ANNEX to GB decision of 20/12/2016

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

2017

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.

1. TABLE OF CONTENT

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2. INTRODUCTION

This document establishes the fourth 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 2017.

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 set up, within the Horizon 2020 Framework programme, as a Joint Undertaking by Council Regulation N° 559/2014. Its aim is to contribute to the Union's wider competitiveness goals, leverage private investment, industry-led implementation structure.

In July 2014, President Jean-Claude Juncker in his Political Guidelines1 highlighted the need "to pool our resources, combine our infrastructures (…) and to diversify our energy sources and reduce the high energy dependency of several of our Member States". Indeed 94% of the EU transport relies nowadays on oil products of which 90% is imported and 75% of the EU housing stock is largely energy inefficient.

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. The European Union is committed to transforming its transport and energy systems as part of a future low carbon economy. 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.

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[2], 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 Maros Sefcovic 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 well below 2°C. 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 40% by 2030.

[1] See: http://www.eesc.europa.eu/resources/docs/jean-claude-juncker---political-guidelines.pdf
[2] http://ec.europa.eu/priorities/energy-union/index_en.htm

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. Canada, Denmark, Germany, Italy, Japan, Korea, Switzerland, the United States and the European Commission announced more than $23 million USD to scale-up support for technology to help countries achieve their commitments under the Paris Agreement.

The Communication from the European Commission[3] on 'A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy' contains among all lines of action:

- energy security, solidarity and trust
- energy efficiency
- decarbonizing the economy
- research, innovation and competitiveness.

In particular, the importance of supporting European Research and Innovation, for which Horizon 2020 represents its largest-to-date implementation tool, has been highlighted by Commissioner Moedas.[4]

The present Annual Work Plan 2017 of the Fuel Cells and Hydrogen 2 Joint Undertaking, outlining the scope and details of its fourth 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 (OJ L 169/108 of 7.6.2014):

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.

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[3] COM(2015)80, Energy Union Package

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

3. ANNUAL WORK PLAN YEAR 2017

3.1. Executive Summary

The Annual Work Plan 2017 for the FCH 2 JU continues the work initiated in previous years with regards to the development of a research and innovation programme aligned with the objectives set in Council Regulation 559/2014 of 6 May 2014 (OJ L 169/108 of 7.6.2014).

During 2017, a call for proposals with an indicative budget of EUR 116 M will be launched in January 2017 (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 Cross-Cutting activities. A total of 24 topics will be part of the call for proposals, including 7 for Transport, 12 for Energy and 5 for Cross-Cutting. They will be grouped into 9 Innovation Actions (IA), 13 Research and Innovation Actions (RIA) and 2 Coordination and Support Actions (CSA).

The Calls for Proposals will be subject to independent evaluation and will follow the H2020 rules on calls for proposals. Upon selection, the Partners will sign a Grant Agreement for Partners with the JU and its contribution will be made to either the final demonstrator or the set of activities which are performed by one or several FCH2 JU Members in the frame of the Grant Agreement for Members.

In addition, work will continue to ensure that the support structure 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 MAWP 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-01-1-2017: Development of fuel cell system technologies for achieving competitive solutions for aeronautical applications FCH-01-2-2017: Towards next generation of PEMFC: Non-PGM catalysts FCH-01-3-2017: Improvement of compressed storage systems in the perspective of high volume automotive application FCH-01-4-2017: Demonstration of FC material handling and industrial vehicles FCH-01-5-2017: Large scale demonstration in preparation for a wider roll-out of fuel cell bus fleets (FCB) including new cities – Phase two FCH-01-6-2017: Large scale demonstration of Hydrogen Refuelling Stations and Fuel Cell Electric Vehicle (FCEV) road vehicles operated in fleet(s) FCH-01-7-2017: Validation of Fuel Cell Trucks for the Collect of Urban Wastes
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-02-7-2017: Development of flexible large fuel cell power plants for grid support FCH-02-8-2017: Step-change in manufacturing of Fuel Cell Stack Components FCH-02-9-2017: Development of next-generation SOFC stack for small stationary applications FCH-02-10-2017: Transportable FC gensets for temporary power supply in urban applications FCH-02-11-2017: Validation and demonstration of commercial-scale fuel cell core systems within a power range of 10-100kW for selected markets/applications
Techno-economic objective 3: increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing	FCH-02-1-2017: Game changer Water Electrolysers FCH-02-2-2017: Game changer High Temperature Steam Electrolysers

operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system is competitive with the alternatives available in the marketplace	
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-02-3-2017: Reversible Solid Oxide Electrolyser (rSOC) for resilient energy systems FCH-02-4-2017: Highly flexible electrolysers balancing the energy output inside the fence of a wind park FCH-02-5-2017: Demonstration of large electrolysers for bulk renewable hydrogen production FCH-02-6-2017: Liquid organic hydrogen carrier FCH-02-12-2017: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas
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-01-2-2017: Towards next generation of PEMFC: Non-PGM catalysts

Five topics are also addressing cross-cutting issues:

- FCH-04-1-2017: Limiting the impact of contaminants originating from the hydrogen supply chain
- FCH-04-2-2017: Harmonisation of hydrogen gas trailers
- FCH-04-3-2017: European Higher Training Network in Fuel Cells and Hydrogen
- FCH-04-4-2017: PNR for a safe use of liquid hydrogen
- FCH-04-5-2017: Definition of Accelerated Stress Testing (AST) protocols deduced from understanding of degradation mechanisms of aged stack components in Fuel Cell systems

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 Commission services and are grouped into 3 categories as follows:

- Horizon 2020 Key Performance Indicators[5] common to all JTI JUs;
- Indicators for monitoring H2020 Cross-Cutting Issues [6] common to all JTI JUs;
- Key Performance Indicators specific to FCH 2 JU

[5] Based on Annex II - Council Decision 2013/743/EU
[6] Based on Annex III - Council Decision 2013/743/EU

The KPIs specific to FCH 2 JU will be reviewed and revised as necessary also taking into account the revision of the MAWP.

Risk Assessment

In the annual risk assessment exercise, conducted in October 2016, the following significant risks & responses to those risks in terms on action plans were identified:

#	**Risk Identified**	**Action Plan**
MEDIUM	Due to BREXIT participation of UK companies (currently representing significant part of FCH 2 JU funding) in the programme at the state of application and 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 untimely payment of the Union contribution to the FCH 2 JU budget of 2017, there is a risk that the pre-financing of call 2016 will not be paid on time.	Liaise with the Commission to ensure that operational capacity to pay the pre-financing in a relatively small window when payment appropriations become available.
MEDIUM	Due to the lean structure of the JU and/or the lack of permanent contracts, rotation of key staff may cause business continuity issues.	Back-up system in place. Introductory workshops/courses organized for new staff and GB members Training plans are prepared on the individual basis and discussed with the line manager based on needs identified, new functions, job descriptions and to be able to ensure full business continuity.
MEDIUM	Due to the increasing number of proposals submitted to the FCH 2 JU and of stakeholders involved in the FCH 2 JU projects, there is a risk that it will not be possible to find enough experts without conflict of interest for the evaluation of the proposals and for the mid-term reviews of the projects.	Management of the experts' database is ongoing; provisions for avoidance of Conflicts of Interests are embedded in the internal procedure. New experts (including non-EUR experts) are considered.

#	Risk Identified	Action Plan
MEDIUM	Risk for 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. Monthly status reporting including proposed actions as necessary will be done by internal control and audit manager to the Executive Director
MEDIUM	Uncertainty of results of1st interim evaluation of H2020 (and final evaluation of FCH JU programme) which may adversely affect discharge procedure. For 2016 annual accounts audit, part of the process will be outsourced (for the first time) to an external audit firm - this change might pose some risk on receiving clean opinion from ECA, which is taken duly into consideration during discharge process.	Active dialogue with the EC in preparations for the 1st H2020 interim evaluation, timely preparations of inputs when requested. Close cooperation with the European Court of Auditors (ECA) and new external auditors.

The FCH2 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 2017 Call for Proposals is the result of a joint effort by the major stakeholders, namely the Hydrogen Europe, N.ERGY 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 Multi-Annual Work Plan: Transport, Energy and Cross-Cutting. Overarching projects, combining the entire supply chain from production of hydrogen all the way to its use in transport applications, have not been 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 particular for this year and in line with the other activities of the FCH2 JU on value chain and supply chain evaluation (see procurement/studies section), and in order to reinforce European supply chain of critical key components by e.g. a higher range of common/standardised parts to be produced in Europe and to enable start investments in European production facilities for further ramp-up in European markets, emphasis is put mainly for big Innovation Actions on:

- establishing a demonstration/commercialisation pathway for European SMEs innovating in the development, manufacturing and supply chain of fuel cell components,
- establishing the basis and further develop, if possible, marketing and sales strategies of European manufacturers,
- increasing awareness of European market for fuel cells.

On the other hand, international collaboration with countries under International Partnership of Hydrogen into the Economy (IPHE) is encouraged for considerable number of topics (see below related chapter). In addition, openness towards markets in the EU13 countries should be explored and integration of participants from those countries in consortia is highly encouraged.

Supported projects will have to report on an annual basis in the FCH2 JU secure online data collection platform, according to template questionnaire(s) relevant to the project content. This will 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 minor adjustments in time.

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.

1. Transport Topics:

Not surprisingly the transport sector continues to attract a lot of attention bearing in mind the importance of this sector of activities on greenhouse gas emissions.

Regarding Research and Innovation Action topics, the development of Fuel Cell Technologies for aeronautical applications is considered as an important issue with particular focus on auxiliary or emergency power generation. The call will also address a major strategic challenge with the expected development and testing of a PEMFC integrating Platinum Group Metals-free catalyst.

Improvements are also targeted for on-board compressed hydrogen storage systems used in automotive applications.

In addition, the call will consider 4 demonstration related topics with clear strategic dimensions. The large scale deployment of hydrogen fueled material handling vehicles based on European Technologies will be supported. A continuation of efforts made in the field of Fuel Cell Buses for Public Transportation applications will also be made as a follow-up to the large scale demonstration programme initiated in the 2016 call. A demonstration topic focusing on Fuel Cell Vehicles Fleets deployment aiming at improving the reliability of vehicles and infrastructure reliabilities through increased utilization in the field is also proposed. Finally, a topic involving the validation of Fuel Cell Trucks for one typical urban application is defined.

It is also worth noting that a special attention has to be made on the need to strengthen the European nature of the FCH Technologies Supply Chain.

2. Energy Topics:

The reduction of costs for hydrogen production technologies has been pursued in recent years' calls through mainly incremental development of related technologies, moving forward the readiness of the technologies and manufacturability as well as upscaling the specific size of stacks and systems up to the multi MW scale for water electrolysis. This approach has provided positive results, in line with the targets set out in the MAWP in terms of KPIs. On the other side, the level of competition in the international markets demands breakthrough steps through research and innovation actions. This is urgent given the pressure at the European level increasing the production capacity of hydrogen from renewable sources.

The game changer is proposing a major step improvement, both for water and steam electrolysers, looking to novel solutions available at the laboratory scale, to significantly increase performances of the electrolysers with the overall scope of hydrogen cost reduction. It is required to surpass the FCH JU's KPIs in terms of cost, efficiency, lifetime and operability.

In parallel, the upscaling of electrolysers will continue to be supported. More promising applications and markets, complimentary to recently supported projects, will continue to move innovation actions toward a roll out of technologies for bulk renewable hydrogen production, looking to the use of hydrogen at a wider scale (e.g. industrial processes as well as transport applications). At the same it is considered highly strategic to embed power blocks of the wind turbines with the electrolysers, at a full-scale plant, leveraging the collaboration effort among the two communities and realizing a cost-effective and effective solution for a P2G technology to be injected in the natural gas piping or in P2P, re-electrifying the hydrogen for grid services.

Considering the European target of CO2 emission reductions, introduction of renewable sources and increase of energy efficiency, new solutions to manage variable and intermittent electricity production are envisaged. The reversible high temperature technology offers the flexibility to enter several markets, with the option of electricity and H_2 production at higher efficiency using external heat, electricity production from H_2 and/or CH_4 using the same device.

The production of hydrogen, either by Steam Methane Reforming, SMR or renewables, considering the expansion of consumption markets, will require soon reliable, low cost, safe hydrogen distribution, compared to the actual pressurized trailers. Among the options, and considering recent developments, end-to-end solutions based on ammonia free liquid hydrogen carriers is a promising direction to explore, in line with the mentioned overall targets.

The stationary fuel cell sector evolves along two distinct axes: fuel cells using hydrogen to provide specific added values such as grid or micro-grid balancing, local pollution reduction and the like, and fuel cells for power providing high electrical and overall efficiencies with the associated primary energy reduction.

Along the hydrogen axis, the progress on the electrolysers in size, reactivity and costs needs to be reflected in a symmetrical way on the fuel cells side for hydrogen to power conversion to offer the full grid balancing capability. While the base technology has already been demonstrated, the cost and flexibility challenges require a systematic analysis of the bottlenecks, and a comprehensive approach integrating the already achieved progress to build appropriate power modules to achieve the entire set of the 2020 KPI targets. Micro-grids integrating both electrolyser and fuel cell technologies integrated into renewable generation raise similar challenges but on a complete different scale and at different cost levels. The challenge there is much more in engineering and demonstration of integrated systems based on technology that can achieve the targeted KPIs with the established base technology. Hydrogen FC can also contribute to pollution (dust, noise and toxic emissions) in hostile environments such as construction sites in cities and the like. The demonstration of fuel cell gensets replacing Diesel generators potentially also brings higher flexibility in the work of construction sites as they can also be run during nights.

Along the efficiency oriented axis, the progress achieved by residential micro-CHP FC demonstration has established a solid base to validate and demonstrate the technology now in the commercial segment. This will open additional markets in various CHP and CCHP applications and also reflect in reduced primary energy consumption. As the cost pressure is still high for the entire sector with respect to the incumbent low-efficiency low-cost technologies, two complementary approaches are supported around the core technology: The first opens the door to new and more cost effective manufacturing technologies, providing the state of the art technology a significant cost reduction in processing based on the current material systems. This is mainly done by the use of manufacturing processes that have become available in the last few years in other industries. The second approach aims at the next generation stack translating R&D results of the recent years into new stack materials system and the associated manufacturing processes. The supported stacks need to demonstrate both equal or improved performance and durability and reduced costs. All three topics are of complementary nature and aim to translate Europe’s technology leadership in high efficiency fuel cells into a competitive advantage for the European industry. All projects favor the emergence of a European value chain with increasingly defined specialization for the different manufacturing steps.

3. Cross-Cutting Topics:

As with previous years, Cross-Cutting 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 AWP 2017 these activities will be conducted through five separate topics covering contaminants in the hydrogen supply chain;

harmonization of hydrogen gas trailers; developing higher training networks across the EU; a PNR basis for safe use of liquid hydrogen; and establishing a definition of Accelerated Stress Testing protocols relating to stack components.

With three of the topics relating to hydrogen transport, storage and supply, the wider challenge being addressed is to ensure that related issues covering contaminants in the supply chain, the risks relating to safe use of gaseous hydrogen trailers and the safe use of liquid hydrogen is clearly defined and understood in advance of the volume scale-up of hydrogen shipped and dispensed. Education and training are critical activities needed to support and sustain a growing FCH Community dealing with an expanding set of FCH technology deployment and operation in both specific applications (transport, CHP, etc.) and wider network configurations (H2 gas to grids, energy storage, combination with renewables, etc.). Previous topics have covered education and training activities incorporating new digital based methods and e-learning concepts to help educate and train undergraduate and graduate students, together with the technical workforce involved in FCH technology deployment. For 2017 this is now to consider the means of proliferating FCH education across the EU independent of educational institution specialization, and looking instead to utilize the beneficial impacts of networks, clusters and harmonization / provision of the highest quality educational materials to reach the widest student cohort possible.

Identifying degradation mechanisms in stack components for differing FC technologies has also been covered in earlier AWP calls. Moving to a formal definition of the Accelerated Stress Testing is a logical progression from the outcomes of earlier topics and FCH demonstration programmes to realize highly relevant ASTs to be taken forward for the FCH community and into EU protocol harmonization and validation activities.

List of actions

For the implementation of the Work Plan, the following actions will be taken in 2017:

A. Call for proposals 2017

Topic descriptions are detailed starting from the next page.

Topic Descriptions

TRANSPORT PILLAR

<u>FCH-01-1-2017: Development of fuel cell system technologies for achieving competitive solutions for aeronautical applications.</u>

<u>Specific challenge:</u>

Driven by the demand for optimised aircraft performances, reduced operating and maintenance costs, increased dispatch reliability, reduced greenhouse gas emissions and quieter aircrafts, and the rapid growth of air traffic for the coming years, both commercial aircraft industry and general aviation are respectively pushing towards the concept of more electric aircraft (MEA) for which electricity is initially used for non-propulsive systems, and for an all-electric aircraft. As highly efficient power generation systems, fuel cell systems can play an important role in the development of the MEA concept.

Target applications range from cabin/hotel loads (5-20 kW), to emergency power units (15-50 kW), Auxiliary Power Units (superior to 50 kW) or regarding general aviation to the light aircraft propulsion systems (> 40 kW). Besides commercial aircraft industry and general aviation, electrical unmanned aerial vehicles (UAV) have also shown interest for fuel cell technology as a key means to offer an improved endurance and range mission capability. Previous (Boeing 2008, DLR A320 ATRA 2011, Antares DLR 2009 and 2012, FCH-JU SUAV 2011) and current (FCH JU funded HYCARUS) projects have demonstrated and confirmed the potential of fuel cell technology to match aircraft needs and have helped identify main remaining challenges and bottlenecks.

Main challenges for fuel cell based energy generation systems for the aircraft industry include the fuel cell system weight and volume, the required extended lifetime and reliability to comply with aircraft operation and maintenance schedules, the ability of the technology to demonstrate compliance with the specific aerospace airworthiness certification requirements (essentially related to safety considerations) , the cost effectiveness of the corresponding fuel cell system designs and their full integration into the aircraft.

<u>Scope:</u>

The objective of the project is the design, development and demonstration under realistic operating conditions (TRL5-6) of an autonomous electric power generation system for non-intrusive applications for auxiliary or emergency power generation.

The consortium should be established to gather required competences and background knowledge to address the above mentioned challenges and the following key objectives:

- Fuel cell system electric power output of at least 10 kW, according to target application power range;
- Pure hydrogen fed fuel cell system;
- Develop corresponding key components and subsystems to achieve compliance with aerospace requirements (weight and power density, safety, lifetime, materials selection, DO160, EASA CS-VLA, EASA CS23 etc) with a particular focus on key equipment such as fuel cell, air compressor and H_2 storage and distribution subsystem. Later, industrialisation and

target aircraft installation should be strong key drivers for any of the considered prototype developments and this should be well documented in the proposal;

- Implement simulation and model-based design methodology for optimal design trade-offs (performance, durability) and definition of most suitable control strategies;
- Demonstration of FC system compliance with applicable aerospace Regulations Codes and Standards (RCS) for the considered application and identification of amendments/evolutions of existing RCS when required;
- Demonstration of system operation and performance under realistic operating conditions representative of the selected application mission profile (validation of operating strategies and assessment of their impact at system level);
- Experimental demonstration at laboratory level of system prototype durability and assessment of system reliability and maintainability under real operation;
- Perform economic assessment and derive fuel cell system Total Cost of Ownership for the selected target application including refueling and system maintenance.

Throughout the project, particular attention should be given to meet the best achievable trade-off between performance, lifetime, reliability, maintainability and system power density. Safety is hereby to be maintained at the required level. Project activities may enable even higher safety levels.

Proposals are also encouraged to consider preparation of flight test demonstrations to be conducted after completion of the project, in order to reinforce demonstration value and representativeness and better prepare for future commercialisation of the technology within the 2025 time frame.

The consortium should include at least one aircraft OEM or one Tier 1 aircraft industry OEM.

The TRL at the start of the project should be 3-4 and the project should aim to reach a TRL of 5-6 at completion.

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

The FCH 2 JU considers that proposals requesting a contribution from the EU of up to EUR 5 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:

- Fully integrated fuel cell system design (regarding target aircraft application and installation), including H2 storage, for airworthiness certification.
- Cost effective fuel cell system design (taking into account integration, compliance with aerospace standards): ≤ 2000 €/kW.
- Demonstrated fuel cell system lifetime and durability under representative operating conditions (≥ 4000 h) corresponding to approx. 4 000 typical flight cycles.
- Proposals should also show a convincing approach to demonstrate that the proposed design can achieve a fuel cell system lifetime ≥ 20 000h.
- Low noise operation - target < 60dB
- Weight optimisation: ≥ 100 W/kg

- Validation and demonstration of system safety strategy and recommendations for RCS definition/amendments in the aerospace sector.
- Industrialization and production ready fuel cell (FC) system design – manufacturing and production processes are expected to be defined as an outcome
- Enhanced electric power generation efficiency (≥ 40% at rated power).

Type of action: Research & 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 2016– 2017.

FCH-01-2-2017: Towards next generation of PEMFC: Non-PGM catalysts

Specific challenge:

The 5th objective of the FCH 2 JU[7] addresses the reduction of critical raw materials[8]. This is the main challenge of this topic. In addition, increase in the competitiveness of European partners in manufacturing Membrane Electrode Assembly (MEAs) and Proton Exchange Membrane Fuel Cell (PEMFC) stacks by reducing the cost of PEMFC stacks and gaining novel materials knowledge is also a major objective of this topic.

An estimated 30% of the cost of PEMFC is driven by the use of Platinum (Pt) as a very effective hydrogen oxidation and oxygen reduction catalyst in low temperature PEMFC fuel cells. In addition, Pt is sensitive to contamination from impurities in the hydrogen and certain air contaminants. Many projects are already dealing with decreasing Pt loading in MEAs, but to ensure Europe's competitive position and to reduce market pressure on the use of scarce noble metals, it is mandatory that the transition to a next-generation PEMFC using Platinum Group Metals-free (PGM-free) catalysts is made as quickly as possible, and that promising routes are explored to remove Pt and other critical raw materials from PEMFC. The ultimate ideal industrial goal is to manufacture PEMFC stacks for transport application with Non-PGM catalysts, and with performance and durability comparable to the targets defined for Pt.

Scope:

As a step towards this ultimate goal, the priority of the project is to develop and test at single cell scale Non-PGM catalysts on the cathode side with sufficiently improved performance and durability compared to the current State-of-Art of Non-PGM catalysts. This step is focused on the cathode side as the Pt loading on the anode side is currently significantly lower than the one on the cathode side. However, reduction or elimination of PGM on the anode is also in the scope. Development on membrane, bipolar plate, or gas diffusion layer is not the subject of this topic.

The project shall address the targets defined in the expected impacts and, as far as possible, evaluate solutions to reach the ultimate ideal goal of the topic step by step (same performance and durability than with pure Platinum). These targets shall be demonstrated under the EU harmonized testing procedures[9] and especially EU harmonized test protocols for PEMFC MEA testing in single cells configuration for automotive applications. A collaboration mechanism needs to be developed with the JRC, in relation to the ongoing EU protocol harmonisation and validation activities performed in support of the FCH2-JU programme.

The proposal should also include:

- Benchmark of SoA low-TRL Non-PGM catalysts.

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

[8] List of critical raw materials: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0297&from=EN

[9] European harmonised testing protocols: http://bookshop.europa.eu/en/eu-harmonised-test-protocols-for-pemfc-mea-testing-in-single-celhttp://bookshop.europa.eu/en/eu-harmonised-test-protocols-for-pemfc-mea-testing-in-single-cell-configuration-for-automotive-applications-pbLDNA27632/l-configuration-for-automotive-applications-pbLDNA27632/

- Diagnostics and analysis tools to better understand durability, performance, electrochemical reaction mechanisms, active site densities, protonic and electronic conductivities, mass transport limitations such as electronic microscopy, modelling, specific local diagnostics and instrumentation, specific tests.

- Assessment of cost, life-cycle and commercial exploitation potential of the proposed solutions compared to the state-of-the-art solutions.

The proposals shall build on results from past or on-going FCH-JU projects dealing with substitution of Platinum for PEMFC.

The proposals should include a clear go-no go decision at mid-term as a basis to decide on the follow-up of the project. The go-no go criteria shall be based on the targets listed under section Expected Impacts.

The consortium should include research organizations, universities, a catalyst manufacturer; and OEM. International collaboration in this field is highly encouraged, especially with IPHE members.

TRL at the beginning of the project: 2

TRL at end of the project: 3

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

The FCH 2 JU considers that proposals requesting a contribution from the EU of up to EUR 2.75 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected duration: 3 years

Expected impacts:

The proposals shall allow reaching the following targets

- Increase the performance of Non-PGM catalysts
  - increase Oxygen Reduction Reaction (ORR) performance to reach at least
    - 75 mA/cm² @0.90 V (iR-free, 1bar, 80°C, H2/O2, RH 100%)
    - 44 mA/cm² @0.90 V (iR-free, 1bar, 80°C, H2/air, RH 100%)
  - Increase the performance up to 600 mA/cm²@0.7V; ~ 0.42 W/cm² (no iR-correction, 2.5 bar anode and 2.3 bar cathode, 80°C, H_2/air, RH 50% anode and 30% cathode, Stoi=1.3 anode and 1.5 cathode, according to harmonized European testing conditions)
  - analyze and reduce the transport losses in the catalyst layer: ionomer, MEA design and optimization, ink formulation and/or MEA process
- Increase the durability of Non-PGM catalysts:
  - Loss of performance @ 1.5 A/cm² (FC-DLC European cycle, 1000 h): < 30%
  - Analyze the degradation mechanisms: Accelerated Stress Tests, operating and mitigation strategies, sensitivity to pollutants…
- Demonstrate the performance in Rotating Disk Electrode (RRDE)
- Demonstrate the performance and durability in single cell: at laboratory scale (at least 25 cm²) and at industrial scale (at least 200 cm²)

and shall also contribute to

- Reduce the MEA active area cost by > 60% for equivalent power (10 to 100 kW) compared with the current State-of-the-Art (SoA)
- Increase the tolerance to impurities (in particular sulphur species and CO)

- Better understand the routes to improve the performance and durability of Non-PGM catalysts for automotive applications

Type of action: Research & 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 2016– 2017.

