. the vessel cost is not eligible);
- Develop a suitable bunkering technology and process, based on existing HRS technology developed in previous FCH JU projects;
- Operation of the FC technology during test period and assessment of the technology in maritime conditions by the end-users including the related infrastructure;
- Transfer of fuel cell technology developed and applied in previous FCH 2 JU projects;
- Assessment of suitable business models for maritime transport applications, to foster further commercialization of technical solutions both on board the vessel and bunkering/refuelling;
- Monitoring during the operation the advantages in terms of emission reduction, noise reduction, improved image, availability, reliability and customer needs;
- Dissemination of the demonstration activities and achievements and support the EU member states promotion of clean vessel technology on the basis of this demonstration;
- The hydrogen infrastructure should be designed to provide hydrogen at the required quality, amounts and reliability to maintain normal operation of the ship. Technology and processes should be based on current proven hydrogen refuelling technology (e.g., for buses).

The project should cooperate on ongoing activities with relevant organisations such as CESNI (European Committee for inland navigation vessels standards), IMO (International Maritime Organisation) and certification bodies. The project shall include an operational period of at least 18 months for each vessel. The proposal is expected to include a vessel OEM to ensure the transition to commercialization of the technology.

TRL at the start of the project: 4-5.

TRL at the end of the project: 6-7.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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: 4 years

Expected impact:

This project is expected to develop and demonstrate hydrogen powered ships for medium sized inland and coastal freight and/or passenger transportation with daily normal missions, meeting customer needs. It is expected that the project provides a significant step towards implementation of FCs and hydrogen as fuel in maritime transport, by reducing costs while increasing the maturity, reliability and lifetime. The project will demonstrate the superior features of FC-based propulsion as compared to pure battery-powered vessels as well as the benefits from hybridising FCs with batteries for maritime transport applications. The demonstration shall also strengthen the European supply chain and reveal viable business models for inland/coastal maritime transport applications. It will, moreover, provide for increased visibility of the potential for FCH technologies as a means for de-carbonizing inland/coastal transportation.

More specifically, the expected impacts include:

- Successful demonstration of two FC-powered ships for inland/coastal applications before 2023;
- The performance targets should comply with the MAWP bus targets;
- Average availability of the ships of at least 90%;
- 100% of on board power for auxiliaries and propulsion to be FC or FC battery hybrid;
- Vessel to be in service no less frequently than the conventional IC engine equivalent;
- Technical solutions meet all local safety requirements concerning gas storage and fuelling within the operational environment;
- Speed and performance no less than the normal IC engine based service;
- Systems design life of at least ten years (servicing allowed);
- Lessons learnt from implementing and operating FC ships, identification of bottlenecks – technical, organisational, structural, financial including RCS and formulation of recommendations on how to address these;
- Lowering CO2 and pollutant emissions from inland/coastal transport;
- Reduce noise in urban areas and increase public awareness;
- 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-01-3-2018: Strengthening of the European supply chain for compressed storage systems for transport applications

Specific challenge:

Compressed hydrogen tanks are a high-value component of strategic importance for the rollout of fuel cell mobility, but with few suppliers. They could constitute a multibillion market once hydrogen mobility matures and could offer a substantial economic opportunity for Europe. While companies with the background and skills to produce high-pressure tanks do exist in Europe, tank manufacture is currently a bottleneck in the European vehicle supply chain, in particular for buses.

The challenge behind this topic lies therefore in strengthening the European supply chain for compressed hydrogen storage for transport applications by driving competition among various players, which should lead to cost reduction and improved technical performance.

While similar projects have been financed in the past, it is necessary to broaden the number of players (Tier 1 and 2 suppliers) able to develop, produce, test, certify and commercialize the vessels and ancillary hydrogen storage systems, contribute to PNR and RCS development thus creating a market ready competitive environment and cost reduction. To this end the following technical areas challenges are fundamental as regards hydrogen tanks:

1. Achievement of the application specific (e.g. automotive, rail, maritime, bus, trucks, aeronautic, etc.) performance and cost targets for a broader market introduction. This is mainly due to intensive carbon fibre use (quantity, quality and hence cost), conventional manufacturing processes and architectural concepts that are not compatible with mass production. To tackle this challenge, significant advances with respect to mechanical reinforcement, composite architectural architecture optimization and improved designs of composite overwrapped pressure vessels (COPV) with respect to cost, performance and manufacturing productivity are required.

2. Hydrogen refuelling times truly comparable to those of conventional fuels require an extended temperature range of the COPV. This would also greatly improve the safety margins with respect to over temperature overshoot caused by possible malfunctions of the refuelling station. Likewise, being able to extract the maximum hydrogen mass flow independent regardless of the state of charge (SOC) calls for the ability of the COPV and the complete refuelling system to withstand and/or operate at lower temperatures.

3. Improvement of the intrinsic safety of COPV with respect to the worst-case scenario of TPRD (Thermally Activated Pressure Relief Device) malfunction within fire conditions.

Scope:

Given the scope of past projects financed by the FCH 2 JU, the topic is open to all transport applications.

The following should fall into the scope of the project:

- Development of new and/or optimized tank geometries having the same storage performance and providing an enhanced integration in vehicle application space at a comparable price. The storage density of the system at room temperature should be at least 0.03Kg/L for 700bar or 0.018Kg/L for 350bar. The cost target for the whole system for a production of 30,000 parts per year basis should be 400€/kg H2 or less;
- Improve filling and venting tolerance of COPV (e.g. enhanced liner materials and multi-material assembling materials and techniques to increase mechanical and temperature tolerance (e.g. real -40°C H2 filling, - 60°C cold filling, +100°C);

- Development and validation of numerical tools (probabilistic models) to perform automatic or semi-automatic optimization of COPV performance and durability and reduce cost and manufacturing discrepancies;
- Provide technical and performance validation of prototypes with respect to EU standards (e.g. EC79);
- Improved safety stemming from demonstration of leak-before-burst vessel designs and fire detection and protection concepts;
- For protection against the worst-case scenario of the failure of the TPRD, a leak-before-burst vessel design should be developed. In this connection, the failure mechanism of the vessel should be studied and the reliability demonstrated. Furthermore, systems for detecting localized fires, and efficient enhanced fire protection systems/strategies as well as additional security measures are to be evaluated;

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

The proposal is expected to include at least one vessel and/or material supplier, one research institute and an OEM, such that the full supply chain is represented and works towards end customer targets. It is also expected to build on experience from past projects in the field (at national or European level) in order to push the most promising materials and technologies to a higher TRL/MRL.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 2.7 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: 3-4 years

Expected impact:

- Coherent strategy defining the ultimate weight/cost savings achievable with conventional COPV and/or novel geometries and/or novel architecture strategies providing the best trade-off;
- Improved filling/venting tolerance of storage systems (temperature range: -60°C to +100°C) to sustain fast-filling and unrestricted extraction;
- Strengthen the European COPV development and supply chain;

The following KPIs are expected to be reached at storage system level in compliance with the MAWP:

- Volumetric capacity: 0.03Kg/L for 700bar or 0.018Kg/L for 350bar;
- Gravimetric capacity: 5,3%;
- Cost target for a production of 30,000 parts per year basis: 450€/kg H2;

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-01-4-2018: Fuel cell systems for the propulsion of aerial passenger vehicle

Specific challenge:

The aeronautic sector is currently entering a major transformation phase triggered by the environmental urgency, the evolution of humans' movements associated to new transportation means and the emergence of new aerial platforms. The reduction of greenhouse gas emissions has driven the aeronautic industry to introduce the concept of More Electrical Aircraft, but a deeper transition is needed and hybrid-electric or even full electric propulsion is now considered to tackle the environmental challenge, as stated in the Clean Sky JU bi-annual work plan 2016-2017[16]. This addresses the need for continuous work on Green Regional Aircraft to mature, validate and demonstrate the technologies best fitting the environmental goals set for the regional aircraft that will fly in 2020+. Accordingly, the Green Regional Aircraft has five main domains of research: low weight configuration, low noise configuration, all electric aircraft, mission and trajectory management, and new configuration. The power requirements for the propulsion of common aircraft are however tremendous (in the range of 1 MW for a 19 pax intercity commuter) and not reasonably achievable today. This assessment accounts for the necessity to start considering this technological challenge today with an intermediate step at lower scale.

The aeronautic industry sees new concepts appear to take advantage of operating in the airspace by introducing new flying platforms, either uninhabited (UAV) or inhabited (passenger aircraft). Personal flying vehicles (2 to 4 pax, 40 to 100 kW or more) are becoming a reality and most of them are based on electric powertrain (Lilium https://lilium.com/, E-Volo http://www.e-volo.com/index.php/en/). Even though fuel cell systems have already been introduced on light flying platforms, it is still necessary to bring it to larger scales, to deploy widely the technology, to make it compatible with market requirements and to address certification.

Most of new flying platforms concepts are electrically driven and powered by batteries. The bottleneck of such vehicles is the strong limitation in autonomy due to the poor energy and power density reached by battery systems. Hydrogen and fuel cell systems are a promising option to increase the range and thus the credibility of such new flying platforms, within a short term. In addition, fuel cell technologies offer more flexibility in operation such as fast refuelling.

The effects of high altitudes (and reduced O_2 concentration and partial pressure levels) on performance need to be further addressed and modular architectures approach considered to optimize the efficiency. The BoP main components, such as the air compressor, the hydrogen storage and the power electronics, will have high requirements, which still need to be clearly defined in accordance with performance dependency to altitude. Even though work has been engaged to define RCS for hydrogen and fuel cells in aviation, a lot remains to be done, especially to consider propulsion applications.

Scope:

The project should develop and demonstrate a fuel cell system dedicated to the propulsion of a 2 to 19 passengers regional aircraft emission free. The fuel cell system (FCS) architecture shall be modular and adaptable to different aerial vehicles such as UAVs with similar payloads capability. The aerial vehicle to be considered for demonstration should be able to carry a payload between 160 and 350 kg and have a range of 1 to 2 hours. The system to be developed should be based on an architecture involving elementary power modules and on technologies previously developed in the scope of previous FCH JU projects. The aim of such modular architecture is first to allow a scaling of the system to address a range of platforms and second to offer redundancy and therefore increase the reliability of the propulsive power source.

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[16] ANNEX to GB decision no CS-GB-2015-12-18 Doc7a Decision WP and Budget 2016-2017 - CLEAN SKY 2 JOINT UNDERTAKING 2016-2017 BI-ANNUAL WORK PLAN and BUDGET – Green Regional Aircraft, GRA3 All Electric Aircraft (p. 38)

In order to bring a competitive and efficient solution, the following key objectives should be considered:

- Fuel cell system power output in the following ranges: fuel cell system total output power on demonstrator: 40 to 150 kW (multiple modules for 19 seater aircraft);
- Adjust or re-use key components and subsystems allowing to reach gravimetric energy and power density, safety and lifetime under aeronautic RCS requirements:

  - Fuel cell stack (at least 2 kW/kg, re-used from previous project);

  - Air feeding subsystem (efficiency > 50 % at high pressure ratio);

  - Hydrogen storage (> 5,5 % mass efficiency);

  - Power converter (> 5 kW/kg);

  - System lifetime target at least 4 000 hours;
- Integration, installation into aircraft, industrialization and cost competitiveness have to be optimized in order to bring realistic solution. When applicable, aeronautic RCS have to be taken into account and compliance should be demonstrated (DO160, EASA CS-VLA, EASA CS23,…). Focus of the project will be the elaboration of the certification plan derived from existing RCS and to apply it to the system to be demonstrated in flight. The most-up to date RCS will be taken into account and gaps in the legislation will be highlighted;
- Implement simulation and model-based design methodology for optimal design trade-offs (performances, durability) and definition of most suitable control strategies;
- Experimental demonstration:

  - At laboratory level for components/subsystem/system, durability and reliability according to application requirements;

  - Under realistic conditions of system performance and range; for passenger aircraft, the demonstration will be performed with elementary power modules (not the full-scale power) composed of full-scale components;

  - An in-flight demonstration of at least a single module in an existing plane.
- Perform economical assessment and derive Fuel Cell system Total Cost of Ownership for the selected target application including hydrogen refueling and system maintenance; Perform environmental assessment and derive fuel cell propulsive system potential GHG emission reductions;

The project should start with a global TRL of 3 to 4 for the considered components and conclude to the demonstration of a TRL 6 with tests in representative conditions of real environment and in flight demonstration.

The consortium should gather both academic and industrials with previous experience in the field of fuel cell applications for aeronautic and able to bring expertise in development, conception and testing in conditions representative of an aeronautical environment.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 4 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: 4 years

Expected impact:

The first expected impact is to increase the range and autonomy of small battery based electrical aerial vehicles by a factor of two to four, allowing reaching relevant levels, compatible with targeted markets (people and goods transportation, industrial applications) and therefore, contributing to decarbonizing transportation. The second expected impact is to increase the credibility and therefore the consideration of fuel cell systems for the propulsion of passenger aircraft and UAVs in order to pave the way toward All Electric Aircraft. The development project of an All Electric 19 pax inter-city aircraft is a tremendous work, which will require major budget. It could only be initiated if feasibility is demonstrated at lower scale and if technical and economic targets are clearly and precisely established earlier.

Another expected impact is the demonstration of the compliance to aviation standards of safety validated and demonstrated, to provide recommendations for RCS definition/amendments in the aerospace sector, for qualification test campaigns. For that, a connection should be established with the EUROCAE WG80 and the FAA's Aviation Rulemaking Committee (ARC), which involve aeronautical industry, FAA and EASA for the development of standards for hydrogen Fuel Cell system for Airborne applications. The project should therefore demonstrate clear in-roads on the path to the certification process, still a major roadblock on future commercialization.

The outcome should also allow to demonstrate the economic viability of a fuel cell and hydrogen based solution for the propulsion of a small aerial platform.

The fuel cell system lifetime and durability under representative operating conditions (≥ 4000 h accumulated operation under load of the very same FCS) is also part of the expected impacts, in addition to the following:

- Silent FC-based powertrain system operation: < 60dB(A);
- Structuration of the European aerospace sector to be in a leading market position for aerospace fuel cell systems, fostering EU FC-supply chain and creation of highly qualified jobs across the complete supply chain;
- Strengthening synergies with Clean Sky 2 JU in order to promote the fuel cell & hydrogen technologies in line with the conclusion from the joint workshop in 2015[17];
- Europe’s competitiveness in the field of FCS for aerial propulsion is key and USA, China, Canada have already demonstrated several prototypes or even products (MMC HyDrone 1800, BOEING EcoDemonstrator, …). The expected impact is to increase the market share to be taken by European industry, creating activity and jobs.

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.

[17] Final report from joint CLEANSKY 2 / FCH 2 JUs workshop on aeronautical applications of fuel cells and hydrogen technologies, 15 & 16 September 2015, Lampoldshausen, Germany.

FCH-01-5-2018: Next generation automotive MEA development

Specific challenge:

Cost still remains one of the key challenges for widespread adoption of Proton Exchange Membrane Fuel Cell (PEMFC) technology in the automotive sector. The stack still represents about 50% of total fuel cell system cost and MEA components ca. 60% of the total stack cost. Therefore, despite considerable progress over the last 10 years in increasing performance, durability and reducing platinum loadings, research and development activities are still required to provide materials and designs that can address the cost issue whilst reaching other important targets like durability, reliability and operating temperature.

Additionally, even though several materials were developed that meet performance at BOL, they tend to degrade rapidly and have other issues (e.g. power instability at lower temperatures). Thus, the purpose of this topic is to address these issues by focusing on MEA development to meet all the requirements at the same time, with a greater focus on achieving a world leading power density of 1.8 W/cm2 @ 0.60 V.

Scope:

As a step towards the final cost goal, proposals should focus on reducing the total platinum loading compared to current state of the art MEAs (currently in the range of 0.25 to 0.35 mg/cm2) and increasing current density to levels that enable a significant reduction of the total stack active area.

As the targets are very ambitious, the proposals will need to address several areas of development at the same time, which will include work on the following areas:

- **Catalyst:** Development of new catalysts with higher mass-specific activity, durability and active surface area. The catalyst has to be capable of being integrated in a layer that allows operation at higher current densities;
- **Catalyst Support:** Development of corrosion resistant supports which promote optimal layer ionomer distribution and operation at high current densities. These supports have also to meet the durability requirements during dynamic operating conditions, such as start-stop, that lead to high potentials;
- **Catalyst layer Design:** New electrode designs, structured layers and additives to improve performance at high current density and increase durability. Focus to be placed on minimization of mass transport losses while ensuring manufacturability of the layer;
- **Catalyst Layer ionomer:** Ionomers with higher protonic conductivity, higher permeability to O2 and stable behaviour at low RH (<50% RH) and high temperatures (80 - 110 °C);
- **Membrane:** Durable membranes with reduced gas crossover and viable operation at higher temperature (to 110 °C), displaying the proton conductivity of currently available ionomers, or better, and mechanically and chemically stable under RH cycling and OCV conditions;
- **GDL (including MPL):** Development of high through-plane thermal conductivity GDLs to enable low local temperatures at the catalyst layers. Higher in-plane diffusivity GDLs are also desired to reduce the effect of wide landings on bipolar plates. A combination of GDL properties are desired, including reduced thickness, to achieve optimum contact resistance, gas flows under the landings, water management and thermal conduction. Development of MPLs designed for high current densities but with a good balance of water management properties at low temperatures and current densities is needed;
- **MEA Integration:** In addition to incorporating the new component materials into MEAs, it is also within the scope to consider alternative MEA designs, constructions, and deposition and assembly approaches that can contribute to the achievement of the

project objectives. Novel designs should maximize the effective use of the constituent materials, enable tailoring to the stack design and minimize the interfacial losses, thereby contributing to the increased performance and reduced cost objectives. This has been addressed in the paragraph below dealing with the output of the project.

The proposal should set targets for each individual component. Those targets need to be quantifiable in single cells relevant for automotive application. The consortium has to demonstrate how the targets have been fixed and how those targets will allow the MEA to achieve the required power density (1.8 W/cm2 @ 0.6 V) in the described operating conditions (already described above).

The output of the project should be a sufficient numbers of MEAs incorporating the new constituent materials and designs that are manufactured by a commercial supplier, by methods compatible with high-volume manufacturing, (but not necessarily using processes already validated for the fuel cell industry), to enable a short-stack test (minimum 10 Cells) of a practical automotive fuel cell.

A cost estimation with assumptions on the quantity of materials, material costs and production costs of the MEA is also expected as an output at the end of the project.

Development of bipolar plates, seals, frame/sub-gasket materials and designs are not in scope of this topic.

TRL at start: 2-3 and TRL at the end of the project: 5.

The proposal is expected to contain at least one OEM as a partner, to provide system and fuel cell design points and counsel on trade off studies. Similarly, to fulfil the manufacturability requirement, it is expected that at least one MEA supplier to be part of the proposal.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 4 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: 3-4 Years

Expected impact:

The proposed development activities shall reach the following collective targets, demonstrated at MEA level:

- Decreased MEA cost: target MEA cost of 6.0 € /kW based on a production volume of 1 Million m2 per year, assuming Pt spot price of 1,200 €/ troy Oz;
- Increased power density: target power density of 1.80 W/cm2 (reference cell voltage: 0.60 V) using Autostack Core bipolar plate as reference (which is commercially available, or a similar bipolar plate with at least 200 cm2, realized as an outcome of a previous FCH 2 JU project). For reproducibility reasons, it is expected that a short stack with a minimum of 10 cells is tested. Operating conditions should be defined by the consortium partners but are recommended to be within the following limits:
    - Pressure: inlet $P_{Cath,An}$<2.5 bar;
    - Stoichiometry: 1.3 < $\lambda_{Cath,An}$ < 1.5;
    - Humidity: 30% <RH_{cath}< 70% (relative to coolant inlet temperature);

- Temperature: 60˚C <Temperature inlet < 70˚C
- 10˚C <Coolant dT < 15˚C;
- 100% H2 concentration at anode inlet;

- Increased durability: MEA maximum power loss of 10% after 6,000 hours of operation under a typical customer usage profile (to be defined by consortium, preference is given to profile suggested by the JRC harmonization protocol). Extrapolations from actual durability tests are acceptable beyond 1,000 hours of tests.
- Increased operating temperature: MEA capable of operation at coolant outlet temperatures of 105 ^{o}C and current densities of 1.5 A/cm2 @ 0.67 V for 5% of the lifetime (approx. 300 h). The exact operating conditions and system component assumptions should be provided by OEMs and system integrators to ensure the target is reachable.