FCH-01-3-2017: Improvement of compressed storage systems in the perspective of high volume automotive application

Specific challenge

Hydrogen tanks for automotive applications are already available but they do not yet fulfil all carmakers' and customers' expectations in the view of hydrogen powered vehicles as an alternative to conventional modern ICE-powered vehicles. Also, the current hydrogen business is small hence production is low, cost competitiveness and build-up of a European supply chain are challenging.

Four key challenges have been identified:

1. Achievement of the automotive performance and cost targets for a broader market introduction. This is mainly due to intensive carbon fiber 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 architecture optimization and improved designs of compressed overwrapped pressure vessels (COPV) with respect to cost, performance and manufacturing productivity are required.

2. Vessel and ancillary component (tank valve, pressure regulator,…) integration in the vehicle in order to ease assembling and integration procedures, thereby reducing cost and maximizing volume available to the customer.

3. 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 temperature overshoot caused by possible malfunctions of the fuelling station. Likewise, being able to extract the maximum hydrogen mass flow regardless of the state of charge (SOC) calls for the ability of the COPV and the complete fuelling system to withstand and/or operate at lower temperatures.

4. Increase the acceptance of COPVs for hydrogen storage in automobile applications by means of offering a higher safety level. It is especially necessary to ensure that COPVs can be transferred into safe mode during thermal incidents.

Scope

- Development of new and/or optimized tank geometries having the same storage performance and providing an enhanced integration in the car space at a comparable price. The storage density shall be 0.023Kg/L or higher. The cost target for a production of 30,000 parts per year basis shall be 500€/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 of an optimized production strategy (increased materials efficiency, weight and volume reduction, manufacturing optimization, optimum storage geometries/designs)
- Miniaturization and integration of tank components, e.g. on-tank valve, pressure regulator
- Define standardized interfaces and (sub)components in order to benefit from the economy of scales.
- 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 input to revised regulation codes and standards for compressed gaseous hydrogen (CGH2) tanks.
- For protection against the worst-case scenario of the failure of the TPRD, a leak-before-burst vessel design should be developed. The failure mechanism of the vessel has to be studied and the reliability demonstrated. Furthermore, systems for detecting localized fires, enhanced fire protection systems/strategies as well as additional security measures are to be evaluated.

The consortium should include at least one vessel supplier, one pressure component developer and an OEM. The consortium should 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.

TRL at start: 4

TRL at end: 6

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

The FCH 2 JU considers that proposals requesting a contribution from the EU of up to 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

- 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.
- Define production strategy in coherence with standard automotive throughput with a significant impact on:
  - COPV manufacturing yield (target: Increase productivity by a factor of 3)
  - Reduced performance scattering (Standard deviation of burst pressure reduced by 30%)
- Improved filling/venting tolerance of storage systems (temperature range: -60°C to +100°C) to sustain fast-filling and unrestricted extraction.
- Provide technical and performance validation of prototypes with respect to EU standards (e.g. EC79)
- Produce whitepapers for RCS and/or maintenance guidance
- Demonstrate leak-before-burst vessel designs and fire detection and protection concepts.
- Strengthen the European industry, by creating knowledge in support of the EU growth and jobs policy agenda.

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

- Volumetric capacity: 0.023Kg/L (2020)
- Gravimetric capacity: 5%
- Cost target for a production of 30,000 parts per year basis: 500€/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 2016– 2017.

FCH-01-4-2017: Demonstration of FC material handling and industrial vehicles

Specific challenge:

Increased productivity powered by renewable energy sources is the primary motivation for the adoption of fuel cell and hydrogen technology in the material handling (MH) and industrial vehicles, e.g. municipal service trucks, markets. Regulations for indoor operations of vehicles and emission regulations for environmental zones in cities generate an increasing demand for zero emission drives for industrial mobile applications.

Promotion of both European based technology and commercialisation of hydrogen and fuel cells for industrial mobile applications are urgently required. Demonstrations MH vehicles fleets applying the latest fuel cell technologies should on one hand prove performance and reliability inducing customer acceptance and on the other hand enable cost reductions in fuel cell system and hydrogen infrastructure.

This demonstration project further aims, on one hand, to deploy, promote and benchmark the EU MH and industrial vehicle FC technology and value chain and on the other hand to evaluate the European market.

The topic is not intended to cover basic R&D on new FC systems. Demonstration shall comprise 400 or more fuel cell MH and industrial vehicle units across multiple vehicle-user sites and applications aimed at proving a commercial customer value proposition. Demonstration should include necessary and relevant support of small-scale and low-cost hydrogen supply infrastructure designed for 35 MPa and the hydrogen generated should be from renewable energy.

Proposals should include installations with typical fleet sizes of 10 to 30 MHVs per site which represents the majority of installations in the EU and in at least 6 sites. However large fleets with 100+ MHVs in one site can also be considered.

This demonstration project therefore aims, on one hand, to deploy, promote and benchmark the EU MH and industrial vehicle FC technology and value chain and on the other hand to evaluate the European market (in at least 6 different sites).

Scope:

The project must cover the deployment and evaluation of an European FC system technology by vehicle-users in real operating environments of a series of at least 400 MHVs and industrial vehicles and the related infrastructure. The FC vehicles are to be implemented in different sites of logistic hubs, municipal service hubs, airports, etc. Projects are expected to cover top-level requirements and criteria for industrial-scale adoption and market entry such as:

- Performance:
  - Optimised operating strategy for application specific drive cycle / load cycle (drive cycle efficiency, start/stop cycling)
  - Operation under application specific indoor / outdoor environmental conditions including cold / freezing ambient conditions, freeze start capability @ -20°C on system level
  - 98% availability in the fleet
  - > 10.000h stack lifetime in the field @ > 40 % end-of-life system efficiency
  - LCA (cradle to grave) of environmental performance of vehicles, infrastructure and energy source
- Safety:
  - FC systems eligible for funding have to address specific European safety standards such as EN 62282-2:2012 Fuel cell technologies - Part 2: Fuel cell modules and EN 62282-4-101:2014 FC Systems Industrial Trucks Safety or EC79/2009 Hydrogen-powered Motor Vehicles as well

  as have to be CE marked or certified according to applicable EU directives for off-road and on-road vehicles and implements.
  - Safety criteria and concepts for indoor operation and refueling of trucks as basis for standardization shall be developed
- Competitiveness (on TCO basis) in comparison to state of the art technologies (ICE, LA / LI battery):
  - Competitiveness to competing technology is to be achieved in the fleet per site;
  - Fuel @ 35 MPa
  - FCH JU project funding covers technology costs (FC systems, H2 infrastructure) which exceed state of the art technology on TCO basis (funding will take away vehicle-users risks of new technology and help ramp-up supplier volumes)
  - TCO comparison shall include investment, maintenance and service expenses, hydrogen consumption, disposal

The minimum operational period for any vehicle demonstrated in the project has to be at least 24 months. Project proposal evaluation benefits if synergies by using 35 / 70 MPa HRS implemented within the project also for other types of fuel cell vehicles like trucks, vans, cars, etc.

The focus of this topic is the demonstration of fuel cell system technology, including stack and BOP components, developed and manufactured in the EU.

Indicative funding:

The fuel cell system manufacturer / supplier should be in the position to offer the fuel cell systems to vehicle-users at a price that enables the user to reduce risks of operation. The funding per FC system may not exceed the maximum funding as defined in the following table:

System continuous power out put	Maximum funding in €
<3 kW	6,500
3 - 8 kW	11,500
8 -15 kW	15,000
>15 kW	20,000

Similarly, the installation costs of hydrogen infrastructure enabling the on-site production and supply of “green hydrogen” at a fuel demand <30 kgH2/d @ 35 MPa are eligible for funding. The funding per site may, however, not exceed 250,000 €.

The consortium should be representative for an European FC technology value chain including FC system integrators, FC system components suppliers (stacks, power electronics …), H2 infrastructure suppliers, MH and industrial vehicle OEMs and different vehicle-users.

End-users should be partner in the consortium or committing themselves to demonstrate a minimum of 200 MH and industrial vehicles at the start of the project. The commitment shall be secured by way of pre-orders or similar before signature of the Grant Agreement.

Techno-economic and environmental assessment of the project should be performed.

FC systems at commencement must be at least TRL 7 and targets TRL 8 or higher at the end of the project.

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

The maximum FCH 2 JU contribution that may be requested is EUR 7.5 million per project. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

A maximum of 1 project may be funded under this topic

Expected duration: 4 - 5 years

Expected impacts:

- Confirmation and promotion of value proposition of fuel cell and hydrogen technology in the MH and industrial vehicles (e.g. municipal services) sector
- Creation and stabilization of Europe-based component and system production, suppliers network and value chain
- Realization of cost reductions on system and component level
- Ripening of European based technology for market entry in Asia and North America
- Environmental benefits by using hydrogen generated from renewable energy and reduction of hazardous materials and waste compared to state of art battery technology
- Emission reductions at logistic centers and cities by using "green hydrogen"
- Strengthen the European industry, by creating knowledge in support of the EU growth and jobs policy agenda.

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 2016– 2017.

FCH-01-5-2017: Large scale demonstration in preparation for a wider roll-out of fuel cell bus fleets (FCB) including new cities – Phase two

Specific challenge:

Thanks to the earlier FCH JU projects (CHIC, High VLOCity, HyTransit, 3EMotion), the hybrid fuel cell bus has made a long way in the urban bus application which continues to show a lot of potential thanks to: a strong and innovative European bus industry; EU, national and local political mandates to reduce emissions and GHG and growing recognition by the operators to electric hybrid traction, in-house fuelling and maintenance.

A large number of cities and operators are prepared to sign-up for large scale demonstrations starting in 2018 and to offer a level playing field with other zero emission options, to meet the next step-change, in number of units, range of models and operational/climate conditions. The majority of European bus OEMs are gearing up to meet the challenge.

In order to further contribute and extend the uptake of fuel cell buses as the next step in the commercialisation process, the following specific challenges have to be met:

1. A further reduction of the capital cost of the fuel cell buses in line with increased volume (total and per site) while at the same time lowering the match funding and the EU contribution.

2. In order to drive the cost to a level of commercial competitiveness with other zero emission technologies, the programme will allow fuel cell buses to:

- Eliminate technological barriers identified in previous projects, e.g. by optimizing the hybrid driveline (latest development of batteries in combination with next generation fuel cells) ;
- Fully develop the necessary supply chains and value chains for related services, including availability of trained personnel, spare parts, etc…, in order to bring this technology on a par with conventional technologies.

3. Considering that most operators have procured or are in the process of procuring battery electric buses, the challenge for fuel cell buses will be to demonstrate the distinct operating advantages of fuel cell buses;

4. Reduce the TCO (Total Cost of Ownership), including fuel, infrastructure and maintenance cost and put the value of societal benefits (environmental, health etc.) in the right perspective as a way to further the use of the technology;

5. Achieve quantified per kilometre well-to-wheel GHG reductions compared with other zero emission alternatives, based on the anticipated revised European Directive for Clean Vehicles[10].

6. Extend the range of potential bus models to all lengths between 9 and 24 meters, including double decker buses.

7. Include range extender models for heavy duty city bus use

8. Include different climate zones and city planning architecture, including interested regions where no FCB demonstration took place so far;

9. Provide answers to the operators as to the degree by which fuel cell buses meet or exceed the fleet operational requirements and expectations, in the different service conditions.

10. Identify and quantify the remaining barriers to market, including financing and merging options with other programmes and sources as well as a plan to implement

11. Provide a "greening pathway" for the production of hydrogen for this application

[10] 2009/33/EC

Scope:

The project will demonstrate a fleet of minimum 125 fuel cell buses and their associated hydrogen infrastructure.

The model range may include urban buses (M3 heavy duty, class 1 or 2) with lengths from 9 m midi buses, 10-12m double decker buses and up to 24m double articulated buses.

The project shall include distinct climate zones as well as different city architecture (including bridges, tunnels, bus lanes etc), with the aim of clearly showing the degree of coping with a vast number of operational challenges.

All buses shall be hybrid (fuel cells and batteries) with brake energy regeneration features.

All buses deployed should have a high level of standardisation between the different bus models offering as a way to lower the cost, increase the acceptance level and facilitate the aftersales service. One of the lessons learned in previous projects is the importance of operator's involvement from the start to embrace the technology in daily operation. The buses are expected to be close to commercial readiness from both a technical maturity and an economic perspective. Prototypes or small initial series may be procured in the programme subject to the terms of the tender.

To achieve the projected result, at least 100 of the buses will be deployed in larger fleets, these will have a minimum fleet size of 10 buses, and at least in 3 of these cities these buses will be deployed in fleets of 20 or more. In addition, up to 5 sites shall procure at least 5 buses. It is recommended to consortium to seek additional source of funding for the related HRS. The buses will be demonstrated for a period of at least 36 months or 150,000 km in operational service and continue service after the project has ended (e.g. the bids could include a commitment as to the minimum period to continue the service after the project has ended). New hydrogen infrastructure or upgrades of existing HRS will also be created.

Buses should have min fuel cell output of 30 kW. Buses below 10m length can be equipped with a fuel cell of minimum of 20 kW.

Buses:

- The following is generally applicable for 12m fuel cell bus as defined. These requirements shall serve as a reference guide for other lengths and specifications, which will be stated in the proposals.
- Capital price of a 12m bus (as defined in the call) will be less than €625,000 as per referenced general definition[11] and for sites with minimum 20 units. Other lengths with deviations (both minus or plus) in acceptable price ratios to 12m and subject to tender conditions.
- Average monthly fleet availability of the buses will be 90% (technical availability after first 6 months as per referenced formula[12])
- Hydrogen consumption of 7-9 kg/100 km (combined SORT 1 and 2 for 12m bus)
- Fuel cell system MDBF) > 3500 km
- Tank-to-wheel efficiency > 42% (in SORT 1 and 2 cycles)
- Guaranteed fuel cell stack life (before replacement) of 20,000 hours

[11] General bus definition (in relation to defined price limit): Basic 12m low entry, class 1 city bus, with 2 doors, air conditioning, min. 30 seats, traction batteries and hybrid drive manually operated handicapped ramp, delivered ex-factory OEM. All IT equipment (except destination signs) delivered by the operator. Extras for special equipment excluded.

[12] Bus fleet availability :

Availability F= (Σ (hours State 1)/(Σ (hours State 1) + Σ (hours State 2))

In which: State 1 = total number of hours that the bus is in operation; State 2 = total number of hours that the bus is out of service for technical reasons to be assumed by the bus OEM.

Series production ability as a result of the project will has to be demonstrated. Buses shall be certified to operate in regular service.

Hydrogen Refuelling Stations (HRS):

- HRS developed under earlier programmes shall show integration of concept and cost down potential of hydrogen storage and production for larger fleets as well as the potential to scale up the capacity;
- The cost of dispensed hydrogen offered needs to be consistent with the national or regional strategy on hydrogen prices, if existing. A cost improvement due to increased production capacity and higher utilisation of the HRS is expected.
- Hydrogen purity at least 99.999 %
- HRS capacity according to fleet requirements, depending on the fleet models and mix, which may be provided by one or more HRSs
- HRS availability >98%
- Hydrogen price to be maximum 9 €/kg.
- At least 60% of the H2 provided to the FCBs must be coming from renewable energy by the end of the project.

The consortium should include multiple bus service providers/operators, refuelling infrastructure providers/operators, fuel retailers, industrial players, local and regional bodies, as appropriate and relevant to the effective delivery of the project.

Proposals should clearly demonstrate the commitment of OEMs to supply vehicles to the project. The involvement of SMEs is encouraged.

TRL level shall be 8 for the buses and TRL level for the HRS shall be at least 8 (at beginning of the project).

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

The maximum FCH 2 JU contribution that may be requested is EUR 25 million. This is an eligibility criterion – proposals requesting FCH 2 JU contribution above this amount will not be evaluated.

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

Expected duration: 6 years

Expected impact:

The programme is building on the 2016 bus topic call – phase 1 objectives to achieve the next and important step to commercialisation, as defined in the Roland Berger Strategy Consultants' study "Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe".

The programme has the potential to bridge the gap to full commercialisation in the 2020-22 timeframe.

The specific impact is to show:

- data illustrating the degree that cost reductions have been achieved or are achievable, such that the Total cost of ownership of fuel cell buses is or will become competitive to other zero emission technologies (measured on a level playing field conditions) ;
- contribute to significant further capital cost reduction; enable start investments in European production facilities for further ramp-up in European markets;

- reinforce European supply chain of critical key components by e.g. core components of FC and H2 storage systems to be produced in Europe. Terms in the proposal and/or tenders for the procurement of buses must include arrangements for bus OEMs and their technology suppliers to provide this information.
- take advantage of the benefits of renewables as part of the overall EU objective with the transport sector being a prime debtor. With conversion options of redundant electricity from sun and wind energy into hydrogen, and P2G possibilities, hydrogen and fuel cell buses, have the potential to make the business case.
- extend to both larger fleets ("leaders") and allow curious but cautious cities to join ("followers") thereby initiating an important mainstream process ;
- make use of the industrial and innovative lead position of the European bus industry and enhance the local value chain.

The indicative target is that FCH JU funding per bus would not exceed €1800 per kW gross output of the fuel cell, in line with the MAWP targets.

The project should envisage and show evidence of co-funding[13] from other EU, national, regional or private sources in order to demonstrate a strong commitment towards clean propulsion and emission free public transport. Any such co-funding should be fully secured before the signature of the grant agreement to ensure timely realisation of the project.

Proposers should provide a clear evidence of political support for the project together with commitment to further involvement in the roll out should be provided as part of the proposal, through a Letter of Intent a comprehensive exploitation plan for the project should also form part of the proposal.

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 2016– 2017.

[13] According to Article 37 of REGULATION (EU) No 1290/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006

FCH-01-6-2017: Large scale demonstration of Hydrogen Refuelling Stations and Fuel Cell Electric Vehicle (FCEV) road vehicles operated in fleet(s)

Specific challenge:

Despite significant improvements achieved over the recent years, the level of utilisation of both Fuel Cell Electric Vehicles (FCEVs) and Hydrogen Refuelling Stations (HRS) remains well under the level currently experienced with conventional technologies.

For FCEVs, the low level of utilisation is defined in terms of limited number of vehicles being in operation in the field and of limited number of kilometres driven per year, thus limiting conditions in usage allowing for a real field experience to be gained.

For HRS, typical utilisation rates are in the range of 5 to 10% on average compared with the 90%+ level encountered in forecourts distributing more conventional fuels. Limitations in improved HRS technology reliability and operations are therefore faced.

This situation is calling for a large scale "market test" with sufficient vehicle numbers per station to generate relevant data based on demonstration of the HRS under high load conditions. Moreover, the project will target a B to B market, gaining experience in higher mileage and more bearable business case for the infrastructure operator. Building on the achievements obtained today through the launch and follow-up operations of large scale FCEVs and HRS demonstration projects[14], it is now necessary to revisit the conditions of such demonstrations in order to allow a pre-commercial evaluation of the FCEVs & HRS technologies.

With respect to the above, consideration to controlled fleets operators can provide such necessary conditions. Fleets of vehicle are also attracting increased attention from public authorities and private stakeholders involved in transport decarbonisation.

Scope:

This topic calls for a large scale pre-commercial demonstration project covering of FCEVs and HRSs under high utilization conditions such as those encountered by commercial fleets operators.

Vehicles

For vehicles, the project will consist in identifying at least two operators of commercial fleets of vehicles such as, but not limited to, taxis, light commercial vehicles parcel delivery services but also potentially new mobility services such as car sharing.

The identified fleet operators will cover the roll-out of at least 180 FCEVs in total with a minimum deployment of 60 FCEVs per site / geographical location, in at least 3 sites.

The vehicles can comprise OEM supplied passenger cars and utility vehicles (light duty vans). The FCEVs are expected to be using a fuel cell system as the key power source and 70MPa storage.

The minimum operation for vehicles is 90 000 km per vehicle within the project with annual mileages equal to the average values observed currently for the equivalent vehicles performing comparable services, running on more conventional fuels. Commercial arrangements for extending operations after the end of the project are expected to be provided.

[14] Such as the FCH2 JU funded projects HyFive, H2ME and H2ME2 in Europe

HRS

In this topic, the focus is on demonstrating the feasibility to operate HRS under pre-commercial conditions in terms of utilization rate.

The minimum number of HRS needed to fulfil the H2 demand and the geographical coverage of the FCVs fleet operated at a given location must be considered.

The HRS must be designed to investigate the specific problems arising from the need to provide high volumes of hydrogen per day while offering satisfactory service to HRS customers in terms of refuelling duration per vehicle and availability (back to back refuelling performance).

When addressing the utility vehicle market or local fleets (as is the main intent of this topic), HRS facilities may be located on private grounds, with or without public access. The latter should be favoured, as long as several other customers are identified as long term users of the HRS. Whenever appropriate to the fleet operators, the use of existing HRS, for example HRS being deployed for FCH JU projects, must be considered subject, when required, to the implementation of upgrades designed to bring the performances of the HRS in line with the users' expectations.

The targeted operation for the HRS is at minimum 5 years (operation beyond the project life is expected and should be demonstrated in the proposal).

Safety assessment shall include the social acceptance dimension.

Overall

Measurement, monitoring and evaluation of specific vehicle and fuelling station parameters should be done using methodologies such as those used in current projects funded by the FCH JU[1]. The project shall prepare for the use of low-carbon hydrogen and aim to reduce the carbon intensity of the hydrogen refuelled by at least 50% on a well-to-wheel basis as compared with new gasoline and diesel vehicles. The results of the CertifHy Project should be taken into account in the analysis of the total well-to-wheel emissions.

A formal, inclusive and creative dissemination programme is required which ensures that the lessons learnt by the project are made available to wider public. In particular, it should be ensured that countries considering development of similar FCEVs/HRS roll-out initiatives should have an easy access to information generated by the consortium.

Proposal may include some provision for funding support to existing HRS upgrades (performance and availability/reliability focus)

Proposers should provide a clear evidence of:

- A comprehensive strategy for commercialization, including (novel) ways to attract the customers by appropriate customer value proposition scenarios
- An evidence of political support for the project together with commitment to further involvement in the roll out must be provided as part of the proposal, through a Letter of Intent
- Justification of the way in which the project will contribute to de-risking commercialization of FCEVs in Europe
- A comprehensive business-plan for the project should also form part of the proposal. Where contributions from end users to vehicles’ costs are assumed, this should be clearly indicated in the project proposal

The consortium should include vehicle fleet operators, , refuelling infrastructure providers and operators, and other actors as appropriate and relevant to the effective delivery of the programme.

The following TRLs are at least required:

- 8 for FCEVs at start of project and 8 - 9 at the end
- 7 for the HRS at start of project and 7 – 8 at the end.

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

The maximum FCH 2 JU contribution that may be requested is EUR 5 million per project. 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: 6 years with minimum 4 years of operation

Expected impact:

The learning experience obtained is specifically intended to trigger further technological improvements of both stations and vehicles and to provide the necessary experience and confidence on the part of investors and policy makers in the business plans for the multi-billion euros of investments needed to establish the HRS infrastructure required for mass market roll-out.

Therefore priority will be given to proposals presenting a comprehensive programme to gather new learning from the project in terms of: customer acceptance, techniques for the operation of a station network, business models for national HRS roll-out, FCEV reliability operated at a high mileage level, technology performance (and requirements for improvement, using the HyLights methodology.

Vehicles

At least 80% of the vehicles to be deployed in the project should be designed to meet the requirements resulting from the severity of usage facing the fleets (e.g. availability, durability)

Technical targets for vehicles:

- >6,000h vehicle operation lifetime
- The key power source of vehicles must be a fuel cell system (full traction FCEV)
- Vehicle range > 500 km
- Availability >98% (to be measured against available operational time)
- Tank-to-wheel efficiency >45%, measured in the New European Drive Cycle (NEDC)

The funding contribution will not exceed 20 k€ per vehicle.

HRS

Assessment of progress towards overcoming the barriers to the roll-out of FCEVs (it is expected that substantial advances in comparison to the state-of-the-art to five of nine of the issues below will be proposed and trialled in the project):

- Quality Assurance issues around hydrogen purity: Progress towards definition of an industry acceptable hydrogen quality compliance system is targeted. Current investigations made at ISO level to be followed.

- Achieving a high level of availability for HRS: Improvements towards 98% HRS availability
- Improved efficiency/performance for HRS:
  - level of back to back vehicle performance to be defined as function of the fleet operational constraint
- Increased availability of hydrogen from renewable sources: level of targeted decarbonization of the hydrogen fuel must be defined according to the national/regional sustainable on-going production roadmap(s) (whenever available.)..

Furthermore, HRS are expected to comply with the following requirements:

- High capacity HRS facilities are encouraged for fleet refuelling. The minimum refuelling capacity should be 200 kg of daily refuelling capacity for all stations. Back-up solutions to be considered and clearly described.
- The cost of dispensed hydrogen offered in the project needs to be consistent with the national or regional strategy on hydrogen pricing. Cost improvements due to increased hydrogen production capacity, and especially higher utilization rates of the HRS, is anticipated in the course of the project. On the other hand the efforts required to lower the carbon footprint could offset these improvements. Thus, the target at the pump is fixed at 10€/kg excl. taxes.
- The fulfilment of the ISO standard 14687-2 is not compulsory for the Hydrogen purity and has to be at least 99.999 % but the actual quality of refuelled hydrogen shall be duly controlled and justified with regards to fuel cells performance preservation.. Vehicle refuelling process must comply with SAE J2601 (2014) and IR communication needs to comply with SAE J 2799. Exceptions may be allowed, if justified by the application

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 2016– 2017.

FCH-01-7-2017: Validation of Fuel Cell Trucks for the Collect of Urban Wastes

Specific challenge:

European urban areas are increasingly facing deterioration of their air quality. Among other contributors, urban trucks equipped with current ICE technologies performing number of services are emitting local pollutants (CO, NO, PM, HC) which cause bad air quality.

Thus, from a healthcare perspective, local pollution in urban areas and city centers are becoming a growing concern for an increasing number people and public authorities.

With the hope to quickly improve air quality, several big European cities have already decided to limit the access to urban areas of diesel-fueled heavy duty-vehicles. Many others are considering applying the same approach.

Therefore, local authorities expect that industry makes available advanced and more sustainable solutions for urban logistics, including innovative zero emission medium- and heavy-duty vehicles.

The first urban logistics truck prototypes powered exclusively by batteries have largely insufficient driving range. Payload penalty and charging time are also major issues, penalizing profitability for loaders and making very unlikely the commercial success of this kind of vehicles.

On the other hand, Fuel Cell technologies may dramatically improve the driving range of these vehicles providing the operational attributes necessary to replace diesel trucks.

An urban fuel cell truck should be able to accomplish the same daily mission as its diesel version (e.g. refueling time), while proposing an acceptable payload in comparison with an “all-electric” version.

Among the different possible urban truck applications, one of the most promising for the implementation and commercialization of Fuel Cell technologies, is that of garbage trucks, i.e. heavy duty trucks specially designed and used to collect municipal solid waste and haul the collected waste to a solid waste treatment facility

Scope:

The topic calls for deployment and validation of at least 10 Fuel Cell urban garbage trucks. The trucks will be operated in different European cities willing to improve their urban logistics via the utilization of innovative solutions. They should be deployed covering at least 3 sites with a minimum of 2 trucks per site. The garbage trucks should have Gross Vehicle Weight comprised between 16 and 26 tons. Said trucks should integrate a FC of at least 40 kW and be able to perform daily back-to-base missions within the urban area where they will be employed.

In the frame of the foreseen project, the garbage trucks should be manufactured, deployed and their behavioral performances should be validated by real end-users in a real operating environment.

The FC trucks object of the present call should be derived from a hybrid or electric platform to limit the risks linked to the electrification of the whole power train and the integration of the fuel cell system and can be equipped with a battery essentially aiming to manage energy braking recovery and power demand peaks.

Nevertheless, it is required that the fuel cell and hydrogen system provides at least half of the energy needed for performing its daily duty.

The trucks should be designed to meet end-users’ needs and the behavioral features of the conventional garbage trucks usually circulating in the cities hosting the project.

The cities shall ensure a high involvement in promoting these technologies, and in particular, facilitating the deployment and the exploitation of the new urban trucks.

The fuel cell trucks are expected to comply with the following requirements:

- > 20,000 h vehicle operation lifetime initially, minimum 25,000 h lifetime as project target

- The key power source of vehicles must be a fuel cell system or an hybrid solution with a battery and a fuel cell
- Fuel cell system MTBF > 2,500 km
- Availability > 90% (to be measured in available operation time)
- Tank-to-wheel efficiency > 42%, for trucks measured in real cycles.
- Series production ability has to be shown

It will be important to demonstrate that the fuel cell garbage trucks will be able to fulfill the typical requirements of this application, assuring one day of operation without refill.

The funding per truck should be the lesser of 1800€/kW installed FC plus 650 €/kg stored H_2 or 300,000 €.

The minimum operational period for any truck demonstrated in the project is 24 months or 8000 hours of operation.

Beyond demonstration of the technology the participating cities shall ensure the communication of their efforts to other cities/regions in Europe and beyond and use appropriate channels/fora to share their experience within the project.

It would be preferable if the project is co-funded by national, regional or private sources in order to prove a strong commitment towards clean propulsion and emission free public transport. In this case, co-funding should be fully secured before the signature of the grant agreement to ensure timely realization of the project.

Proposers should provide a clear evidence of:

- political support for the project together with commitment to further involvement in the roll-out must be provided as part of the proposal, through a Letter of Intent
- a comprehensive exploitation-plan for the project should also form part of the proposal.

The consortium should include trucks fleet providers/operators, trucks OEMs and FC systems integrators, industrial players, local and regional bodies, as appropriate and relevant to the effective delivery of the program.

The following TRL is at least required: 6 for the FC truck at start of 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), which manages the European hydrogen safety reference database, HIAD (dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu).

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

A maximum of 1 project may be funded under this topic

Expected duration: 4-5 years

Expected impact:

It is expected that the project provides a significant step towards successful market introduction of FC trucks by reducing their cost significantly while increasing their maturity, reliability and lifetime. It is also expected that by using FC systems (preferably already demonstrated successfully in FC passenger cars) in this road transport application, the uptake of FC technology and cost reduction of FC and FC system components is significantly increased.

Existing and/or new hydrogen refueling stations will be heavily utilized due to the large H2 consumption expected for this type of heavy-duty trucks and therefore generate a bigger learning effect in comparison to under-utilized stations for other applications. This is a precondition on the pathway towards commercial operation of refueling infrastructure. It shall increase the confidence of end-users and fleet operators in reliable fuel supply and demonstrate the viability of fuel cells for trucks.

The project should identify and disseminate:

- Lessons learnt from implementing and operating urban heavy-duty trucks for early adopters
- Quantitatively and qualitatively evaluate the impact of the technology on public health and urban living (e.g. comparison against incumbent technology, in situ measurement etc.)

Professional dissemination of information on the activities of the project to the broad public is seen as a key part of the demonstration project. It should especially be foreseen to communicate the benefits of hydrogen and fuel cells in public transport. Regional authorities should support the project with communication.

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 2016– 2017.

ENERGY PILLAR

FCH-02-1-2017: Game changer Water Electrolysers

Specific challenge:

When monitoring water electrolysis related literature over the last few years, one can find many promising ideas and performance claims at laboratory scale that hold a lot of potential for the future of hydrogen generation. However, very few of them have made it to a commercial scale. This call aims at moving these findings and technologies to the next stage of engineering so they can disruptively alter electrolysis technologies and lead to a game changing electrolyser.

This topic aims to develop game changing PEM or alkaline electrolysers with the potential to surpass the FCH-JU KPI's in terms of cost, efficiency, lifetime and operability. Principal expected areas of game changing development are: high pressure operation, rapid response, increased energy density, reduced critical raw materials and/or high temperature operation, but the topic remains open to other innovations.

The proposed technology is aiming to address the following application for the relevant energy sector of:

- higher pressure electrolysis for reducing mechanical compression requirements and so improving the energy performance of electrolyser-HRS or of power-to-gas systems injecting hydrogen into the high-pressure gas transmission network;
- rapid response electrolysis to enable the participation of electrolysers in the most demanding grid balancing markets (primary reserve);
- higher current density operation to enable more compact installations;
- higher temperature electrolysis to improve conversion efficiency.

Scope:

The operating characteristics of existing PEM and alkaline electrolysers limit their implementation in prospective commercial applications. Output pressures are generally <35bar (PEM) and <10 bar (Alkaline). This requires compressors in several applications, which place energy, space and cost penalties on the electrolyser. Existing response times of minutes or tens of seconds preclude their application in grid balancing markets, some of which demand sub-second response. Current densities of <2A/cm2 for PEM and <0.5A/cm2 for Alkaline provide footprint constraints. Operating temperatures are typically 60-75 Celsius, but increases of only 10C can make a large improvement in conversion efficiency. For these reasons, several step changes are desirable.

The scope of this Topic is the development of a prototype PEM or alkaline based electrolyser, including stack and balance of plant. The reduction of costs for PEM and alkaline electrolysers is the main target. To reach that, proposals should focus at least on one or more of the following priorities:

- high pressure electrolysis with hydrogen output pressure of at least 100 bar;
- rapid response of below 1 second for a hot start and below 10 seconds for a cold start;
- increased base load current density to at least 4 A/cm2 for PEM or 1 A/cm2 for Alkaline;
- increased peak-load current density for short periods of up to 1 hour to above 6 A/cm^2 for PEM or above 1.5 A/cm^2 for alkaline;
- electrolysis at water temperature of above 80°C;
- other step-change improvements in water electrolyser stacks or balance of plant which can significantly improve efficiency or cost.

Each of these requires detailed attention to cell and BoP development, especially with respect to the reduction of critical raw materials (such as catalysts) and the advancement of the EU supply chain. The capacity of the prototype is expected to be around 10 to 50 kW base load, but larger capacities are in scope as well. However, the technology developed should be suitable for multi-MW scale electrolysers.

Project proposals should clearly state the expected commercial benefits of the proposed technology improvements and projects should include an assessment to verify these benefits.

The prototype must be tested under steady and, if relevant, transient operating conditions, achieving cumulative running time of at least 2000 hours. Rates of degradation should be measured and, if necessary, routes to conformance with the 2023 target in the MAWP must be proposed. Testing should be done in accordance to the FCH JU harmonised testing procedures developed by the JRC in collaboration with European industry and researchers.

The consortium should include at least one electrolyser manufacturer, research institution or academic group.

It is expected that the technology starts at TRL 3 and reaches TRL 5 at the end of the project.

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

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

Expected duration: 3 years

Expected impacts:

A step-change improvement in water electrolysis is expected, enabling additional commercial roll-out of electrolysers post 2025:

- the development and validation of a prototype game changer electrolyser;
- new knowledge with respect to the design and operation of an electrolyser with one or more of the improvements mentioned;
- Assessment of the additional commercial opportunities that are achievable with the game changer electrolyser compared with current electrolysers.

With further development, the technology must be able to meet or surpass the efficiency, lifetime and cost targets set out in the MAWP of 50kWh/kg @ 1000kg/day, 1.5M€/ (t/d), <1s hot start, <10s cold start (table 3.1.1.2) and the central trend lines in the Study on development of water electrolysis in the EU [E4Tech and Element Energy, Feb 2014].

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 2016– 2017.

FCH-02-2-2017: Game changer High Temperature Steam Electrolysers

Specific challenge:

High temperature electrolysers (HTE) can potentially replace fossil energy input with renewable electricity for the generation of hydrogen, for example in refineries and chemical industry, whereby available waste heat from the plant improves the efficiency of the electrolysis process.

This topic is aimed at a step change improvement in high temperature electrolyser technology to enable future commercial introduction.

This improvement can be on the level of the cell, stack or system layout. To develop a wider market, medium term targets for this technology are in relationship with step change and improvement in performances of the technology, trying to overcome some of the actual limiting factors and / or introducing novelties in the cell, stack and system layout able to catch better performances (e.g. current densities, cells and stacks dimensions, stack pressurization).

The improved high temperature electrolyser technology must be tested in a relevant environment.

In agreement to the MAWP, targets related to efficiency, OPEX, pressure, lifetime and cost of hydrogen need to be addressed and fulfilled by the high temperature steam electrolysers covered by that topic.

Scope:

Proposals should focus on the development, and testing in a relevant environment, of a low-cost, high-temperature electrolyser system, targeting the following improvements which are in line with the MAWP targets, without compromising the other targets included in the MAWP:

- Larger cells and stacks compared with the state of the art, for both atmospheric or pressurized operation: for atmospheric operation a value of at least 50 kW (electrical) per stack is targeted; for pressurized operation, a value of 10 kW (electrical) per stack is targeted;
- Improve total electrical efficiency to above 75% based on higher heating value, in agreement with the MAWP KPI (> 2023 value);
- Cost reduction through use of standard industry components (power electronics, heat exchangers,..), to decrease the cost of the hydrogen produced below 6.9 €/kg, in agreement with the MAWP KPI (2020 value);
- All these improvements being done in conjunction with extended dynamic operation without decreasing the durability.

In addition, the proposal should address at least one of the following optional targets:

- higher flexibility in start / stop, increasing 10 times the SoA performances;
- high pressure electrolysis with hydrogen output pressure of at least 30 bars;
- other step-change improvement in high temperature electrolysis.

The expected electrolysis system, including stack, balance of plant and power electronics, should be developed at a relevant scale. If an atmospheric system is considered, a minimum value of 50 kW electrical is considered, while it should exceed 10 kW in the case of a pressurized system.

Projects should feature:

- Integration of the targeted improvement in a complete electrolyser system;
- Coupling, including thermal management, of the system with a (waste) heat source;
- Demonstration of the system in a relevant environment for at least 2000 hours.

Projects should further include the following analyses:

- a techno-economic analysis of the technology, including projected hydrogen production cost as function of relevant parameters (electricity price, capital cost, stack lifetime, utilisation);
- a life-cycle analysis including CO2 footprint in using the electrolyser;
- recommendations for further development needs for commercialisation.

Testing should be done in accordance to the FCH JU harmonised testing procedures developed by the JRC in collaboration with European industry and researchers.

It is expected that the technology starts at TRL 3 and reaches TRL 5 at the end of the project.

The consortium should include at least one SOEC stack/module manufacturer, research institutions and academic groups.

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

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

Expected duration: 3 years

Expected impacts:

A step-change improvement in HT electrolysis, enabling additional commercial roll-out of HT electrolysers post 2025.

- Improvement of AC electric efficiency above 90%HHV, which is well above MAWP KPI value for HTE in 2023, thanks to the thermal coupling with a heat source to avoid the energy consumption for steam production. Thanks to this, the OPEX will be much improved as compared to the KPI 1 set for PEM and alkaline electrolysis;
- System cost below 8.8 M€/(t/d) with a route to further cost reduction to 2.7 M€/(t/d) post 2020. While there is no CAPEX values in the MAWP for HTE, those values position HTE only one step behind PEM and alkaline more mature technologies by comparison with alkaline and PEM electrolysis KPI set in MAWP;
- Efficient use of renewable electricity to generate hydrogen for industry;
- Technology demonstrated in a relevant environment, enabling potential roll-out in industry post 2025.

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 2016– 2017.

FCH-02-3-2017: Reversible Solid Oxide Electrolyser (rSOC) for resilient energy systems

Specific challenge:

For hydrogen energy technologies to be able to compete in the energy storage market, the power-to-power round trip efficiency must be improved reducing at the same time costs.. Using two separate devices, namely an electrolyser and a fuel cell means both will be used part time, which increases the investment cost. Solid Oxide Cells (SOC) are intrinsically reversible and thus can be operated either in electrolysis mode to produce hydrogen from steam, or in fuel cell mode to produce electricity, depending on the needs. Thus, only one device is required, which is operated almost full time with fewer start/stops. In addition, Solid Oxide Fuel Cells (SOFC) and Solid Oxide Electrolysers (SOE) can achieve higher efficiencies while in SOFC mode electricity can be produced from H_2 and/or CH_4 using the same device, offering an additional flexibility.

The ability of reversible solid oxide cell (rSOC) devices to perform real dynamic cycling between power storage and power generation modes (SOE to SOFC and back) while keeping an acceptable degradation is still to be demonstrated though. Improvements to cell materials and construction are required as well as enhancements to system level issues of steam supply management, gas composition change during inversion from one mode to the other, thermal management, etc. The extensive cycling requirements to create a commercial rSOC system that can be coupled to renewable energy production systems such as wind and solar power has not been addressed to date.

Scope:

This project will focus on enabling more widespread integration of renewables through the use of r-SOC technology. Two business cases can be particularly addressed:

- first, the renewable energies storage in off-grid remote areas, or in non- or low-interconnected islands, where there can already be an early market driven by emerging renewables curtailment and very high fossil generation costs[15];
- second, eco-building or eco-districts, where renewable energies like PV are installed where energy storage is required to achieve consistently high penetration rates of PV production and increase profitability of PV investment while minimizing the amount of power purchased from the grid: this market has a short term, economically viable use[1]. For residential houses, storage can allow increasing the consumption of local electricity generation from the 20-40% "natural" self-consumption to values above 50%[16], and either hydrogen or solid state battery storage or a combination of both is the most suitable option[17]. For commercial buildings where consumption profiles can be very different over a week (e.g. week-end with less or no consumption and potentially high production), the need of storage is even more evident in order not to curtail the PV production, and hydrogen-based P2P system can avoid the installation of MW-size battery systems. In addition, H_2 produced can be used as fuel for vehicles if needs exist, and in case of H_2 shortage, rSOC operating in fuel cell mode can be fueled with natural gas, thus offering flexibility and convergence of multiple usages.

For both cases, the rSOC technology, which allows a higher power-to-power efficiency and a maximized utilization rate, is beneficial for OPEX and CAPEX respectively. The development of these market segments will allow creating technological learning so that the larger energy storage

[15] FCH-JU, "Commercialisation of energy storage in Europe", 2015

[16] http://www.idekassel.de/fileadmin/user_upload/downloads/Project_Results_for_PV_Battery_Systems_for_Self-Consumption_in_Households.pdf

[17] Rasmus Luthander, « Photovoltaic self-consumption in buildings: A review", Applied Energy 142(2015) 80–94

market could be also assessed in the near future with such systems. In the project, one of those business cases, or any other documented business case will be targeted.

The following specific issues should be addressed:

- Component development and system design for dynamic and reversible operation (e.g. high efficiency both in fuel cell and electrolysis mode, gas tightness, high durability in long term operation);
- System operation strategies to manage switches from SOFC to SOEC operation mode: these should be aligned with ongoing normative and standardisation activities;
- Reversible operation with both H_2 and CH_4 (SOFC) and steam (SOEC);
- Optimise fuel utilisation and steam conversion rates to 80-85 % in both SOFC and SOEC mode on system level;
- Develop a smart concept for electrical connection to decrease cost for power electronics;
- Power modulation 50 - 100 % in fuel cell mode, H_2 production rate modulation 70 – 100 % in electrolysis mode;
- Minimise thermal losses and optimise thermal integration for maximum efficiency;
- Demonstrate at system level a power of 50 kW (electrical) in electrolysis mode, and up to 20 kW (electrical) in fuel cell mode;
- Concept design study for system scale-up towards 1 MW_{el} (SOFC);
- Prediction of production cost, electricity cost and hydrogen cost for up-scaled system based on real application and volume scenarios;
- Develop a business model and a techno-economic analysis, including comparison of the overall efficiency, reliability and cost-competitiveness with other state-of-the-art power-to-power technologies, demonstrating distinct advantages of hydrogen based systems.

The consortium should include at least one SOEC stack/module manufacturer, research institutions and academic groups.

Liaison with representative bodies developing standards and procedures for rSOC operation is recommended.

It is expected that the technology starts at TRL 3 and reaches TRL 5 at the end of the project

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

The FCH 2 JU considers that proposals requesting a contribution from the EU 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 years

Expected impacts:

The project should show a functional rSOC system operating in both modes allowing a proper validation of the performance characteristics (efficiency, modulation, operation dynamics) for future application scenarios. The following KPIs are expected to be reached at system level:

- 200 full cycles from SOFC to SOEC and back during operation with minimum degradation (<2%/1,000 h);
- Overall electrical energy efficiency target in electrolysis mode on steam ≥75% (HHV), which is aligned with MAWP KPI (value for 2023);
- Overall electrical energy efficiency target in fuel cell mode on methane ≥ 55% (LHV), which is aligned with MAWP KPI (value for 2020 and 2023);
- System operation time of >7,000 h;
- Fuel utilisation and steam conversion rate of >80 % on large stack module level;
- rSOC system CAPEX < 3.6 M€/(t/d) (electrical input in electrolysis mode), in a series

production of 1,000 units/year. While no CAPEX target is set for high temperature electrolysis in the MAWP, the above values, by comparison to the KPI 2 for alkaline and PEM water electrolysis, is close to the 2018 value. For fuel cell mode it corresponds to a value of 3750 €/kW (electrical output), which is aligned with MAWP 2023 KPI for commercial mid-size fuel cells.

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 2016– 2017.

FCH-02-4-2017: Highly flexible electrolysers balancing the energy output inside the fence of a wind park

Specific challenge:

Over the past years, electrolysers have demonstrated their high flexibility and potential to deliver grid balancing services as a flexible load. Due to its variable character and increasing penetration, the integration of wind energy is becoming more challenging in Europe especially in weak power grids.

Locating an electrolyser inside the fence of a wind park presents potentially many advantages such as the smoothing of the power output (feed-in) of the wind park, the optimization of power management between the two technologies, the avoidance of (transmission and distribution) grid costs on the power used by the electrolyser, a clear renewable character of the hydrogen produced from wind power, the possibility to develop new operating strategies in order to maximize the energy production from wind turbines (curtailment avoidance) and to experiment new types of combined grid services.

The specific challenge of the topic is to achieve a full and efficient integration between the wind power generation systems and the capacity of hydrogen generation through electrolysers in a new and highly integrated layout.

Scope:

This topic aims at demonstrating an electrolyser in combination with an existing wind turbine or wind park. The electrolyser should be located inside the fence of a wind park and deliver balancing services through improved grid stabilising features of the wind turbine – electrolyser integration upstream of the wind park transformer.

Within the project, the smart energy management system and the necessary controls will be developed to operate the wind park and the electrolyser in the most optimal way, exploiting technical and economical synergies. The project should include the development of an advanced control system with power set points to combine the volatility of the wind park and the flexibility of the electrolyser. This control system should also consider economical parameters such as the provision of grid balancing services, the hydrogen demand profile for the selected application and the optimization of the economics of the whole plant (wind power sale and hydrogen sale).

The project should further demonstrate:

- A state of the art, fast response electrolyser of at least 2MW with a CAPEX @ rated power below 3 M€/tpd;
- A successful operation for a cumulated duration of at least 2 years and the cumulated production of at least 100 tons of hydrogen;
- Its ability to meet at least one of the following targets:
  - smoothen the power output of the wind turbine (or wind farm) significantly with the aim that:
    a) the energy can better be integrated in the trading of electricity; or
    b) the power system operator allows to increase the overall penetration with volatile sources, such as wind.
  - capture revenues in combination with the wind park for the provision of grid services, such as primary, secondary and tertiary response markets, or other electrical services that a power system operator is willing to pay for.
- the technical and economic benefit of having an integrated concept.

A significant part of the hydrogen produced during the project should be valorised, sold for example to a customer (industrial or mobility), injected in a natural gas or hydrogen grid or re-electrified. The downstream costs associated with the hydrogen use (outside the fence) are not considered eligible for funding under this topic by the FCH JU.

Furthermore, the project shall provide:

- a detailed analysis of the business case for the direct connection of electrolysers with wind farms as well as a market outlook for such an integrated concept;
- a technical and economic analysis covering the further integration of electrolyser technologies with wind turbines (or wind parks) in several key configurations (e.a.: dedicated wind turbine for hydrogen production, off-shore hydrogen production from wind energy);
- an analysis of the environmental performance of the integrated system;
- an impact analysis on the European energy system and the potential impact of this concept on regulations, codes and standards.

The technology should be moved from TRL 4 to TRL 6 with respect to the balance of plant and the system integration with the wind park. The consortium should include at least a wind farm operator, an electrolyser manufacturer and a grid operator.

International collaboration in this field is highly encouraged, especially with IPHE members.

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

The maximum FCH 2 JU contribution that may be requested is EUR 5 million per project. 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 impacts:

- Demonstrate to reach the MAWP 2020 KPI's targets, in particular:
  - energy consumption at rated power below 52 kWh/kg;
  - hot start from min to max power in less than 2 sec;
  - a cold start in less than 30 sec;
  - an efficiency degradation @ rated power below 1.5% per year (8000 operating hours).
- Perform an engineering study to show path towards MAWP 2023 targets;
- Development of new control systems at wind park level integrating an electrolyser inside the fence, exploiting technical and economical synergies between the two technologies;
- Demonstration of:
  - the economic and technical synergies between electrolysers and wind power parks and the overall benefits for the technology developers, the project owners and the grid operators;
  - the integration of both technologies could generate more benefits than the sum of the two technologies at two different sites.
- Assessment of which additional grid balancing services could be captured by the combined system and the potential extra revenues, respectively how markets and products for grid services should be developed, in order to facilitate the combined use of wind turbines and electrolysers.

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 2016– 2017.

FCH-02-5-2017: Demonstration of large electrolysers for bulk renewable hydrogen production

Specific challenge:

The increase of intermittent renewable electricity (solar and wind) raises the need for more flexibility in the power market and falling costs of renewable power open up the possibility to generate hydrogen at large scale from renewable power through electrolysis. Several sectors, namely the steel, refineries, chemistry, transport and even the natural gas sectors are exploring the reduction of their CO_2 footprint by incorporating large quantities of renewable hydrogen in their processes.