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-01-6-2018: Game changer fuel cell stack for automotive applications

Specific challenge:

The present PEMFC stack technology for automotive application shows limitations (performances, durability, production cost) which appear to be difficult to overcome by incrementing each component such as membrane, catalyst or MEA. In order to reach the OEMs targets and to prepare the next generation of stack for transport applications and in order for Europe to stay competitive versus North America or Asia, new disruptive stack concepts are needed involving new stack architecture, new materials and new processes.

For a next generation with higher performance new concepts considering the stack as a whole and no more as the sum of individual components have to be investigated. In this approach, each stack component will be designed and optimized simultaneously, as part of a more complex system.

Scope:

To develop a higher performance stack for automotive application, all components (BBP, GDL, MPL, electrodes, and membrane) have to be designed accordingly, in a full size single cell approach. For this purpose, there has to be a focus on interface optimisation between components where new material and processes will have to be investigated, in order to optimise performance and durability while decreasing production cost. An integrated solution at the single cell level is highly recommended.

Beyond performance increase, thanks to new design and associated processes, new stack architecture allowing a simplified BOP will be privileged in order to have a global system approach for system cost reduction. As an example, new stack concept working at lower pressure without compressor is among the possible solution.

New innovative material solutions (such as new membrane) will be also a disruptive way to be associated to the previous challenge.

Furthermore, new concepts for stack integration and interfaces with BOP will have also to be investigated (integrated terminal plates, innovative connection with BOP…).

The selection between best material/process solutions should be justified and documented, possibly through modelling.

TRL start: 2 and TRL end: 3.

The consortium should include component and stack suppliers, component-testing organisations. The project should build on the activities and results reached in previous or existing FCH 2 JU projects, e.g. Autostack or Autostack Core projects, dealing with stack and stack component development.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected duration: 3-4 years

Expected impact:

The main impacts to be addressed are the following:

- Power density > 2 W/cm2 at 0.66 V;
- Volumetric power density > 5 kW/l at nominal power;
- Specific power density > 4 kW/kg at nominal power;
- Durability: > 6,000 hours;
- Stack production cost < 20 €/kW (for > 100 000 units/year);
- Stack max operating temperature of 105 °C;

The outcome will be at least a short-stack (minimum power 5 kW), to be tested with AST protocol representative for at least 6 month real operative conditions.

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-01-7-2018: Improvement of innovative compression concepts for large scale transport applications

Specific challenge:

Costs associated to the hydrogen refuelling station represent a large share of the overall hydrogen costs in transport applications, with a strong impact on the business models of hydrogen mobility. Large scale refuelling (e.g. hydrogen passenger cars, busses and trucks fleets, rail transport as well as maritime applications) expected in the next years will require hydrogen refuelling stations with capacities of 1 t/day or more, at pressure levels of 350 bar or 700 bar (i.e. 450 bar or 900 bar at the station). CAPEX and OPEX (energy costs + maintenance) of the station can represent 3 €/kg H2 or more. About 50% of these costs are related to the compression, making this component a significant bottleneck for FCV deployments, as also found in fuel cell bus demonstration projects (CHIC, CUTE. HYTRANSIT…). In particular, operational expenditures are critical in the context of large-scale stations. These costs include energy, maintenance, as well as the indirect costs induced when a station is out of order.

Currently available mechanical hydrogen compressors are too costly for large-scale applications and lack the desired durability, efficiency and reliability. This results in high operational and maintenance costs. Lack of reliability of mechanical compressors is due to the large number of moving parts, the challenge of guaranteeing the tightness of high-pressure moving parts, and the lifetime of membranes (~2000 h).

Breakthrough disruptive technologies exist (including electrochemical and metal hydride compressors) and promise significant reduction of total cost of ownership of hydrogen refuelling stations because of the elimination of mechanical compressor disadvantages. However, the maturity of these technologies has to be increased with respect to capacity, durability, lifetime and reliability. None of these technologies has demonstrated until now the ability of providing sufficient flow rates for large-scale applications at reasonable costs. Previous FCH 2 JU funded projects have enabled the development of small prototypes (PHAEDRUS, COSMHYC). However, no large-scale system has been developed to date, as the focus was set on 200 kg/day stations, corresponding to the needs of the market introduction of passenger cars.

Therefore, there is a need for major improvements to meet the criteria of large refuelling stations, both at the scale of the core technology (focus on kinetics and scale effects in selected materials, impact of improved kinetics on life time and performances, architecture of core components) as well as for the system integration (design of entire system, innovative concepts adapted to larger scale, choice of adapted auxiliaries). In addition, the new technologies currently require the use of critical raw materials (such as platinum or rare earths) in most of the developed concepts.

Scope:

This topic calls for proposals to develop and test at pilot scale an innovative compressor concept for hydrogen refuelling stations that is able to provide large flow rates (50 kg/h or more) at affordable costs and is well adapted for at least one representative transport application (350 bar or 700 bar). The compression concept should include either one of the disruptive technology (e.g. electrochemical or metal hydrides; any other disruptive technologies can be eligible if an appropriate argumentation is provided) or a combination of hybridised compression technologies, including at least one disruptive technology.

Hydrogen should contribute to the integration of renewable energies into the European energy mix. Therefore, the compression concept should be able to use hydrogen from different sources (onsite electrolysis, biogas reforming, hydrogen bottles and pipeline). Consequently, the allowable inlet pressure should be low (preferably in the range of 20 bar, or lower).

The project should contribute to increase the maturity level of at least one disruptive compression technology. In particular, it should enable to:

- decrease the degradation of the technology down to at least the same level as mechanical compressors;
- reduce the use of critical raw materials;
- demonstrate an improvement of the reliability and availability of the HRS;
- decrease the total costs of ownership of the HRS;
- improve the efficiency of the hydrogen value chain by decreasing the electricity consumption.

Proposals should plan to assess the overall economic feasibility of the proposed compression concept, addressing operational and installation cost of the system, benchmarking with current HRS systems and including potential impacts on the rest of the station (storage, cooling etc.). The total cost of ownership (TCO) of the compression concept should be calculated, as well as the economic impact of the concept on the overall costs of the hydrogen refuelling station.

In the case of a hybridised system, the project should include modelling of the hybridised compression system in order to demonstrate that the proposed solution represents a techno-economic optimum.

The project should include demonstration of the performance of the compression concept by long term tests (a period of at least 6 months) in a relevant environment, for example a hydrogen refuelling station without public access or an outdoor test facility, at minimum 1/10 of real scale.

TRL start: 3 and TRL end: 5.

The consortium should include component suppliers, component testing entities, hydrogen system integrators or operators. The project should build on the activities and results reached in previous or existing FCH 2 JU projects, such as PHAEDRUS, COSMHYC or H2REF.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 2.75 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:

The following KPIs should be reached:

- Development of a compression concept from low pressure (in the range of 20 bar or less) to 450 bar or 900 bar (deviations are acceptable if justified by the proposed concept), being able to use hydrogen from different sources (onsite electrolysis, biogas reforming, hydrogen bottles and pipeline) and to reach flow rates of at least 4 kg/h and show scalability in order to reach 80 kg/h or more (corresponding to 2t/day or more) on the mid-term. The concept should take into account the change of scale compared to small compressors in the early design phase;

- Demonstrate perspective for overall investment costs reduced down to < €2000/kg H2/day, reaching < €1000/kg H2/day on the long term for a system of 1t/day or more. Demonstrate the potential for low electricity consumption for large installations (<4 kWh/kg for a suction pressure similar to current HRS and <8 kWh/kg for a very low suction pressure, i.e. <5 bar);
- Demonstrate maintenance costs of less than 5% of the investment costs per year;
- Demonstrate availability of more than 95%;
- If the technologies implemented induce the use of critical raw materials, demonstrate significant improvements in reducing or even avoiding the use of these critical raw materials (including platinum and rare earths, as defined in the MAWP of the FCH 2 JU); Critical raw materials should represent no more than 10% of the total investment costs of the compressor;
- Demonstrate less than 1% performance decay in 1000 hours of operation;

This topic will contribute to meeting the techno-economic objectives 3 and 5 of the MAWP, by reducing the dependency from critical raw materials as well as the operating and capital costs of the hydrogen infrastructure.

In addition, the project should:

- Provide recommendations supporting further technology developments, enabling future large scale production of low-costs compression systems for large flow rates;
- Demonstrate that innovative compression concept does not introduce additional contaminants in the hydrogen so that ISO 14687:2-2012 quality can be fulfilled.

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.

ENERGY PILLAR

FCH-02-1-2018: Demonstration of a large-scale (min. 20MW) electrolyser for converting renewable energy to hydrogen

Specific challenge:

The increase of intermittent renewable electricity raises the need for more flexibility and energy storage in the power market. Falling costs of renewable power open the possibility to generate hydrogen at large scale from renewable power through electrolysis. Several sectors, including refineries, chemical industry, transport, and the natural gas sector are exploring the reduction of their CO_2 footprint by incorporating large quantities of renewable hydrogen in their processes.

The challenge is to demonstrate a large-scale electrolyser converting renewable energy into renewable hydrogen for use in an end–market valorising the renewable character of the hydrogen. The electrolyser technology should be at a scale that can modularly be implemented to achieve large capacities (tens of MW), in view of reducing both investment (CAPEX) and operating costs (OPEX). It should be developed to operate flexibly to harvest maximum renewable power and provide grid-balancing services.

The challenges addressed by the project are:

- Demonstrating & improving the current state-of-the-art of 10s of MW electrolyser technology by significantly lowering the operating costs; minimizing footprint and addressing scalability;
- Provision of large quantities of green hydrogen on a commercial basis for application(s) that valorize(s) the renewable character of the hydrogen;
- Demonstration of the working flexibility of the electrolyser on a commercial basis by harvesting renewable power and in the meanwhile offering grid balancing services;
- Demonstration of future economic viability of the technology;
- Operation of an electrolyser system in real life conditions.

Scope:

The project should aim at demonstrating electrolyser technologies beyond actual state-of-the-art producing hydrogen with favourable economic conditions, e.g. upstream of the point a wind park is connected to the grid, when power prices are low, when additional revenue can be generated by providing high value grid balancing services and where the renewable character of the hydrogen can be valorised.

The scope of the project is:

- To develop a new large-scale electrolyser of minimum 20 MW of sufficiently rapid response time (of the order of a few seconds) from hot standby mode. If connected to the grid, the installed power and operating regime should be duly justified to identify the advantages offered to the grid within the long-term business model. The hydrogen purity should meet the hydrogen market requirements. The output pressure shall be designed to fulfil, when possible, the required pressure for the hydrogen application targeted - including buffer storage needs if any - and reduce as far as possible the need for dedicated hydrogen compression units downstream;
- To minimize the footprint of the electrolyser with a single balance of plant including all required electrolysis utilities such as water purification, power rectification with

appropriate grid interfaces and hydrogen purification, process cooling, etc. for delivery to the proposed application sector. Industrial integration with certification attested by a Notified Body should be foreseen;

- The electrolyser should be adapted to the conditions of its operating environment, thus minimizing requirement for operation and maintenance activities;
- To demonstrate an energy consumption consistent with 2020 expectations of 52,8 kWh/kg at nominal power;
- To demonstrate the economic benefits of the project for the selected application. The consortium should demonstrate revenues from commercial contracts with the chain stakeholders who value the renewable character of the hydrogen;
- The proposal should provide the operating scenarios, the expected annual production, the use foreseen and a detailed business case analysis. The electrolyser and downstream systems must be installed and operated for a minimum period of three to four years;
- Electrolyser systems will demonstrate a sufficient level of responsiveness to meet the Grid Services requirements;
- The proposal must thus include a plan for use of the installation after the project.

It is expected that proposal will address any industrial sector that has not until now been supported by the FCH 2 JU, e.g. use of hydrogen in steel manufacturing or direct replacement of net hydrogen demand in refinery should be excluded. The power connection costs, building costs and the electricity costs for the commissioning phase are eligible for funding. Electricity costs during demonstration / business operation are not eligible. The results of a techno-economic assessment should be reported after each year of operation, including information on the individual cost and revenue streams related to the electrolyser.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 11 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

More than one project may be funded for different electrolyser technologies and/or different market applications (industrial sectors).

Expected duration: 5 to 6 years (including minimum 3 to 4 years of demonstration).

Expected impact:

The proposal is expected to demonstrate in an operational environment improved electrolysis technology at the 10s of MW scale, configured to attract revenues from grid services and/or power price opportunities in addition to the main business of providing bulk renewable hydrogen to an industrial scale hydrogen user.

The consortium will ensure that actions are included in the project to generate learning and reach KPI and commercial targets, such as:

- Demonstrating feasible operation of large scale electrolysis and the use of the produced hydrogen in an application valorising the renewable character of the produced hydrogen;
- Assessment and operational experience, including safety, of the contractual and hardware arrangements required to distribute and supply hydrogen to the specific industrial and/or transport market;
- Perform techno-economic analysis of the performance of these systems;
- Technical assessment of the suitability of the electrolyser equipment to operate in its expected environment and suggestion of best practices;
- Evaluation of the environmental performance of the system in alignment with the recommendations of the CertifHy project[18] – with attention to the CO2 intensity of the hydrogen produced versus NG route, which should include an understanding of the CO2 impact of the grid services mode selected and CO2 footprint impact in the addressed hydrogen end-user markets;
- Projections of the value and size of the markets addressed by provision of the services and supply to multiple hydrogen markets, not excluding the transport sector;
- If relevant, assessment and operation experience of the contractual and hardware arrangements required to access the services and operate the electrolyser systems;
- Assessment of the legislative and RCS implications of these systems and any issues identified in obtaining consents to operate the system;
- Recommendations for policy makers and regulators on measures helping to maximise the value of renewable energy and stimulate the market for renewables-electrolyser systems.

Proposals should describe how learnings will be communicated and dissemination beyond the consortium (upon sanitation to protect business data), including those regions in Europe where large-scale electrolysis has not yet been demonstrated.

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.

[18] http://www.fch.europa.eu/project/developing-european-framework-generation-guarantees-origin-green-hydrogen

FCH-02-2-2018: Demonstration of large-scale steam electrolyser system in industrial market

Specific challenge:

More than 90% of total hydrogen demand comes from large industrial applications, e.g. chemical, refinery and metal works. Today, the vast majority of this hydrogen is produced centrally from natural gas using steam reformers at very low costs (<3 €/kg). Steam reformers typically have capacities of up to 10,000 kg/h hydrogen production and emit 8-11 kg CO_2 per 1 kg of hydrogen. Large-scale, efficient electrolysis technologies to produce green hydrogen from renewable electricity could significantly reduce those emissions, if costs can be reduced.

High temperature steam electrolysis (SOEC) has the potential to decrease green hydrogen costs to a level close to fossil hydrogen, as it can use low-cost waste heat or steam at low temperatures (< 200°C) from industrial process to reduce the electrical energy requirement. With availability of steam the electricity consumption can be reduced to <40 kWh/kg. This promises a significant reduction of hydrogen costs for industrial applications.

With support from FCH 2 JU, steam electrolysis has reached TRL 4-5. The challenge is now to scale-up the technology to a level relevant for industrial customers, bring the steam electrolysis closer to the TRL of PEM and alkaline electrolysers and show a perspective for the reduction of hydrogen costs close to steam reformer level.

Furthermore, the proof of the high efficiency, degradation rates and stack lifetime requires long-term testing under industrial conditions. This is key for achieving competitive hydrogen costs in industrial applications, as well as the reduction of CAPEX of steam electrolysers from today's 10-12 M€/(t/d) to below 3 M€/(t/d). The reduction of CAPEX requires large-scale application and an increase in production volumes.

A scale-up to 'megawatt class' is considered an important milestone in system development in the electrolysis industry, when targeting large scale applications. At this scale, specific costs of balance of plant components become more competitive and industrial, more affordable components can be used in the electrolysis systems.

Scope:

This topic calls for a large-scale steam electrolyser with an output of at least 15 kg/h to be demonstrated in a relevant industrial environment (iron and steel works, refinery, or industry with excess heat / steam that uses H2). The system must use renewable electricity either through direct connection to a renewable power source or through a contractual relationship with a renewable power source (e.g. via a power purchase agreement). In the latter case, the procedure and pitfalls as well as learnings and best practices should be reported. The electrolyser system needs to be equipped with all necessary ancillary equipment for steam and electricity supply as well as hydrogen processing to meet the customer's expectations in terms of purity, volume and pressure.

The electrolyser should operate for at least two years, whereas a scheduled stack replacement is not foreseen within this time period.

The demonstration should validate prospects for the business case for industry-scale steam electrolysis. The valorisation of any side product (e.g. oxygen) within the industrial environment should be investigated aiming to improve the business case.

The project should aim to the following:

- Development of an improved steam electrolyser system of at least 15 kg/h hydrogen production capacity and demonstration in an industrially relevant environment to benchmark the requirements from the industrial hydrogen consumer against the capability of fossil-based systems. The evaluation will consider innovative business models that could motivate industrial consumers to switch from fossil-based systems to renewable ones;
- A cumulated production of at least 50 tons of renewable hydrogen;
- Specific electricity consumption (beginning-of-life): < 40 kWhel/kg (<3.6 kWhel/Nm^3) @ rated power based on external steam supply and without compression; the steam must be provided by the industrial source directly or created from waste heat. The electrical production of steam for the electrolysis is not eligible within this project;
- Demonstrate the hot start from min to max power in less than 5 mins, to provide secondary grid balancing services, as well as the capability of steam electrolysers to follow the fluctuations of renewable power production;
- Average specific electricity consumption (over the project period) should be documented;
- Demonstrate the production of renewable hydrogen, based on the definition of the CertifHy project[19];
- Maintenance and repair costs will be reported and compared to a target of 225 €/(kg/d)/year by 2020, as well as the CAPEX target of 4,500 €/(kg/d) by 2020 and recommendations to meet this target will be given;
- Perform a techno-economic analysis that proves the feasibility of the business case over the lifetime of the system. This analysis should also incorporate the expected operational behaviour of the system during lifetime due to stack degradation;

The grid connection costs, electrolyser costs and the electricity costs for the commissioning phase are eligible for funding. Electricity costs during demonstration / business operation are not eligible and should be covered through the sale of hydrogen.

The proposals should provide the evidence that a suitable electrolysis system can be made available for the project.

The consortium should include at least the electrolyser developer and an industrial hydrogen consumer, who can substitute a substantial amount of its present fossil hydrogen demand with hydrogen production out of steam electrolysis.

TRL at start: 5 and TRL at end: 7.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 4 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.

[19] http://www.fch.europa.eu/project/developing-european-framework-generation-guarantees-origin-green-hydrogen

Expected duration: 4 years.

<u>*Expected impact:*</u>

A large-scale steam electrolyser system is expected to demonstrate the current cost level, maturity, conversion efficiency advantages and CO_2 reduction potentials against state-of-the-art hydrogen production routes (including water electrolysis) in an operational environment.

The project should demonstrate a power purchasing strategy that guarantees the renewable origin of the electricity; however, the electrolyser does not have to be physically connected to a renewable power generation source.

- Proof that steam electrolysers can operate reliably in an industrial environment and consume up to 20% less electricity compared to state of the art low temperature electrolysers;
- Demonstrate a successful operation for a duration of at least 12,000 hours with an availability of > 95 % and without the need of scheduled stack replacement;
- Allow a reliable evaluation of current investment costs (<12 M€/(t/d) in 2017 and 4.5 M€/(t/d) in 2020) with further recommendations for a pathway to capital cost reduction down to <2.4 M€/(t/d) after 2023;
- The hydrogen price after funding should be <7 €/kg and a clear perspective for costs <5 €/kg shall be demonstrated;
- Large-scale demonstration is needed for the development of common interfaces, for the integration and operation of steam electrolysers into an already existing 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-02-3-2018: Robust, efficient long term remote power supply

Specific challenge:

Fuel cell based power generation has a valuable business case for off-grid power generation in certain special markets such as powering the gas and oil infrastructure in remote regions with harsh climate conditions (-40 to +50 °C) and the continuous power supplies of telecommunication equipment (e.g. telecom base stations). This market is dominated by diesel generators today in accessible regions and by thermoelectric generators with very low efficiency in very remote areas. Both of these solutions have high environmental impact. Fuel cell based systems due to their higher efficiency and low maintenance requirements can offer significant primary energy and carbon savings and can significantly lower the total cost of ownership (TCO) for the end user as well as offering. These application areas provide very promising export markets for the European fuel cell industry.