This topic aims to demonstrate a large scale electrolyser generating bulk renewable hydrogen for use in one or a combination of these sectors. The electrolyser technology should be further up scaled, in view of reducing investment costs by economies of scale and developed to operate flexibly when power prices are low and provide grid balancing services.

The challenges addressed by the project are:

- Demonstration of a large electrolysis unit (min 10MW) using the latest available technology with a very low capital investment;
- Providing large quantities of renewable hydrogen on a commercial basis for targeted large scale applications, or within industries or in the transport;
- Demonstrate the value of the flexibility of the electrolyser on a commercial basis by providing advanced grid balancing services;
- Integration of a large scale flexible hydrogen production unit with the end user demand profile.

Recent years of R&D have significantly improved the production ramp up and down flexibility of electrolysis technology and improved the scalability from kW to MW size. What is still lacking is large scale infield demonstration at sites where both grid services are required and where hydrogen can be valorized in large quantities. Only such applications can provide both the scale for providing grid balancing and reaching cost levels where additional revenue can be generated from hydrogen distribution and sales.

Scope:

This Innovation Action seeks proposals which demonstrate improved electrolyser technologies beyond actual state-of-the-art producing hydrogen with favorable economic conditions, e.g. when power prices are low, when additional revenue can be generated by providing high value grid balancing services and where the CO_2 reduction footprint can be valorized.

The scope of the project is:

- To develop a new large scale electrolyser of minimum 10 MW of sufficiently rapid response time (of the order of a few seconds), to participate in the existing primary and secondary grid balancing markets and explore possibilities of more advanced grid services. 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 application requirements. The output pressure shall be designed to fulfill, 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. Storage and compression are not in the scope of this topic;
- To demonstrate a minimal footprint of the electrolyser, with a single balance of plant including all required electrolysis utilities such as water purification, power rectification with suited grid interfaces, and hydrogen purification for delivery to the proposed application

sector. The 10MW scale unit should be designed as a building block for the plants of the future. Industrial integration with certification attested by a Notified Body involvement should be included;

- To focus on specific improvements of the current state-of-the-art related to the electrolyser operation under partial loads, quick response, system operation for providing reserve and frequency response services, forecasting models for electricity price and renewable energy production;
- To demonstrate an energy consumption consistent with 2020 expectations of 48 kWh/kg @1000+/kg for PEM technology at nominal power[18];
- To demonstrate a CAPEX for the electrolyser consistent with 2020 expectations of 1000 €/kW for PEM technology at nominal power. These target costs do not include the specific tailoring of the electrolysis to be compatible with the grid services to be brought;
- To demonstrate the economic benefits of the project for the selected application. Here, the consortium will demonstrate that they are able to obtain these revenues by entering into commercial contracts with the chain stakeholders (e.g. grid operators or utilities) who value these services. The value could be demonstrated also by other means that confirms the revenue potential;
- The proposal will indicate the operating scenarios, the duration of production, the quantities of hydrogen produced, the use foreseen and a detailed business case analysis. State of the art electrolysers and downstream systems must be installed and operated for a minimum period of two years;
- Electrolyser systems will strive to demonstrate a sufficient level of responsiveness to meet the requirements of the produced hydrogen for the services offered and power price opportunities, (e.g. for rapid modulation, rapid start, frequency response, as required by the services offered to the grid); this will be done in collaboration with chain operators of the market sector identified;

Consortia will preferably build upon outcome from previous projects funded by the FCH-JU and on already feasible business cases, so that potential customers do not discontinue the use of the installation after project end, but on the contrary support continued market roll-out efforts. The proposal must include an initial plan for use of the installation after the project. The proposal is expected to address new applications than the one already supported (i.e. steel industry).

To address adequately the challenges of this project, the consortium should include at least the electrolyser manufacturer, the hydrogen end-user and a power services company or the local power grid operator.

Specifically, the consortium should include strong links to:

- the necessary contractual and commercial expertise to access revenues from the grid services and/or power price opportunities;
- technical expertise for the design, provision and operation of the electrolyser and associated hydrogen distribution and supply technologies;
- market access for downstream provision of hydrogen in the selected application.

The capacity of the electrolyser should be linked to the budget via the cost KPIs in the MAWP but also reflect the specific tailoring costs for ensuring electrolysis is compatible with the grid services requirements. The grid connection costs, building costs and the electricity costs for the

[18] Reference: Water Electrolysis in the European Union (2014) (http://www.fch.europa.eu/node/783 reference: page 11-13)

commissioning phase are eligible for the funding. Electricity costs during demonstration / business operation are not eligible. The results of a techno-economic assessment must be published after each year of operation, including information on the individual cost and revenue streams related to the electrolyser. The Technical report however should present these figures for techno-economic assessment purposes.

Storage/compression costs should not be included.

To be eligible for participation a consortium must contain at least one constituent entity of the Industry or Research Grouping.

It is expected that the technology starts at TRL 7 and reaches TRL 8 at the end of the project.

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

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

Expected duration: 5 years

Expected impacts:

The proposal is expected to demonstrate in an operational environment improved electrolysis technology configured to attract revenues from grid services and/or power price opportunities in addition to 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 rapid response electrolysis and the integration the produced electrolytic hydrogen in an established industrial process;
- Assessment and operation experience, including safety, of the contractual and hardware arrangements required to distribute and supply hydrogen to the specific industrial and / or transport market;
- Implementation of the necessary grid interfaces to provide grid balancing services;
- Perform techno-economic analysis of the performance of these systems;
- Evaluation of the environmental performance of the system in alignment with the recommendations of the CertifHy project – with attention to the CO_2 intensity of the hydrogen produced, which should include an understanding of the CO_2 impact of the grid services mode selected and CO_2 footprint impact in the addressed hydrogen end-user markets;
- Projections of the value and size of the markets addressed by provision of the grid balancing services and supply to multiple hydrogen markets, not excluding the transport sector;
- Assessment and operation experience of the contractual and hardware arrangements required to access the balancing 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 required to stimulate the market for these systems.

Versions of ‘lessons learnt’ reports addressed to the public should be prepared and disseminated across Europe and potentially wider.

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 2016–2017.

FCH-02-6-2017: Liquid organic hydrogen carrier

Specific challenge:

The amount of hydrogen that can be transported by a compressed gas distribution trailer is limited to 300 kg (at 200 bar). The pressure in hydrogen delivery trucks is expected to rise from 250 to around 550 bar increasing payload up to 600 kg. Using liquid organic hydrogen carriers (LHOC)[19] this amount can be more than doubled, while using lower cost distribution trailers at the same time. Similarly, the storage of these hydrogen carriers is more cost effective than the storage of hydrogen itself. Additional advantages are the lower flammability and lower explosive nature of LOHC's compared with compressed hydrogen storage. Some LOHC's show even no explosive nature, reducing the storage costs considerably.

However, the use of these carriers requires a hydrogenation step at the hydrogen production facility and a dehydrogenation step at the point, or time, of use. Recent advances in hydrogen carriers have led to end-to-end system cost that could be comparable or better than gaseous hydrogen storage and distribution.

This topic calls for the demonstration of such a carrier for large scale hydrogen storage and/or hydrogen distribution

Scope:

Demonstration of a liquid organic hydrogen carrier for distribution and/or storage of hydrogen, including hydrogenation at a hydrogen production facility; transport of the hydrogenated compound and/or storage of the compound over several days and dehydrogenation at the point or time of hydrogen use.

The system should demonstrate

- chain efficiency above 70% by:
    - Utilization of released heat during the hydrogenation step, preferably within hydrogen production system feeding the LHOC system with hydrogen;
    - Reduce energy use for releasing the hydrogen below 10 kWh/kg H_2 by system & catalysis improvements or utilizing waste heat.
- the use of existing infrastructure for distribution and/or storage of gases or liquids;
- overall cost below that of gaseous high pressure (500+ bar) truck distribution and/or gaseous hydrogen storage;
- suitability of the technology for the intended application with regards to operational aspects, i.e. footprint and noise on a retail station;
- safety along the chain, including toxicity and health aspects;
- quality of hydrogen that fulfils ISO 14687:2-2012. It shall be demonstrated that trace amounts of liquid organic hydrogen carrier in line of ISO norm or demonstrated to not affecting PEMFC performance for road transportation.

The scope includes the following analyses, comparing to gaseous storage and/or distribution:

- an economic analysis;
- a lifecycle greenhouse gas emissions analysis;
- if relevant, a local pollutant emissions analysis.

It is expected that the technology starts at TRL 4 and reaches TRL 6 at the end of the project.

International collaboration in this field is highly encouraged, especially with IPHE members.

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[19] Liquid hydrogen (LH2) is excluded from this topic

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

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 2.5 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: 3 years

Expected impacts:

- Demonstrate to reach the following MAWP KPI's in 2020 and perform an engineering study to show path towards 2023 targets:

Topic	Parameter	Unit	2012 (SoA)	2020	2023
H_2 transport	Trailer Capex	M€/t capacity	0.55 @400kg	0.55 @800kg	0.45 @1000kg
H_2 storage	System Capex	M€/t	0.5	0.45	0.40

- Proof of competitiveness of liquid/gaseous carrier technology compared with compressed hydrogen gas technology at 500+ bar;
- Cost reduction for storage and/or distribution of hydrogen;
- Enabling of large scale storage of hydrogen independent of location and/or reduction of the number of hydrogen distribution truck kilometres;
- Proof of hydrogen quality fulfilling ISO 14687:2-2012.

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 2016– 2017.

FCH-02-7-2017: Development of flexible large fuel cell power plants for grid support

Specific challenge:

With the Paris Climate Agreement, the need for short and long term sustainable grid support, has become more urgent than ever. A zero emission alternative for fossil fuel based (backup) power supply is needed. Excess electricity, from wind and solar renewable generation, can be converted into hydrogen and stored for re-electrification during periods of energy shortage.

Grid operators need power supply technologies on MW scale that have fast response times and excellent load-following capabilities. With such a technology they can facilitate efficient and reliable interaction with the grid on both transmission and distribution level, and ensure energy security for end users. Flexible hydrogen fuelled fuel cell power plants (FCPP) could be perfectly suited for this purpose as, compared to other technologies, they have very high efficiency, potential for fast and effective load-following capabilities, zero emission, and can be used for both short *and* long term grid support (winter months). Together with large (MW scale) rapid response electrolysers, which are developed and demonstrated in previous calls, large hydrogen-fuelled FCPPs have the potential to become one of the key enabling technologies for the future renewable energy based infrastructure of Europe.

1-2 MW size hydrogen FCPP's have both been built and successfully demonstrated via European programs in recent years. However, these systems, its fuel cells, and other key components were not designed for flexible dynamic power to power operation. Moreover, with the applied fuel cells and system design the required cost levels cannot be reached, even not if the units are built in high volumes. This is because the fuel cells applied were not designed for MW size applications, the system and component development was not well integrated, and a modular approach and capital equipment cost level (Capex) did not have priority. So, significant (design) improvements of the system and the fuel cells are required. Furthermore, we need experience how to connect flexible FCPP to the grid.

Only via a joint step-by-step innovative approach the European technology, the European supply/value chain, and the market can be further developed. Europe is still leading with large-scale hydrogen FCPP technology but the basis of the European supply chain is small. To be competitive with existing technologies (*e.g.* diesel gen sets), Capex of < 1,500 Euro/kW is required to open this market for large-scale hydrogen FCPP technology.

Scope

- Design of a *modular* highly flexible MW size fuel cell power plant for dynamic P2P applications of H2 and baseload operation to be connected to the grid.
  - Next to the complete design of the FCPP, it includes the design and development of key components and validation of their performance and scale up potential, with the purpose to optimise performance and minimise Capex for a MW size system (*e.g.* 2 MW).
  - The Capex reduction could for example be accomplished by a reduction in the materials costs, the number of components and connections, the production steps, costs power electronics, and most importantly the development of larger fuel cell stacks.
  - The chosen concepts should be modular and integrating manufacturability approach, resulting in a design that is fit for mass production.
- Validation via a pilot scale flexible FCPP in an industrially relevant environment and compatible with large scale manufacturing. H2 can originate from P2G and/or industry H2 vents.
  - The selected size of the pilot installation should be logical in view of the modular design of the MW size FCPP and validation purposes (*e.g.* 75 – 200 KW).
  - The individual fuel cells stacks should have the same power output during the

validation period as envisaged for the MW size FCPP and are fully integrated into the pilot FCPP system.
    - The project should strive to validate a sufficient level of responsiveness to meet the requirements of the grid services and dynamic electricity price opportunities (*e.g.* for rapid modulation, rapid start, frequency response, as required by services offered to the grid).
    - It should include control systems, diagnostics and monitoring, management of unbalanced stack (due to *e.g.* degradation), management and forecasting for better grid integration and will be connected to the grid.
    - The duration of the validation in an industrial relevant environment should be at least 8 months.
    - The proposal must include an initial plan for use of the pilot installation after the project.
- In order to optimize the design of system and components the suppliers and system integrators should work closely together and show that they apply a joint, open, integrated and multidisciplinary approach.
- Learnings from other (national and international) projects, including the projects in the frame of the LCE topic for smart grid, storage and system integration technologies for distribution system, should be included where possible.
- Further develop and reinforce (repeatable) business models, plans, and service strategy.

This topic puts significant focus on the further development of the *FC stack* and is a prerequisite for the success and competitiveness of the European sector in future.

TRL start: 3, TRL end: 6

MRL start 2, MRL end 6

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

The FCH 2 JU considers that proposals requesting a contribution from the EU of up to 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 years

Expected impacts:

- The proposal is expected to design and develop a *modular* flexible MW size FCPP for dynamic P2P applications of H2 and baseload operation for connection to the grid.
    - Capex < 1500 Euro/kW system in case of series production of MW size FCPP with total capacity of 25 MW/year (not included cost for transport, installation, project management, and utilities).
- Development and validation of key components, in particular fuel cells, demonstrating scale up potential and Capex reduction.
    - Lifetime expectation fuel cells > 20000 h, FC efficiency > 55%, Capex FC < 450 Euro/kW stack (series production with total capacity of 25 MW/year).
- Validation of operation flexibility and grid stabilisation capability via a pilot FCPP via fast (within seconds) response times and load following capacity over a 20-100% power range. 50% power in < 20 seconds and 100% power in < 60 seconds.
- Electrical efficiency FCPP > 50%. This number is higher than mentioned in the MAWP because the focus is to optimize electrical efficiency
- Availability expectation FCPP > 95%
- Design of competitive demand response programmes for the benefit of the grid and the

consumers considering integration of FCPP systems.

- Strengthened and further develop European supply/value chains and sustainable partnerships between different European suppliers and stakeholders. Strengthen the European industry, by creating knowledge in support of the EU growth and jobs policy agenda.
- Increased public and market awareness and acceptance of fuel cells and the important role hydrogen and hydrogen technology can play in the future sustainable energy infrastructure. *E.g.* via press releases, conferences, workshops, television programs, etc.
- Overview of threats/barriers to achieve Capex and efficiency targets on full MW scale and recommendations to overcome these in future demonstration projects.

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 2016– 2017.

FCH-02-8-2017: Step-change in manufacturing of Fuel Cell Stack Components

Specific challenge:

While fuel cell systems have generally reduced their cost in recent years by building pilot manufacturing lines and benefiting from some early volume take-up on the Balance of Plant side; the cells, stacks and stack components are still the major limiting factors on the cost reduction curve. In the industry, several manufacturing processes for stacks and their key components have emerged as state-of-the-art, since their original development from the 1990s until today. More recent new and innovative processes, implemented in other sectors, have not yet been considered for fuel cell stacks and components, as the emphasis has been on making fuel cells perform as effectively as possible. Past FCH JU calls (2014-2015) have focused on BoP manufacturing and the improvement of existing manufacturing methods to increase yield and repeatability and reduce costs. However, in a young industry such as fuel cells, more innovative manufacturing processes, production techniques and approaches offer significant prospects for the greater cost reductions and quality improvements that are required as the industry moves toward mass production to follow the increased demand from growing fuel cell markets.

The most prominent step change featured in this call is to seek cross-fertilisation between fuel cell and other manufacturing sectors so that the use of less typical but potentially disruptive manufacturing techniques can bring the cell, stack components and stack cost, quality and performance a significant step beyond that achievable by today's more "conventional" manufacturing process technologies. Among others, techniques such as extrusion, co-sintering, vacuum deposition and coating technologies, 3D (additive layer) and inkjet printing, as well as other technologies used in, for example, the microelectronics industry, are notable examples of newly-established industrial processes, which could provide benefits if implemented for fuel cells manufacturing.

Scope:

The projects will develop new, or adapt significantly different, manufacturing processes, already established in other high-volume manufacturing sectors, to replace the "FC-conventional" and cost-limiting processes employed in current pilot manufacturing lines for cells, stacks and stack components. The new processes will substitute entire manufacturing steps with new core process technologies or equipment. Once developed and validated, the new steps will be integrated into already existing pilot plants or full-scale manufacturing plant.

The innovative manufacturing technologies will need to be more efficient and less expensive than the techniques currently in use. The new manufacturing processes will also consider environmental aspects and aim at a reduced materials and energy use.

It is expected that projects will exploit the possibilities given by mature technologies, which will ultimately guarantee a combination of cost reduction with an increase in volume production, quality and cell performance.

The scope of each proposal is required to address the following main activities:

- Identify at least two mature methodologies from other industries, whose implementation for the production of cells, stack components or stacks, could significantly improve their production process as specified hereafter.
- For the identified methodologies, demonstrate the advancements with respect to the solutions currently in use and the benefits achievable for:
    - production process: cycle time, yield, materials input, reliability of the production process, product reproducibility and increased control over specifications.
    - manufacturing costs: cost of production line (i.e. less capital investment), operating costs (i.e. less expensive), energy input (i.e. more efficient), product quality (i.e. low variability);

    - cell/stack performance: power density, efficiency, degradation.
- Down select the most promising new process for extensive manufacturing development and implementation and evaluation on existing small production lines or pilot plants and quantify and verify the expected benefits.
- Evaluate in a consistent framework the performance and the quality of the cell, stack or stack components against the performance of those manufactured with one of the traditional methodologies.
- Identify the limiting development factors of the other methodology/methodologies – not selected for the production testing – then improve the features and capabilities to reduce the gap towards the implementation within a medium time horizon (i.e. after the project end).

The projects shall

- produce a sufficient volume of components by the new process to validate its capability and to enable the assembly and testing of at least two existing stack designs relevant to a practical stationary application;
- demonstrate that innovative manufacturing routes can be scaled above 50 MW per year in a single production line while maintaining their competitive advantage.

The topic is not intended to cover the establishment of pilot or full-scale manufacturing plants, or basic research on new materials, or fundamentally new cell and stack designs.

The proposal has to include how the project strengthens the European industry and favours the creation of European anchored jobs.

Consortia should include at least one stack manufacturer and include a description of their supply chain including European companies. It is expected the involvement of industries or SMEs who may benefit from the creation of a new supply chain ready for larger production compared to the state-of-the-art.

To be eligible for participation a consortium must contain at least one constituent entity from the Industry or from the Research Grouping.

MRL start: 3

MRL end: 6

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

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

Expected duration: 3-4 years

Expected impacts:

Worldwide cost and quality leadership in cells and stacks can be achieved through this call, as cost-effective equipment and processes are essential to counterbalance somewhat higher labour costs in the EU. Innovative technologies will allow a more efficient and better controlled raw materials distribution into the electrodes, waste reduction, higher flexibility and reproducibility in terms of size and shape with respect to current technologies (e.g. tape casting, spray-drying, screen printing etc.). Moreover the new processes should guarantee the enhancement of cell performance towards the increase of power density, efficiency and durability. A successful project shall

- demonstrate the potential cost reduction and scalability of the improved processes and assess their impact on EU competitiveness;
- enable the production equipment manufacturers to open fuel cell manufacturing as a new market segment and generate and secure highly qualified jobs within the EU.

The projects should aim at a strong contribution to go clearly beyond the targets envisaged in the MAWP 2014 – 2020 (page 35) that could be achieved by simply following the established routes. Projects will demonstrate the achievement of cost reduction, as well as quality and performance improvement with respect to the following KPIs:

Specific KPIs for SOFC:

- Stack Capex < 400 € /kW.
- Power density > 0.35 W/cm^2.
- Degradation < 1.5% after a year test including 50 thermal cycles. Reference test conditions are reformate gas with S/C around 2 and fuel utilisation above 75%.
- Lifetime expectation > 40000 h including typical start-/stop requirements for operations, maintenance and emergency shut-downs.

Specific KPIs for PEMFC:

- Stack capex < 350 € /kW.
- Power density > 0.67 W/cm^2.
- Degradation < 0.25%/1000 h.
- Lifetime expectation > 20000 h.

Proposals should clearly report testing and operation conditions for a consistent assessment of the targeted KPIs.

The projects will pave the way towards the establishment of supply-chains with a positive impact on the creation of new jobs by enlarging the application of mature production methodologies to the fuel cells sector. This would also help to shift traditional production towards more added value components, leading to an increase in high profile jobs. Therefore, it is expected that the successful projects will make a valuable contribution to the achievement of other EU societal objectives (i.e. industry and economy growth, as well as jobs creation). Thus this will demonstrate that Europe will become a global leader in high volume and low cost fuel cell production, especially compared to Asia and America. Moreover, as a global leader, the reduction in imports from outside Europe could also be addressed together with the likely growth of the export market.

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 2016– 2017.

FCH-02-9-2017: Development of next-generation SOFC stack for small stationary applications

Specific challenge:

The market for fuel cells in small-power applications (between 0.3 and 5 kWe), is progressively taking shape worldwide. The most promising application, in terms of societal and environmental impact, is the residential micro Combined Heat and Power (µCHP), as suggested by the study *Advancing Energy Systems* (reference 1) published by FCH-JU in 2015. Other small-scale applications (telecom towers, data centers, HVAC, remote power, small commercial etc.) use the same technical platform and may provide a quicker market uptake. The Japanese industry, thanks to its ambitious ENE-FARM program, has taken the lead in technology development in this field, and is enjoying economies of scale. In Europe, a much smaller-scale effort is underway, in a more fragmented market.

Until now, PEMFC (Proton Exchange Membrane Fuel Cell) technology dominates the market with Intellectual Property largely in the hands of Japanese groups. However, ceramic-based technologies, in particular SOFC (Solid Oxide Fuel Cells), still pose as a promising alternative for future systems.

Despite its recognized potential, the SOFC technology still needs to mature on specific dimensions at cell, stack and hotbox levels (such as material sets, manufacturability and components design), in order to fulfill the cost and performance demands of the small-power customer– typically a long lifetime (10 years), high electrical efficiency (55% to 60% or more) and acceptable cost (less than 15 000 €/kW for a system). Moreover, working on next-generation, disruptive technology will allow European industries and consumers to avoid depending on Asian-imported technology.

The main challenge that this project intends to address is to develop a next generation Solid Oxide Fuel Cells (SOFC) stack/hotbox technical platform for small stationary applications, which is fully competitive with today's integrated Japanese SOFC power modules, and which satisfies fully the European customers' needs while leveraging the European supply chain.

Scope:

The goal of the topic is to foster the development of next-generation SOFC stack and/or hotbox/ integrated stack module technology, of European ownership, as a technical platform serving small-power (<5 kWe) stationary applications, including but not limited to Residential µCHP, by improving:

1. *Product design*: increasing the electrical efficiency and the durability of the ceramic-based cells, stack and ancillary hotbox components used for small-power CHP and power-only production, while reducing costs, in order to secure a clear value proposition to the final customer compared to conventional solutions;
2. *Manufacturability*: integrating industrialization considerations into the design, from the start, by implementing world-class ceramic technologies, with high-volume, low cost / high productivity characteristics, in the field of forming, sintering / depositing, finishing and assembly. These ceramic technologies should be easily scalable in the future to ensure the cost-down potential;
3. *Standards and European Supply Chain integration*: cooperating between European component and system manufacturers to solidify EU supply chains, and define battery limits compatible for integration. Those agreed battery limits will be publicly available also to other EU stack manufacturers not participating;
4. *Intellectual Property*: strengthening European technology leadership by leveraging the European industry's capabilities and ceramic know-how, and consolidating IP positions with European ownership.

In order to solve the challenge the project is expected to include some of the following tasks:

- the elaboration of advanced ceramic-based cell structure and design, including innovative electrolyte / electrodes / interconnect layers;
- new material sets allowing better durability, electrical efficiency, low cost and better processability;
- high productivity / low cost ceramic manufacturing processes (raw material batch preparation, green forming, sintering / depositing, finishing, assembly);
- novel geometries and designs for the stack and ancillary hotbox/integrated stack module components (insulation, gas manifold, electrical connections, heat exchangers etc.);

Within the project, the following will be performed:

- the design and development of (at least) one 1 kWe cell stack (potentially integrated into a hotbox/integrated stack module) prototype;
- a test-bench demonstration of performance under application-relevant test conditions, including a durability run lasting more than 5000 consecutive hours, start-up and shut down cycles, dynamic load cycles, fuel quality (hydrogen, reformed gases);
- a detailed cost model allowing to assess economic benefits of such new stack options in comparison with more conventional solutions.