Several European fuel cell companies are already addressing this market with solutions for niche applications in low volume. In order to enter high volume applications (i.e. the rapidly growing telecom sector in several emerging markets) further cost reductions are needed on both of stack and the specific Balance of Plant components.

Applications in remote areas are characterized by other key requirements: low maintenance, long service life of components, capability of remote monitoring and reliable operation in critical applications like oil and gas or safety infrastructure both in cold and in hot regions. Besides typical fuel cell components like stacks and reformers also several balance of plant (BOP) components such as electronic equipment, blowers, gas metering, sensors have to be specifically designed. They need to match the needs of reliable and rugged long term performance in order to provide long lasting, low maintenance products for remote applications. This provides an opportunity of a joint supply of the specific Balance of Plant components for remote operation by the European system manufacturers. This can increase the volume of such low-volume specialised items (tolerance to wide operating temperatures, high humidity).

Although first products have touched the market in prototype and pre-series state, currently the lack of long-term track records together with the high CAPEX, due to high cost of stacks and certain critical BOP equipment (i.e. power electronics, electronics suitable for low temperatures) provide a barrier for a large scale roll-out of fuel cell based power generators.

Scope:

The project should develop and demonstrate the next generation system products in gas and oil infrastructures in remote regions (monitoring and communication, control of block and gate valves, corrosion protection, etc.) and possibly the telecommunication towers power supply that grows fast in emerging countries. Both applications have a typical power need in the range of 0.5 to 5 kW under harsh climate conditions.

The manufacturers' solutions should provide products meeting all relevant requirements for remote power generation in potentially harsh climate conditions and develop technological strategies in order to close the gap between prototypes and pre-series manufacturing to a commodity.

Applicants should demonstrate firm commitment from end-users, through conditional orders or direct participation in the consortium during the application phase. In addition, projects should involve all relevant parties from the end user side such as gas and oil companies, telecommunication tower operators, telecommunication companies, fuel cell manufacturers and ideally suppliers of critical Balance of Plant components.

Applicants should also focus on the following targets.

Technical:

- Provide next generations of FC based systems for remote power supply that consider local/regional requirements to provide global products with regionally adapted solutions that match normative requirements like CE marking or other standards. This includes:
    - For the application in cold areas, the ability to start-up systems from -40°C from Natural Gas or from -15°C for LPG;
    - The fuel cell based systems demonstrate significantly higher efficiency compared to diesel generators with an AC electrical efficiency above 30% (LHV);
    - A design of BOP components should be realized for a broad range of climate conditions, which can be made available for different manufacturers. The projects should identify critical BOP components and where possible define common standards to generate synergies in the supply chain. Component suppliers are encouraged to participate in the projects to engineer and validate their solutions;
    - The broad applicability should be validated and demonstrated in a large field test, in order to verify the reliable operation (24/7/365 over 24 months). The intervals for proactive maintenance should be more than 12 months;
    - The service lifetime should be comparable to established solutions and life cycle costs should be lower than those of competing solutions. As necessary, further strategies for life cycle cost reduction should be developed;
    - The use of locally available fuels e.g. natural gas (from gas pipeline) or other relevant fuels should be demonstrated;
    - Remote system access and diagnosis plus smart service and maintenance concepts should be implemented;

Conceptual:

- Transform the prototype manufacturing into a concept for serial production, where reproducibility of production stages and availability of larger quantities are realised. Maintainability and reparability of components have to be improved in order enable local, less educated personal to do it within short time at low cost.
- Gain relevant statistical data for availability, degradation and service cost that will enable manufacturers to build guarantee and service contract concepts for end-customers.

Economical:

- The transfer from prototype to series production needs to reduce the balance of plant component costs by at least 30% for prototypes or be compatible with conventional series production where available through a technology platform approach. This involves value engineering e.g. simplification of the generator structure and modularization of the system and scale effects in the manufacturing process.
- Identify markets and needs for the distribution of the product and adapt it to specific requirements, if necessary. Search for existing networks of potential customers; possibly recruit local distributors for the marketing, sales, installation, commissioning and service.

The above-mentioned targets should be validated and demonstrated in a field test of pipeline and telecommunication applications by at least 3 stack manufacturers or fuel cell integrators with at least total 15 units in the power range of 0.5 to 5 kWe. Applicants should demonstrate a total sum of system electrical power capacity of at least 15 kW.

TRL at start: 5 and TRL at end: 7.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), in order to benchmark performance of components and allow for comparison across different projects.

International collaboration with countries under International Partnership of Hydrogen into the Economy (IPHE) is specifically encouraged for this topic.

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: 4 years.

Expected impact:

- Strengthening and growth of the European value chain for FC technologies by capitalising and seizing the large export market opportunity that fuel cell based remote power generation provides;
- Introduction of technology to niche markets for approval and demonstration at international customers' sites under real conditions such as oil and gas companies in e.g. North America and Europe, Asia and MEA will provide the base for long term experience to gain customer trust and for further cost reduction;
- This will enable to grow the application range to further markets with larger volume potential of several 1000 new installations per year in the telecom sector only in Asia, where usually no landlines will be installed and instead of that, cell phone communication will be established exclusively with increasing energy demand for internet services via mobile devices;
- Increase of trust towards new customer groups and improvement in the visibility as reliable and long lasting technology in the energy market, by demonstrations in relevant field environments in collaboration with stakeholders from other industry segments e.g. gas- and oil industry or telecommunication industry;
- A cost reduction of minimum 30% by means of value engineering and serial manufacturing technologies for systems and core system parts and use of standardized BOP components;
- Providing improved energy efficiency products with early commercial viability will contribute to the economic viability of fuel cell products overall and to the creation of a Tier level industrial structure allowing transferring scale effects to other applications;

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-02-4-2018: Thermochemical Hydrogen Production from Concentrated Sunlight

Specific challenge:

Carbon-free hydrogen production from water decomposition pathways powered by solar energy is a major part of the long-term R&D strategy of the FCH 2 JU for sustainable hydrogen supply. Thermochemical processes require less energy conversion steps for hydrogen production by renewable energy compared to electrochemical processes. Therefore, they have the potential to be more efficient.

Solar thermo-chemical cycles are capable to directly transfer concentrated sunlight into chemical energy by a series of chemical reactions. Based on concentrated solar radiation technologies the processes can be scaled-up to very large scale exceeding 100 MWth. Recent solar thermochemical research has focused on metal oxide based and sulphur based thermochemical cycles since they have the highest potential to be competitive, practicable and scalable up to an industrial level.

The success of those processes is often strongly linked to the availability of materials and components with the required properties. The performance of the current materials, mainly redox materials and catalysts is limiting the production rate of hydrogen in a concentrated solar power reactor. Sufficient heat can be introduced in the solar reactor. However, the mass transfer to the reactive surface, the heat transfer to and between the reactants and the chemical conversion rate of steam to hydrogen is limited by the properties and structure of the adsorbent materials currently available. Therefore, smart technical solutions are needed for material properties and structures on the one hand and for solar interfaces, reactor designs and for fluids consumption and handling on the other hand. Highly efficient components of the solar receiver/reactor unit as well as of the heat recovery unit are essential to achieve the required overall process efficiencies.

Scope:

Proposals should focus on improving performances and looking for compatible target costs of the final technology Improving performance and reduce cost of thermochemical hydrogen production from concentrated sunlight. New solutions of components and overall system should be validated in the field.

The project proposal should address the following elements:

- Improve the stability, cyclability and performance of functional materials for high temperature water splitting; in many cases a suitably tailored microstructural design of reactor materials shows promise to overcome some of the challenges; these suitable materials need to exhibit sufficient stability and activity over at least 1000 cycles or 5000 hours of operation;
- Design novel solutions for high temperature solid-solid and solid-gas heat recovery. This is of utmost importance to achieve highly efficient processes. Ca. 5 % are reported as the highest solar to fuel efficiencies of state of the art processes. To get closer to competitiveness such value needs to be doubled. Heat recovery rates substantially higher than 50 % are requested to meet that target;
- Design of highly efficient solar interfaces and reactors. High efficiencies are often bound to high reaction rates achievable through smart material solutions and fluids handling;
- Provide suitable and robust materials and design solutions for plant components with high thermal loads. The temperatures of the key components are very high. To provide such components ensuring lifetimes of more than 10.000 hours is crucial. Demonstration of long-term performance of materials and key components under realistic boundary conditions using existing solar test facilities is needed. A representative and meaningful

demonstration will be possible with core components like the solar receiver in a scale of about 500 kW. The testing period of the hardware should be of a relevant and representative duration, for a period of minimum 6 months;

- Design and development of intelligent systems and a smart process of control and automation, including predictive and self-learning tools;
- Embed and validate smart solutions to minimize the consumption of auxiliaries like flushing gas. Target should be to reduce energy losses through such auxiliaries to less than 25 % of the energy output;
- Comparative potential benchmarked analyses assessing the technical and economic viability prospects of the technology towards benchmark other processes needs to be refined based on state-of-the-art materials, components and processes;

TRL at start: 3 and TRL at end: 5.

The proposal should build on previous FCH 2 JU projects' results on related processes and should seek intensive cooperation with European and national projects dealing with thermochemical fuel production; cooperation with Mission Innovation challenge 5 ('Converting Sunlight')[20] is 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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected duration: 3 - 4 years.

Expected impact:

The project is expected to advance the knowledge and prove the technological feasibility of the concept of solar thermochemical water splitting including the environmental, social and economic benefits. The proposal should show its contribution towards building a sustainable renewable energy system contributing to the decarbonisation of our economies. The proposed solutions are expected to contribute to strengthening the EU leadership on renewables. In the case of solar-thermochemical water splitting this will be achieved through proving the feasibility and performance of key materials and key components needed to carry out the process in relevant scale.

The consortium will ensure that following actions are included in the project to fulfil to the planned target and reach the KPIs, such as:

- The process should be demonstrated at realistic scale and working conditions, ideally using an existing solar demonstration facility (>2 hundred-kW range);
- The process and plant behaviour should be validated through medium to long-term operation;
- Finalization of a design and development of a technology with annual solar-to-fuel efficiencies in the range efficiency of 10 % (ratio of solar radiation entering the plant to calorific value of the fuel exiting the plant), doubling the state-of-the-art efficiency for processes with about 5 %;

[20] http://mission-innovation.net/our-work/innovation-challenges/

- Demonstration of at least 5 % efficiency in the field tests;
- Achieving of heat recovery rates of high temperature heat in excess of 60 %;
- Achieving a process strategy allowing full automation.

These are needed to establish solar thermochemical water splitting as a completive technology for suitable sites and to contribute to achieve economic competitiveness to hydrogen production through PV or CSP powered electrolysis.

The project results should contribute to an increased decarbonisation of the transport sector, to a reduced dependency on fossil fuels and to a reduction of emission of air pollutants. The project should create significant visibility to the potential of applying solar thermal energy for fuel and in particular hydrogen production.

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-02-5-2018: Hydrogen carriers for stationary storage of excess renewable energy

Specific challenge:

Hydrogen storage and delivery are essential components of future fuel cells and hydrogen-based technologies. Depending on applications, different sizes of storage of hydrogen close to the final use may be necessary, e.g. industrial scale storage is required to deal with imbalances between supply and use of hydrogen, those caused by fluctuations in availability of renewable electricity.

Storage and handling of hydrogen in gas phase often needs significant amount of energy for hydrogen compression up to at least 350 bar. This process is usually performed with mechanical instruments (i.e. compressors, pumps), with low efficiency and heat losses. Therefore, the use of low-pressure (i.e. lower than 50 bar) alternatives based on hydrogen carriers could decrease CAPEX and OPEX of hydrogen storage significantly.

The basic aspects of hydrogen carrier technologies are well established, but the demonstration to efficiently store and/or deliver hydrogen is still in an early stage of industrial development and while the basic aspects of individual components of such a storage solution are well established, there has not been a lot of research that focused on a proof-of-concept that demonstrates this storage solution from end to end.

Further developments and demonstration in applications with larger market potential (like e.g. low-pressure hydrogen storage in residential applications for medium to long-term energy storage or at off grid locations) are necessary.

Scope:

Novel energy efficient, compact and cost effective hydrogen carrier solutions should be developed for hydrogen storage in grid independent energy supply systems, e.g. for on-site hydrogen production from renewables connected to green hydrogen supply to FC (HT-PEFC, SOFC, etc.) to be used in stationary applications.

Safety issues for hydrogen storage and delivering should be specifically addressed. Suitable normative related to hydrogen handling using carriers should be considered. The use of non-Critical Raw Materials is highly recommended.

The projects should demonstrate a prototype of a storage system based on hydrogen carriers for an application with significant market potential, in order to move hydrogen carriers out of niche markets. The integration of the prototype system from a hydrogen production to delivering is required within the project. The results of the project will support the management of variable sources in applications at the medium – large scale, such as energy generation from power plans based on renewable sources.

Projects should achieve a break-through in increased energy efficiency and compactness of the complete system with respect to current technologies, as well as reduction of necessary hydrogen compression steps, optimizing the complete hydrogen storage and delivery chain. Depending on selected storage technology, a purification step might be included.

Project work should encompass a complete energy and cost analysis of the state-of-the-art in the specific application, including cost for hydrogen and energy supply, cost for storage including hydrogen processing as well as depreciation of system components.

The overall achieved improvements in increasing energy efficiency and safety, while reducing cost for the system itself and its maintenance should be investigated in a techno-economical evaluation of the developed system.

A LCA of the concept should be included to evaluate the potential improvement in energy efficiency and environmental performance of the complete system with respect to current technologies. The LCA should contemplate also the management of raw and waste material, as well as other recycling issues.

Based on a specific business case, the amount of H2 to be stored should be clarified and a cost analysis of the whole hydrogen storage and delivering chain should be provided.

Proposed projects should have at least one industrial partner (carrier and/or storage system production) in the consortium, to both exploit the results and prove a business case for the developed hydrogen storage solution based on the particular hydrogen carrier.

Projects within the scope of call topic FCH-02-6-2017 (Liquid organic hydrogen carrier) are not eligible for this call.

TRL at start: 3 and TRL at end: 5.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected duration: 3 years

Expected impact:

The expected achievement from the project is a proof of concept of a hydrogen carrier system for stationary storage, integrated with hydrogen production from renewables and use in energy supply devices (e.g. FC). This application area is expected to provide promising export markets for the European industry.

A medium-scale prototype system with developed carriers should be demonstrated by the end of the project with a capacity of ≥ 50 kg H2 and integrated with an existing application, including hydrogen storage and delivering steps. Optimized hydrogen and thermal management should be demonstrated. The system should demonstrate a safe operation and maintenance along the whole chain, including toxicity and health aspects. An added value to the proposal is the hydrogen production and use as a part of the project, however their cost is not eligible in the proposal.

The KPIs for hydrogen storage include the whole process for carriers' hydrogenation as well as dehydrogenation. All of the following specific KPIs should be obtained and demonstrated:

- Target of hydrogen stored capacity for in-field testing > 50 kg H2;
- Carrier volumetric density > 0.1 kg H2/litre;
- Discharge energy use from sources external from the prototype system < 5.0 kWh/kg H2, i.e. less than 15% of the energy content of hydrogen per kg;
- Total round-trip energy efficiency > 70% including compression, energy supply to store and BoP, etc.;
- Loading and unloading of hydrogen has to be demonstrated in the carrier for at least 250 cycles and in the prototype for at least 50 cycles, with acceptable loss of storage capacity less than 0.2 % per cycle;

- Hydrogen purity at point of delivery at least 99.99 %.

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-02-6-2018: Cost-effective novel architectures of interconnects

Specific challenge:

Interconnects are crucial components in the upscaling of successful cell concepts to stack performance and reliability. Compared to PEM technology, this pathway is more critical for SOFCs and SOECs (SOCs, including reversible SOC), where cell-interconnect contacting is an enduring challenge. Interconnects are located between individual cells, thus being exposed to both reducing and oxidizing atmospheres at the SOC's elevated temperatures. This leads to highly stressful conditions for the interconnects, causing significantly higher ASR values per cell in stack configuration than for a single repeating unit for SOC.

Furthermore, due to poor stability over long operating periods of the contact area of coated interconnects, Ohmic resistance increases with time – mainly on the oxygen side – affecting the electric performance of the stack. Thus, SOC interconnects are called for with robust, conductive coating, able to withstand extensive thermal cycling, with fully compatible thermal expansion coefficient, and with improved architecture and/or surface material to guarantee better as well as more durable contacting between cells and interconnect. While ceramic interconnects deliver desirable electronic and mechanical properties, the low ductility of the material challenges their contacting capabilities. Adding to the low design flexibility of ceramics, the low porosity leads to high-pressure drops, lowering the overall efficiency.

Scope:

Besides maintaining excellent, long-term electrical contact through high specific-surface current collection area, it is crucial to maintain low-pressure drop in the channel distribution of the interconnect, while providing fine flow field patterns for optimal contact resistance and high-power output. Fabrication costs should be kept low and the manufacturing investment cost-effective. Uniform and impermeable gas-tight coating should be achieved to protect against chromium evaporation with high electrical conductivity material. It is recommended that outcomes of FCH 2 JU projects Scored 2.0 and Evolve are taken into account.

The interconnect solution developed in this project should include the bi-polar plate itself together with the protective coating and the contacting materials to make the junction between cells. The development should make use of novel 3D contact Materials and manufacturing solutions that are flexible in use and could be adapted to any manufacturer's planar stack design, as well as being adaptable to mass-manufacturing processes. Designs that reduce to a minimum the required manufacturing steps is desirable in this respect: this should be proven with a representative stack production batch. The solution proposed should be operational in a temperature range of 600-750°C or 750-900°C, as these two temperature ranges will most likely lead to different material requirements. For electrolysis operation, the fuel side will pose harsher demands on the interconnect than in fuel cell mode (e.g. chromium evaporation), which should be accounted for.

The solution should provide excellent capacity for absorbing applied pressure between current collectors and interconnect, as well as compensating planarity tolerances of adjacent components, allowing 30-50-micron tolerances. It should thus ensure uniform mechanical pressure on the whole cell and maintain lightness of stack. Chemical and thermomechanical compatibility with neighbouring component materials, including sealing when relevant, and electrode materials, should be guaranteed for the targeted operating conditions. The developed interconnect should maximize gas permeability to guarantee low-pressure drops. Improved, uniform conducting throughout the operation ranges prevents hotspot formation and lifetime benefits are to be expected.

Regarding interconnect materials, critical rare-earth elements should be avoided as much as possible, in view of a strategic supply chain for Europe, and long-term stability should be guaranteed, avoiding material inter-diffusion between contacting components.

The final interconnect design(s) should be demonstrated for more than 3000 hours and 50 cycles in a 1 kW stack.

TRL at start: 3 and TRL at end: 5.

MRL at start: 4-5 and MRL at end: 7-8.

The full value chain of the proposed novel interconnect (from raw materials supply to fabrication and assembly methods, compatibility with SOC technology type and material recovery) should lead to a strategic position of established European manufacturers in the international SOC supply chain and leverage job creation opportunities in the EU. It is expected that the proposal involves a component manufacturer based in EU or H2020 Associated Countries, who should be willing to expand or significantly enlarge its current product portfolio with low-cost interconnects. Similarly, it is expected to involve at least one stack manufacturer to adopt the novel interconnect architecture and show marginal dependence of interconnection fabrication costs on SOC stack design.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected duration: 3 years.

Expected impact:

Improved contacting, flow distribution and interface stability will lead to radically better performing interconnects, and thus SOC stack performance and durability. This should lead to a demonstrated increase in stack lifetime in representative operating conditions, allowing service that is more reliable to the end user.

Furthermore, it is expected that – by virtue of the materials chosen and their assembly – the interconnect materials system and shaping process proposed shall be global and the solution should be adaptable at low cost into any SOC manufacturer's specific stack design, benefiting the lifetime and stackability of individual cells.

Finally, the impacts on the overall supply chain should boost European competitiveness by generating a strategic position in terms of the capability of shaping specialty materials for advanced applications, leveraging capital and excellence in European manufacturing industry, and should build on research organisations' existing competences and ultimately stimulate competition on the International market.

Technical targets, considering both fuel cell and electrolysis operation modes:

- ASR of the interconnect as a component: <25 mOhm.cm^2
- Gas pressure drop: below 30 mbar/plate across the interconnect in stack configuration
- ASR-Degradation: <5 mOhm cm^2 or <0.2 % (whichever the higher value) per 1000 hours or 10 cycles in a system relevant environment

- Extrapolated Costs: <5€ per unit for interconnect materials + <5€ per unit for coating and processing at a production volume of 50 MW per year.

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-02-7-2018: Efficient and cost-optimised biogas-based co-generation by high-temperature fuel cells

Specific challenge:

Biomass can be easily converted to fuel gases rich in CH_4, CO, and H_2, depending on the biomass treatment in anaerobic digestion, thermochemical conversion, or fermentation. The direct use of biomass-derived fuel in high-temperature fuel cells for combined heat and power (CHP) promises significantly higher electrical efficiencies of 55 to 60% and ultra-clean exhausts. Unlike for gas grid injection, the CO_2 content in biogas does not have to be removed from the fuel stream, but can on the contrary be used as reforming agent (dry reforming) and increase the electrical efficiency. This greatly simplifies the system layout and avoids the supply of steam for reforming. In addition, separation of leftover bio-CO_2 after the CHP generation process will be straightforward and can bring significant benefit to the use of High Temperature Fuel Cells (HTFC) CHP systems in future CO_2 valorisation scenarios. For all of these reasons HTFC systems have the potential to achieve technical, environmental and economic advantages relative to currently available biogas conversion technologies.

The use of HTFC is currently being demonstrated in ongoing projects. In particular, the FCH 2 JU funded project DEMOSOFC is demonstrating the use of biogas from a wastewater treatment plant for heat and power production using a HTFC. In this project, the HTFC requires to first clean-up and purify the biogas to grid quality prior to conversion into power and heat. This represents a significant added cost to the overall system, hindering cost-effective exploitation of the technical and environmental advantages of the use of raw biogas in HTFC.

Biogas is primarily methane (CH_4) and carbon dioxide (CO_2). Depending on its origin, it usually contains small amounts of hydrogen sulphide (H_2S), moisture and siloxanes, or also significant amounts of nitrogen in the case of landfill gas. The removal of pollutant and CO_2 for the purpose of grid injection is increasingly applied for wastewater treatment plants, which often are located close to the gas grid and present significant volumes of gas. However, biogas from distributed sources such as agricultural waste and manure, or dilute gases like from landfill, are rarely injected. Farms are usually not connected to the gas grid, and in the case of landfill gases, it is rarely economic to concentrate the methane to grid quality. In the latter case, it is even common practice to add methane to the biogas to flare(burn) the gas in order to prevent the methane to vent directly to the atmosphere. This transforms a primary fuel in an energy consumer.

HTFC are in principle able to able to exploit the contained CO2 to increase the conversion efficiency by using the CO_2 as reforming agent. The so-called dry-reforming process is replacing then either steam-methane reforming or the catalytic partial oxidation commonly used in fuel cell systems. HTFC as electrochemical energy conversion devices have a high resilience to inert gases such as nitrogen compared to combustion engines. The fuel cell exploits directly the chemical energy contained in the fuel without a combustion process. Independent from above elements, the pollutants such as sulphur components, halogens and siloxanes still need to be removed.

The challenges addressed is to perform the pollutant removal for the HTFC in a simple, low-cost, modular manner, capable to operate on multiple feedstock sources of biogas (organic fraction of urban waste, agricultural/farming residues, landfill, etc.). The removal needs to be able to cope with seasonal or geographical variations, and to reduce significantly complexity and costs related to biogas pre-processing. On the level of system integration, the appropriate conditions for the use of dry-reforming instead of steam reforming with a minimal changes with respect to standard HTFC systems is a further challenge, as only limited customisation can be economically justified. Furthermore, HTFC system operation strategies need to be elaborated to allow system operation with dilute fuels, again with ideally no hardware changes with respect to standard HTFC systems.

Scope:

The scope of the project is to design and engineer an integrated biogas-fed fuel cell system architecture with minimal gas pre-processing. The aspects of low-cost pollutant removal and thermal integration of the system to increase the system efficiency by using the inherent CO2 of the biogas should be the focus of the project. Operation strategies allowing the system to use dilute gases should also be studied.

Proposals submitted under this topic should focus on the conceptual and detailed design of a HTFC-CHP system optimised for raw biomass-derived gaseous fuel operation in a real environment, processing different types of biogas feedstock, coping with gas composition fluctuations and pollutants. More than one type of biogas should be considered, especially considering applications where conversion to bio methane and injection into the natural gas grid is not feasible. In the design, gas fuel pre-processing should be kept to the absolute minimum, integrating potentially processing catalysts for pollutant removal and fuel pre-reforming. The interface between the raw (2nd generation) biomass processing reactor and the fuel cell hot module should be a unique, one-stop appliance that is able to process the full range of bio fuel-gas compositions expected from a given bio-waste valorisation chain. The output gas has to match the requirements of the fuel cell module optimized for bio fuel-gas conversion.

To this effect, targeted tests on clean up, reforming and HTFC materials and components (catalysts, supports, adsorbents, membranes, cells/stacks), where not available from the state-of-the-art, are within the scope of the project. They aim to provide pollutant tolerance level of the critical components of a HTFC system and will provide the base for the final design specifications of the gas cleaning unit. The impact of dry reforming on anode electrodes, to avoid auxiliary steam supply in the system should be evaluated at laboratory scale and reported according to procedures developed in relevant FCH 2 JU projects.

The one-stop bio fuel-gas processing stage should take into account outcomes of previous projects investigating this coupling, such as DEMOSOFC. Where applicable, thermal integration between the FC module and the bio fuel-gas generation should be considered in the system architecture to maximize process efficiency.

Developments that directly modify and adapt the stack and/or reformer to increase their pollutant tolerance levels should only be planned where reduced total cost of ownership for the generated electricity can be expected. This is always to be analysed in comparison with the current base method of purification for pollutant removal.

The design of full-scale FC-CHP units for installation at biogas production sites should be addressed in the project. This should include pathways for the use of bio-CO2 produced. The selection of the size of full-scale should be based on existing market analysis with clear indications of the technical and economic advantages in comparison to both other power conversion technologies (e.g. combustion engines) and gas grid injection.

TRL at start: 3 and TRL at end: 5-6.

At least 2 HTFC manufacturers should participate to open an opportunity to exploit the built-up competences in biogas pre-treatment independently from the FC system manufacturer, offering a business opportunity for specialised actors.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 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: 2 years

Expected impact:

The use of HTFC-CHP systems is well aligned with European energy and waste related policies. The EC communication on "The role of waste energy in the circular economy"[21] prioritises the use of advanced conversion technologies to obtain bio-derived gas especially for the treatment of biodegradable waste. The expected impact of biomass driven HTFC is therefore very high being a very significant entry market for the deployment of renewable sources-driven HTFC in the medium industrial scale. Based on the modularity of fuel cells, they will likely address initially smaller, distributed power ranges, before addressing at a later stage the large quantities of low quality gases of landfill and retired coal fields.

To profit from this opportunity, the specific impacts the proposed design should achieve are then:

- Increased conversion efficiency of waste-derived fuel to electricity and heat, with electrical efficiency above 53% for ordinary biogas;
- Energetic exploitation and reduced methane consumption for strongly dilute biogas sources, providing a net electricity output;
- a modular biogas processing design that can be easily retrofitted to existing biogas sources;
- an opportunity for European gas component manufacturers to provide flexible gas cleaning modules to several FC system manufacturers, in Europe and world-wide;
- a gas cleaning system eliminating external auxiliary reactant supplies and coping with a variety of biomass-derived fuel-gases, ideally operable in flexible fuel mode;
- standardization of the clean-up section to address different types of biomass-derived fuel gases, leading to compositions acceptable for long-term operation of the optimized fuel cell hot module;
- validation of dry reforming capability in the fuel cell to improve efficiency and cost-effectiveness of the integrated system;
- projected cost target of < 3.500 €/kWel fuel cell and gas cleaning system at a production volume of 25 MW p.a.;
- demonstration of environmental benefits using an LCA;

[21] Brussels, 26.1.2017 COM(2017) 34 final

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.

<u>FCH-02-8-2018: Waste-stream based power balancing plants with high efficiency, high flexibility and power-to-X capability</u>

<u>Specific challenge:</u>

Renewable energy sources are significantly reshaping the energy production scheme in Europe. Today's still dominating fossil fuels will be significantly reduced in their role as electricity source. Despite this, carbon containing renewable primary energy in form of industrial and municipal waste, secondary and tertiary biomass, or even waste discharge recovery sites will remain available in significant amounts. Those waste streams can be converted through various processes into syngas containing hydrogen, carbon monoxide and carbon dioxide in varying quantities. The flexibility of Solid Oxide membrane reactors to operate both in electrolyser and fuel cell mode offers the possibility to exploit those streams both to convert electricity into gas and to convert the streams directly into electricity. Balancing power plants can and play an important role for both power generation in low production periods and grid stabilisation and energy storage through their power-to-gas capability. They also offer a potential low-cost source for renewable CO2.

The challenge addresses the elaboration of concepts (process flow diagrams) for power balancing plant based on the thermal integration of various gasification processes and Solid Oxide membrane reactors. Both the waste-to-syngas process and the solid oxide membrane reactor operate at elevated temperatures and offer thereby possibilities of synergies for H2 or CO2 out-coupling, use of O2 enriched air for gasification and thermal coupling are available. The aim is to provide high energy system benefits in the evolving energy landscape, making use of the carbon containing waste streams for the simultaneous application of power generation and energy storage in a single balancing plant. The plants both contribute to the elimination/transformation of municipal waste, industrial waste, waste disposal site recovery and the balancing of the electricity grid. This kind of plants are closing one gap in the circular economy.

<u>Scope:</u>

Based on existing future energy and sustainability scenarios, the project should identify:

- What low-grade waste streams will likely remain available in the long term and
- What processes could be suitable to transform them inside Solid Oxide Cell membrane reactors into fuel for power generation or feedstock for power-based chemicals and fuels.

To reach economic viability, such plants need to integrate the usually energy consuming waste preparation steps tightly into the different operating modes. Flow sheeting including pinch analysis provide a base for selection of optimised solutions in terms of electrical efficiency and/or flexibility in use for the provision of grid services. The analysis performed should clearly identify the requirements of the integration into a RES dominated power generation landscape. Economic viable paths to reach power scales both meaningful for the waste conversion and power balancing are to be elaborated. Analysis should be performed on what size of balancing plant is suitable both based on available waste stream and the propriety of a RES electricity supply. From there, the economic requirements in terms of investment costs for such a plant have to be estimated to define the conditions for business cases. A pathway for a gradual integration of such plants based on today's State of the Art is to be elaborated. The small size of the current stacks and systems likely requires a modular up-scale approach. Supply chain constraints of the first commercial products are important boundaries. Experiences and learning curves from other modular industries e.g. the semi-conductor industry can be used as reference cases to understand under what conditions such a new industry could emerge.

The project should:

- Identify the long-term available low-grade waste streams;
- Elaborate RES Integrated large Power Balancing Plant Designs/flowsheets with Solid Oxide technologies at the core for the scales of 1, 10, 100 MW and 1 GW. The conversion plants integrate directly waste preparation process on both thermal and electrical level;
- Suggest development paths and strategies for Solid Oxide Cell power plants from current small-scale technologies and products;
- Identify technical bottlenecks at any level (materials, components, systems, externals such as CCU limitation) that need to be resolved for realising such plants and suggest possible measures;
- Elaborate under what conditions centralised large scale power conversion plants can be technically and economically realised within the next 10 years;

The technical readiness level will remain on the same level during the project (TRL 2), as conceptual engineering work is in focus rather than experimental work. However, the work goes clearly beyond a conventional study as new concepts are to be elaborated on the technical level, making use of thermodynamic simulation tools and methods such as pinch analysis.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 0.5 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: 18 months.

Expected impact:

The project will provide paths for the techno-economic viability for the deployment of centralized large-scale Solid Oxide plants to buffer the power needs emerging from intermittent and fluctuating RES and offer power storage options in renewable carbon- based chemicals and fuels.

Power conversion plant designs integrating required waste preparation steps (various gasification processes, alternative purification processes) will prepared.

System management and operating strategies integrating partial/peak loading fluctuations amplitudes and frequencies will be recommended.

The outcome of successful project should lay ground towards technological development to address a large market for Solid Oxide reactors in conjunction with RES and the possibilities of providing power storage in synthetic fuels and providing renewable CO2 for further use. The technical concepts elaborated should provide pathways for a faster transition towards a RES dominated energy system at lower overall 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.

OVERARCHING ACTIVITIES

FCH-03-1-2018: Developing Fuel Cell applications for port/harbour ecosystems

Specific challenge:

Ports/harbours facilities are typically located near cities/residential areas and are negatively affecting the environment, in terms of air and water quality, noise and emissions. To meet regulatory requirements for urban air quality and the establishment of low emission zones within cities increasingly requires that emissions for industrial mobile applications must be addressed in addition to road transport. The environmental footprints from ports that are close to urban centres are high not only due to for the presence of shipping with large diesel engines, but also due to the large numbers of vehicles and cranes that move goods. Emissions from terminal port container operations associated with electric power are estimated to contribute approximately 10% of the total port GHG emissions (CO_2) while emission caused by port transport typically accounts for up to 30%, with the remaining majority of emissions caused by to ships' generators. Concerning port operations, rubber tired gantry (RTG) cranes, yard trucks and material handling vehicles dominate fuel consumption. Some projects supporting the deployment of battery electric vehicles or LNG fuelled vehicles have proven effective to reduce fuel consumption and to enhance port operation. With increasing focus on both local and global emissions, zero emission solutions that have a capability exceeding current battery electric propulsion technology or cable reel electric supply[22] are required. For such applications, the suitability and viability of fuel cell technologies should be assessed. Based on this assessment, the most promising solutions should be developed and validated in the field, including logistic solutions for hydrogen refuelling, possibly combining fuel infrastructure with supplies to other local users.

Fuel Cell technologies are able to challenge the autonomy and charging time problems in the short term with the adoption of automotive stacks technologies on board various applications of port vehicles (forklift, rubber cranes, container handlers and so on). The adoption of hydrogen technologies could have an economical advantage inside an integrated port environment that consider at the same time shore mobile applications, on board applications and semi-stationary APU (auxiliary power unit) support systems that may be used for example to provide shore based electrical power to ships in port.

Scope:

This project aims to develop, to deploy and to benchmark industrial FC vehicle for port operation, evaluating FC technology applications and emission reduction impact inside EU ports. The project will cover the R&D cost of new FC vehicles that will integrate the already existent FC power systems available on the market (the project will not cover the cost of R&D for new FC systems).

Proposal should include the installation of at least two of the following types of vehicles:

Vehicle Type	Power Range. (Minimum Fuel cell Power: 50kW)
Gantry cranes	50 to 120 kW
Yard Trucks	50 to 80 kW

[22] https://www.kalmarglobal.com/equipment/shuttle-carriers/FastCharge/

Special Material Handling vehicles such as straddle carriers	60 to 320 kW

The proposal should consider not only vehicle deployment but also:

- Hydrogen port infrastructure for land vehicles, including synergies with other local hydrogen consumers;
- Hydrogen port infrastructure plan/strategy for ships, cruise ships and working boats;
- Hydrogen logistic and refuelling;
- Safety aspect related to emergency protocols, staff training, refuelling (vehicles), bunkering (ships);
- Collaboration with Marine Coast Authority and other relevant certifying authorities;
- Customer acceptance;
- Evaluation of EU market (port applications);
- Evaluation of emission reduction impact.
- Appropriate battery hybridisation, particularly for cranes.

The overall scope will be to investigate an integrated Fuel Cell based solution for port equipment that will enable regional authorities to meet EU air quality requirements, IMO pollutant emission prescription and the second step of the European Commission strategy for the reduction of maritime CO_2 emissions/greenhouse gas reduction targets for the maritime transport sector. The project should address the following issues:

- Select the most feasible solution (types of vehicles and number) in terms of technical and economic aspects, able to prove the most effective reduction of CO_2;
- Reduction of vehicle noise under 60 dBa and global operation noise reduction;
- FC systems and operating procedures should address specific European safety standards;
- Consider a refuelling station with onsite hydrogen production or with external hydrogen supply;
- LCA of environmental performance of vehicles, infrastructure and energy source (from energy source to vehicle);
- Total fuel cell system installed power of at least 250 kW;
- The vehicles should be validated and tested for a total period of minimum 2 year or vehicle operation > 5000 h, demonstrating a lifetime of 20,000 h;
- Availability > 90% (measured on operation time);
- Ability of the systems to withstand pollutant air coming from salt, PM and unburned fuels coming from ICEs exhausts of ships and other machines;
- The solution should be replicable in other ports/harbours.
- Assess the business model for deployment and identify the ports and harbours where most benefit could be achieved.

The vehicles, cranes and industrial equipment should be designed to meet end users' requirements. The vehicles could be pure fuel cell powered or use a FC/battery hybrid architecture.

The project should perform an economic assessment and derive fuel cell system total cost of ownership for the selected target application including refuelling and system maintenance and comparison with alternate zero emission technologies such as direct electric supplies or batteries.

TRL start: 4-5; TRL end: 6-7

The consortium should include a port authority (public entity in general), at least one terminal operator (passenger, container or other) – end user, and a regional or urban authority responsible for air quality in an advisory role.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 4 million per project 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: 4 years.

Expected impact:

Expected impacts of the project include:

- Validated FC technology performance in terms of emission reduction (CO_2), pollution reduction (SOx, NOx, PM) and techno-economic aspects for port industrial vehicles;
- Assessment of the FC technology market potential for port industrial vehicles, cranes and mobile equipment;
- Successful introduction of hydrogen technologies in ports and marine sector (new sector);
- Increased users' hydrogen acceptance and knowledge;
- Industrialization and production ready FC vehicles, cranes and mobile equipment are expected to be defined as an outcome;
- Validation and demonstration of system safety strategy and recommendations for the port and marine sector.

The project should provide a significant step towards successful market introduction of FC industrial vehicles inside the port sector, with a significant impact in the reduction of CO2 emissions and air pollution from ports. The project should support the establishment of a European Supply Chain and foster value creation in European industry. Professional dissemination of information on the activities of the project to the broad public is considered as a key part of this project; it should especially be foreseen to communicate the benefits of hydrogen and fuel cells for port operations. Regional authorities could support the project with communication activities.

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-04-1-2018: PNR for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces

Specific challenge:

It is a long standing finding of the research community that hydrogen behaves very benign in free environment. Confinement and congestion, however, promote more severe accidental consequences. The Network of Excellence (NoE) project HySafe derived from this the strong need for improving the principal understanding of and the development of validated risk assessment tools for the accidental behaviour of hydrogen in tunnels and summarised the state-of-the-art in the HyTunnel study[23]. Facing the intended accelerated deployment of hydrogen powered mobility on one side and the steadily increasing part of traffic infrastructure, which is established in tunnels or in similar confined spaces on the other side, will urge any new standard or regulation for transport systems to address also the specific safety issues involved with this new alternative fuel in tunnels and similarly confined space, like underground parking etc. Serious fires in some road tunnels in the Alpine countries during the years 1999 and 2001 triggered the issuing of the European tunnel safety directive 2004/54/EC[24]. National implementations of this directive are due by 2019[25]. Neither this directive nor any other international regulation, codes or standards, e.g. PIARC 1999[26] or NFPA 502[27], provide specific guidance for evaluating the appropriateness of conventional mitigation technology (ventilation, water spray or fog, foams, etc.), conventional safety management and established first responders strategies in case of a tunnel accident with an hydrogen vehicle or hydrogen transport involved. The referred methodologies (FMEA, CFD, etc.) are rather generic and lack validated models for evaluating the effectiveness of the quite expensive tunnel equipment.

Therefore, the aforementioned European regulation related to tunnel safety and safe efficient supply of the alternative fuel hydrogen (AFI Directive) and the related safety assessments urgently require a sound scientific basis and a better understanding underpinned by experimentally generated validation data. Obvious knowledge gaps concerning the interaction of hydrogen dispersion and in particular combustion with existing safety installations have to be filled with pre-normative research, relying equally on experimental proofs and numerical extrapolations. The generated knowledge and tools should be translated to similar scenarios, including railway tunnels and underground or multi-storey car parking.