A collaboration mechanism needs to be developed with the JRC, in relation to the ongoing EU protocol harmonisation and validation activities performed in support of the FCH2-JU programme.

To be eligible for participation a consortium must contain at least one constituent entity from the Industry and from the Research Grouping.

TRL 3 at start to TRL 5 at the end.

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

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

Expected duration: 3 years

Expected impacts:

The projects are expected to contribute to validate the targets contained in the MAWP 2014–2020, or even go beyond, in particular the specific KPIs related to small-power (<5 kWe) stationary applications, including but not limited to Residential µCHP, using SOFC / ceramic-based technologies. It is believed that if the following criteria are met, the SOFC system's performance and economics will be suitable for a market take-off.

- Stack performance in commercially relevant assembly (note : not individual cell performance): DC efficiency of at least 55%, for example by achieving voltage 0.83 V/cell at current density 0.30 A/cm2 under reformed natural gas and air. Operating conditions : air utilization >35% and fuel utilization >65%
- Lifetime > 90 000 hours (defined as accumulated performance loss reaching 20%) :
    - Steady state degradation rate <0.1% per thousand hours, proven over a test duration of at least 5000 hours

    - Resistance to normal cycling : <0.01% per cycle (controlled shut-down with stack brought to T<125°C) proven over at least 50 cycles
    - Resistance to emergency shut-down : <0.25% per cycle (redox cycle such as fuel loss at operational temperature, specific to the system outlay) proven over at least 10 cycles
- Stack Cost: below 1000 €/KWe ultimately, as manufactured in a production plant with a capacity of > 50 MWe/y. This stack cost includes not only the cells but also the gas manifold, current collectors, compression systems, and potentially insulations and heat exchangers depending on the design;

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 2016– 2017.

FCH-02-10-2017: Transportable FC gensets for temporary power supply in urban applications

Specific challenge:

The EU market for temporary and transportable power is increasing due to the general improving economic outlook driving the growth in construction activities, and the increase of social and cultural events (festivals and markets) in urban areas. Diesel gensets are the current status quo in the targeted applications and the societal challenge to be addressed is the reduction of carbon emissions and noise pollution, while achieving higher energy efficiencies in the urban environment. This topic provides a potential ‘doorway’ to the much larger diesel genset replacement market by facilitating fuel cell deployment into “early markets” where diesel genset replacement is reachable due to increasing urban regulations on noise and harmful emissions. The current “clean” alternative is putting connections to the local electricity grid in place. However, due to capacity issues on the grid -most often caused by the charging of electric vehicles- these cables are getting very expensive and/or it is impossible to find the right connection to the grid. The aim of this topic is to demonstrate the technical and business case viability of fuel cells as a disruptive technology capable of replacing transportable diesel gensets and competing clean energy alternatives in the European urban stationary power market in the electrical power range of 25to 400 kW. The specific challenge is providing easy-to-install and easy-to-operate transportable fuel cell solutions - a technology not generally designed to be installed, decommissioned and transported to and from sometimes non-ideal operating environments multiple times during the product life-cycle.

Scope:

This topic focuses on demonstrating robust, transportable, easy-to-install, easy-to-transport FC gensets including feasible fuelling logistics for temporary applications in the power range 25 to 400kW in urban environments. The project has to also include a complete LCA of the concept, including the fuel and logistical costs. The proposals should include at least two manufacturers of FC systems and demonstrate viability in at least two different environments/market segments. Applicants should demonstrate firm commitment from end-users, through conditional orders or direct participation in the consortium during the application phase.

- Applicants should demonstrate a total sum of system electrical power capacity of at least 500kW ; a minimum of 4 systems of 75kW or above built in order to follow the construction site power needs through the whole construction cycle and 4 systems in the lower power range, 25kW or above, to address festivals
- Applicants should demonstrate robustness and ease-of-installation, through the transport and relocation of individual fuel cell systems and that a cumulative electrical power requirement of at least 750 kW will be served by project end.
- Applicants should aim for on-site FC operation for at least 24 months (or 8000 hours). In such a case that the application requirements are less than one year of operation at a particular installation site (festivals, etc.), the applicants should demonstrate the transport and re-use of individual systems at more than one location annually
- Applicants should establish a demonstration/commercialisation pathway for European SMEs innovating in the development, manufacturing and supply chain of fuel cell components
- Establish the basis and further develop, if possible, marketing and sales strategies of European manufacturers
- At project start, system lifetime should be over 15,000 hours and 20,000 hours at project end
- System CAPEX target and availability to be achieved by 2023 is 3,500 -6,500€/ kW and >97% respectively (as defined by the MAWP). Development or procurement of auxiliary system

components, robust sheltering and refuelling equipment for challenging transportation, harsh work environment, ambient climatic environment and end-user safety is also within the scope of funding if the applicants can demonstrate them to be crucial as well as non-recurring engineering for the targeted market segment
- The fuel should be hydrogen which is expected to be stored onsite. The fuel delivery and storage has to be demonstrated as well. Fuel production is not included in this topic, but fuel logistics must be mapped and included while analysing the commercial feasibility of the FC gensets.

TRL start: 6

TRL 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), which manages the European hydrogen safety reference database, HIAD (dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu).

The maximum FCH 2 JU contribution that may be requested is EUR 5 million per project. 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: 5years

Expected impacts:

- Demonstrate the safe transport and operation of fuel cell systems, portable/transportable fuel storage and refuelling logistics
- Demonstrate the economic viability of each application/ business case selected in the project through real-world TCO analysis
- Demonstrate reduced noise and pollutant emissions related to providing temporary power supply in urban applications as well as faster authorisation process for FC gensets (as compared to diesel generators or grid connections) with respect to regulations concerning installations in , specifically noise and pollution, urban areas
- KPIs to be demonstrated include system CAPEX of 3,500 -6,500€/ kW, availability over 97% and lifetime over 20,000 hoursHigher visibility of stationary FC and hydrogen technology in the public consciousness through high profile urban demonstrations
- A commercial pathway for replacement of diesel gensets with economically feasible, easy-to-install (truck-in and plug-in) power supply in urban areas. A theoretical analysis on viability of FCs as a disruptive ‘diesel genset replacement’ technology post 2020 is highly recommended. This should take into account data collected during the project and a credible analysis of the market situation at project end. This should include but not be limited to H2 cost reductions, improvements in FC lifetime, system and stack component cost reductions, development of alternate fuel/ fuel storage technology, economy-of-scale effect on the supply chain through synergies with large scale FC transport deployments

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 2016– 2017.

FCH-02-11-2017: Validation and demonstration of commercial-scale fuel cell core systems within a power range of 10-100kW for selected markets/applications

Specific challenge:

The European landscape of stationary fuel cells for highly efficient distributed generation has grown richer and more diverse. The industry provides solutions for different use cases in three scales of residential, commercial and industrial applications.

Several European companies provide core component technologies (i.e. stacks, sometimes integrated with the fuel reformer) in ene.field and PACE and have already demonstrated such concepts in larger system designs. Other companies provide already full system solutions demonstrated as prototypes in ongoing FCH2-JU projects. While FC based micro-CHP applications have found their first markets and pick up industrial dynamics, the larger in power commercial applications using the same core technology still need to gain the full trust of system integrators. The validation of the technological performance and reliability and of attractive business cases is key. Large companies in Asia and North America are currently successfully pursuing the development and market entry of fuel cells in the commercial segment. Some of these companies are looking to incorporate next generation European technology. European companies need therefore to validate and demonstrate the successful integration into reliable products now in Europe, ensuring that Europe avoids importing high cost products based on inefficient or poorly matched technologies.

Besides the technical and commercial risks, the integrator industry also shows some reluctance to engage in development as their own investments depend on the core components of SME, as today most stacks are provided by medium size manufacturers that are financially more exposed than large corporations.

This notwithstanding, if FCs are to become economically competitive it is necessary to achieve a substantial reduction in capital costs by increasing production volumes while simultaneously improving the technology behind them. The learning curve needs to be similar to that exhibited by renewable energy technologies.

It is important to leverage the field and demonstration project of the micro-CHP sector to enhance the first achievements of the implementation of fuel cells. The larger production volumes of systems and components need to be translated in further improvements in both cost and quality, and into the validation and demonstration of the technology in further market segments.

Thus further demonstration projects and/or field trials are now required in order to validate the technology at higher power ranges for applications in the commercial building segment.

Scope:

Main scope of this topic is to validate and demonstrate European CHP solutions for the commercial building sector within the specified power range.

> *Technical*: Provide advanced fuel cell based CHP concepts demonstrating the superior advantages of fuel cell based CHP systems by achieving a high level of electrical efficiency (50%+) and an overall efficiency of 90%+ (combined use of heat)
>
> *Economical*: Demonstrate the customer advantages and viable business models in the aforementioned power range with fuel concepts using the existing high-quality, low-cost gas grid and highly efficient power generation and measure these against previous investigations

from the FCH-JU (i.e. "Advancing Europe's energy systems: Stationary fuel cells in distributed generations" (2015).

European industry: Derive concepts on how to integrate fuel cell core systems into final customer products for the European market by OEMs and system integration companies. Provide common standards and battery limits to make the fuel cell solutions commonly available and thus minimizing the risk to OEMs and system integrators when integrating FC technologies into their products.

Projects within this topic should demonstrate both operation in relevant environments and the route to high availability in significant volumes (10 - 20 installations and 400 - 600 kW installed power).

In addition to the aforementioned targets, projects within this topic shall include some of the following tasks:

- Present advanced, innovative concepts that demonstrate the benefits of the use of European FC technologies as part of CHP systems for the commercial sector (e.g. combined heating and cooling (CCHP), integration into critical infrastructures, smart metering and control, other polygenerational concepts).
- Validate the expectations on how fuel cell based CHP can improve air quality and reduce CO2 emissions and avoid further emissions (particulate, NOX)
- Show how the availability and lifetime required for the abovementioned market segments can be achieved (either by further technological improvements or accompanying service concepts) and how this benefits the expansion of renewables
- Define standard interface concepts for FC components and core modules in order to enable non-FC manufacturers to integrate FC generators into their final products using standardized interfaces and battery limits, thus paving the way for new distribution channels.
- Design business model[20], installation, maintenance and service concepts for commercial customers.
- Develop novel DAQ, monitoring and data analysis concepts and combine them with the latest smart control concepts and products (i.e. support demand-side management).

The consortium should include at least three core fuel cell component suppliers (like stack and reformer) from the European fuel cell industry and in addition to two stakeholders from other areas like

- FC system integrators
- Relevant suppliers of BoP components (i.e. power electronics, heat exchangers)
- Providers of service and maintenance
- Utilities or municipal energy suppliers

Research institutions and academic groups may also be included to take a supporting role (i.e. for example as partners responsible for the monitoring of KPIs).

Collaboration with national initiatives is recommended in order to leverage additional funding for the second demonstration step.

Where applicable the topic shall build upon the experience and achievements from earlier projects and further bring about cost reductions by increasing the volume of component (and in particular

[20] Building on the back of the latest EU studies (Roland Berger study & current Business Model study)

stack) production and thus improve and strengthen the competitiveness of the European supplier industry.

Projects under this topic shall improve the state of the technology from a TRL at level 5 to level 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), which manages the European hydrogen safety reference database, HIAD (dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu).

The maximum FCH 2 JU contribution that may be requested is EUR 7.5 million per project . This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

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

Expected duration: 3-5 years

Expected impact:

The project shall explicitly strengthen the European value chain for key components:

- Stack
- Reformer
- High-temperature heat exchangers
- Further sub-supplied components such as power electronics and desulphurization devices

Proposals need to explain which of these issues can be addressed by raising volumes and in turn improving and strengthening the competitiveness of the European supplier industry.

Other impacts expected will be the

- Cost reduction of around 30-50 % compared to current production costs.
- Increase in the lifetime of core systems and key components.
- Installation and monitoring of 10-20 systems with an overall installed power of 400 – 600 kW depending on the size of the systems in question.
- Enhanced supply chain and further synergies with spill-over effects to other applications (i.e. microCHP) that contribute to the success of the entire fuel cell industry.
- Improved visibility within the public sphere, and in particular within relevant stakeholder groups in the field of distributed energy (e.g. system integrators, installers and ESCOs).
- Further transfer the fuel cell technology into the existing energy industry enabling existing installation and maintenance networks to support FC products.
- OEM system integrators committed to the development and deployment of high efficient CHP and CCHP products

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 2016– 2017.

FCH-02-12-2017: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas

Specific challenge:

Isolated areas in Europe (e.g. villages, alpine refuges or 1000s of islands) have high electricity generation cost, due to the special challenges posed by the remoteness in terms of difficult access, harsh climate, low population density. The production of electricity in these areas generally derives from combustion plants powered by fossil fuels and the cost of electrical energy in these areas is heavily dependent on the high cost of these fossil fuels (i.e. the installation cost, the service logistics and the fuel transport) due to the remote location.

Today, numerous islands have significant renewable energy capacity or plan to invest in this sector. However, most of these isolated energy systems have not yet been able to guarantee their independence from fossil fuels. This is mainly because of the renewables intermittency and the lack of long term (weeks, months) energy storage solutions for these remote locations.

The specific challenge of the topic is to demonstrate in isolated micro-grids and/or off grid sites the implementation of reliable and clean integrated power solution based on electrolyser and fuel cell technology to secure cost-effective power supply, with the following site characteristics:

- Accessibility for installation, service and maintenance is complex and expensive (transport and time);
- Current power supply is not reliable (many power outages);
- Import of fuel is expensive resulting in high electricity price (at least 0.25 Euro/kWh);
- Use of fossil fuel and CO2 emissions are high;
- Local commitment to go for 100% renewables energy system;
- Storage of local energy sources is not in place today.

Scope:

The goal of this topic is to demonstrate the technical and economic viability of fuel cell technologies generating electrical energy in off-grid or isolated micro-grid areas, as stand-alone solution integrated with electrolyser and renewables.

Fuel cell technologies in the power range of 5-200 kW will be demonstrated in at least 2 sites as stand-alone and back-up power supply of technical installations (i.e. telecommunications equipment or similar) OR as end user power supply in off-grid or micro-grid remote areas. A minimum of 250 kW total power production (fuel cell) will be demonstrated. This will allow addressing different load requirement of isolated sites (e.g. remote businesses or housing/schools).

Existing sources of renewable energy will be used. Demonstration of electrolyser, storage equipment and fuel cell system is in the scope of the project. The size of the electrolyser will be defined according to the specific site requirements (i.e. type and size of the local renewable source, and especially time profile of the renewable along the day/week).

The project should:

- Validate real demonstration units in representative applications of isolated micro-grid or off-grid areas, in order to enable suppliers, end users and general stakeholders to gain experience throughout the value chain; and
- Demonstrate the added value of hydrogen based power-to-power energy storage

solutions with respect to alternative technologies in terms of economics, technical capabilities and environmental benefits.

- Demonstrate a successful operation for a cumulated duration of at least 2 years

Further objectives:

- Demonstration through field applications of the advantages of innovative technologies (hardware or software) including, but not limited to, monitoring, control, diagnostics, lifetime estimation, new BoP components;
- Demonstration of cost efficient solutions to the remote area, service and maintenance challenges;
- Online monitoring of operating conditions, load demands and system output will provide initial data to determine the overall efficiency of the system within the testing period;
- Optimization of power electronics to guarantee a proper integration of electrolyser and fuel cell products with the renewable source and end user/microgrid.

The project will be open to all fuel cell technologies.

Field demonstration usage data, efficiency, reliability are to be reported.

The proposals should represent a step forward former micro-grid and off-grid project results.

The consortium will include EU electrolyser and fuel cell system manufacturers, relevant suppliers for Balance-of-Plant components and research institutions or academic groups.

International collaboration in this field is highly encouraged, especially with IPHE members.

TRL at start: 6

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), which manages the European hydrogen safety reference database, HIAD (dedicated mailbox JRC-PTT-H2SAFETY@ec.europa.eu).

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

Expected duration: 3-5 years

Expected impact:

Following the topic from AWP2015 related to the development of electrolysers for hydrogen production in off-grid applications, this topic will focus on demonstration of integrated fuel cell-based energy solutions in off-grid remote areas or isolated micro-grid.

This demonstration must not only raise public awareness; it should be used to establish confidence in technology, business models and market readiness with end-users and authorities of isolated territories.

The project should focus on the following impacts:

- Energy independency at the local scale, with maximum recovery of locally available RES;
- Reduction of the cost of energy to the final users;
- Reduction of use of fossil fuels and CO_2 emissions;

- Reduce CAPEX in line with KPIs at 2020 of the MAWP: 3M€/(t/d) for electrolysers and 4,500€/kW for fuel cell systems. Proposals able to achieve improvements on the MAWP targets will be given preference.
- Increase system lifetime to more than 15 years.
- Demonstrate a viable solution and a replicable business case.
- Improvement of energy supply security and reliability.
- Supplier and user experience of installation/commissioning, operation, maintenance and use of fuel cell power generation.

To enable generalization of the field experience obtained, benefit from experience worldwide and facilitate technology replication, it is desirable that the selected project could feed into relevant ongoing standardization activities on fuel cells during the project.

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 2016– 2017.

CROSS-CUTTING PILLAR

FCH-04-1-2017: Limiting the impact of contaminants originating from the hydrogen supply chain

Specific challenge:

The composition of hydrogen delivered to fuel cell electric vehicles (FCEVs) has a significant impact on fuel cell stack durability and system efficiency. International standards dealing with hydrogen quality specifications have been created (ISO 14687-2:2012 and ISO 14687-3:2014) and the former is currently under revision (ISO TC 197/WG 27&28).

The contaminants included in these standards are primarily associated with hydrogen production and purification processes. European and international research efforts have been contributing to better understanding of the effects of such contaminants (e.g. CO, HCHO, HCOOH) and their maximum acceptable levels are already relatively well understood. Nevertheless, most of these investigations are conducted using individual contaminants under static operation conditions, at relatively low maximum current density (1 A cm^{-2}), and not necessarily with MEA configurations appropriate for future automotive applications.

Furthermore, contaminants originating from hydrogen refuelling stations (HRS) may also impact the quality of hydrogen delivered to FCEVs. The effects of irreversible contaminants (sulphur, halogenates such as tetrachlorohexafluorobutane, contaminants from ionic compression, etc.) as well as those arising from HRS operation and maintenance are less well known. A major issue with some of these contaminants (e.g. grease from compressors) is that relatively large amounts of contaminant can be introduced into the hydrogen due to improper maintenance procedures or component failure.

Scope:

The main focus of the project should be to understand the effect of contaminants originating from the hydrogen supply chain, as specified in current standards ISO 14687-2:2012 and ISO 14687-3:2014, on fuel cell performance and durability under dynamic load cycle conditions. MEA configurations representative of state-of-the-art transport applications shall be utilised.

A particular challenge concerns the identification and characterisation of contaminants originating from the HRS (TRL 8) and their impact on fuel cell performance and durability.

Based on the results, mitigation methods (e.g. in-line monitoring of hydrogen quality at HRS) should be developed and appropriate revision of ISO 14687-2:2012 proposed. A major focus should be on avoiding the use of 'total' parameters where possible. The work will also support revision of ISO 14687-3:2014.

Tolerance levels for impurities depend on the fuel utilisation and load profile of the PEMFC. Therefore, the susceptibility to contaminants should be characterised at PEMFC system level, using realistic automotive conditions and drive cycles, including frequent voltage and start-stop cycling as well as very high maximum current densities (2.5 A cm^{-2}). The susceptibility to contaminants should be characterised using representative fuel utilisation rates, including enrichment of contaminants in the anode recirculation loop. Ultra-low anode PGM loadings (0.02 mg cm^{-2} or less) should be included to support minimising use of PGM and provide information for future revisions of ISO 14687 standards.

The project should address the following key issues:

- Evaluate the impact of contaminants, including relevant mixtures of contaminants, based on risk analysis of hydrogen supply chain, under automotive operation conditions, using MEA configurations appropriate for future automotive applications.
- Identify the critical components and maintenance practices in the HRS that can, in addition to other common sources, introduce contaminants into the hydrogen fuel.

- Provide technical data on fuel composition and impurity concentrations at HRS, focusing on impurities originating from HRS components and maintenance practices.
- Set up the basics to establish practically a European Laboratory beyond the project, capable of measuring all of the contaminants in the current ISO standards (14687-2:2012 and 14687-3:2014).
- Develop and characterise existing and novel methods for in-line monitoring of hydrogen quality at HRS for the most critical impurities identified.
- Build on existing knowledge through extensive use of results achieved in previous and on-going European projects as well as international networking and exchange.
- Study the short term (reversible) and long term (irreversible) effects of the identified critical impurities in a way that is representative of automotive PEMFC system operation (e.g. high fuel utilisation, start-up/shut-down cycling).
- Through risk analysis (production process) and fuel cell durability tests, identify the key impurities that can be measured instead of performing 'total' measurements as specified in ISO 14687 and recommend revision of the standard to ISO TC 197.
- Measure accumulation of contaminants in the anode recirculation loop or at the anode gas outlet; accumulation of contaminants in purged anode water; cross-over of contaminants to the cathode through the membrane, and vice versa; conversion of contaminants in the anode recirculation loop including the effect of oxygen permeating from the cathode.
- Communicate the results and their relevance in an effective way to ISO TC 197/WG 27&28, as well as other standard drafting organisations, enabling specification of an independent and comprehensive revised hydrogen fuel impurity matrix.

The proposal should establish a link to the FCH2-JU project HyCoRA, in order to ensure complementarity and adequate take-up of its outputs, including the utilisation and further development of the qualitative and quantitative risk assessment approach of the HyCoRA project.

The subject addressed in this topic has been identified as a priority by many countries working on hydrogen and fuel cells. Collaboration with relevant international partners is recommended.

A collaboration mechanism needs to be developed with the JRC, in relation to the ongoing EU protocol harmonisation and validation activities performed in support of the FCH2-JU programme.

All deliverables and data should be public in order to support standardisation work as effectively as possible. Data anonymisation should be avoided.

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

The FCH2-JU considers that proposals requesting a contribution from the EU of EUR 3.5 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: 3 years

Expected impact:

The proposed developments will improve understanding of contaminant effects, and thus present an important base for appropriate future hydrogen standards. This understanding will also support the discussion of "hydrogen quality requirements vs affordable hydrogen costs".

Successful development and application of in-line continuous monitoring of hydrogen impurities would reduce the incidence of poor vehicle performance and potential loss of reputation of fuel cell technology.

The expected impacts of the project include:

- Identification of critical impurities originating from HRS components and operation/maintenance practices.
- Technical data for impurity concentrations at HRS nozzle with focus on impurities from HRS components and operation/maintenance practices.
- Develop and set the basics for the possibility to establish the laboratory beyond the project, capable of measuring all of the contaminants in the current ISO standards (14687-2:2012 and 14687-3:2014) in order to offer this service to the European FCH community.
- Recommendations for revision of ISO standards, under consideration of dynamic operating conditions, continuous full power operation (2.5 A cm^{-2}) and future MEA configurations with anode PGM loadings of 0.02 mg cm^{-2} or less.
- Recommendations for revision of ISO standards concerning HRS components, commissioning and maintenance practices.
- Recommendations for revision of ISO standards for contaminants introduced by HRS components and operation and operation/maintenance practices.
- Recommendations for revision of ISO 14687 to allow compliance testing against hydrogen purity specifications to be more achievable.
- Improved and/or new methods for in-line continuous monitoring of hydrogen impurities in HRS, with a focus on CO measurement.
- Recommendations on the concept of an on-board hydrogen purifier.

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 2016– 2017.

FCH-04-2-2017: Harmonisation of hydrogen gas trailers

Specific challenge

Compressed gas truck distribution will initially be the most common way to transport hydrogen from central production sites to consuming facilities. Significant introduction of hydrogen vehicles requires a scale up of two orders of magnitude hydrogen truck distribution. At the same time developing and deploying a high volume trailer is necessary to address both the H2 Mobility market but also the industrial market to increase the volume transported so as to decrease transportation cost and CO2 emissions in a context of increasing fuel cost; to increase customer autonomy and storage footprint and to reduce the HRS investments and ease the ramp up of first stations[21].

Current standards, regulations and safety codes have been developed for a relatively small market volume and deliveries mostly to industrial sites. These standards need to be reviewed, and adapted if needed, to ensure safe, efficient and low-cost hydrogen delivery at larger scales and in residential areas. These regulations and standards need to be harmonised across Europe.

Scope:

The following specific issues should be addressed by the project:

- Identify and quantify the risks associated with compressed hydrogen delivery on a large scale, taking into account the whole chain from filling of trucks at a terminal, driving from supplier to customer and delivery of hydrogen at a retail station or other customers;
- Propose mitigation actions for the most critical risks;
- Provide a roadmap for standardisation of compressed hydrogen trucks and interfaces between the truck and the supply and customer sites that balance safety aspects with commercial, environmental and feasibility aspects. This includes a strategy for effective influence on:
    - ISO TC 58/SC3 Gas Cylinders Design;
    - WG 35 Refillable permanently mounted composite tubes for transportation: ISO 17519 CD;
    - WG 32 Refillable composite reinforced tubes of water capacity between 450 L and 3000 L – Design, construction and testing: ISO 11515;
    - WG 27 Gas cylinders of composite construction: ISO 11119-X;
    - ADR - Dangerous Goods Transport.
- Develop a position paper that, considering actually available European Regulations on max pressure and max quantity of hydrogen transported all over Europe, can propose a modification and derogation proposal to the ARD[22].