Scope:

The scope of the proposed project shall be confined to traffic infrastructures, in particular tunnels according to the implementation of EU directive 2004/54/EC and the effectiveness and interaction of conventional and innovative safety measures in case of accidents with hydrogen-powered vehicles or hydrogen transport in tunnels. For providing guidance and suitable performance based requirements to regulatory bodies, technology suppliers and operators, an experimental program shall be designed

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[23] HyTunnel Internal Report, NoE HySafe
www.hysafe.net/download/1763/Hyunnel_Final%20ReportDraft_20Feb09_final.pdf

[24] European Directive 2004/54/EC on minimum safety requirements for tunnels in the Trans-European Road Network

[25] Richtlinie für die Ausstattung und den Betrieb von Straßentunneln'' (RABT), German Implementation of the European Directive 2004/54/EC

[26] World Road Association (PIARC) (1999). Fire and smoke control in road tunnels. World Road Association, Paris, France

[27] NFPA (2004). NFPA 502 – Standard for Road Tunnels, Bridges, and other Limited Access Highways, (a) 2004 ed.; (b) 2008 ed. National Fire Protection Association, Quincy, Massachusetts

and executed to analyse the interaction of hydrogen, its mixing and combustion behaviour, with conventional extinguishing agents, such as water sprays, water fogs, and foams, to investigate the influence on and effectiveness of ventilation and concerned ventilation strategies, to test the functionality and effectiveness of conventional safety installations and measures and if necessary to provide additional requirements for technical improvements regarding specific prevention and innovative mitigation techniques. The potential accumulation of hydrogen in air ventilation ducts, apertures and chambers and the specific hazards imposed by late ignitions and subsequent explosions shall be taken into consideration. Beyond that, the project shall also address the opportunity to support with the new data the validation of already existing models and quantitative risk assessment tools Thereby the results of the project will be available not only for safety evaluations of tunnels systems but also for similar confined traffic infrastructures like parking garages etc.. It will make the safety assessments more robust and potentially reduce costly over-conservatism. The analysis should also provide suitable data and information to instruct first responders for revision and improvement of their intervention strategies as well as of the general accident management. So the project activities should encompass:

- Review of the current knowledge (state of the art) concerning safety in confined traffic infrastructures (especially tunnels) and its underpinning experiments as well as situation related to RCS in Europe;
- Definition, characterisation and delimitation of EU tunnels as well as confined spaces in subcategories pertaining to the relevance of hydrogen vehicles and transportation (e.g. by length, cross section, ventilation rate, traffic throughout, hydrogen present per km, existing fire management facilities etc.) to aim on detailed understanding of fire and safety issues by category;
- Identification and prioritisation of relevant knowledge gaps and scientific results (data) compared to the scope above;
- Definition and realisation of necessary experiments, to investigate the interaction of hydrogen and hydrogen flames with conventional mitigation systems and strategies to prove effectiveness of conventional safety measures and/or deviate mitigation techniques and concepts;
- Identification and evaluation of innovative safety strategies and engineering solutions to prevent and mitigate potential accidents with hydrogen powered vehicles in confined infrastructure with an initial focus on tunnels;
- Check, and in case develop further intervention strategies and tactics for first responders providing conditions for their life safety at an accident scene and to maximise property protection;
- Derive guideline for the proper use of mitigation systems and draft recommendations for standards developing organisations (SDOs);
- Establish communication channels with other research communities worldwide and involved international SDOs for the sustainable implementation of the project outcomes;
- Collaboration with FCH 2 JU safety panel and identified experts worldwide.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 per project 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:

- Unique experimental data concerning the interaction of hydrogen with tunnel safety equipment and the special geometries of confined infrastructures will be available;
- Deeper knowledge of the relevant physics will provide better hydrogen safety engineering to underpin the development of innovative prevention and mitigation strategies;
- Experimental data to support further development and validation of relevant physics models, simulation and risk assessment tools;
- Recommendations for prevention and mitigation concepts for inherently safer use of hydrogen vehicles and safer transport of hydrogen in tunnels, and other confined infrastructures, such as underground parking;
- Analysis of effectiveness of conventional safety measures in tunnels and other confined infrastructures like underground garages etc.;
- Potential reduction of over-conservatism and increased efficiency of installed safety equipment will save costs;
- More appropriate intervention strategies and tactics for first responders to tackle potential accidents with hydrogen powered vehicles in tunnels and underground parking etc. will protect life of first responders, people and property;
- Commonly agreed, scientifically based recommendations for the update of relevant RCS will lead to a more harmonised normative landscape and level up the safety culture in general;

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-04-2-2018: Hydrogen admixtures in the natural gas grid

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 (see e.g. working document on Energy storage – the role of electricity SWD(2017) 61). There are, however, a number of challenges for the existing gas grid infrastructure and end use equipment to operate safely with the admixture of hydrogen (H2NG). 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. Depending on the hydrogen concentration, among other parameters, different components of the gas system or end-user appliances and processes may be affected. Generally, the addition of hydrogen to natural gas influences gas properties and therefore operational aspects, functionality of devices and appliances, degradation of materials and infrastructure requirements (safety and functionality). The performance and safe operation of existing industrial turbines, industrial burners and residential burners have been identified as critical issues that need to be addressed on short term to enable the further uptake of hydrogen in the natural gas grid (e.g. see the Final Report of the CEN - CENELEC Sector Forum Energy Management/Working Group Hydrogen). For turbines and burners, the actual impact of a continuous and likely varying supply of H2NG on the combustion is to be verified with the potential impacts on the safety of appliances and applications and the impacts on efficiency, lifetime and environmental performance (e.g. NOx emissions). Results from previous and ongoing national and EU projects should be considered (e.g. NaturalHy, GASQUAL, HIPS, DOMHYDRO, GRHYD, HyDeploy, etc.).

Power-to-gas systems injecting admixtures of 2% have been widely demonstrated, further demonstrations of up to 20% (e.g. GRHYD, HyDeploy) are underway and it has been shown that such systems can operate to provide grid services and absorb surplus renewables. However, the economic factors in progressing from natural gas to H2NG blends within the gas grid have yet to be established. An exhaustive techno-economic evaluation of admixture of hydrogen into the natural gas grid adapted to the local, regional or national situation should therefore be undertaken, with a particular focus on policy options. Such an evaluation should identify all relevant cost drivers, benefits and risks, considering both technical and financial aspects. Cost efficient strategies for adapting the infrastructure can then be developed and a roadmap for the injection of hydrogen prepared to support a macro-economically feasible transformation path towards higher limits for allowable hydrogen concentrations in the gas system.

Scope:

The scope of this topic encompasses a techno-economic assessment in addition to pre-normative research activities. There are two main activities to be carried out:

1. *Pre-normative research on critical issues related to end-use applications and equipment.*

The core of the topic is the evaluation of the actual impact of H2NG mixtures on the combustion process (flame speed, shape, temperature, emissivity, emissions) of end-use applications, and equipment: their safety, efficiency and lifetime across a wide range of hydrogen concentrations. Whereas hydrogen concentrations around 20 vol% can be considered a long term goal, already now 10 vol% of hydrogen are feasible in some parts of the natural gas system. Close to CNG stations, 2 vol% hydrogen is today a limiting factor due to the use of steel tanks for CNG vehicles. The hydrogen concentrations used for testing should be chosen accordingly.

An assessment should be performed aiming at the selection and clustering of end-use applications. An in depth assessment and analysis of previously carried out research shall be undertaken, including an analysis on the transferability of results. This analysis should be used to guide the selection of applications. The selection of critical end-use applications to be further investigated shall be done according to the following criteria and dimensions:

- Prioritisation of critical end-use applications in terms of sensitivity and resistivity to H2NG. Giving a fair balance between the sensitivity of the segment to H2NG and the market share among applications;
- For a number of low, medium and high hydrogen concentrations, identify if and what adjustments and design changes are required for:
  (i) gas burners as used in common domestic/commercial/light industrial/industrial equipment (i.e. boilers, cookers, gas heaters, ovens, dryers, furnaces etc.) and
  (ii) gas heat engines (reciprocating engines and gas turbines);
- Integrating the new gas technologies (e.g. micro-cogeneration, gas heat pumps, fuel cells) that will play an increasing role in the future;

Pre-normative research on end-use appliances and equipment, including control devices, should be performed based on this selection and prioritisation work, aiming at assessing compatibility, performance and lifetime of end-users applications (or their critical components such as burners, engines), under conditions not yet covered by other studies. It should be ensured that already installed gas appliances and equipment can continue to function safely and with a satisfactory level of efficiency and environmental performance when supplied with H2NG instead of natural gas for low, medium and high hydrogen concentrations.

Appliances certification aspects (including re-certification needs) should be considered. To investigate combustion behaviour and its influence on the mentioned criteria of material compatibility, performance and lifetime, the experimental campaign should be chosen representing as far as possible real operative conditions, and full components should be preferred (as far as possible) to downsize laboratory samples. This pre-normative research can include the development of testing methods and procedures.

The project should develop a suitable detailed experimental program, which should be derived from agreed priorities at European level. Appliances compliant with the Gas Appliance Directive, both domestic and non-domestic, will be evaluated. Common burner types used for large commercial and industrial boilers as used in ovens, dryers, furnaces etc. should also be investigated. Common types of gas engines should be considered.

The combustion parameters Wobbe index, methane number and laminar flame speed should be considered. Different compositions of H_2 gas should be taken into account. Fluctuations in the concentration of hydrogen will have to be considered as well.

Tests should be carried out for boilers, cookers, water heaters, space heaters, µCHPs, gas heat pumps, fuel cells and gas engines following an appropriate testing protocol. The tests should include an evaluation of the sensitivity of the application to hydrogen and consider the impact on safety, efficiency, reliability, lifetime, CO, NOx and other possible impacts.

Test gases used for the certification of gas appliances by notified bodies (as required by the Gas Appliance Directive), include for the gas group most widely used in Europe test gas G222 consisting of 77 % CH_4 and 23 % H_2. It is however used only for tests of a short duration. Longer-term testing, also with higher H_2 concentrations should be carried out. Tests should assess the potential long-term effects of hydrogen. Validated accelerated stress testing should be performed, considering gas quality fluctuations and changes in environmental conditions.

The impact of H_2 content on NOx levels, for which European legislation sets lower limits than previously should be verified.

For gas engines specifically, the effect of hydrogen on knock and pre-ignition should be investigated, as well as on the control systems.

2. *Techno-economic assessment including analysis of policy options to enable the wide adoption of H2NG blends.*

A techno-economic analysis, identifying plausible remuneration frameworks and policy options needs to be undertaken to ensure that the respective stakeholders (i.e. renewable power generators, electricity grid operators, gas network and storage operators as well as H2NG customers) can realise the benefits of adopting H2NG blends. There are several policy options to consider (including government imposed targets for the decarbonisation of gas grids, a higher carbon tax on natural gas for funding the implementation of H2NG, a voluntary Guarantee of Origin scheme for the gas industry, the removal of taxes and levies on electricity used by power-to-gas systems and feed-in-tariffs for various concentrations of H2NG).

Further analysis should then be undertaken to consider cost drivers and policy options for enabling a progression in the concentration level, as a function of the findings of the first challenge related to end-use appliances and equipment. The assessment of the regulatory hurdles that prevent the increased uptake of hydrogen in the natural gas grid and its use by end-user applications will have to be mapped, considering individual EU Member States' limitations. A pre-requisite for the work to be performed is an overview of the materials, components and equipment actually present in the gas chain at European level. The entire gas chain including all end-users of natural gas should be considered. Based on the outcome of the assessment, cost efficient strategies for adopting H2NG blends, ownership and operating models for injecting H2NG blends and policy suggestions should be prepared to support a macro-economically feasible transformation path from low to high hydrogen concentrations in the gas system.

It is expected that proposal will include appliance and burner manufacturers, power-to-gas technology providers, gas consumers and gas industry.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), in order to benchmark performance of components and allow for comparison across different projects.

International collaboration with member countries of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) is specifically encouraged for this topic.

The FCH 2 JU considers that proposals requesting a contribution of EUR 2.75 million per project 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:

The proposed techno-economic assessment and pre-normative research will enable an easier and wider development of injection of hydrogen admixtures into natural gas networks, supporting deployment of hydrogen technologies and contributing to decarbonisation of the European energy system and to European energy security goals. This will be achieved by comprehensive knowledge of cost drivers and policy options at European level. The project will ensure that the safe operation of existing and future gas appliances and applications is not jeopardised by the supply of H2NG instead of the natural gas composition range for which they have been designed and certified for; 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 how much hydrogen can be added to natural gas without changing the existing certification of appliances. Establishing how the existing certification can be adapted to possibly allow higher concentration of hydrogen, including the related additional costs, and the required changes to common gas burners to combust such mixtures;
- Improved knowledge on effect of H2NG on common burner types used for large commercial and industrial boilers as used in ovens, dryers, furnaces, including necessary adjustments and design changes;
- Recommendations for revision of EN or ISO standards or drafting of new standards based on PNR results and review of the existing testing methods;
- Mapping of EU member state regulations limiting the hydrogen concentration in the gas system and identification of critical regulatory bottlenecks including proposal to address those;
- Identification of policy options, remuneration frameworks and operational models for enabling the wide adoption of hydrogen admixtures in European gas networks.
- Developing an EU level roadmap for the increase of hydrogen concentration in natural gas up to 2030;

The efforts related to the experimental part of the pre-normative research on end-use applications are estimated to be about 70% of the total budget.

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-04-3-2018: Accelerated Stress Testing (AST) protocols for Solid Oxide Cells (SOC)

Specific challenge:

This approach addresses key aspects of interest for the industry related to durability, particularly regarding the stack components as cells, interconnects or seals. Targeting the understanding of realistic failure modes and the development of ASTs that address those failure modes is a valuable contribution in order to shorten the development time of new materials to be integrated in the next system generation. While different ASTs are already available for PEMFC, this topic is much less advanced in SOCs.

Degradation rates currently reported in SOFCs are below 1%/1000h, and they are a bit higher in SOE mode (a few %/1000h). Performing very long tests (several years) are generally not compatible with the availabilities of test stations in laboratories. In addition, the validation of stack components over several years before their integration in a real system is neither compatible with times requested by fuel cell manufacturers for the market deployment of their product.

Therefore, accelerated stress testing is of great benefit. First accelerated testing has been done in SOFC and to a much less extent in SOE, but an extensive work is needed for correlation or transfer function to “Real World” data. As of today, a growing number of FCH 2 JU demonstration projects involving SOFCs are ongoing and expected in Europe, such as for example ENE.FIELD and PACE including SOFC systems, while SOE demonstration projects don’t exist yet but are expected in a near future (such as already in this work-plan). Some projects like ENDURANCE improved the understanding of natural and event-related degradation processes of SOFC materials, thanks to systematic post-mortem investigation that identified critical components for stack lifetime. Multiscale models were set up and refined and specific samples and experimental sessions were designed to statistically validate suggested improvements. A similar coupled experimental/modelling approach has been developed and validated in SOPHIA project, highlighting some phenomena having more extensive effects in SOE.

Finally, some monitoring and diagnostic tools are developed by GENIUS, DESIGN and DIAMOND projects, providing feedback regarding evolution of the performance of the system in correlation with user profile. The availability of quantitative information on stack and its components lifetime as function of system operations, as well as analytical tools to forecast their durability is a valuable asset for further actions towards e.g. optimal maintenance plans.

In order to retrieve most benefits from these past, on-going or starting projects it is important to link these evolutions to materials evolution with quantitative data for various usages.

Scope:

The project should address:

- Identification of degradation mechanisms and quantification of degradation on aged stack components (in particular electrodes, interconnects, sealings) coming from existing demonstration projects;
- Development of advanced in situ and ex situ characterization techniques and accelerated stress test (AST) protocols, compatible to existing test station hardware, with the identification of transfer functions of the component degradation measured in an AST to real-world behaviour of that component.
- Proposal and validation of AST from materials to stack components and optionally stack level, the latter potentially more application specific when relevant. The developed AST protocols should follow where possible the formats of protocols developed in the

SOCTESQA project, in order to be integrated with the EU protocol harmonization undertaken by JRC (see JRC activities);

- Development of models related to degradation mechanisms, implementing models describing degradation mechanisms into performance models. Evaluation of the capability of performance/degradation models to confirm and quantify the accelerating impact by adapting some operating or load profiles should be considered. The modelling tools should lead to improved in-operando prognostics and estimation of remaining useful lifetime of the SOC stack in a relevant operational environment;

A key requisite for the project should be the certainty of acquisition of at least 6 aged samples of a given stack component (cell, interconnect, sealant) of at least 3 different stacks (ideally from at least two suppliers) and of the corresponding user profiles.

Projects should focus on a SOC technology (SOFC, SOE, R-SOC). Therefore, the relevant actors should be included in the consortium and/or letters of intent of the materials providers should be provided. Availability of comparable non-aged materials or stack components should be foreseen, to ensure relevant comparison between “real-world” ageing and ageing caused by selected AST.

International collaboration with member countries of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) is specifically encouraged for this topic.

Laboratories taking part in the proposal should have a record of quality assurance in SOFC/SOEC testing to guarantee reliability and repeatability of the test results.

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.

Test activities should collaborate and use the protocols developed by the JRC Harmonisation Roadmap (see section 3.2.B "Collaboration with JRC – Rolling Plan 2018"), 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 per project 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:

ASTs will allow faster evaluation of new materials and provide standardized sets of tests to benchmark materials and/or stack components, and will accelerate the development to meet cost (7€/kg H2 produced in 2020 and between 4500 and 7500 €/kW for commercial mid-size SOFCs in 2020) and durability targets (2 years in SOEC and 8-20 years for mid-size stationary SOFCs).
This is based on the following elements:

- Enhanced understanding of physical correlation between user profile and degradation mechanisms on at least three stack components (e.g. cell, interconnect, sealing) and its validation with models related to degradation mechanisms;
- Define testing methods and evaluation criterion / criteria to allow faster evaluation than current AST of new materials and standardised tests to benchmark materials on the selected stack components with a quantified correlation between AST results and lifetime in a user profile (hydrogen production, CHP), where results should show at least similar

ranking between materials or stack components with a good correlation between quantitative degradation features (to be selected such as performances degradation rates, properties losses, microstructure modifications);

- Validation of the methodology (i.e. comparison and correlation between "real-world" behaviour and AST caused degradation) should be achieved through a plan for coordination and agreement within the European SOC community, involving the JRC, to confirm the robustness of the AST procedures identified;
- Provide recommendations about improvements of monitoring and tracking systems for future deployments in order to capitalise on return of experience;
- Final document, including AST test methods, evaluation criteria & validation methodology, with reference to existing global SoA AST, explaining differences and additional valuable information;
- Recommendations for international standardisation of Accelerated Stress Testings within IEC TC105 which should where appropriate lead to a New Working Item Proposal (NWIP) or feed into ongoing standardization processes;

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-04-4-2018: Strengthening public acceptance and awareness of FCH-technologies by educating pupils at schools

Specific challenge:

Public awareness and social acceptance regarding FCH technologies have an essential role on the market uptake of FCH applications, as they foster the commercial demand and strengthen the integration and deployment of available and future FCH technologies in both public and private sectors.

FCH technologies have positive impact on increasing the use of renewable resources and renewable energy and on the reduction of CO2 emissions. Moreover, FCH technologies are the ideal link to couple different sectors of the energy mix such as the electricity grid, gas grid, etc. strengthening the entire energy sector. The benefits of implementing hydrogen as energy carrier and fuel cells into the energy system must be known and communicated to the society.

Nevertheless, the majority of FCH technologies are not well known by the public and they are not mentioned in books and lectures. Overcoming this gap is a major European challenge. To address this, a “bottom up approach” starting at pupils (primary and secondary schools) appears to be one of the most promising approaches to transfer the essential knowledge to the public. On one hand, this ensures the education of the highly qualified workforce needed by the FCH industry in the coming years, and on the other hand, increases the public awareness about the role of FCH technologies to achieve the energy transition.

Previous FCH JU activities on education and training have targeted specific groups i.e. undergraduates, postgraduates and professionals (HYPROFESSIONALS, TRAINHY-PROF, HyFacts, Knowhy, HyResponse). Targeting primary and secondary schools and their teachers will ensure that FCH technologies are presented within the energy context among other technologies generally known (PV, wind, batteries…) at a very early stage of education. This will benefit beyond the school gates, e.g. friends, parents and relatives and this will bring opportunities to initiate interest to pupils to be informed and well educated on the functioning and possibilities of FCH technologies before they chose their carrier choices.

Scope:

The project is expected to provide a set of educational materials (documents, presentations, fact sheets, practical exercises, etc.) adapted to the respective level of pupils to follow up successfully the “bottom up approach” of communication and dissemination of knowledge about FCH technologies.

The project is expected to build communication channels down to schools, teachers and education and public authorities in order to ensure the alignment of the education materials on national levels and level of education (primary and secondary). The project should connect with local, regional and national organisations to identify and engage schools in a programme of workshops or educational activities and should identify key local stakeholders to be part of the educational programme delivery. Appropriate channels may include national, regional and city hydrogen FCH associations and partnerships, existing education networks, etc.

As an essential part to the success of the project, a specific project website should be developed as a “connecting point” to exchange educational materials and to assist communication generally (e.g. by guidelines and instructions). The project website should also make more visible the FCH industry and its activities as well as research and development, providing further information on the technology.

To motivate pupils, an open contest should be organised to increase participation to the educational program, e.g. by offering an award to schools or classes in each respective country for the best “new idea on FCH application to contribute to fight the climate change”. The project should put in place a jury and the criteria to award the prices.

The project is expected to address the following activities:

- Development of educational materials (e.g. slides, practical exercises) on respective level of education (primary and secondary schools) concentrating on explanation of technology, its functioning and application and its role in the global energy context;
- Translation of developed educational materials to at least 10 different European languages (e.g. assisted by international colleagues or FCH associations);
- The development of a programme of workshops or educational activities in the targeted countries.
- Development of a specific project website as “connecting point” to exchange educational materials and providing further explanations, instructions, guidelines etc.;
- Announcing an annual award to the best “…..” (theme and scope open) in each country and level of education to motivate the willingness of teachers and pupils on learning about FCH technologies; including an award ceremony.
- Establish an educational programme delivery model that is sustainable in time and linked to industry priorities.

The FCH 2 JU considers that proposals requesting a contribution of EUR 0.5 million per project 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: 2 years.

Expected impact:

- To raise public awareness and acceptance across Europe on FCH technologies and its significant contribution to achieve the European energy targets, including a set of indicators to quantify the awareness raised by the project activities in the targeted countries at local (e.g. city), regional and national level;
- To increase awareness and interest of FCH technologies amongst school pupils and their teachers on the potential of FCH technologies to achieve the European energy targets and to offer qualified job opportunities with the integration of the developed educational materials into general lectures on energy, including a set of indicators to quantify the awareness raised by the project activities in the targeted countries;
- An accessible European web-based platform as “connecting point” to exchange educational materials and providing further explanations, instructions, guidelines, etc;
- An educational programme delivery model that is sustainable in time and linked to industry priorities.

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.

B. Collaboration with JRC – Rolling Plan 2018

The Commission's Joint Research Centre (JRC) undertakes high quality research in the field of fuel cells and hydrogen that is of considerable relevance to the implementation of the 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, including Rolling Plan 2016 as its annex 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 2018, a maximum budget of 1 million euros 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 2018 (based on the similar plans approved and executed in 2016 and 2017), 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*".

A recent analysis (PO, JRC, RCS Chair) has identified improvement needs for the group to increase its impact on the programme goals. Therefore, in 2018 JRC will not only continue to deliver data and gap analysis as done in the past 2 years, but will also undertake a more steering role as coordinator of the group[28]. 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's:

Annual deliverables:

B.1.0 RCS SC group work plan 2018 (strategy implementation, timeline, methodological approach) (January 2018);

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

B.1.1 Updated mapping of programme PNR progress and its link to the international and European standardisation activities (November 2018);

B.1.2 Workshop with FCH 2 JU transport demo projects and related report regarding their findings and recommendations on PNR and RCS priorities (April 2018);

B.1.3 Annual report on RCS SC group activities, as input to the Annual Activity Report (November 2018);

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 IPR issues, JRC has already achieved industry-consented harmonised test approaches for PEMFC for automotive applications. This effort has been extended to other applications and technology in 2016 and 2017. In addition, upon request of industry, JRC has foreseen the design and prototyping of a 'reference testing cell', to be used to quantitatively assess performance on innovative fuel cells. The following deliverables are foreseen for 2018, as part of the testing harmonisation multiannual plan:

B.2.1 Harmonisation of automotive protocols - Testing Hardware:

2018 (2Q) Manufacturing and validation experiments at JRC laboratories of the single cell test hardware Prototype 1 to design Prototype 2;

2018 (3Q) EU Round Robin testing of the single cell hardware Prototype 2;

2018 (4Q) EU/US Round Robin testing of Prototype 3, which will be tested at various EU laboratories for final acceptance of the design;

B.2.2 Harmonisation of automotive protocols - Testing Protocols:

2018 (3Q) EU/US review of the published report (ISBN 978-92-79-54132-2) based on the harmonised test hardware;

2018 (4Q) Final Report;

B.2.3 Harmonised Electrolysis Testing

Terminology for High Temperature Water Electrolysis: 2018 (4Q) Final Report;

Testing protocols for Low Temperature Water Electrolysis: 2018 (4Q) Final Report;

Single Cell Testing hardware for Low Temperature Water Electrolysis: 2018 (4Q) Final Report on Round Robin Test;

Testing Procedures: 2018 (2Q) Final Reports on Polarisation curve, Cross Over and Impedance;

B.3 JRC contribution to programme monitoring and assessment

Technology benchmarking by means of data collection. As part of technology monitoring against state-of-art and multiannual strategy targets of the FCH 2 JU, PO is collecting every year data from supported projects in the internal TRUST database, which is therefore populated with data by the FCH 2 JU and project participants. 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' (or state-of-art data) need also to be collected. In 2016 JRC has delivered already the reference data related to first priority sub-technologies; a second set of priority sub-technologies has been tackled in 2017 and to continue, in 2018 JRC will focus on:

B.3.0 Support to the PO to further harmonise the TRUST templates with the updated KPI in the reviewed MAWP 2014-2020 (July 2018);

B.3.1 Provision of reference international technology data adapted to TRUST needs and structure for the technologies not tackled in 2017 according to the agreed priority ranking. (November 2018) [29]

B.3.2 Updates of the state-of-art (SoA) data from 2016 (November 2018);

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

B.3.3 Customised FCH media monitoring system European Media Monitor FCH EMM (first draft January 2018, final in December 2018);

B.3.4 Customised FCH Technology Innovation Monitoring System FCH TIM (first draft January 2018, final in December 2018);

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

B.3.5 Updated methodology for the PRD submitted for approval by PO (April 2018). This will consider the lessons learned from the 2017 PRD;

B.3.6 Draft report delivered before the PRD2018 (October 2018);

B.3.6 Final JRC report delivered for finalization & publication by PO (December 2018);

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 2 JU has defined a Life-Cycle Assessment (LCA) methodology to be applied to its projects and products[30]. Accordingly, "*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 (International Reference Life Cycle Data System), and maintained by the industry partners of the FCH 2 JU. The FCH 2 JU shall also establish an international exchange thus providing a globally consistent framework*."

An inventory of the work performed in the various projects and in studies can provide the FCH 2 JU with an overview of the progress achieved so far in this field and allow for a gap analysis:

B.3.7 A report mapping of the LCA effort executed in the projects and studies under the 2 framework programmes, including a gap analysis and recommendations for future AWP's (September 2018);

B.4 JRC contribution to safety dimension and safety awareness

In the frame of the FCH 2 JU strategy on safety aspects at program level, the Hydrogen Incidents and Accidents Database HIAD 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.

B.4.1 HIAD operation: HIAD population with the events delivered by projects and annual report[31] *(December 2018);*

B4.2 Annual report on the contribution to the European Hydrogen Safety Panel, (this is a continuous activity, and JRC tasks are described in more details in the annual work plan of the panel);

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[29] More detailed plan for each of the sub-technology will be agreed with the Knowledge Manager of the PO. The final deadline of November relates to the requirement to be ready for the PRD 2018;

[30] See project FC-HyGuide, http://www.fc-hyguide.eu/

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

B4.3 Report on 2018 research progress in the field of hydrogen safety. This is a joint report with the EHSP, will be based as usual to a broad range of sources and serve also the prioritization work in B.1 (November 2018);

B.5 JRC support to FCH Smart Specialisation

No activities foreseen in 2018.

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, 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 two years, this deliverable was not activated.

The indicative resources needed for the delivery of this contribution are presented in the table below.

Deliverable number	Deliverable title	Effort [PM]	Costs [k€]
B.1	**Support to formulation and implementation of RCS strategy**	13	-
B.2	**Direct contribution to implementing RCS strategy**	18	-
B.3	**Contribution to programme monitoring and assessment**	18	-
B.4	**Support to safety aspects**	7	-
B.6	*Testing in support to specific activities of the FCH 2 JU programme*	*TBD*[32]	-
	Manpower Totals [PM]	**56**	**500**

	Overview indicative costs (with overhead), [k€]
Manpower	**625.0**
Missions	**37.5**
Consumables	**50.0**
Subcontract *(for TIM and EMM, deliverables B.3.3 and B.3.4)*	**187.5**
Total indicative cost for 2018	**900.0**
Max amount per year	*1000*

Costs includes overhead costs of 25%.

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

[32] Depending on ad-hoc requirements for testing in ongoing projects (as reference/benchmarking) and included in the maximum total budget of 1 million euros.

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

The implementation of a Regulations, Codes and Standards Strategy is crucial for the market deployment of FCH systems as the lack of harmonized RCS and PNR to fill RCS knowledge gaps at EU (and world) level is still recognised as one of the major barriers for the commercialization of FCH products.

The overall goal of the RCS Strategy is to enable the development and actual use of harmonized performance-based standards for FCH appliances and systems, together with their safety in 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 was created in 2015 with the aim of addressing the needs of the European FCH sector.

The RCS SC Group, consisting of the Hydrogen Europe and Hydrogen Europe Research representatives supported by the European Commission's Joint Research Centre (JRC) and the FCH 2 JU Programme Office (PO), coordinates the strategy on RCS. The three 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. Define a strategy to be put in place to pursue the priority RCS issues.

Other 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, particularly by introducing European interests into these bodies; and coordinating the attendance of European representatives in the relevant standardisation and Regulatory Bodies.

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 concrete topics to be incorporated in 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 will develop and execute 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 and regulatory bodies.

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.

The EHSP is composed of a multidisciplinary pool of safety experts grouped in ad-hoc working groups (task forces) according to the tasks to be performed and to expertise. The scope and activities of the EHSP are structured around four main areas.

D.1 Support at project level

The EHSP task under this category includes the development of a package of measures to avoid any accident by integrating safety learnings, expertise and planning into FCH 2 JU funded projects and by ensuring that all projects address and incorporate the state-of-the-art in hydrogen safety appropriately. To this end, a Safety guidance document for hydrogen and fuel cell projects will be produced.

D.2 Support at programme level

Activities under this category include answering questions related to hydrogen safety in an independent, coordinated and consolidated way, via hotline-support or if necessary, via physical presence of safety representative at the FCH 2 JU. It could also include a short introduction to hydrogen safety, and the provision of specific guidelines for the handling, storage and use of hydrogen in the public domain. For 2018, as a start, a clear strategy on this should be developed and therefore related Multi-annual work plan 2018-2020.

D.3 Data collection and assessment

The EHSP tasks include the analysis of existing events already introduced in the European Hydrogen Safety Reference Database (HIAD) and of new information from relevant mishaps, incidents or accidents. The EHSP should therefore derive lessons learned and provide together with the involved parties further general recommendations to all stakeholders, based on these data. For 2018, the following deliverables should be produced: methodology to collect inputs from projects and to provide lessons learned and guidelines, assessment and lessons learned from HIAD and a report on research progress in the field of hydrogen safety.

D.4 Public outreach

Framed within the context of the intended broad information exchange, the EHSP tasks under this category include the development of a newsletter to be released and published on a regular basis (e.g. quarterly), and a regularly updated webpage hosted on the FCH 2 JU website.

E. Knowledge management. Dissemination and communication on projects results

Technology monitoring will continue with its collection of data from projects on annual basis, in the internal developed database/data collection platform TRUST[33]. Following its successful development and first use in 2017 (to collect project data generated in 2016), projects will be requested similarly to provide their data in 2018 concerning results generated in 2017, allowing to benchmark project progress against the targets defined in the MAWP and related AWPs.

Each project active in the year 2017 (previous year to the exercise) will thus 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 2017, 19 different questionnaires were used (so called "templates"), and an additional one is foreseen to be developed for the 2018 data collection campaign, for co-electrolysis research.

The templates can be consulted online on http://www.fch.europa.eu/projects/knowledge-management.

Within each questionnaire, several parameters should be filled and each of them can individually be tagged as public or confidential. The FCH 2 JU is committed to the respect of confidential data (according to the conditions setup by the Grant Agreement) and will only use them in the respect of this attribute: confidential data will never 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. The data acquired in 2016 (for 2015 project data) have also been uploaded into TRUST, so that the system will allow soon to either record and map evolution/progress over last years or to plot possible trends. Progress and findings that can be shown will be made public (normally associated to the Programme Review exercise – see below).

In parallel to this, JRC (see section B above) will support the PO by updating international state-of-the-art, SoA figures 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.

Finally, through the forthcoming TIM[34] database (development started in 2017 also by JRC for FCH technologies) scientific publications will be mapped according to the authors' organisations; fuel cell and hydrogen universes will be defined (to isolate information on related literature only) from which to further tag and filter FCH 2 JU beneficiaries and publications related to FCH 2 JU projects. This should allow tracking developments in the FCH technologies and related impact of FCH 2 JU funding.

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 world may also be included for benchmarking. The development of the European Media Monitoring (EMM)[35] for FCH technologies with support of JRC (mainly for communication purposes), should

[33] http://www.fch.europa.eu/sites/default/files/TRUST_ExplanationFile_Draft_3.pdf
[34] http://www.timanalytics.eu/
[35] http://emm.newsbrief.eu/overview.html

however provide a more comprehensive press screening mechanism and allow a more thorough capture of the relevant information in the future.

In particular, for the cars, this should be completed 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. The data are treated as confidential and thus only aggregated values are disclosed.

Development is also ongoing to better integrate the FCH 2 JU supported projects into a broader European database of projects related to fuel cells and hydrogen technologies (by the Hydrogen Europe). Information from the supported projects on the FCH 2 JU website will be mirrored on the similar Hydrogen Europe website, which will contain additionally all national, regional or private supported projects. FCH 2 JU will control the accuracy and correctness of information provided by its supported projects; this should be also ensured by direct link to the European Commission Cordis[36] projects webpage (fed with meta-data through the European Commission project management tools) for each project, including references and links to project patents and publications, public summaries and public deliverables. Additional features include an interactive map of projects, including both the location of demonstration units and location of the leading organisation for the different research themes.

Dissemination and communication on projects results

The FCH 2 JU is also part of the Horizon 2020 DiEPP platform (Dissemination & Exploitation Practitioners' Platform) which was created to support the exchange of information and best practices on dissemination and exploitation at the level of the European Commission (EC) Research and Innovation Family.

In close relationship with daily knowledge management activities, such activities will continue as part of the European Commission initiatives in the field (e.g. in 2017: invitation to projects to participate in the EC Common Exploitation Booster (CEB) and Common Dissemination Booster (CDB) and monitoring of any activity of FCH 2 JU projects within these initiatives to receive dedicated assistance in either exploitation or dissemination of results).

In 2018, the DiEPP aspects will mainly involve (1) the Innovation Radar initiative to be associated to mid-term project reviews: a dedicated expert will be mandated to identify potential innovations and weigh them in terms of maturity, market potential, possible impact etc. and (2) in continuation of efforts of 2017 pursue the IRIS/OSIRIS initiative concerning text mining for EU policy purposes of project documents (proposals, grant agreements, amendments, reports, deliverables, etc).

Not directly related to the CDB, the possibility of FCH 2 JU energy projects to participate in the SSERR (Support Services for the Exploitation or Research Results) initiative of DG RTD remains in 2018, whereby projects can receive consultancy-type advice on exploitation aspects.

Continuing on the good experience and practice so far, the 8th annual **Programme Review Days** will be organised in autumn 2018. The review will be carried out with the support of JRC (see section B above).

[36] http://cordis.europa.eu/

F. Support to policies and funding/financial engineering

The FCH 2 JU is contributing to the activities of a number of services in the European Commission (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 the contribution they can provide 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, taking an active role at the meetings, providing written technical input and ensuring that fuel cells and hydrogen technologies are properly represented in the relevant sectors.

Supporting DG ENER, RTD, MOVE and CLIMA the FCH 2 JU is actively following and contributing to the European Strategic Energy Technology Plan (SET-Plan) activities, in particular on 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[37] 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 is part of the "Sustainable Transport Forum" and the "Clean Bus Expert Group". The latter group is dedicated to work on specific policy recommendations and financing topics related with clean buses' deployment. The FCH 2 JU took also part in 2017 in the ETS Innovation Fund activities, supporting the inclusion of fuel cell and hydrogen technologies in the scope of this new financial tool.

The FCH 2 JU is also supporting the Joint Research Centre of the EC by taking part in the activities of the International Energy Agency Hydrogen Implementing Agreement (see International Cooperation below).

FCH 2 JU support to policy makers in the EC goes beyond energy and transport policies. Supporting the EU objectives of sustainable growth and innovation, the FCH 2 JU Study on Value Chain and Manufacturing Competitiveness Analysis for Hydrogen and Fuel Cells Technologies has been used to provide evidence base to DG GROW on how fuel cells and hydrogen sector could contribute to strengthening and reinforcing the competiveness of EU industry.

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. For example on the transport sector, the FCH 2 JU has worked with INEA on activities related to fuel cell buses and Hydrogen Refuelling Stations (HRS).

The above are just examples of some of the activities the FCH 2 JU is involved. The FCH 2 JU shall continue, to reinforce the collaboration with policy makers in the European Commission. This should also include Executive Agencies in charge of managing other parts of H2020 and centrally managed EU funds, to better exploit synergies among funding programmes.

There are several funding and financing schemes for complimentary projects to the ones directly supported by the FCH 2 JU. Reaching out to alternative funding and financing sources leverages the impact of FCH 2 JU projects and enhances the achievement of its objectives. The FCH 2 JU has been addressing these funding sources on a case-by-case basis[38] but it is now time to initiate a structured approach to it.

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37 http://artfuelsforum.eu/

38 Example combined projects JIVE/MEHRLIN

As also observed by the Independent Experts Group during the Interim Evaluation of the FCH 2 JU[39], funding/financial engineering activities have been integrated recently 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 FCH 2 JU supports.

The activities under the funding/financial engineering work stream sub-divide into the following areas:

- EU Funding (grants) – synergies and blending opportunities with other EU funds;
- EU Financial Instruments – increase access to finance leveraging on EU financial instruments;
- Raise awareness of FCH 2 JU projects' results within the finance community – activity to be developed in addition to the exploitation and dissemination exercises mentioned in the previous section.

Although the FCH 2 JU has already successfully enabled the blending of different EU funds into a few projects under its portfolio, 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[40]. By combining or opening access to new funding streams for FCH 2 JU projects, it is expected that the time to market of R&D supported under FCH 2 JU operations will be reduced.

The FCH 2 JU shall seek to engage with Executive Agencies 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 may provide advice and support to prospective or past beneficiaries of FCH 2 JU projects in order to combine (cumulative or consecutive) funding from various programmes and optimize structured finance operations respectively.

The FCH2 JU has launched (and will continue to do so) several studies[41] and initiatives[42] concurring to the need for further improving awareness of financial institutions (including insurance companies) towards FCH technologies and its industrial players' financing and funding needs to ensure the high technology deployment level envisaged by the FCH 2 JU.

The FCH 2 JU will launch a sub-webpage dedicated to this topic to enable better communication and systematize the approach in this area. It will include the lessons learned from already supported projects benefiting from the combination of funds, highlighting specific requirements that potential

[39] http://www.fch.europa.eu/news/publication-fch2-ju-interim-report

[40] EU funds can be managed centrally by the EC and its Executive Agencies (e.g. H2020, CEF, ERDF's Interreg), and centrally or regionally by the Member States or its Regions respectively (e.g. ESIF)

[41] Examples of recent studies and reports that assess the economic and financial viability of different business cases of different technologies receiving support from the FCH 2 JU:
(1) study on "Early Business Cases for Power-to-Hydrogen (P2H) in Europe" (23/06/2017): http://www.fch.europa.eu/publications/study-early-business-cases-h2-energy-storage-and-more-broadly-power-h2-applications);
(2) project delivering a report on "new bus refuelling for European Hydrogen Bus Depots - guidance document on large scale hydrogen bus refuelling" (15/03/2017): http://newbusfuel.eu/publications/);
(3) study on "strategies for joint procurement of fuel cell buses" (08/07/2016): http://www.fch.europa.eu/publications/strategies-joint-procurement-fuel-cell-buses);
(4) study on "business models and financing arrangements for the commercialisation of stationary applications of fuel cells" (ongoing);

[42] The FCH 2 JU's "Regions & Cities' initiative" was launched in 2016 and includes a study recently awarded (05/2017) on "development of business cases for fuel cells and hydrogen applications for European regions and cities". More information at http://www.fch.europa.eu/page/about-regions

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 will also provide web access to the IT funding tool that is being developed under the "Regions & Cities' initiative", allowing for detailed analysis of existing grant funding opportunities on a simple and user-friendly platform. While this tool is being designed to provide support for the deployment of FCH technologies projects by the Regions and Cities, the tool is expected to also benefit the beneficiaries of FCH 2 JU calls for proposals, enabling them to better navigate around the array of EU funds available in different regions and Member States.