To address the issues basic experimentation or simulations may be required, for example to determine optimal flow rates and to optimise ways of equipment handling.

It is expected that the conclusions and results of the project are made public.

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

The FCH 2 JU considers that proposals requesting a contribution from the EU 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: 3 years

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[21] From DeliverHy – Recommendations to Industry (http://www.fch.europa.eu/project/optimisation-transport-solutions-compressed-hydrogen)

[22] ARD (ADR): European agreement on the international carriage of dangerous goods on road

Expected impacts:

The following impacts are expected as a result of the PNR activities:

- Deeper knowledge of the risks associated with compressed hydrogen delivery on a large scale and the mitigation actions for the most critical risks, ensuring that risks related to distribution during the hydrogen market development phase are minimised;
- Harmonization of hydrogen distribution with high pressure trucks in the current standards, regulations and safety codes, making possible by the end of the project the distribution of hydrogen with high pressure trucks in Europe with the same framework or regulation in all member states
- The project shall provide evidences of the reduced cost in the hydrogen value chain due to increased standardisation.

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 2016– 2017.

FCH-04-3-2017: European Higher Training Network in Fuel Cells and Hydrogen

Specific challenge:

A firm basis needs to be prepared for an EU-wide human resources development of scientists and especially engineers to feed the growing European fuel cell and hydrogen (FCH) industry. The SET-Plan Education, established in 2012/2013, expected a human resource of 57,000 highly skilled staff required by 2020, and 190,000 by 2030 in the FCH business. Supplying this resource is a major challenge in reliably building the FCH value and supply chain.

The SET-Plan Education identified a number of activities in university and vocational education, covering BSc/BEng, MSc/MEng, and PhD training across the EU that would be necessary in securing the education for the numbers of skilled workers needed in the future. The deficits identified were the lack of high quality teaching material and lack of student access to courses across Europe, as well as the lack of mobility incentives, including staff exchanges between academia and industry. The challenge addressed here is to devise a structure through which FCH education can be delivered at a high quality throughout Europe and be fully recognised and integrated into the European university and vocational educational system. Specific challenges are the harmonisation of teaching material, the accreditation of courses, the recognition of credit points, and the integration of the industrial perspective into teaching.

At the level of the FCH JU a number of activities in education have been completed or are still under way. The projects TrainHy, HyProfessionals, HyFacts, HyResponse, and KnowHy have been developing elements of teaching, e-learning, and practical training for a variety of target groups, ranging from university degrees over technician training to specific training of stakeholders and emergency crews. This project will build on the currently fragmented outcomes of these projects and integrate them into a new body of teaching, educational material, and courses offered across Europe at the quality level of university education (BSc/BEng/MSc/MEng/PhD and vocational training equivalents).

This activity calls for university-level education, both for scientists and engineers, looking at the highest skilled workforce of scientists and engineers totalling 17,000 in 2020 and 50,000 in 2030 (SET-Plan). Currently, HEI (Higher Education Institutions) in the EU are annually turning out about 250 to 350 PhD students with a specialisation in FCH technologies and about 1,000 graduates (BSc/BEng/MSc/MEng) with general knowledge in the area. These numbers clearly need to be stepped up. Currently the main bottleneck is the limited number of universities offering specialised training due to limited resources and lack of trained lecturers.

Scope:

This project is to develop the means for proliferating FCH education across the EU and offer students' access to courses independent of the specialisation of the university they are enrolled at. In order to do this it will build a cluster of universities and other educational institutions that will lead and coordinate the activities related to FCH at the qualification level of university undergraduate and graduate training. The cluster will represent this topic and its community towards EU level stakeholders.

The network cluster will harmonise high-level training across Europe to make best use of teaching resources and offer the highest quality of educational FCH material to as many students as possible. It shall be positioned to become a representative of FCH training, in order to act as a "single stop shop" and "single voice" with respect to associations such as EPUE, European University Association, etc. and monitoring, leading, or guiding any initiative in this field at European level.

The project will create a cluster of EU universities and other HEI that will lead and coordinate FCH training activities across Europe. It will establish a core body of harmonised teaching material and offer a platform centre of access for students across the EU to receive education in FCH technologies at the level of graduate (BSc/BEng/MSc/MEng) and postgraduate training, including the equivalent level in vocational training, and Continuous Professional Development (CPD). It will include not only universities but also other vocational training institutions that can represent the industrial perspective. By taking resource to the same teaching material, vocational training institutions closer to industry than to HEI can profit from the activities of the project. The project will run exchange programmes with industry in order to both deliver the industrial context to the HEI as well as allowing industry access to quality training material. Integrating CPD elements will further strengthen the aspect of delivering training capacity to industry and shall be fully integrated into the educational framework. All network partners need to be able to attribute ECTS points or equivalent (convertible) credits to their courses.

Based on an in-depth analysis of European market's needs in terms of educational demand in the area of FCH and a review of all previous FCH JU projects and EU initiatives, the project will deliver an educational framework that is benchmarked with other regions of the world that currently have successful programmes in place. Building on this analysis and using results from previous projects, it will create a harmonised teaching programme across the network. Local delivery might vary according to the national educational system but will adhere to the same principles and build on the same base material. All content will be fully accredited for ECTS points (and equivalent, convertible) schemes. A structured mechanism of systematically and continuously updating and improving the teaching material in line with future directions of teaching (including e-learning) and FCH technology will be implemented.

The project will

- install a cluster of a minimum of 10 universities and other HEI that will take the lead in providing FCH topic education across Europe, mostly in countries which have adopted the AFI Directive; this cluster will use and regularly amend a common body of teaching materials and platforms integrating results from previous projects in order to build a repository of teaching content, tools, knowledge, databases, etc. dedicated to undergraduate, graduate and postgraduate courses for FCH training activities across Europe;
- offer joint courses or minimum harmonised local courses that address undergraduate, graduate, and postgraduate levels of university (BSc/BEng/MSc/MEng/PhD) as well as the corresponding vocational training levels; all courses need to carry ECTS points (or convertible equivalents) and all partners thus must be in a position to grant ECTS points or equivalent (convertible) credits;
- proposed programme should envisage setting-up of a cross-European challenge-based contest to stimulate academic community and raise the attractiveness of the FCH curricula;
- perform a trial course at a minimum of five partner institutions in year 2 of the project and full course runs in year 3 and 4 (length depending on 12, 18, or 24 month duration of courses) with a minimum of 20 students enrolled per course in Year 4;
- perform and schedule trial courses at a minimum of five partner institutions at the first stage of project and full courses in the second stage of project with a minimum of 20 students enrolled per course. (length of courses should be in accordance to the thematic lectures)
- include CPD schemes in the network activities, cooperating closely with the vocational training partners;
- provide a web access point or use an existing web based platform to host the teaching materials and give students across Europe access, including the provision of e-learning and communication instruments;
- provide Massive Open Online Courses, MOOC's as a tool for delivering teaching content but also addressing the general public and stakeholders in the FCH area;
- establish a student and staff exchange programme between educational and vocational training institutions and industry with minimum 30 exchanges across the programme;
- set up an industry advisory board to inform educational activities of industry needs and future technological trends;
- set up an associate network of universities participating in the activities of the project without being a partner in order to smoothly expand activities post-project;
- include provision of all material in a minimum of five EU languages;

- establish a business model to continue and maintain the network after completion of the project with the aim of seamlessly continuing the delivery of courses and educational materials post-project; the cluster should be able to continue its activities for at least 5 years post-project;
- organise alumni and student conferences and workshop meetings of graduates from its own programme and previous programmes;

The topic should be specifically open towards and integrate EU13 Member States applicants. Collaboration with relevant international partners from IPHE countries is recommended.

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

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 0.75 - 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: 2-3 years

Impact

The project will:

- allow students across Europe access to high quality, harmonised, and certified training material in FCH; courses will be credit bearing and support training in general and specific topics in FCH for building the HR resource necessary to staff the market introduction of FCH technologies;
- address undergraduate, graduate and post-graduate university students, as well as young professionals in industry; it will deliver courses and teaching material suitable for obtaining credits for CPD schemes and build a bridge between university and vocational type training at the highest skill level;
- offer a staff and student exchange programme across Europe between participating HEI, vocational training institutions and industry, giving a broader perspective to both the educational and commercial participants;
- train the general public, politicians, and other stakeholders in FCH content in the form of MOOCs and general educational material and short courses;
- boost industrial R&D by offering education and training, as well as exposure to university type research approaches and equipment; likewise it will encourage students and research fellows to take opportunity of industrial placements to augment their knowledge of industrial processes and perspectives

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 2016– 2017.

FCH-04-4-2017: PNR for a safe use of liquid hydrogen

Specific challenge:

As a prenormative project the topic addresses mainly those areas where LH2 specific standards do not exist or should get reworked. Rather it addresses all safety related standards and regulations (ATEX directive, etc…) requiring a minimum safety performance of the respective technology (refuelling, transport, etc). However, there are a few international standards already dealing with LH2 like ISO 13984:1999 Liquid hydrogen - Land vehicle fuelling system interface, ISO 13985:2006 Liquid hydrogen - Land vehicle fuel tanks, the ISO/TR 15916:2015 Basic considerations for the safety of hydrogen systems, or ISO Standard 21012:2006 Cryogenic vessels - Hoses (Applicable to fuel storage system design) which should be revised on the basis of the outcome of the project. As EU regulations are built on or tend to refer to international standards ("modern approach") there are actually no LH2 specific regulations at all.

For scaling up the hydrogen supply infrastructure the transport of liquefied hydrogen is the most effective option due to the energy density. Especially for the transport sector with the planned large bus fleets, the emerging hydrogen fuelled train, boat and truck projects and even for the pre-cooled 70 MPa car refuelling liquid hydrogen (LH2) offers sufficient densities and gains in efficiency over gaseous transport, storage and supply. However, LH2 implies specific hazards and risks, which are very different from those associated with the relatively well-known compressed gaseous hydrogen. Although these specific issues are usually well reflected and managed in large-scale industry and aerospace applications of LH2, experience with LH2 in a distributed energy system is lacking. Transport and storage of LH2 in urban areas and the daily use by the untrained general public will require higher levels of safety provisions accounting for the very special properties. The quite different operational conditions compared with the industrial environment and therefore also different potential accident scenarios will put an emphasis on specific related phenomena which are still not well understood. Specific recommendations and harmonised performance based international standards are lacking for similar reasons. However, for a safe scale-up of the described promising hydrogen solutions science based and validated tools for hydrogen safety engineering and risk informed, performance based, international standards specific for LH2 technologies are imperative.

So the potential for increased handling and distribution of LH2 in the public highlights the need to address unanswered questions related to these prototypical accident scenarios via pre-normative research, thorough laboratory scale experimental and theoretical investigations. In particular, appropriate models for the flashing multiphase, multicomponent release phenomena, cryogenic plumes and jets, the potential for flame acceleration and deflagration-detonation-transition in these multiphase mixtures, have to be developed on a new experimental basis. The suitability of conventional mitigation techniques needs to be checked carefully and partially overly conservative safety distance requirements have to be revised on the basis of an improved understanding of the physics and with the help of the new models. The intrinsic safety advantages of LH2 over compressed hydrogen offer indeed a high potential for safer, more economic innovative solutions. However, this potential might be used only if the required knowledge base is provided.

Scope:

The scope of this topic encompasses pre-normative research on the associated risks related to the accidental behaviour of LH2 and finally the derivation of suitable engineering correlations and enhanced recommendations for safe design and operations of LH2 technologies.

In a more detailed view, the envisaged project shall develop a suitable detailed experimental program, which shall be derived from internationally agreed priorities. The preliminary list of critical phenomena presented in the specific challenge paragraph above has to be revised to comply with those topics which receive highest ranks from all stakeholders, mainly research and industry. Thus the generated experimental program and the accompanying analytical and numerical studies will improve the understanding of the most relevant safety related issues of distributed use of LH2 in the most efficient way.

The generated experimental results shall be extensively documented, published and translated into easily applied, but sufficiently conservative criteria or engineering correlations, directly applicable in the design process or associated risk assessment procedures. Implementation of the criteria and correlations in an open software integration platform for risk assessment or improved design of mitigation concepts shall be envisaged. New recommendations and guidelines including appropriate safety distance correlations and advice for proper use of mitigation technologies shall be derived. Thus, the results shall support the further development of the related specific international standards via a solid extended scientific basis. A set of communication peer reviewed papers shall be prepared, suitable to internationally disseminate the findings of the project to the different stakeholders.

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

It is obvious that in particular in the field of hydrogen safety international collaboration with similar activities ongoing in IPHE countries will be an advantage and will strengthen the whole FCH community.

The FCH 2 JU considers that proposals requesting a contribution from the EU 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: 3 years

Expected impact:

- Closure of knowledge gaps related to the LH2 behaviour in accidental conditions related to the new public use case
- Enhancement of the state-of-the-art by development, verification and validation of predictive models, analytical and numerical tools for characterization of LH2 hazards and associated risk mitigation barriers
- Review of existing standards against new knowledge and missing to suggest the implementation and modification of standards
- Provision and execution of specific experiments and tests according new phenomena concerning the physical behaviour of LH2
- Providing appropriate guidelines for safe design, based on the experimental results and simulations, implementation and operations of distributed LH2 logistic systems
- Inclusion of the enhanced state-of-the-art, the related models and recommendations in updated or new specific, performance based, new international standards
- Exploiting the potential of LH2 for safer and more economic innovative hydrogen technology solutions
- Enabling FCH industry scaling-up attractive hydrogen technologies mainly in the transport sector

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 2016– 2017.

FCH-04-5-2017: Definition of Accelerated Stress Testing (AST) protocols deduced from understanding of degradation mechanisms of aged stack components in Fuel Cell systems

Specific challenge:

This approach addresses key aspects of interest for the industry related to durability particularly regarding the stack components as MEA or bipolar plates. Targeting the understanding of realistic failure modes and the development of ASTs that addresses 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. Actually, ASTs will allow faster evaluation of new materials and provide a standardized test to benchmark materials and/or stack components, and will accelerate the development to meet cost (100€/kW @system for passenger cars in 2020 and between 1500 and 10000 €/kW for stationary fuel cells depending on their size in 2020) and durability targets (6,000h for automotive and 80,000h in stationary applications). While different ASTs are already available (DOE-FCTT, Japan-FCCJ but no European ones), there is still a lack of correlation or transfer function to "Real World" data. As far as PEMFC are concerned, AST on electrocatalyst is the most critical, AST for membrane and support appear consolidated but have been recently adapted by DOE and no tests are available for GDLs. AST depend both on the application and on the technology. Therefore specific AST have to be developed for PEMFC and SOFC stack components in different user profiles. For SOFC, first accelerated testing have been done, but they are less advanced than in PEMFC, and in all cases they will be different in terms of solicitations.

As of today, a growing number of FCH JU demonstration projects involving hydrogen technologies (buses, cars, stationary applications) are ongoing and expected in Europe. Some monitoring is in place providing feedback regarding evolution of the performance of the system in correlation with user profile. In order to retrieve most benefits from these past or on-going demonstration projects, it is important to link these evolutions to materials evolution with quantitative data for various usages.

Scope:

The objectives of this project dealing with either transport or energy pillars and PEMFC or SOFC technology may include:

(1) Identification of degradation mechanisms and quantification of degradation on aged stack components (bipolar plates, electrodes, gas diffusion layers, membranes, cells, sealing's …) coming from FCH JU demonstration projects,

(2) 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 behavior of that component. For PEMFC technology, finalization and validation of the new single cell design initiated by the working group coordinated by JRC has to be taken into account. Proposal and validation of AST from materials to stack components and optionally stack level, the latter potentially more application specific when relevant,

(3) 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.

A key requisite for the project is the certainty of acquisition of at least 6 aged samples of a given stack component (MEA for PEMFC or cell for SOFC, bipolar plate) of at least 3 different stacks and of the corresponding user profiles. Projects are open to any application (transport or stationary) and should focus on a fuel cell technology (PEMFC, SOFC). 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 envisioned to ensure relevant comparison between "real-world" ageing and ageing caused by selected AST.

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

A collaboration mechanism needs to be developed with the JRC, in relation to the ongoing EU protocols harmonization and validation activities performed in support to the whole FCH2 JU program.

International collaboration through scientific exchanges or an advisory board with entities outside Europe (e.g. IPHE countries) investigating this field is highly recommended in so far proposals include a specific activity to frame and justify their work and its contribution within the international activity.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 2.5 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:

- Enhanced understanding of the correlation between user profile and degradation mechanisms on at least two stack components (gas diffusion layer, catalyst layer , membrane for PEMFC, cell for SOFC, bipolar plate and potentially its sealing) and its validation with models related to degradation mechanisms
- Define updated testing hardware for PEMFC, testing methods and evaluation criterion / criteria to allow faster evaluation than current AST of new materials and standardised tests to benchmark materials on at least two stack components (gas diffusion layer, catalyst, membrane for PEMFC, cell for SOFC, , bipolar plate) with a quantified correlation or between AST results and lifetime in a user profile (transport, stationary)
- Validation of the methodology (i.e. comparison and correlation between "real-world" behaviour and AST caused degradation) should be achieved owing to experimental and/or modelling results showing at least similar ranking between materials or stack components with a good correlation between quandtitative degradation features (to be selected such as performaces degradation rates, properties losses, microstucture modifications)
- Provide recommendations about improvements of monitoring and tracking systems for future deployments in order to capitalise on return of experience.
- Integration of the developed AST with the EU harmonized test protocols (for PEMFC). Final document 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 lead to a New Working Item Proposal (NWIP)

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 2016– 2017.

Conditions for the Call

Call identifier: **H2020-JTI-FCH-2017-1**

Total budget[23]: EUR 116 million [24]

Estimated Opening date: 17th of January 2017

Estimated Deadline: 20th of April 2017[25]

Indicative budgets:

Topic	Type of action	Indicative budget (million EUR)
1. TRANSPORT PILLAR		
FCH-01-1-2017: Development of fuel cell system technologies for achieving competitive solutions for aeronautical applications	Research & Innovation (RIA)	5
FCH-01-2-2017: Towards next generation of PEMFC: Non-PGM catalysts	Research & Innovation (RIA)	2.75
FCH-01-3-2017: Improvement of compressed storage systems in the perspective of high volume automotive application	Research & Innovation (RIA)	4
FCH-01-4-2017: Demonstration of FC material handling and industrial vehicles	Innovation (IA)	42.5
FCH-01-5-2017: Large scale demonstration in preparation for a wider roll-out of fuel cell bus fleets (FCB) including new cities – Phase two	Innovation (IA)	
FCH-01-6-2017: Large scale demonstration of Hydrogen Refuelling Stations and Fuel Cell Electric Vehicle (FCEV) road vehicles operated in fleet(s)	Innovation (IA)	
FCH-01-7-2017: Validation of Fuel Cell Trucks for the Collect of Urban Wastes	Innovation (IA)	
2. ENERGY PILLAR		

[23] 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.

[24] The 2017 Call for Proposals has a total indicative amount of EUR 116 M of which EUR 90.2 M from 2017 Commitment Appropriations for operations and EUR 25.8 M€ reactivated unused commitment appropriations from years 2016 and 2015 resulting mainly from the outcome of the Call 2016 evaluations (EUR 25.6 M and 2015 operations (EUR 0.2 M).

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

FCH-02-1-2017: Game changer Water Electrolysers	Research & Innovation (RIA)	2
FCH-02-2-2017: Game changer High Temperature Steam Electrolysers	Research & Innovation (RIA)	3
FCH-02-3-2017: Reversible Solid Oxide Electrolyser (rSOC) for resilient energy systems	Research & Innovation (RIA)	3
FCH-02-4-2017: Highly flexible electrolysers balancing the energy output inside the fence of a wind park	Innovation (IA)	5
FCH-02-5-2017: Demonstration of large electrolysers for bulk renewable hydrogen production	Innovation (IA)	10
FCH-02-6-2017: Liquid organic hydrogen carrier	Research & Innovation (RIA)	2.5
FCH-02-7-2017: Development of flexible large fuel cell power plants for grid support	Research & Innovation (RIA)	4
FCH-02-8-2017: Step-change in manufacturing of Fuel Cell Stack Components	Research & Innovation (RIA)	3
FCH-02-9-2017: Development of next-generation SOFC stack for small stationary applications	Research & Innovation (RIA)	3
FCH-02-10-2017: Transportable FC gensets for temporary power supply in urban applications	Innovation (IA)	12.5
FCH-02-11-2017: Validation and demonstration of commercial-scale fuel cell core systems within a power range of 10-100kW for selected markets/applications	Innovation (IA)	
FCH-02-12-2017: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas	Innovation (IA)	5
3. OVERARCHING – N/A		
4. CROSS-CUTTING		
FCH-04-1-2017: Limiting the impact of contaminants originating from the hydrogen supply chain	Research & Innovation (RIA)	6.25
FCH-04-2-2017: Harmonisation of hydrogen gas trailers	Coordination and Support Action (CSA)	
FCH-04-3-2017: European Higher Training Network in Fuel Cells	Coordination and	

and Hydrogen	Support Action (CSA)	
FCH-04-4-2017: PNR for a safe use of liquid hydrogen	Research & Innovation (RIA)	
FCH-04-5-2017: Definition of Accelerated Stress Testing (AST) protocols deduced from understanding of degradation mechanisms of aged stack components in Fuel Cell systems	Research & Innovation (RIA)	2.5
TOTAL		116

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 8 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 2017 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.

B. Collaboration with JRC – Rolling Plan 2017

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 FCH1 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 Horizon 2020 Rules for Participation is not possible. The scope of the Framework Contract therefore does not cover the JRC participation to FCH 2 JU funded projects, but 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 2017, a maximum budget of 1 million euros from the FCH2 JU operational budget is foreseen.

The JRC support activities to the FCH2JU programme covered by the Framework Contract are discussed and agreed on an annual basis between the JRC and the Program Office, with involvement of a representative of Hydrogen Europe and of N.ERGHY.

The annual **Rolling Plan 2017** (based on the already approved structure of the similar plan in 2016), constitutes part of this work-plan and it 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 which JRC performs without payment (heading A in Article 2) are not listed in this document.

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*".

The RCS SC group has elected a chair (from N.ERGHY) and met regularly in 2016. JRC has delivered the 2016 deliverables. In 2017 similar outputs is foreseen, JRC will support the group activities with related data mining and assessment[26]. If required by the chair, JRC will also deliver operative support to the functioning of group. 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:

B.1.1 Annual report on achievements and the evolution of the PNR-relevant activities of the multi-annual programme, including a ranking of PNR priorities. (April 2017)

B.1.2 Updated mapping of international and European standardisation activities. April 2017)

[26] Additional JRC contribution to the RCS SC group will depend on the detailed RCS group plan 2017, which is not yet available. Deliverables will be adapted according to the specific rolling agenda of the group.

B.1.3 Annual report on research priorities in hydrogen safety[27]. (November 2017)

B.2. JRC direct contribution to implementing RCS strategy

To provide inter-project comparable results and to facilitate assessment of technology progress without compromising on 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. The following deliverables are foreseen for 2017, as part of a multiannual plan:

B.2.1 Final report on harmonised testing hardware. (November 2017)

B.2.2 Final report on the harmonisation of testing protocols for stationary applications (this requires an agreement on initial operating conditions and stressor test matrix at the start of the year). (November 2017)

B.2.3 Final report on harmonised testing protocol for electrolysis applications (July 2017)

B2.4 Final report on the CFD benchmarking results including recommendations (pending successful testing phase) (November 2017)

B.3 JRC contribution to programme monitoring and assessment

Technology benchmarking by means of project data collection: Currently the internal existing database is populated by the PO and project participants. What is additionally needed is the comparison with international state of the art, so-called 'reference data'. In 2016 first priority sub-technologies were completed, second priority sub-technologies will be tacked in 2017[28]:

B.3.1 Provision of reference international technology data adapted to database needs and structure for the technologies not tackled in 2016 according to the agreed priority ranking. (October 2017)

B.3.2 Analysis and optimisation of the templates performance indicators for the above mentioned technologies (October 2017)

Additionally, FCH2 JU might require JRC to assist with the Programme Impact Assessment (e.g. TIM, EMM databases/apps developed by JRC in-house for all research family DGs of the EC).

Programme Annual Review Assessment PO has asked the JRC to support the design of an improved methodology and perform the full review cycle for the year 2017, including the final report. *(Note: this depends on the availability of additional manpower at JRC)*

B.3.5 Methodology for the PRD submitted for approval by PO (April 2017)

B.3.6 Draft report delivered for finalization by PO (December2017)

B.4 JRC contribution to safety dimension and safety awareness

In the frame of an improved FCH2 JU strategy on general safety aspects at program level, the Hydrogen Incidents and Accidents Database HIAD is collecting safety-related events from projects.

[27] The main outcome of the international Conference on Hydrogen Safety (ICHS17, 11-13 September 2017) will be among the sources for the 2017 report.

[28] More detailed plan for each of the sub-technology will be agreed with the Km of the PO. The final deadline of November relates to the requirement to be ready for the PRD 2017

HIAD is the optimal tool for a repository of safety information generated by the FCH2JU programme, including communication, lessons learned and safety improvement dimension. So far, few projects have already interfaced with HIAD, and the exercise has generated development needs. One of these is related to HIAD data input, implying a software update.