The FCH 2 JU's Regions and Cities Initiative[43] encourages local and regional governments to include fuel cells and hydrogen within their regional priorities when managing certain European Structural and Investment Funds (ESIF). . The FCH JU shall now aim at making better use of the State Representatives Group (SRG) and the National Contact Points (NCPs) in view of establishing strong links and relationships with countries and regions managing EU Funds (particularly relevant, as they serve the common purpose of supporting economic development across all EU countries, in line with the objectives of the Europe 2020 strategy). Tapping into regional funding is of special relevance as for the first time, the rules on the European Regional Development Fund (ERDF) for 2014-2020 stipulated a mandatory minimum spending for the low-carbon economy: 20% of national ERDF resources in more developed regions, 15% in transition regions and 12% in less developed regions .

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. To this end similar opportunities for collaboration will be explored with other EU mechanisms like the CEF, ETS and Executive Agencies, namely the Innovation and Networks Executive Agency (INEA) and the Executive Agency for Small and Medium-sized Enterprises (EASME). The FCH 2 JU will seek to establish close collaboration links with these agencies 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 continue working 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 has full awareness 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 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.

[43] http://www.fch.europa.eu/page/about-initiative

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"[44]. 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 in areas of cross cutting nature such as regulatory and policy frameworks, socio-economic and environmental assessments, codes, standards, safety or harmonised methodologies for monitoring of activities (for example hydrogen purity, hydrogen cooling and hydrogen dispensing measurement). These areas play a very important role in early market activation and where intellectual property rights are less of an issue.

In this context 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)[45], Advanced Fuel Cell Implementing Agreement and the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)[46]. The FCH 2 JU will hence continue to collaborate closely with the EC representatives in the steering committees of these international agreements/associations.

Synergies will also be explored with the Climate Technology Centre & Network (CTCN)[47], which is the implementing body to the COP[48], making sure developing countries adopt the right climate technologies to reach the 2°C target.

Moreover, collaboration and support to the Mission Innovation[49] activities will be encouraged, especially through projects collaboration with similar worldwide activities under the specific innovation challenges.

Contacts will also be maintained and further expanded where appropriate with non-EU and non-Associated Country (AC) states that have significant and sustained involvement in the development and deployment of FCH technologies, namely Japan, South-Korea, Canada, South-Africa, China, India, Australia and the USA or through the International Partnership for Hydrogen into the Economy (IPHE).

[44] COM(2012)497
[45] http://ieahydrogen.org/
[46] http://www.iphe.net/
[47] https://www.ctc-n.org/
[48] http://unfccc.int/bodies/body/6383.php
[49] http://mission-innovation.net/about/

H. Public Procurements

In 2018, 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 2.7 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, supporting the 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
Hydrogen for Decarbonizing Heat *Assess if and how hydrogen can help achieve deep decarbonization of the various segments of the gas grid by 2050*	300,000.00	Open procedure	Q2
European Economic fuel cell Bus by 2020 *Analysis of requirements and additional needs/steps to reach the agreed objective of 450,000€/bus prices by 2020 mainly from market perspective, including the infrastructure needed.*	300,000.00	Open procedure	Q1
FCH Market potential in Central and Eastern Europe *Active market study to identify applications which corresponds to the needs of central European countries, the potential customers/suppliers, potential funding/financing partners and prepare concrete roadmaps.*	300,000.00	Open procedure	Q2
European business cases for FCH trains and technology development roadmap (regional trains, shunting locomotives, freights/last mile) *Follow up of the common workshop FCH 2 JU/Shift2Rail JU*	300,000.00	Open procedure	Q1

Subject (Indicative title)	Indicative budget (EUR)	Expected type of procedure	Schedule Indicative
Fuel cells and hydrogen market and policy observatory *Systematic, comprehensive and publicly available market statistics, policy framework (at national level and at regional, when relevant and including jobs creation, employment and education needs of FCH industry), national and regional R&D programs supporting FCH technologies etc.*	1,500,000.00	Open procedure	Q1

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-2018-1**

Total budget[50]: EUR 73.2 million

Estimated opening date[51]: **16 of January 2018**

Estimated deadline[52]: **24 of April 2018**

Indicative budgets:

Topic	Type of action	Indicative budget (million EUR)
1. TRANSPORT PILLAR		
FCH-01-1-2018: Large Scale Demonstration of H2 fuelled HD Trucks with High Capacity Hydrogen Refuelling Stations (HRS)	Innovation (IA)	17
FCH-01-2-2018: Demonstration of Fuel Cell applications for mid-size passenger ships or inland freight	Innovation (IA)	
FCH-01-3-2018: Strengthening of the European supply chain for compressed storage systems for transport applications	Research & Innovation (RIA)	2.7
FCH-01-4-2018: Fuel cell systems for the propulsion of aerial passenger vehicle	Research & Innovation (RIA)	4
FCH-01-5-2018: Next generation automotive MEA development	Research & Innovation (RIA)	4
FCH-01-6-2018: Game changer fuel cell stack for automotive applications	Research & Innovation (RIA)	3
FCH-01-7-2018: Improvement of innovative compression concepts for large scale transport applications	Research& Innovation (RIA)	2.75
2. ENERGY PILLAR		
FCH-02-1-2018: Demonstration of a large-scale (min. 20MW) electrolyser for converting renewable energy to hydrogen	Innovation (IA)	18
FCH-02-2-2018: Demonstration of large scale steam electrolyser system in industrial market	Innovation (IA)	
FCH-02-3-2018: Robust, efficient long term remote power supply	Innovation (IA)	

[50] 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.
[51] The Executive Director may decide to open the call up to one month prior to or after the envisaged date of opening.
[52] The Executive Director may delay the deadline by up to two months. The deadline is at 17.00.00 Brussels local time.

FCH-02-4-2018: Thermochemical Hydrogen Production from Concentrated Sunlight	Research & Innovation (RIA)	3
FCH-02-5-2018: Hydrogen carriers for stationary storage of excess renewable energy	Research & Innovation (RIA)	2
FCH-02-6-2018: Cost-effective novel architectures of interconnects	Research & Innovation (RIA)	2
FCH-02-7-2018: Efficient and cost-optimised biogas-based co-generation by high-temperature fuel cells	Research & Innovation (RIA)	1.5
FCH-02-8-2018: Waste-stream based power balancing plants with high efficiency, high flexibility and power-to-X capability	Research & Innovation (RIA)	0.5
3. OVERARCHING ACTIVITIES		
FCH-03-1-2018: Developing Fuel Cell applications for port/harbour ecosystems	Research & Innovation (RIA)	4
4. CROSS-CUTTING ACTIVITIES		
FCH-04-1-2018: PNR for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces	Research & Innovation (RIA)	8.75
FCH-04-2-2018: Hydrogen admixtures in the natural gas grid	Research & Innovation (RIA)	
FCH-04-3-2018: Accelerated Stress Testing (AST) protocols for Solid Oxide Fuel Cells (SOFC)	Research & Innovation (RIA)	
FCH-04-4-2018: Strengthening public acceptance and awareness of FCH-technologies by educating pupils at schools	Coordination and Support (CSA)	
TOTAL		73.2

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 4 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 FCH 2 JU Founding Regulation 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 2018 Additional Activities Plan, subject of a separate document 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[53] 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 but also eligible to participate 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 all Innovation Actions, an **additional eligibility criterion** has been introduced to limit the FCH 2 JU requested contribution, as follows:

FCH-01-1-2018: Large Scale Demonstration of H2 fueled HD Trucks with High Capacity Hydrogen Refueling Stations (HRS)

The maximum FCH 2 JU contribution that may be requested is EUR 12 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-01-2-2018: Demonstration of Fuel Cell applications for mid-size passenger ships or inland freight

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

FCH-02-1-2018: Demonstration of a large-scale (min. 20MW) electrolyser for converting renewable energy to hydrogen

The maximum FCH 2 JU contribution that may be requested is EUR 11 million. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-02-2-2018: Demonstration of large-scale steam electrolyser system in industrial market

The maximum FCH 2 JU contribution that may be requested is EUR 4 million. This is an eligibility criterion – proposals requesting FCH 2 JU contribution above this amount will not be evaluated.

FCH-02-3-2018: Robust, efficient long term remote power supply

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.

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.

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

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)[54] 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 [55].

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) from the ranked list(s) whose corresponding topic or area addresses EU specific policy needs beyond H2020; in this respect, topic '*FCH-02-1-2018: Demonstration of a large-scale (min. 20MW) electrolyser for converting renewable energy into hydrogen'* has been identified as such and should be given priority if sufficient additional budget become available;
2. 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;
3. Selecting the proposal(s) from the ranked list(s) having the highest oversubscription;
4. 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.

[54] 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

[55] 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 outreach activities

A. Communication objectives

The FCH 2 JU Communication Strategy was adopted by the Governing Board in 2015. It highlights 2 central groups of objectives:

1) Raising the FCH 2 JU Programme's profile

- To maintain political and public awareness on the FCH JU and its activities
- To highlight the programme's contribution to the Energy Union
- To mobilise more strongly committed applicants to broaden participation in the programme
- To increase synergies with additional funding programmes with potential for complementarity with FCH2 JU

2) Highlighting technology potential and market readiness

- To highlight key benefits of the technology with real-life examples and projects 'results

The target audiences as identified by the FCH 2 JU Communication Strategy is summarised in the table below.

CATEGORY	TARGETS AUDIENCE
Policy-makers	EU level, Member States, municipal and regional authorities, councillors and scientific attachés of National Permanent Representations to the EU
New public	Public transport authorities, bus operators, renewables and energy associations, energy service companies (ESCOs), utilities, decentralised heating operators, actors in the building and renovating field
Decision supporters and multipliers	Environmental and national energy and mobility associations, NGOs
General public	
FCH stakeholders and potential applicants	IG/RG group, technological experts, new beneficiaries (SMEs and Member States which are not represented), National Contact Points (NCP)
Financial actors	EU/national and regional funding programmes and structures

Implementing these objectives and addressing the identified audiences will continue to be the core of the FCH 2 JU Communication activities in 2018.

A detailed **Communication plan** will be developed early 2018 in collaboration with the FCH 2 JU member's representatives. Some of the main actions are however already outlined below.

B. 2018 Communication actions

Communication activities undertaken in 2017 led to the gathering and production of significant material attesting of the programme's progress and benefits in several areas. For 2018, a logical follow-up will be key and communication actions will focus on exploiting and increasing visibility around these activities/projects findings and outcomes. Reach-out activities and project results will stay closely linked in order to raise awareness on the technology advantages tapping into the FCH 2 JU most successful projects' outcomes. Main themes include, amongst others:

- Most advanced FCH technologies and applications areas: transport (buses, cars and related infrastructure) and energy (electrolysers and micro CHP) with particular focus on FCH 2 JU projects' results and success stories;
- Collaboration between research and industry, and related exploitation of projects' results;
- Small and Medium Enterprises, socio-economic benefits etc;

Success Stories:

Activities around success stories will be twofold: updating existing stories to provide new information and producing brand new articles. While specific new areas are already identified (e.g. SMEs, energy storage etc), new subjects may add-in. These activities will be done as much as possible in closed collaboration with EC communication services. Publications around specific stories will follow also, when possible, EC communication calendar in order to drag attention on specific results at strategic timings. Additional communication activities will build around success stories, such as the production of a booklet and further dissemination/communication actions.

Website & Newsletter:

Based on the forthcoming media-monitoring, EMM tool (to be provided by JRC – see section B above), the FCH 2 JU will enhance its media and press monitoring activities, in order to gather specific information around its events and supported projects. These highlights will be further communicated via a regular newsletter. The FCH 2 JU communication team will therefore put in motion a new feature in addition to the existing news-alert system.

Social media:

The FCH 2 JU twitter account has stimulated broader outreach and triggered interest from a growing diverse community. Communication activities will continue leveraging this channel to relay news information, drive traffic to its website and go further mainstream.

The FCH 2 JU has already in place a You-TUBE channel that synchronises with its website's media section. One of the priorities will be to continue feeding this channel and other social media with FCH 2 JU projects' videos (in conjunction with the recent EC campaign). The communication team will further develop and exploit this channel also to continue promoting its video, which is key to boost awareness around FCH 2 JU's most advanced applications.

Awareness-raising activities:

Communication activities of the FCH 2 JU will coordinate with projects' individual activities in order to better raise awareness, especially to the general public.

EU funding acknowledgement:

The FCH 2 JU communication activities will put emphasis on incorporating EU funding reference systematically both on its material as well as for its projects; specific awareness activities have been already launched in this respect and a dedicated webpage[56] created for projects' beneficiaries activities on communication and dissemination.

[56] http://www.fch.europa.eu/page/fchju-projects-communication-dissemination

C. Events

At the time of drafting this work plan, not all events of interest for the new FCH 2 JU communication objectives have been identified. At the beginning of 2018, a detailed event list will be part of the FCH 2 JU communication plan.

The FCH JU team will participate and contribute to different events, conferences and workshops to keep informing on the organisation's achievements, work and funding opportunities.

At this stage, in addition to the annual FCH 2 JU Programme Review Days and Stakeholder Forum, the following specific events have been identified as follows:

1) Hannover Messe 2018

2) European Sustainable Energy Week

3) International Transport Forum

Next to these well-established annual events, the FCH JU may organise specific events along the 2018 EU presidencies (Bulgaria and Austria), but also dedicated technology/applications oriented events (e.g. regional/smart-specialisation event on energy storage). The FCH JU will closely work with projects' communication and dissemination teams for other project-related events.

FCH 2 JU Stakeholder Forum (SF)

The concept and organisation of the Stakeholder Forum for coming editions will reinforce the aspects related to openness and transparency to the stakeholder communities in FCH deployment (cities, NGOs, consumers …). Means to gather the opinion of these other relevant stakeholders will be sought.

FCH 2 JU Programme Review Days (PRD)

Initiated in 2011, this annual exercise, managed by the FCH 2 JU with the 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 opportunities for project participants.

Both last events will be organized in Q4 of 2018.

For further information about projects results' dissemination, please refer to part "3.2 "Operations – sub-title "Knowledge management. Dissemination and information about projects results".

Procurement and contracts

In order to reach its objectives and adequately support its operations and infrastructures, FCH 2 JU allocates funds to procure the necessary services and supplies.

Moreover, to make tendering and contract management as effective and cost-efficient as possible and to reach optimization of resources, the FCH 2 JU joins inter-institutional tenders launched by the European Commission and launches joint calls for tenders with other Joint Undertakings.

In 2018 the procurement activity will be centred on the following domains:

- With a view to modernise and increase efficiency of procurement procedures, closely follow-up on developments and assess the necessity of joining parts or the whole suite of eProcurement solution; in particular, enhance pre-award and contract management procedures through joining eProcurement solutions (e-Submission, e-Invoicing);
- Join new inter-institutional procurement procedures planned among others in the field of HR (training), IT (conference services, mobile telephone and telecommunication services);
- Launch a new joint procurement procedure with the other Joint Undertakings located in the White Atrium for ICT services (on-site and off-site service desk, service management, infrastructure and networks maintenance, etc…);
- Reopen the competition for the award of a contract for the audit on annual accounts for 2018 and 2019;
- Finalize procurement procedure for FP7 financial audits;
- Financial and administrative management of procurements;

The table below provides a summary of the tenders planned for 2018 under administrative budget (excluding the inter-institutional tenders where FCH 2 JU merely joins the process and the joint JU tenders) and the related procurement procedure expected to be used based on the information currently available that may be subject to modifications.

Subject	**Indicative budget (EUR)**	**Expected type of procedure**	**Schedule *Indicative***
Organisation of the PRD/SF 2018	134,000	Negotiated procedure for middle value contracts	Q2

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 2018 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 for 2018:

- Further to the preparation of the handover of the telephony services with the new service provider under the EC framework contract, implementation of the transfer and preparation of the renewal of the old PABX hardware by new modern and flexible calling services;

- Enhancement of the applications regarding performance, usability and user interface in order to improve the end-user experience and facilitate FCH staff work by the deployment of the Directaccess building block included in the infrastructure-as-a-service (IaaS) solution successfully deployed in 2017;
- In the context of the Future Office Automation Environment (FOAE), 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);
- Preparation and launch of the call for tender for the next Framework Contract to be signed in 2019 for common IT services provisions and maintenance (continuous) of the common infrastructure, networks and end-user office-automation support covering incidents, service requests and improvements;

2) Information systems for operational and administrative activities:

- Completion of the enhancement of the project related information on the website initiated in 2017 in collaboration with Hydrogen Europe and aiming to facilitate mapping of projects and interaction with the site while ensuring data quality and consistency;
- Follow-up on migration to HAN (ARES);
- Development of paperless workflows for administrative transactions;

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. In 2018 special focus will be put on equipping a joint JU meeting room for the necessary audio-visual & web conferences services given the support offered by recent framework contracts available to the JU in this context.

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 2018 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 personal effectiveness, new EC applications, ethics; provide the Management team with quarterly status report;
- Revise HR policies and procedures as necessary to align them to the new legal environment, in particular to the new implementing rules on learning and development; engagement of CAs; prevention and management of conflicts of interests of the staff members;
- 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: middle management, advisers, temporary posting, guidelines on whistleblowing. Launch and follow up the call for traineeship for year 2018 ;
- Regularly review and maintain up to date the manual of procedures.

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 2018 activities will focus on the following:

- Prepare 2019 budget in liaison with Commission services;
- Report on 2017 budget execution and financial management;
- Ensure efficient budget forecast and maintaining a high level of accuracy in budgetary forecasting;
- Produce regular reports containing key elements to 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;

Data protection

The FCH 2 JU data protection officer will continue to ensure and apply the data protection legal framework within the Joint Undertaking, as stated in *Regulation (EC) 45/2001 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data*[57], "The Implementing Rules concerning the Data Protection Officer at the FCH 2 JU" and the EDPS' "Position Paper on the role of Data Protection Officers in ensuring effective compliance with Regulation (EC) 45/2001".

Upon coming into force of the General Data Protection Regulation and the corresponding "*REGULATION 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*

[57] Official Journal L 008 , 12/01/2001 P. 0001 - 0022

Regulation (EC) No 45/2001 and Decision No 1247/2002/EC"[58], the FCH 2 JU data protection officer will oversee the process of transition to the new data protection legal framework.

In 2018, the following actions will be taken:

- Update of the data protection framework in view of the entering into force of the new data protection legislation: drafting and adopting complementing procedural rules; update of the notifications and privacy statements; any other measures required by the new legislation after its adoption;
- 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;
- General and ad-hoc advice to the controller in fulfilling its obligations;
- Giving support to the preparation of notifications and preparation of privacy statements for the information to be supplied to data subjects, for any new processing operations. Moreover, support will be given to the modification of the on-line mechanisms for consent, as per the requirement of the new legislation;
- 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 impacting the field of data protection in the context of FCH 2 JU's activities;

[58] This regulation is currently at the stage of Proposal, under revision by the European Parliament. The text of the "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 and Decision No 1247/2002/EC" is available here: http://eur-lex.europa.eu/procedure/EN/2017_2

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 2018.