B.4.1. HIAD operation: HIAD population with the events delivered by projects and annual report (November 2017)
B.4.2. HIAD report: finalisation of the new database, including a new web-access for data retrieval. (July 2017)
B.4.3. As HIAD operator, contribution to the future Hydrogen Safety Panel, as a permanent panel of safety experts, for the evaluation and qualification of the events and conclusion in terms of lessons learned (continuous activity).

B.5 JRC support to FCH Smart Specialisation

In 2015, FCH2JU and JRC organized a workshop on Smart Specialisation on FCH Technologies. As a result of the workshop a need was perceived to continue this effort by the organization of subsequent workshops tailored to specific FCH applications. Two such applications have been identified (buses and back-up systems), but would need further check before proceeding in 2017, depending on the interest shown later by the different regions (see activity on MS and regions). The role of Directorate JRC-B in Seville is to assist FCH2JU in the implementation of the EU Smart Specialisation Strategy in regions who have identified FCH technologies as a priority, whereas Directorate JRC-C in Petten will provide scientific-technical input outlining the status and potential of relevant FCH technologies.

B.5.1 Support to two workshops to be organized in 2017 (the extent and the type of the support can only be defined later).

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

This 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.

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

Deliverable number	Deliverable title	Effort [PM]	Indicative Costs [kEUR]
B.1	**Support to formulation and implementation of RCS strategy**	19	219.5
B.2	**Direct contribution to implementing RCS strategy**	30	317.5
B.3	**Contribution to programme monitoring and assessment**	23	170.6
B.4	**Support to safety aspects**	14	132.1

B.5	**Support to Smart Specialisation**	2	14.5
B.6	**Testing in support to specific activities of the FCH2JU programme**	TBD	
	Manpower Totals [PM]	**88**	**854.2**
			Overview indicative costs [kEUR]
	Manpower		**854.2**
	Missions		**20.0**
	Consumables		**12.5**
	Subcontract (B.3 and B.4)		**70**
	Total cost for 2017		**956.7**
	Max amount per year		*1000*

Costs includes overhead costs = 25%

JRC will meet and report on a permanent basis (every month) with the Programme Office, with clear progress reporting every three months.

C. RCS Strategy Coordination (RCS SC) Group

Nowadays, 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 barrier for the commercialization of FCH products, and the implementation of an RCS Strategy is crucial for the market deployment of FCH systems.

The overall goal of 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 the deployment of the 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 European and international 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 Cross-cutting 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. Composed of Hydrogen Europe and N.ERGHY representatives together with the support of the Programme Office (PO), the RCS SC Group will follow-up on the strategy in consultation with all European stakeholders and will take the necessary actions to implement it in line with the requirements of the European Standardization Regulation[29]. As an important first step, over 2016 the RCS SC Group has identified and prioritised the main RCS needs of strategic importance for EU and based on them, has provided recommendations of concrete topics to be incorporated in the next call of proposals. During 2017 the RCS SC Group will coordinate the following FCH 2 JU activities:

- Follow RCS developments, and update and prioritize RCS needs of the sector through a continuous global watch function; interface with regulatory bodies (EC and UN), and international organizations for standardization (ISO IEC and CEN/CENELEC30) for development/amendment of international standards and regulations; and coordinate the attendance of European representatives in the relevant standardisation and Regulatory Bodies.
- 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; A mechanism to liaise with the H2 safety Panel (see below) should be envisaged.
- Collect and evaluate RCS-relevant information from demonstration projects; monitor PNR activities.
- Maintain, consolidate and disseminate results of RCS and PNR activities (targeted communication actions, awareness workshops, development of training content, etc.).

These RCS and PNR identified priorities will serve as basis for new topics to be proposed in the next Annual Working Plans (AWPs).

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[29] REGULATION (EU) No 1025/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on European standardisation

[30] ISO, International Standardization Organization; IEC, International Electrochemical Commission; CEN/CENELEC, European Committee for Standardization, European Committee for Electrotechnical Standardization.

As part of the JRC support activities (see point above - Collaboration with JRC – Rolling Plan 2017), JRC will assist the RCS Group and the PO in their activities.

D. H2 Safety Panel

The International Association for Hydrogen Safety (HySafe) was founded in 2009 by the members of the corresponding precursor, the EC Network of Excellence (NoE) HySafe, which was one of the first IPHE acknowledged projects. HySafe is an international non-profit organisation residing in Brussels. With more than 30 members from industry, research organizations and universities representing 14 countries worldwide, this international association continues the activities of the European NoE in supporting the safe introduction of hydrogen as energy carrier. By providing unique opportunities for information exchange and research coordination for its members from research institutions, academia and industry and for all other stakeholders, it represents the international focal point on hydrogen safety.

HySafe has a unique structure that includes a research committee attending to the state-of-the-art research in hydrogen safety, an industry relations committee attending to the needs of industrial stakeholders both in hydrogen safety and standardization, an education, public relations and knowledge dissemination committee attending to outreach and educational and training needs of various stakeholders, and a conference committee that leads the scientific organization of the worldwide unique International Conference on Hydrogen Safety (ICHS).

The above activities follow the emphasis of Horizon 2020 in the sense that international cooperation is essential for fundamental research in order to capture the benefits from emerging science and technology opportunities (COM(2011)808). With regards to standards development and safety, the proposal for Horizon 2020 noted that activities in support of standardisation and interoperability, safety and pre-regulatory activities will be promoted (COM(2011)809). On the other hand, the Impact Assessment for setting up FCH2 JU under Horizon 2020 explicitly includes Regulations, Codes and Standards, including safety standards and norms under the cross-cutting activities (SWD(2013)260).

In view of the above, HySafe will provide proactive support on safety-related issues to FCH2 JU, contributing to the safe realization of its objectives, as set out in the MAWP. In this regard, HySafe, supported by JRC and reporting to the Programme Office (PO), will set up and coordinate a FCH2 JU Hydrogen Safety Panel (HSP). The envisaged HSP will assist the FCH2 JU at both programme and project level in assuring hydrogen safety is adequately handled. The HSP will mainly provide to the PO a unique, practical and direct access to an objective: state-of-the-art expert judgment for all issues regarding hydrogen safety.

It is anticipated that the IPHE and US DoE will support a cooperation of the safety panels to further an even more consistent, European and worldwide harmonized approach to hydrogen safety and an improved education, training and public outreach. Similar to the activities of the well-established US Safety Panel (see https://www.hydrogen.energy.gov/pdfs/review16/scs019_barilo_2016_o.pdf for reference), one of the objectives of the HSP is to coordinate a package of measures to avoid any accident by integrating safety learnings, expertise and planning into FCH2 JU funded projects, by ensuring that all projects address and incorporate the state-of-the-art in hydrogen safety appropriately.

Besides answering urgent questions related to hydrogen safety in an independent, coordinated and consolidated way, the HSP activities could include the offer of basic short introductions to hydrogen safety (H_2 safety 101), review of safety plans, laboratory visits to conduct site inspections and safety assessments and monitoring the appropriate safety performance of all relevant publicly co-funded projects.

One of the tasks foreseen for the HSP is related to 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 HSP will interpret these data together with the involved parties, derive lessons learned and provide further general recommendations to all stakeholders. A quality control mechanism will be developed to ensure the needed data quality. This will include expanded collaboration with similar activities of the US DoE and EIGA in terms of entry of new events. The benefit for the FCH2 JU is that HIAD will assist with identifying safety-related gaps, best practices and lessons learned.

Regarding public outreach and framed within the context of the intended broad information exchange, the FCH2 JU HSP will offer a newsletter and a regularly updated website, containing the lessons learned and links to other important safety related information. As an additional value proposition, the HSP may contribute to the development of a comprehensive outreach, education and training programme for the safety component of FCH2 JU projects to ensure complete and effective information dissemination from all FCH2 JU demonstration projects.

In conclusion, the proactive safety management support envisaged from Hysafe and articulated through the FCH2 JU HSP will contribute to improve the efficiency of utilization of limited funding dedicated to the FCH2 JU cross-cutting activities, and the accomplishment of its objectives.

E. 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. It is described in the communication entitled "Enhancing and focusing EU international cooperation in research and innovation: a strategic approach"[31]. Following this principle, in order to align with, facilitate and accelerate world-wide market introduction of fuel cell and hydrogen technologies the FCH 2 JU will identify priority areas, at the policy and technology level, for coordinated and collaborative international activities.

As the deployment of fuel cells and hydrogen technology is carried out globally and key partners of the FCH 2 JU are involved in these developments, it is envisaged that close links will be established with the major deployment programmes globally, to harmonize standards and regulations as well as to accelerate the market preparation.

Among the relevant international activities those developed by the International Energy Agency (IEA) under the Hydrogen Implementing Agreement and Advanced Fuel Cell Implementing Agreement and by the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), are those where relevant objectives and targets have already been set. In particular, FCH 2 JU will collaborate closely with the EC representatives in the steering committee of the Hydrogen Implementing Agreement in order to optimize and share the effort and participation. In that case, FCH 2 JU could provide expertise to scientific, technical, and strategic tasks of the Hydrogen Implementing Agreement in alignment with Member State representatives and FCH 2 JU funded projects could be involved in and contribute to its different Tasks. As for the Advanced Fuel Cell Implementing Agreement, participation and follow-up should be better explored with EC. Fuel Cells and Hydrogen outreach will be a specific target for FCH 2 JU participation in any international agreement, such as IPHE (International Partnership for the Hydrogen Economy).

Contacts will also be maintained and further expanded where appropriate with non-EU and Associated Country (AC) states that have significant and sustained involvement in the development and deployment of FCH technologies, namely Japan, Korea, Canada, South-Africa, China, India and the USA or through the International Partnership for Hydrogen into the Economy (IPHE). Of special interest in this context are regulatory and policy frameworks, socio-economic and environmental assessments, LCA, RCS, safety, development of common methodologies for monitoring large-scale demonstrations and alternative technical solutions and/or options considered for hydrogen purity, hydrogen cooling and hydrogen dispensing measurement.

For the following topics the consortia are highly encouraged to collaborate with entities from countries members of the International Partnership for Hydrogen into the Economy (IPHE):

- FCH-01-2-2017 : Towards next generation of PEMFC: Non-PGM catalysts
- FCH-02-4-2017: Highly flexible electrolysers balancing the energy output inside the fence of a wind park
- FCH-02-6-2017: Liquid organic hydrogen carrier

[31] COM(2012)497

- FCH-02-12-2017: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas
- FCH-04-1-2017: Limiting the impact of contaminants originating from the hydrogen supply chain
- FCH-04-3-2017: European Higher Training Network in Fuel Cells and Hydrogen
- FCH-04-4-2017: PNR for a safe use of liquid hydrogen
- FCH-04-5-2017: Definition of Accelerated Stress Testing (AST) protocols deduced from understanding of degradation mechanisms of aged stack components in Fuel Cell systems

F. Public Procurements/Studies

In 2017, the FCH 2 Joint Undertaking will carry out a number of activities via calls for tenders (i.e. public procurement) for an indicative amount of **EUR 3 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 Commission participation. The following indicative list of procurements is currently foreseen:

Subject (Indicative title)	Indicative budget (EUR)	Expected type of procedure	Schedule Indicative
Hydrogen Refueling Stations (HRS) Operational Status System for FCEV users	400,000.00	Open procedure	Q2
Provision of services towards the implementation of a robust and widely accepted Guarantees of Origin scheme in Europe	700,000.00	Open procedure	Q1
Study on value chain and manufacturing competitiveness analysis for hydrogen and fuel cell technologies	200,000.00	Open procedure	Q2
Hydrogen Regions/cities Initiative coordination, including business cases, roadmaps, financing and awareness	1,300,000.00	Open procedure	Q1
Certification & implementation in National and EU regulation of H2 quantity measuring device	400,000.00	Open procedure	Q2

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

G. Dissemination and information about projects results. Knowledge management

Knowledge management activities will continue in terms of collection of data from completed and ongoing projects with the aim of obtaining a comprehensive view of the progress achieved within the financed activities vis-a-vis the state-of-the art and the Work Plans' targets (annual and multi-annual). The findings will be made publicly available either in terms of aggregated values (for confidential data) and specific results (for non-sensitive information).

In practice, a systematic campaign of data collection will be organised in spring 2017, whereby all projects running in 2016 will be asked to report on their results during this calendar year. Projects will be asked to report on several parameters (the template questionnaires can be consulted online (http://www.fch.europa.eu/projects/knowledge-management) related to their FCH JU-funded activities and assign for each a public or confidential status. The data reported will be analysed by the FCH2 JU and, whenever possible within the respect of confidentiality, made public, namely in comparison with the MAWP targets and the state of the art.

In parallel, a systematic collection of data from press articles concerning plans, targets, deployments and other results in the fields of hydrogen and fuel cells will be performed. This is intended to gather an overall view of the market trends, prospects advances. Moreover, the state of the art of the various technologies will be further fine-tuned in collaboration with the JRC (see chapter on JRC support).

The FCH 2 JU website is going to be complemented with a systematic input of data from the projects (co)financed by the JU, both under FP7 and Horizon 2020. Output from all projects, such as publications, patents and immaterial deliverables (reports, studies, websites, etc.), will be made available from the website (either through uploaded documents or links to relevant websites) in all cases where this is in line with the relevant confidentiality and public access settings.

Information on the Horizon 2020 projects will be added progressively to the website as soon as the new grant agreements are signed. News will be published concerning the start of new grants and ongoing project achievements. Interested readers have now (since 2016) the possibility to subscribe to related notifications.

In addition, ad hoc reports for stakeholders will be produced on an as-need basis and figures will be produced for various presentations and other FCH JU literature.

Continuing on the good experience and practice so far, the 7th annual Programme Review Days will be organised in autumn 2017 (see further details on JRC support and Communication activities).

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 2016– 2017[32] (with the exceptions introduced in this work plan, see below).

3.3.1. List of countries eligible for funding

Part A of the General Annexes to the Horizon 2020 Work Programme 2016–2017 applies mutatis mutandis.

3.3.2. Standard admissibility conditions and related requirements

Part B of the General Annexes to the Horizon 2020 Work Programme 2016–2017 applies mutatis mutandis.

3.3.3. Standard eligibility conditions

Part C of the General Annexes to the Horizon 2020 Work Programme 2016–2017 applies mutatis mutandis.

The following **exceptions** apply regarding additional conditions for participation:

1) According to Article 9(5) of Regulation (EU) No 1290/2013 the annual work plan where appropriate and duly justified, may provide for additional conditions according to specific policy requirements or to the nature and objectives of the action, including inter alia conditions regarding the number of participants, the type of participant and the place of establishment.

2) It is imperative that key innovation actions of strategic importance, which accelerate the commercialisation of fuel cell and hydrogen technologies and thereby achieve the principal objective of the FCH 2 JU partnership, are closely linked to the FCH 2 JU constituency in order to ensure full alignment with the FCH 2 JU strategic agenda (MAWP) and to ensure the continuity of the work performed within projects funded through the FCH 2 JU under FP7, by building up on their experience.

3) In this context it is also crucial to secure that relevant project results are exploited fully in line with the commercialization needs of the European industry with maximised cross-fertilisation of knowledge within the whole sector, which can be greatly facilitated by the presence of Hydrogen Europe or N.ERGHY members[33] in these consortia.

4) Strengthened exchange of information between the sector players (through presence of members) will help avoid duplication of effort with other activities performed outside the FCH 2 JU and contribute to a maximum coherence of the overall European technology investment and a maximum impact of the EU funding.

5) For some, well-identified topics it is therefore duly justified to require as an additional condition for participation that at least one constituent entity of the Industry Grouping or Research Grouping is among the participants in the consortium. These topics should relate to topics of

[32] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016-2017/annexes/h2020-wp1617-annex-ga_en.pdf

[33] For clarity purposes, both Industry Grouping and Hydrogen Europe on one hand, and Research Grouping and N.ERGHY on the other are used in the text indistinctively.

strategic importance of horizontal nature: large demonstration projects or specific projects of key significance for the FCH sector from energy and transport pillars

6) It is necessary to identify those large demonstration and overarching projects and specific projects of key significance and for the latter to justify their significance for the FCH sector as follows:

FCH-02-5-2017: Demonstration of large electrolysers for bulk renewable hydrogen production

The proposed project is upscaling the technology with respect to previously funded initiatives. The level of bulk renewable hydrogen production will be at a scale where the application must be identified and secured since the beginning of the project.

The participation of **at least one member from Hydrogen Europe or N.ERGHY** will allow on one side the continuity and complementarity with already funded initiatives, on the other a strong link with the Multi-annual strategy of FCH 2 JU, looking to the roll-out of technologies in the short term. This specific topic will develop a technology not limited to an industrial plant, but in connection to a wider Urban/Regional system where hydrogen could find exploitable ways. In such way, the FCH 2 JU is developing a programme to reach out all those EU regions/cities having an interest in the potential use of fuel cell and hydrogen (FCH) based products to help them achieve their decarbonisation goals. Having this and other specific initiatives on the background, the specific project will have a stronger motivation and opportunity to develop, not only on the technical and economic, but even on political, social and environmental aspects.

FCH-02-8-2017: Step-change in manufacturing of Fuel Cell Stack Components

This topic is strategic for the reduction of FC core technology cost and for a further enhancement of stationary FC performance. Results from projects that successfully address the challenges will provide a significant step forward towards the achievement of MAWP objectives as well to strengthen the competitiveness of the European stakeholders. The involvement of **at least one member of Hydrogen Europe or N.ERGHY** guarantees a long term vision and a commitment that those objectives will be taken into account with the right attention.

FCH-02-9-2017: Development of next-generation SOFC stack for small stationary applications

This topic is strategic for the further enhancement of SOFC performance. Results from projects that successfully address the challenges will provide a significant step forward towards the achievement of MAWP objectives as well to strengthen the competitiveness of the European stakeholders. Since in ceramic technology it is difficult to distinguish product development from manufacturing process development the involvement of **at least one member of Hydrogen Europe or N.ERGHY** guarantees a long term vision and a commitment that those objectives will be taken into account with the right attention.

The following **exceptions** apply regarding the maximum JU contribution requested:

For all Innovation Activities, an additional eligibility criterion has been introduced to limit the FCH 2 JU requested contribution, as follows:

FCH-01-4-2017: Demonstration of FC material handling and industrial vehicles

The maximum FCH 2 JU contribution that may be requested is EUR 7.5 million per project. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-01-5-2017: Large scale demonstration in preparation for a wider roll-out of fuel cell bus fleets (FCB) including new cities – Phase two

The maximum FCH 2 JU contribution that may be requested is EUR 25 million per project. This is an eligibility criterion – proposals requesting FCH 2 JU contribution above this amount will not be evaluated.

FCH-01-6-2017: Large scale demonstration of Hydrogen Refuelling Stations and Fuel Cell Electric Vehicle (FCEV) road vehicles operated in fleet(s)

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

FCH-01-7-2017: Validation of Fuel Cell Trucks for the Collect of Urban Wastes

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

FCH-02-4-2017: Highly flexible electrolysers balancing the energy output inside the fence of a wind park

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

FCH-02-5-2017: Demonstration of large electrolysers for bulk renewable hydrogen production

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

FCH-02-10-2017: Transportable FC gensets for temporary power supply in urban applications

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

FCH-02-11-2017: Validation and demonstration of commercial-scale fuel cell core systems within a power range of 10-100kW for selected markets/applications

The maximum FCH 2 JU contribution that may be requested is EUR 7.5 million per project. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

FCH-02-12-2017: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas

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

3.3.4. Types of action: specific provisions and funding rates

Part D of the General Annexes to the Horizon 2020 Work Programme 2016–2017 applies mutatis mutandis.

3.3.5. Technology readiness levels (TRL)

Part G of the General Annexes to the Horizon 2020 Work Programme 2016–2017 applies mutatis mutandis.

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)[34] requirements have been also introduced.

3.3.6. Evaluation rules

Part H of the General Annexes to the Horizon 2020 Work Programme 2016–2017 applies mutatis mutandis[35].

3.3.7. Budget flexibility

Part I of the General Annexes to the Horizon 2020 Work Programme 2016–2017 applies mutatis mutandis.

3.3.8. Conditions related to open access to research data

Part L of the General Annexes to the Horizon 2020 Work Programme 2016–2017 applies mutatis mutandis.

There is no derogation from the H2020 Rules for Participation.

[34] 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

[35] 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 FCH2 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 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 be the core of the FCH2 JU Communication activities in 2017.

A detailed Communication plan will be developed early 2017 in collaboration with the FCH2 JU member's representatives.

B. 2017 Communication actions

Dissemination activities will continue to be organised following a "one voice" approach. Key actions will concern, amongst others, the following themes:

New information material

Print & Digital

Significant information material has been generated in 2016, allowing for the FCH 2 JU to optimise its visibility through innovative and up-to-date data. Following this first phase production, activities in 2017 will aim at disseminating further this information but also at producing new detailed communication material (technology-oriented, per pillar, success stories, policies...). Thanks to the new format of materials, it will be feasible to put even more emphasis on the "Energy Union" concept and how FCH technologies have the potential to address its different dimensions.

Media

Setting-up a new interactive media-library system is also part of the priority actions. This aims at gathering a pool of latest projects' media information and allowing the FCH JU to better exploit fresh visual material.

New video will be produced to further feed the FCH JU U-tube channel and present the organisation as well as its activities in a dynamic and interactive way. The FCH JU will launch a procurement procedure for a framework contract related to video-services.

Success Stories

Additional success stories will be produced and existing ones will be further disseminated. In addition, tailoring them to different audiences, messages and formats will be one of the core tasks of 2017 activities.

Website & Monthly Newsletter

News publications will keep the new rhythm initiated in 2016 in order to increase visibility on the FCH JU projects developments

New specific pages will also be developed with the purpose of providing specific facts and figures, highlighting detailed advantages of the technology in various ways.

The website will be better harmonized with FCH2 JU members (EC and private members).

Leveraging channels

The FCH 2 JU will further develop its existing channels for a better reach-out and efficient dissemination. Acknowledging the specific impact of social media and how it allows for efficient synergies with communication partners, communication activities will optimise usage of social media to stimulate public interaction on key issues. Additional synergies with EU institutional partners is also foreseen in this area to allow for a strategic reach-out at key moments (promoting the Stakeholder Forum,..)

Media Relations and Activities Monitoring

A new Framework contract will be in place, focusing on media relations. Resourcing to this new instrument will help reinforcing the FCH2 JU media network of press and media contacts.

In addition, specific tools will be developed to assess more efficiently the impact of communication activities.

C. Reaching-out

EU institutional arena

It is important to keep MEPs informed about the FCH JU activities and projects' developments. The FCH JU will continue therefore to proactively meet with MEPs to keep them informed on the benefits and advancements of four core activities.

Likewise, the FCH JU will make additional efforts to raise its profile within the more relevant DGs in the European Commission, explaining the added value of the Programme and the technologies it is supporting.

Member States

Through the States Representative Group, the FCH JU will work to identify additional sources of funding already in place in individual countries for the potential implementation of projects in Member States. Depending on the identified schemes and the nature of projects envisaged, bilateral discussions may ensue between the FCH JU Programme Office and national agencies to find the specific ways in which these synergies can be utilised more effectively.

Regions

Following the signing ceremony of 23 November 2016 held in Brussels in which more than 30 regions and cities stated their keen interest to participate in an initiative launched by the FCH JU to explore markets for hydrogen and fuel cell products, local actors will become a key focal point during 2017.

It is expected that the study involving regions and cities will commence in early 2017 and carry on throughout the year. These activities will involve a close cooperation between these local authorities, industrial partners and related national associations, identifying those products that are in highest demand, developing their related business cases and finding ways to implement their commercialisation, including funding and financing tools. Therefore, the level of outreach from the FCH JU to this set of stakeholders will be much increased during 2017.

Two Smart Specialisation workshops will be organised with support of JRC (see related chapter).

New audiences

New audiences (refer for example to energy and transport associations; NGOs; utilities,..) remain a priority target in order to raise the awareness about the technology's potential and help accelerating its market entry. Activities in 2016 allowed for a better reach-out to these publics (EUSEW; SF) and the purpose for 2017 will be to build on these primary efforts to reinforce links and collaborations. Activities and events will be selected accordingly.

C. Events and communication activities

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 2017, the FCH 2 JU will develop a communication plan including a detailed event list.

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.

Next to the several activities, the FCH JU will identify 2 main events (Energy + Transport) that will justify for specific resources optimisation. The FCH JU will closely work with projects' communication and dissemination teams for these 2 events.

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

1) Hannover Messe 2017

2) European Sustainable Energy Week

The FCH 2 JU will pursue its fruitful collaboration with the EUSEW and aims at participating to the 2017 edition programme as well as contributing to parallel activities (online contest,...)

FCH 2 JU Stakeholder Forum (SF)

The 2016 edition initiated a first revamp of the conference's DNA by allowing external audiences to take part in the programme. The concept and organisation of the Stakeholder Forum for coming editions will reinforce this new aspect in order to reshape the event as a general conference on sustainable issues rather than a specific event. 2017 will welcome the 10^{th} edition of the Stakeholder Forum and will therefore allocate specific resources in order to deliver a different and memorable quality event. If the event is to be hold in a private venue, the location will be selected following procurement

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, 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.

In the 2017 edition, the seventh edition of the PRD will be organized in Q4.