The indicative key decisions of the GB in the year 2018 are listed below:

Key decisions in 2018 – timetable	
Endorse the revised MAWP 2014-2020	Q1
Elect new Chair and Vice-Chair	Q1
Approve the Action Plan on recommendations of the H2020 interim evaluation	Q1
Adopt the AAR 2017 and its assessment by the GB	Q2
Adopt an opinion on the Final Accounts 2017	Q2
Approve the lists of actions for funding (main and reserve lists, and the list of rejected proposals)	Q3
Adopt the Internal Control Principles	Q3
Adopt the 2019 AWP & Budget/SEP	Q4
Approve the 2019 Additional Activities plan	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 2018, in Q2 (tentatively around May) and Q4 (in November around the Stakeholder Forum). There are no major changes or decisions foreseen for 2018. Issues that are likely to be covered include:

- Input to AWP2019;
- Status of national plans and activities on hydrogen and fuel cells, potentially including the follow-up to responses to the Alternative Fuel Infrastructure Directive;

Furthermore, after adoption by the FCH 2 JU Governing Board of the action plan on recommendations of the interim evaluation of FCH 2 JU under Horizon 2020, measures to enhance the role of the SRG will be followed up.

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 2018.

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 11th edition of the SF will take place in Q4 2018 (see also communication section above).

3.6. Internal Control framework

The priority objective is 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.

One of the main objectives in 2018 will be to move to the principle-based system already adopted by the European Commission[59].

In 2018 focus will be put on the following:

- After the adoption of Internal Control Principles by the FCH 2 JU Governing Board (Q3), disseminate the knowledge and make the staff aware of the impact of these changes by organising an informative session;
- Further to the risk management exercise carried out in October 2017 ensure a specific follow up of the actions to manage the main risks identified;
- Carry out the annual assessment on the level of implementation of Internal Control Principles;

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 66 of the Financial Regulation, Article 18 of FCH 2 JU Financial Rules provides that “each operation shall be subject at least to an ex ante control based on a desk review of documents and on the available results of controls already carried out relating to the operational and financial aspects of the operation”. Therefore, the main objective of ex ante controls is to ascertain that the principle of sound financial management has been applied.

An ex-ante control can take the form of checking grant agreements, initiating, checking and verifying invoices and cost claims, carrying out desk reviews (performed by 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 2018, focus will be placed on:

- Implementation of the H2020 ex-ante control framework for interim and final payments of H2020 projects & active participation on the horizontal ex-ante control workshops organized by CSC;
- Participation of project and finance officers at H2020 project kick-off meetings in order to clearly communicate the financial reporting requirements;
- Increased financial checks during the Grant Agreement Preparation (GAP) phase;
- In cooperation with Internal Control and Audit Manager, organize a financial workshop for FCH 2 JU beneficiaries on H2020 financial reporting & prevention of errors in H2020 audits;

[59] http://ec.europa.eu/budget/library/biblio/documents/control/C_2017_2373_Revision_ICF_en.pdf

- Organisation of webinars with consortia to clarify financial issues before claiming costs.

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 which are carried out by external audit firms. The complete lifecycle of FCH-FP7 audits is managed and monitored by FCH 2 JU. For FCH- H2020 grants this is performed by the CAS (Common Audit Support – Unit J2 of the CSC) in close cooperation with the FCH 2 JU, except for implementation which remains fully with the FCH 2 JU.

In 2018, 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 (indicative audit programmes, endorsement of the JUs' sampling methodology 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;
- Update of the current Working Arrangements for the provisions on Article 10 (i.e. Layer 3 audits) as part of H2020 audit strategy for JUs' specific audit samples;
- In cooperation with CAS, and in line with H2020 Working Arrangements, ensure launching and monitoring of timely completion of the H2020 audits 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 under review by OLAF in November 2017. It includes an action plan which implementation is monitored through regular meetings of the Fraud and irregularity Committee (FAIR).

In 2018, FCH 2 JU will continue to apply preventive measures for fraud detection, participate to FAIR meetings organized by DG RTD, follow-up on the update of the common strategy and action plan and as necessary on actions that may be identified as a result of the survey on fraud prevention awareness carried out in November 2017. Following the adoption of new guidelines for whistle-blowers by the EC and after clarification with the SWP it will also adopt guidelines for whistle-blowers.

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 2018, focus will be put on the following:

- Development and implementation of the action plan regarding IAS audit of 2017 on Coordination with CSC and implementation of CSC tools & services;
- Coordination of the new risk assessment to be carried out by the IAS in view of their strategic internal audit plan for 2019 – 2021.

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

- Liaise with an independent auditor (to be 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 2017 and 2018 accounts and possibly on the Performance audit of PPPs.

4. BUDGET YEAR 2018

4.1. Budget information

The draft budget 2018 is in line with the preliminary budget presented in the Fiche Financière and with the draft budget sent to GB members on 8 February 2017 except for the following two elements:

1) Due to the impact from the adjustment of the EFTA contribution from 2.44 % (initial assumption in the Fiche Financière) to 2.33 % (final EFTA rate for 2018), there is a total reduction of:
   i) EUR 85,764 in commitment appropriations (EUR 80,729 for operational expenditure and EUR 5,035 for administrative expenditure) and
   ii) EUR 107,474 in payment appropriations (EUR 102,439 for operational expenditure of H2020 and EUR 5,035 for administrative expenditure).
2) Reactivation of EUR 1,847,044.11 of unused commitment appropriations from operations from year 2017, resulting mainly from the outcome of the call 2017 evaluations (EUR 1,767,086.22) and from unused appropriations of the amount reserved for JRC annual plan 2016 (EUR 79,957.89) These appropriations will be used for 2018 operational activities.
3) Reactivation of EUR 43,353.60 of unused commitment and payment appropriations from administrative costs from year 2017, stemming from de-commitments.

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 2017 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 2016 CA (executed)	Budget 2016 PA (executed)	Budget 2017 CA	Budget 2017 PA	Budget 2018 CA	Budget 2018 PA	Remarks
2001	***European Commission subsidy for operational expenditure (FP 7)***	0	46,206,111	0	20,364,173		25,686,390	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***	739,988	739,988	1,801,377	1,801,377	2,341,924	2,341,924	Council Regulation 559/2014 of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking includes EFTA (2.94% in 2015, 2.73% in 2016 and 2017)
2003	***Industry Grouping contribution for administrative expenditure***	2,602,321	2,602,321	2,058,391	2,058,391	2,014,054	2,014,054	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***	432,163	432,163	342,877	342,877	327,869	327,869	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)***	104,955,460	48,358,358	94,234,786	154,747,416	75,099,696	95,296,147	Council Regulation 559/2014 of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking includes EFTA (2.94% in 2015, 2.73% in 2016 and 2017)
2006	***JTI revenues***	479,387	479,387	109,484	109,484			Interest, income from liquidated damages & others
	sub total title revenues	109,209,318	98,818,328	98,546,915	179,423,718	79,783,543	125,666,384	
3006	***C2 reactivation of appropriations for administrative expenditure (2014)***	1,491,547	1,491,547					FCH 2 JU Financial rules article 6 - unused PA for administrative costs re-entered to be used for administrative costs
3007	***C2 reactivation of appropriations for operational expenditure (2014)***							FCH 2 JU Financial rules article 6 - de-committed CA for operational activities re-entered to be used for operational activities
3008	***C2 reactivation of appropriations for administrative expenditure (2015)***		594,429	912,443	912,443	734,699	734,699	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)***	17,061,432	14,631,121	25,861,251				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	43,354	43,354	
3011	***C2 reactivation of appropriations for operational expenditure (2016)***			2,108,756	17,050,367	1,847,044		
	sub total reactivation	18,552,979	16,717,098	28,902,450	18,788,078	2,625,097	778,053	
	TOTAL REVENUES	**127,762,297**	**115,535,426**	**127,449,365**	**198,211,797**	**82,408,640**	**126,444,437**	

The FCH 2 JU 2018 budget amounts to a total of EUR 82,408,640 in CA and EUR 126,444,437 in PA with the following breakdown:

Title Chapter Article Item	Heading	Executed 2016		Financial year 2017		Financial year 2018		*Ratio 2016/2018*	*Ratio 2016/2018*	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	2,635,011	2,654,067	3,074,600	3,109,711	3,352,600	3,352,600	79%	79%	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	32,650	32,050	17,510	18,110	46,400	46,400	70%	69%	Miscellaneous expenditure on staff recruitment: installation and travel expenses
1 3	MISSION AND TRAVEL	115,000	106,384	135,000	152,439	137,700	137,700	84%	77%	Mission expenses
1 4	SOCIOMEDICAL INFRASTRUCTURE	36,672	33,288	44,990	52,853	40,000	40,000	92%	83%	Training, medical service and mobility costs
1 5	ENTERTAINMENT AND REPRESENTATION EXPENSES	2,636	2,935	5,600	6,914	5,600	5,600	47%	52%	Representation and receptions
	TOTAL TITLE 1	**2,821,968**	**2,828,725**	**3,277,700**	**3,340,027**	**3,582,300**	**3,582,300**	**79%**	**79%**	
2	**INFRASTRUCTURE**									
2 0	INVESTMENTS IN IMMOVABLE PROPERTY RENTAL OF BUILDINGS AND ASSOCIATED COST	300,101	295,186	502,455	507,455	370,400	370,400	81%	80%	Rent, works, insurance, common charges (water/gas/electricity), maintenance, security and surveillance
2 1	INFORMATION TECHNOLOGY	281,208	230,754	225,824	373,501	209,200	209,200	134%	110%	IT purchases, software licences, software development
2 2	MOVABLE PROPERTY AND ASSOCIATED COSTS	3,896	6,082	10,023	12,386	5,000	5,000	78%	122%	Purchases and rental of office equipment, maintenance and repair
2 3	CURRENT ADMINISTRATIVE EXPENDITURE	11,633	7,088	14,971	20,944	7,000	7,000	166%	101%	Office supplies, library, translation service, bank charges and miscellaneous office expenditure
2 4	CORRESPONDENCE, POSTAGE AND TELECOMMUNICATIONS	10,541	8,172	15,000	22,097	12,000	12,000	88%	68%	Telephones, video conferences and postal services
2 5	EXPENDITURE ON FORMAL AND OTHER MEETINGS	45,287	32,269	89,100	107,482	90,000	90,000	50%	36%	Official meetings such as SRG, Scientific Committee, Governing Board
2 6	COMMUNICATION COSTS	296,850	238,929	440,000	603,684	440,000	440,000	67%	54%	External communication and events
2 7	SERVICE CONTRACTS	451,740	268,264	234,500	587,007	282,000	282,000	160%	95%	Studies and audits
2 8	EXPERT CONTRACTS AND MEETINGS	423,692	437,966	435,000	475,257	464,000	464,000	91%	94%	Costs related to expert contracts (evaluations, mid-term reviews)
	TOTAL TITLE 2	**1,824,948**	**1,524,710**	**1,966,872**	**2,709,814**	**1,879,600**	**1,879,600**	**97%**	**81%**	
	TOTAL TITLE 1+2 (ADMINISTRATIVE EXPENDITURE)	**4,646,916**	**4,353,435**	**5,244,572**	**6,049,841**	**5,461,900**	**5,461,900**	**85%**	**80%**	
3	**OPERATIONAL EXPENDITURE**									
3 0 0 1	Implementing the research agenda of FCH JU: FP7	56,949	44,910,439	2,108,756	36,434,740		25,686,390	N/A	77%	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	94,591,748	47,657,699	120,096,037	155,727,216	76,946,740	95,296,147	123%	50%	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)	**94,648,697**	**92,568,138**	**122,204,793**	**192,161,956**	**76,946,740**	**120,982,537**	**123%**	**77%**	
	TOTAL EXPENDITURE	**99,295,614**	**96,921,574**	**127,449,365**	**198,211,797**	**82,408,640**	**126,444,437**	**120%**	**77%**	

Revenues

The members' contribution to administrative costs in the 2018 budget refers only to H2020. As of 2018, no FP7 contribution for administrative costs will be asked.

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 2018 administrative budget is boosted by EUR 778,053 in total from unused administrative appropriations of previous years.

Expenditure

Overall the administrative budget (Titles 1 and 2) is increased by 4.1% (+ EUR 217,328) compared to 2017.

In more details:

Title 1 – Staff

Title 1 (staff costs) represents 66 % of the administrative costs in the 2018 budget. It mainly covers salaries (94%) and other budget lines cover missions, training & socio-medical costs, recruitment costs and representation expenses.

The increase in title 1 in 2018 compared to 2017 (+ 9.3% amounting to EUR 304,600) is explained by the following:

- *in staff in active employment (+ EUR 278,000)*
  1 additional contract agent at FGII and 1 additional interim is included in the budget compared to 2017. An indexation of 3% is assumed.
- *in recruitment (+ EUR 28,890)*
  The difference is due to the provision for installation and daily subsistence allowance for the new recruitments.
- Mission expenses are indexed to the anticipated inflation rate (2 %).
- The decrease in socio-medical infrastructure (- EUR 4,990) reflects the change in the price of medical and training services offered by the Commission, applicable as of 01.01.2018.
- No change in the entertainment and representation expenses.

Title 2 – Infrastructure

Title 2 represents 34 % of the administrative costs in 2018.

The budget of this title is decreased by 4.4 % (amounting to EUR 87,272) compared to 2017 and explained as follows:

- *Rental costs (- EUR 132,055)*
  Rental costs were increased in 2017 due to the works and refurbishments in the building. No works are foreseen in 2018. The decreased costs in 2018 (-26%) include rent, common utility charges, security and insurance services.
- *Information technology (- EUR 16,624)*
  The decrease by 7.4% is mainly due to the fact that no replacement of hardware is anticipated in 2018.
- Movable property, current administrative expenditure and postage and telephone costs are all decreased to the average consumption of the last 2 years.
- Expenditure on formal and other meetings remain at 2017 level.
- Communication costs remain at 2017 level.
- Service contracts are increased by 20% due to the need for contracting audit services for the

annual accounts of 2018 and 2019.

- The increase by EUR 29,000 in expert contracts and meetings is due to the increased number of H2020 mid-term reviews foreseen.

Title 3 – Operational

Commitment appropriations correspond to H2020 programme and are decreased by 35.9%. They will amount to EUR 76,946,740 (including EUR 1,847,044 of reactivations of non-used appropriations from 2017) and will cover the 2017 operational activities as described in section 3.2 of the document.

Payment appropriations correspond to estimated needs to cover:

1) Payment obligations under FP7 projects (interim & final payments) for EUR 25,686,390, a decrease by 29.5% compared to 2017 level reflecting the decreased number of FP7 projects that remain open.
2) Payment obligations under H2020 projects for EUR 95,296,147, decreased by 38.8% as in 2017 the pre-financing of 2 calls (2016 and 2017) were included in the budget. The 2018 payment appropriations will cover part of the pre-financing for calls 2018, 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.

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 (2017-2020 and following years) to meet budget commitments entered into earlier financial years (before 2017).

SUMMARY SCHEDULE OF PAYMENTS (Operational)

2016 Outturn		2017 Budget		2018 Budget		Difference (2017/2016)	
CA	PA	CA	PA	CA	PA	CA	PA
94,648,697	92,568,138	122,204,793	192,161,956	76,946,740	120,982,537	-37%	-37%

DETAILS OF PAYMENT SCHEDULE (Operational)

FP7

		Payments					
Commitments		2017	2018	2019	2020	Outstanding amount	**Total**
Pre-2014 commitments still outstanding (RAL)	**70,233,419**	14,394,637	25,686,390	6,508,360	6,620,215	17,023,818	**70,233,419**
TOTAL	**70,233,419**	14,394,637	25,686,390	6,508,360	6,620,215	17,023,818	**70,233,419**

H2020

		Payments					
Commitments		2017	2018	2019	2020	Outstanding amount	**Total**
Pre-2017 commitments still outstanding (RAL)	**142,448,058**	28,820,797	39,870,462	29,636,404	22,959,503	21,160,892	**142,448,058**
2017 commitment appropriations still outstanding (RAL)	**117,830,602**	64,292,396	13,695,740	16,537,972	5,263,020	18,041,474	**117,830,602**
2018 commitment appropriations	**76,946,740**	-	41,729,946	500,000	10,495,977	24,220,818	**76,946,740**
TOTAL	**337,225,400**	93,113,193	95,296,147	46,674,376	38,718,500	63,423,184	**337,225,400**

State of play on 06/10/2017 - RAL refers to open commitments on 06/10 - payments for 2017 refer to foreseen payments from 06/10/2017 until the end of the year

2016 CA outturn refers to the 19 individual commitments for the call 2016 and the balance of the global commitment on the call 2016 as well as the individual commitment for JRC and re-commitments for FP7 projects

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 2018 Staff Establishment Plan is shown below:

Grade	2017 amended	2017 filled	2018 budget
AD 16	-	-	-
AD 15	-	-	-
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	1	1	3
AD 5	3	3	1
Total AD[60]	**15**	**15**	**15**
AST 11	-	-	-
AST 10	-	-	-
AST 9	-	-	-
AST 8	2	2	2
AST 7	1	1	1
AST 6	1	1	1
AST 5	-	-	1
AST 4	4	4	4

60 AD stands for Administrator

AST 3	1	1	-
AST 2	-	-	-
AST 1	-	-	-
Total ***AST***[61]	**9**	**9**	**9**
Function Group IV	1	1	1
Function Group III	1	1	1
Function Group II	-	-	1
Function Group I	-	-	-
Total Contract Agents	**2**	**2**	**3**
Total Seconded National Experts	**2**	**0**	**2**

[61] AST stands for Assistant

5. LIST OF ACRONYMS

Term	Definition
AAR	Annual Activity Report
ABAC	Accrual Based Accounting
APU	Auxiliary Power Unit
ASIL	Automotive Safety Integrity Level
AWP	Annual Work Programme/Plan
BoP	Balance of Plant
CA	Contract Agent
CAPEX	Capital Expenditure
CAS	Common Audit Service
CHP	Combined Heat Power
COP21, 22, 23	Conference of the Parties
COPV	Compressed Overwrapped Pressure Vessel
CSC	Common Support Centre
DiEEP	Dissemination & Exploitation Practitioners' Platform
DSO	Distribution System Operator
CTCN	Climate Technology Centre and Network
EC	European Commission
ECA	European Court of Auditors
EFTA	European Free Trade Area
EU	European Union
EUSEW	EU Sustainable Energy Week
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 Research and Innovation programme over 7 years for the period 2007 to 2013
GAP	Grant Agreement Preparation
GB	Governing Board
GHG	Green-House Gases
HD trucks	Heavy-Duty trucks
HIAD	Hydrogen Incident and Accident Database
Horizon 2020 (H2020)	EU Research and Innovation programme over 7 years for the period 2014 to 2020
HRS	Hydrogen Refuelling Station
HTPEM	High Temperature PEM
IAC	Internal Audit Capability
IAS	Internal Audit Service
ICE	Internal Combustion Engine
ICS	Internal Control Standards

IEC	International Electrotechnical Commission
IPHE	International Partnership for Hydrogen into the Economy
ISO	International Standards Organization
JRC	Joint Research Centre of the European Commission
KPI	Key Performance Indicator
LHV	Lower Heating Value
LNG	Liquefied Natural Gas
MAWP	Multi-annual Work Plan
MCFC	Molten Carbonate Fuel Cell
MEA	Membrane Electrode Assembly
MRL	Manufacturing Readiness Level
MTBF	Mean Time Between Failures
NG	Natural Gas
NGO	Non-governmental organisation
N.ERGHY	Research Grouping
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
PEM/PEMFC	Proton Exchange Membrane Fuel Cell
PNR	Pre-normative Research
PPP	Public Private Partnership
PRD	Programme Review Days
QA	Quality Assurance
RCS	Regulations, Codes and Standards
rSOC	Reversible Solid Oxide Cell
R&D	Research and Development
SEP	Staff Establishment Plan
SF	Stakeholders Forum
SOC	Solide Oxide Cell
SOFC	Solid Oxide Fuel Cell
SRG	States Representative Group, advisory body of the FCH JU gathering representatives from Member States and Associated Countries
SU/SD	Start Up/Shut Down
TA	Temporary Agent
TCO	Total Cost of Ownership
TRL	Technology Readiness Level
TSO	Transmission System Operator
UAV	Unmanned Aerial Vehicle

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[62] 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

[62] (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[63]	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

[63] 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 [64]	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		90% 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 in charge.

[64] Additional indicators can be proposed/discussed with R.1 and/or DG HR

TABLE II

Indicators for monitoring Horizon 2020 Cross-Cutting Issues[65] 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

[65] (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[66]	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

[66] 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[67] 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)		

[67] 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[68]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)[69]	Responsible Directorate/Service/Joint Undertaking	JU AAR RTD Monitoring Report		

[68] RTO: Research and Technology Organisation

[69] 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	N/A	JU	Result of FP7		
	Demonstrator projects hosted in MSs and regions benefiting from EU structural funds	N/A	JU	Result of FP7		