For further information about projects results' dissemination, please refer to part "3.2 "Operations – sub-title "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. To make tender 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 2017 the procurement activity will be centred on the following domains:

- Join new interinstitutional procurement procedures planned among others in the field of IT;
- Launch procurement procedures in the field of communication activities (a list for FCH 2 JU launched procedures is provided in the table below);
- Financial and administrative management of procurements;
- Internal monitoring through ABAC assets system;

The table below provides a summary of the tenders planned for 2017 under administrative budget (excluding the inter-institutional tenders where FCH 2 JU merely joins the process) and the related procurement procedure expected to be used on the basis of the information currently available which may be subject to modifications.

Subject	**Indicative budget (EUR)**	**Expected type of procedure**	**Schedule** *Indicative*
Video services, animation material	134,000	Negotiated procedure for middle-value contracts	Q1
Design and writing services, proof-reading	134,000	Negotiated procedure for middle-value contracts	Q2
Venue rental for PRD/SF 2017	134,000	Negotiated procedure for middle-value contracts	Q2

IT and logistics

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 2017 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 2017:

- Further to the preparation in 2016 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;
- Implementation of the infrastructure-as-a-service (IaaS) solution for the replacement of the equipment of the JUs common IT infrastructure;
- 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).

2) Information systems for operational and administrative activities:

- Further enhancement of tools for reporting and monitoring of projects results
- Deployment of ABAC Assets to manage the complete lifecycle of the goods and services and to facilitate the inventory management.

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.

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 2017 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 in line with the new organisational structure; provide the Management team with quarterly status report;
- Revise HR policies and procedures to align them to the new legal environment, in particular to the new implementing rules on engagement of TAs, learning and development; prevention of harassment
- Follow-up on the implementing rules of the revised staff regulations which cannot be adopted by analogy in liaison with the Standing Working Group of agencies and the Commission (DG HR), such as: middle management, learning and development, role of adviser; engagement of CAs 3a
- Launch and follow-up the selection procedure for Seconded national experts (SNEs);
- 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 2017 activities will focus on the following:

- Preparation of 2018 budget in liaison with Commission services;
- Ensure efficient budget forecast and monitoring through optimal use of tools and close follow-up with operational initiators;
- Produce regular reports and advise on budgetary and procedural issues;
- Ensure transactions are financially and procedurally correct, that is , in conformity with the contracts and grants and respecting the Financial Regulations and other relevant rules in operations;
- In liaison with the Operations and Communication Unit, closely monitor projects' implementation to ensure that deadlines are respected;

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, "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".

In 2017 the following actions will be taken:

- Preparation of the data protection framework in view of the entering into force of the General Data Protection Regulation in 2018.
- Continuation of the awareness raising for staff in internal meetings with regard to their own rights and also in relation to the implementation of the accountability principle as requested by the European Data Protection Supervisor (EDPS), in order to effectively respect the fundamental right to data protection of both staff and citizens;
- General and ad-hoc advice to the controller in fulfilling its obligation;
- Giving support to the preparation of notifications and preparation of privacy statements for the information to be supplied to data subjects
- Participate in the data protection working groups of the EU institutions and bodies for the preparation of the necessary documentation relating to data protection in the framework of Horizon2020, and, where necessary, further customise it for the FCH 2 JU specificities.

Ensure follow-up with guidelines provided by the EDPS, CJEU decisions impacting the field of data protection in the context of FCH 2 JU's activities.

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 (N.ERGHY). The GB is planning to hold three meetings during 2017.

The key decisions of the GB in the year 2017 are listed below:

Key decisions in 2017 – timetable	
Appoint or renew members of the FCH 2 JU Scientific Committee	Q2
Approve the lists of proposals to be selected for funding	Q3
Adopt the AAR 2016 and its assessment by the GB	Q2
Adopt an opinion on the Final Accounts 2016	Q2
Adopt the revised MAWP 2014-2020	Q4
Adopt the 2018 AWP & Budget/SEP	Q4
Approve the 2018 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 two meetings in 2017, in Q2 (tentatively around May) and Q4 (in November around the Stakeholder Forum).

There are no major changes or decisions foreseen for 2017. Issues that are likely to be covered include: (i) Input to AWP2018 and (ii) Status of national plans and activities on hydrogen and fuel cells, potentially including the follow-up to responses to the Alternative Fuel Infrastructure Directive.

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 world-wide recognized expertise from academia, industry and regulatory bodies. The SC role is to provide (a) advises on scientific priorities to be addressed in the annual work plans; (b) advises on scientific achievements described in the Annual Activity Report (c) input for the Programme Review Days. 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 2017. The mandate of 8 out of 9 of its members expires in June 2017 and may be renewed by the FCH 2 JU Governing Board or new appointments made. The tasks of the Scientific Committee in relation to the Programme Review Days will be clarified and revised.

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 10th edition of the SF will take place in Q4 2017 (see also communication section).

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.

In 2017 focus will be put on the following:

- Further to the risk management exercise carried out in October 2016 ensure a specific follow up of the actions to manage the main risks identified;
- Following the approval of the updated Internal Control Standards (ICS), monitor on requirements and timely implementation of the action plans;
- Carry out the annual assessment on the level of implementation of Internal Control Standards;

Ex-ante and ex-post controls

Ex-ante 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 and Article 18 of FCH 2 JU Financial Rules "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 of invoices and cost claims for administrative expenditure, 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 2017, 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;

Ex-post controls

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 will be performed by the CAS in close cooperation with the FCH 2 JU, except for implementation which remains fully with the FCH 2 JU.

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In 2017 focus will be put on the following:

- Launch of a new batch of financial audits of FCH-FP7 grants
- Liaise with CSC on the recent developments of the methodology for the H2020 (audit strategy, audit programmes, JUs' sampling methodology etc.) to ensure the smooth transition between FP7 and H2020 programme taking into account the specificities of the FCH 2 JU;
- Contribute, in cooperation with the Common Audit Service (i.e. CAS), to the successful implementation of H2020 working arrangements for the effective management of H2020 ex-post audits;
- In cooperation with CAS, and in line with H2020 Working Arrangements, ensure launching and monitoring on timely completion of first H2020 audits for FCH 2 JU as part of H2020 audit strategy

Anti-fraud strategy

FCH 2 JU implements the common Research Anti-Fraud Strategy adopted in July 2012, and updated in March 2015. It includes an action plan which implementation is monitored through regular meetings of the Fraud and irregularity Committee (FAIR).

In 2017 FCH 2 JU will continue to apply preventive measures for fraud detection, participate to FAIR meetings organized by DG RTD and adopt guidelines for whistleblowers.

Audits

IAS audits

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

In 2017 focus will be put on the following:

- Follow up on the action plan regarding IAS audit from 2016 on Performance Management of the FCH 2 JU (Final Audit Report communicated by the IAS in November 2016).

- Coordination of a new internal audit to be launched by the IAS as per the strategic internal audit plan for 2015 – 2017 (most likely topic for 2017: Coordination with CSC and implementation of CSC tools & services)

ECA audits

In 2017, the FCH JU will:

- Liaise with, an independent auditor (PKF LJ contracted based on the results of the procurement procedure in 2016) 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.

4. BUDGET YEAR 2017

4.1. Budget information

The draft budget 2017 is in line with the preliminary budget presented in the Fiche Financière and with the draft budget sent to GB members on 22 February 2016 except for the following two elements:

1) Due to the impact from the adjustment of the EFTA contribution from 2.73 % (initial assumption in the Fiche Financière) to 2.44 % (final EFTA rate for 2017), there is a total reduction of:
   i) EUR 267,093 in commitment appropriations (EUR 266,772 for operational expenditure and EUR 321 for administrative expenditure) and
   ii) EUR 404,634 in payment appropriations for operational expenditure of H2020 and EUR 321 in payment appropriations for administrative expenditure.

2) Reactivation of EUR 25,861,251 of unused commitment appropriations from operations from year 2016, resulting mainly from the outcome of the call 2016 evaluations (EUR 25,682,353), from unused appropriations of call 2015 (EUR 12,013) and from unused appropriations of studies included in AWP 2015 (EUR 166,885). These appropriations will be used for 2017 operational activities.

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 2015 CA (executed)	Budget 2015 PA (executed)	Budget 2016 CA	Budget 2016 PA	Budget 2017 CA	Budget 2017 PA	Remarks
2001	***European Commission subsidy for operational expenditure (FP 7)***		34,672,477		46,206,111		32,178,026	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***	2,293,402	2,292,250	739,988	739,988	1,801,377	1,801,377	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***	2,588,692	2,587,701	2,602,321	2,602,321	2,058,391	2,058,391	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***	429,847	429,685	432,163	432,163	342,877	342,877	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)***	112,322,123	29,915,275	104,955,460	48,358,358	94,234,786	142,933,563	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***	1,001,565	1,001,565	0	0			Interest, income from liquidated damages & others
	sub total title revenues	118,635,629	70,898,954	108,729,931	98,338,941	98,437,431	179,314,234	
3006	***C2 reactivation of appropriations for administrative expenditure (2014)***		861,996					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)***	13,948,227	23,328,170	1,491,547	1,491,547			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	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
	sub total reactivation	13,948,227	24,190,167	18,552,979	16,717,098	26,773,694	912,443	
	TOTAL REVENUES	**132,583,855**	**95,089,121**	**127,282,909**	**115,056,038**	**125,211,125**	**180,226,677**	

The FCH 2 JU 2017 budget amounts to a total of EUR 125,211,125 in CA and EUR 180,226,677 in PA with the following breakdown:

Title Chapter Article Item	Heading	Executed 2015		Financial year 2016		Financial year 2017		*Ratio 2015/2017*	*Ratio 2015/2017*	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	2,596,036	2,521,057	3,071,808	3,032,773	3,087,600	3,087,600	84%	82%	Salaries for temporary staff and contract agents and allowances, social contributions and annual travel costs
1 2	EXPENDITURE RELATED TO RECRUITMENT	39,745	34,491	47,254	20,000	115,294	115,294	34%	30%	Miscellaneous expenditure on staff recruitment: installation and travel expenses
1 3	MISSION AND TRAVEL	120,000	100,276	154,518	134,912	135,000	135,000	89%	74%	Mission expenses
1 4	SOCIOMEDICAL INFRASTRUCTURE	18,780	11,186	60,614	55,864	39,000	39,000	48%	29%	Training, medical service and mobility costs
1 7	ENTERTAINMENT AND REPRESENTATION EXPENSES	5,200	2,779	7,723	5,400	5,600	5,600	93%	50%	Representation and receptions
	TOTAL TITLE 1	**2,779,761**	**2,669,789**	**3,248,949**	**3,341,917**	**3,382,494**	**3,382,494**	**82%**	**79%**	
2	**INFRASTRUCTURE**									
2 0	INVESTMENTS IN IMMOVABLE PROPERTY RENTAL OF BUILDINGS AND ASSOCIATED COST	355,714	316,297	333,400	318,400	339,000	339,000	105%	93%	Rent, works, insurance, common charges (water/gas/electricity), maintenance, security and surveillance
2 1	INFORMATION TECHNOLOGY	169,710	67,436	346,749	181,660	223,100	223,100	76%	30%	IT purchases, software licences, software development
2 2	MOVABLE PROPERTY AND ASSOCIATED COSTS	7,223	2,249	10,221	10,368	10,023	10,023	72%	22%	Purchases and rental of office equipment, maintenance and repair
2 3	CURRENT ADMINISTRATIVE EXPENDITURE	6,324	4,408	18,509	40,589	11,471	11,471	55%	38%	Office supplies, library, translation service, bank charges and miscellaneous office expenditure
2 4	CORRESPONDENCE, POSTAGE AND TELECOMMUNICATIONS	10,800	1,884	19,120	16,500	15,000	15,000	72%	13%	Telephones, video conferences and postal services
2 5	EXPENDITURE ON FORMAL AND OTHER MEETINGS	43,173	33,701	70,031	63,240	47,000	47,000	92%	72%	Official meetings such as SRG, Scientific Committee, Governing Board
2 6	COMMUNICATION COSTS	342,514	230,455	503,124	400,000	345,000	345,000	99%	67%	External communication and events
2 7	SERVICE CONTRACTS	360,039	190,452	646,361	545,000	269,000	269,000	134%	71%	Studies and audits
2 8	EXPERT CONTRACTS AND MEETINGS	376,314	262,528	571,015	441,312	473,000	473,000	80%	56%	Costs related to expert contracts (evaluations, mid-term reviews)
	TOTAL TITLE 2	**1,671,810**	**1,109,411**	**2,017,069**	**2,518,530**	**1,732,594**	**1,732,594**	**96%**	**64%**	
	TOTAL TITLE 1+2 (ADMINISTRATIVE EXPENDITURE)	**4,451,571**	**3,779,200**	**5,266,018**	**5,860,447**	**5,115,088**	**5,115,088**	**87%**	**74%**	
3	**OPERATIONAL EXPENDITURE**									
3 0 0 1	Implementing the research agenda of FCH JU: FP7	21,895	44,644,225	1,742,791	60,558,091		32,178,026		42%	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	111,316,764	29,636,133	120,274,101	48,637,500	120,096,037	142,933,563	93%	21%	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)	**111,338,659**	**74,280,358**	**122,016,891**	**109,195,591**	**120,096,037**	**175,111,589**	**93%**	**42%**	
	TOTAL EXPENDITURE	**115,790,230**	**78,059,558**	**127,282,909**	**115,056,038**	**125,211,125**	**180,226,677**	**92%**	**43%**	

Overall the administrative budget (Titles 1 and 2) is decreased by 2.9% (- EUR 150,930) compared to 2016.

In more details:

Revenues

The members' contribution to administrative costs in the 2017 budget is presented in the following table:

	Amount (in EUR)
European Commission(1)	1,801,377
Industry Grouping(2)	2,058,391
Research Grouping(3)	342,877
Re-activation following 2015 budget execution	912,443
Total revenues	**5,115,088**

(1) FP7 contribution: 1,744,619 corresponding to the remaining amount from commitment done in 2013 to cover running costs of period 2014-2017 under FP7
H2020 contribution: 56,758 as per article 13.2 of the Statutes of the Council Regulation No 559/2014 of 06/05/2014 (50% of the administrative costs under H2020)
(2) FP7 contribution: 2,009,579 as per article 2(1).1 of the Financing Agreement signed with Industry Grouping on 30/06/2014
H2020 contribution: 48,812 as per article 13.2 of the Statutes of the Council Regulation No 559/20142 of 06/05/2014 and article 2(1).2 of the Financing Agreement signed with Industry Grouping on 30/06/2014 (43% of the running costs expenditure under H2020)
(3) FP7 contribution: 334,931 as per article 2(1).1 of the Financing Agreement signed with Research Grouping on 30/06/2014
H2020 contribution: 7,946 as per article 13.2 of the Statutes of the Council Regulation No 559/20142 of 06/05/2014 and article 2(1).2 of the Financing Agreement signed with Research Grouping on 30/06/2014 (7% of the running costs expenditure under H2020)

Expenditure

Title 1 – Staff

Title 1 (staff costs) represents 66 % of the administrative costs in the 2017 budget. It mainly covers salaries (92%) and other budget lines cover missions, training & socio-medical costs, recruitment costs and representation expenses.

The increase in title 1 in 2017 compared to 2016 (+4.1% amounting to EUR 133,545) is explained by the following:

- *in staff in active employment (+ EUR 76,827)*

  As of 2017 there is a provision for contributing to the costs of the European school. The increase due to indexation is offset with the decrease of interim needs.

- *in recruitment (+ EUR 73,294)*

  the increase reflects the allowances paid to the 2 Seconded National Experts.

- The increase in representation expenses is due to indexation (estimated at approximately 2%)
- The decrease in socio-medical infrastructure (- EUR 16,864) reflects a reassessment of foreseen needs based on past experience.
- Mission expenses remain at the 2016 level.

Title 2 – Infrastructure

Title 2 represents 34 % of the administrative costs in 2017.

The budget of this title is decreased by 13.4 % (amounting to EUR 269,475 compared to 2016). This is mainly due to the decrease in audits costs (under service contracts budget line) by EUR 207,775 and reflects (1) the maturity of FP7 programme: less assignments are expected in 2017 to reach the coverage level, (2) the fact that there will be a limited number of H2020 audits in 2017 as only few cost statements will be validated and (3) the fact that part of the H2020 audit costs is covered by the CSC. For the other budget lines, the following changes are noted:

- The decrease in current administrative expenditure and meetings reflects a reassessment of foreseen needs based on past experience.
- The decrease in communication costs is due to the reclassification of the costs of experts being invited to the PRD (from communication to experts budget line). Experts budget line includes also evaluators for which the estimated costs are lower than in 2016.
- Experts costs are decreased by EUR 16,927 due to significantly less FP7 mid-term reviews expected (reflecting the end phase of most projects) and despite the fact that in 2017 the first H2020 mid-term reviews are foreseen. The costs for experts invited to the PRD are reclassified to this budget line.
- Only Ares is a new IT solution envisaged in 2017. The decrease by EUR 22,642 is due to the fact that the development of a new project data acquisition tool was contracted in 2016 under the 2016 budget.
- The increase by EUR 20,600 in rental costs is due to increased security needs estimated and indexation of 2%.

Title 3 – Operational

Commitment appropriations amounting to EUR 120,096,037 (including EUR 25,861,251 of reactivations of non-used appropriations from 2016) correspond to H2020 programme and will cover the 2016 operational activities as described in section 3.2 of the AWP 2017.

Payment appropriations correspond to estimated needs to cover (1) payment obligations under FP 7 projects (interim & final payments) for EUR 32,178,026 and (2) payment obligations under H2020 projects for EUR 142,933,563: pre-financings for calls 2016 and 2017, payments in line with the JRC agreed rolling plan and payments of studies procured under the operational budget as described in section 3.2. The increase by nearly EUR 94,2 M in the payment appropriations for H2020 compared to 2016 is due to the fact that the pre-financing for 2 calls (call 2016 and part of call 2017) will be paid in 2017.

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 (2017-2018 and following years) to meet budget commitments entered into earlier financial years (before 2016).

FCH 2 JOINT UNDERTAKING

Budget 2017

SUMMARY SCHEDULE OF PAYMENTS (Operational)

2015 Outturn		2016 Budget		2017 Budget		Difference (2017/2016)	
CA	PA	CA	PA	CA	PA	CA	PA
111,316,764	74,280,358	122,016,891	109,195,591	120,096,037	175,111,589	-2%	60%

DETAILS OF PAYMENT SCHEDULE (Operational)

FP7

Commitments		Payments					
		2016	2017	2018	2019	Outstanding amount	Total
Pre-2014 commitments still outstanding (RAL)	**100,856,179**	18,022,280	32,178,026	19,816,242	5,439,065	25,400,565	**100,856,179**
TOTAL	**100,856,179**	18,022,280	32,178,026	19,816,242	5,439,065	25,400,565	**100,856,179**

H2020

Commitments		Payments					
		2016	2017	2018	2019	Outstanding amount	Total
Pre-2016 commitments still outstanding (RAL)	**116,556,862**	121,445	37,807,734	31,620,875	21,703,731	25,227,077	**116,480,862**
2016 commitment appropriations still outstanding (RAL)	**94,285,498**	-	53,097,695	8,591,550	8,315,280	24,280,973	**94,285,498**
2017 commitment appropriations	**120,096,037**	-	52,028,134	16,985,647	16,537,972	34,544,284	**120,096,037**
TOTAL	**330,938,397**	121,445	142,933,563	57,198,072	46,556,983	84,052,334	**330,862,397**

Remarks

State of play on 31/10/2016 - RAL refers to open commitments on 31/10 - payments for 2016 refer to foreseen payments from 31/10/2016 until the end of the year

2015 CA outturn refers to the global commitment for the call 2015 and the global and individual commitments for the studies included in AWP 2015

4.2. Staff Establishment Plan

The JU team of statutory staff consists of 26 positions (24 TA and 2 CA)

The 2017 Staff Establishment Plan is shown below:

Temporary Agents

Grade	2016 authorized	2016 filled	2017 budget
AD 16			
AD 15			
AD 14	1	1	1
AD 13			
AD 12			
AD 11	2	2	2
AD 10			
AD 9	3	3	4
AD 8	5	5	4
AD 7			
AD 6			
AD 5	4	4	4
Total AD[36]	**15**	**15**	**15**
AST 11			
AST 10			
AST 9			
AST 8	2	1	2
AST 7		1	1
AST 6	2	2	1
AST 5			
AST 4	3	3	3
AST 3	2	2	2
AST 2			
AST 1			
Total *AST*[37]	**9**	**9**	**9**
TOTAL	**24**	**24**	**24**

36 AD stands for Administrator

37 AST stands for Assistant

Statutory staff also includes 2 contract agents: 1 in Function Group (FG) III and 1 in FG IV.

In addition staff resources include 2 Seconded National Experts (SNE).

Comments:

Compared to 2016 the headcount of statutory staff (TA and CA) is unchanged at 26.

In accordance with the rules on the secondment of national experts to the FCH 2 JU adopted by the FCH 2 JU Governing Board on 25 October 2016, the FCH 2 JU plans to host 2 SNEs in particular to promote and monitor demonstration projects in countries benefitting from the European Structural and Investment Funds (ESIF) and to assist the FCH 2 JU in its mission to support smart specialisation efforts, to develop synergies and to strengthen local, regional and national research and innovation capabilities in fuel cells and hydrogen technologies.

5. LIST OF ACRONYMS

Term	Definition
AAR	Annual Activity Report
ABAC	Accrual Based Accounting
ASIL	Automotive Safety Integrity Level
AWP	Annual Work Programme
BoP	Balance of Plant
CA	Contract Agent
CAPEX	Capital Expenditure
CAS	Common Audit Service
CHP	Combined Heat Power
EUSE	Court of Justice of the European Union
COPV	Compressed Overwrapped Pressure Vessel
CoR COTER	Committee of the Regions - Commission for Territorial Cohesion Policy and EU Budget
CoR ENVE	Committee of the Regions - Commission for the Environment, Climate Change and Energy
CSC	Common Support Centre
DSO	Distribution System Operator
EC	European Commission
ECA	European Court of Auditors
EFTA	European Free Trade Area
EU	European Union
EUSEW	EU Sustainable Energy Week
FCH 2 JU	Fuel Cells and Hydrogen
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
HIAD	Hydrogen Incident and Accident Database
Horizon 2020	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
ICS	Internal Control Standards

IEC	International Electrotechnical Commission
IPHE	International Partnership for Hydrogen into the Economy
ISO	International Standards Organization
KPI	Key Performance Indicator
LHV	Lower Heating Value
MCFC	Molten Carbonate Fuel Cell
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
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	State of Charge
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
TRL	Technology Readiness Level
TSO	Transmission System Operator

6. Annex

<u>Horizon 2020 INDICATORS FOR JOINT UNDERTAKINGS</u>

- 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[38] 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

[38] (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[39]	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

[39] 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
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

		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
HR	NA	Vacancy rate (%)		% of post filled in, composition of the JU staff [40]	Joint Undertaking	n.a. [new approach under Horizon 2020]		
JU EFFICIENCY	NA	Budget implementation/execution: 1. % CA to total budget 2. % PA to total budget	Realistic yearly budget proposal, possibility to monitor and report on its execution, both in commitment (CA) and payments (PA), in line with sound financial management principle	% of CA and PA	Joint Undertaking		100% in CA and PA	Yes
	NA	Administrative Budget: Number and % of total of late payments	Realistic yearly budget proposal, possibility to monitor and report on its execution in line with sound financial management principle	Number of delayed payments % of delayed payments (of the total)	Joint Undertaking			Yes

NOTES:

18* This indicator is not a legally compulsory one, but it covers several additional specific indicators requested for more societal challenges by the services in charge.

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

TABLE II

Indicators for monitoring Horizon 2020 Cross-Cutting Issues[41] 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

[41] (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	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
		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[42]	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

[42] 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[43] 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)		

[43] 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[44]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)[45]	Responsible Directorate/Service/Joint Undertaking	JU AAR RTD Monitoring Report		

[44] RTO: Research and Technology Organisation

[45] Data relates to pre-granting ethics review. This time span runs in parallel to granting process.

	Cross-cutting issue	Definition/Responding to Question	Type of Data Required	Data to be Provided by	Data to be Provided in/to	Direct Contribution to ERA	Automated
NA	Audit	Error rate	% of common representative error; % residual error	CAS	JU AAR RTD Monitoring Report		Yes
NA		Implementation of ex-post audit results	Number of cases implemented; in total €million; ´of cases implemented/total cases	CAS	JU AAR RTD Monitoring Report		Yes

Notes:

* Horizon 2020 applicants - all those who submitted Horizon 2020 proposals
* Horizon 2020 beneficiaries - all those who have signed a Horizon 2020 Grant Agreement

*Responsible Directorate - DG RTD Directorates and R&I DGs family in charge with management of Horizon 2020 activities

*Services -Executive Agencies and other external bodies in charge with Horizon 2020 activities

*Project officer - is in charge of managing Horizon 2020 projects in Responsible Directorate/Service including Executive Agencies

TABLE III

Key Performance Indicators specific to FCH 2 JU

#	Key Performance Indicator	Objective	Data to be Provided by	Baseline at the Start of Horizon 2020	Target at the End of Horizon 2020	Automated
	Share of the fund allocated to the following research activities: - renewable energy - end user energy-efficiency - smart grids - storage		JU	Result of FP7		
	Demonstrator projects hosted in MSs and regions benefiting from EU structural funds		JU	Result of FP7		