

ANNEX to GB decision no/2015.

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

2016

ANNUAL WORK PLAN and BUDGET



In accordance with the Statutes of the FCH2 JU annexed to Council Regulation (EU) No 559/2014 and with [Article 31] of the Financial Rules of the FCH 2 JU.

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

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2. INTRODUCTION

This document establishes the third 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 2016.

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 Strategy², 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”.

The Communication from the European Commission³ 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.

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

³ COM(2015)80, Energy Union Package

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 2016 of the Fuel Cells and Hydrogen 2 Joint Undertaking, outlining the scope and details of its third 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.

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 2016

3.1. Executive Summary

The Annual Work Plan 2016 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 2016, a call for proposals with an indicative budget of 117.5M€ will be launched in January 2016 (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, and complemented by Overarching topics. A total of 24 topics will be part of the call for proposals, including 10 for Transport, 11 for Energy, 2 for Cross-Cutting and 1 Overarching. They will be grouped into 7 Innovation Actions (IA), 15 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-01-1-2016: Manufacturing technologies for PEMFC stack components and stacks
	FCH-01-2-2016: Standardisation of components for cost-efficient fuel cell systems for automotive applications
	FCH-01-3-2016: PEMFC system manufacturing technologies and quality assurance
	FCH-01-4-2016: Development of industrialization-ready PEMFC systems and system components
	FCH-01-5-2016: Develop new complementary technologies for achieving competitive solutions for marine applications
	FCH-01-6-2016: Develop new complementary technologies for achieving competitive solutions for rail applications
	FCH-01-7-2016: Improvement of compressed storage systems and related manufacturing processes in the perspective of automotive mass production
	FCH-01-9-2016: Large scale validation of fuel cell bus fleets FCH-01-10-2016: Validation of fuel cell urban trucks and related infrastructure
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-02-5-2016: Advanced monitoring, diagnostics and lifetime estimation for stationary SOFC stacks and modules
	FCH-02-6-2016: Development of cost effective manufacturing technologies for key components or fuel cell systems for industrial applications
	FCH-02-8-2016: Large scale demonstration of commercial fuel cells in the power range of 20-100kW in different market applications
	FCH-02-9-2016: Large scale demonstration of commercial fuel cells in the power range of 100-400kW in different market applications
	FCH-02-11-2016: MW or multi-MW demonstration of

	stationary fuel cells
Techno-economic objective 3: increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system is competitive with the alternatives available in the marketplace	<p>FCH-01-8-2016: Development of innovative hydrogen compressor technology for small scale decentralized applications for hydrogen refuelling or storage</p> <p>FCH-02-1-2016: Establish testing protocols for electrolysers performing electricity grid services</p> <p>FCH-02-2-2016: Development of compact reformers for distributed bio-hydrogen production</p> <p>FCH-02-3-2016: Development of processes for direct production of hydrogen from sunlight</p> <p>FCH-02-4-2016: Co-generation of hydrogen and electricity with high-temperature fuel cells</p> <p>FCH-03-1-2016: Development of innovative hydrogen purification technology based on membrane systems</p>
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	<p>FCH-02-7-2016: Demonstration of large-scale rapid response electrolysis to provide grid balancing services and to supply hydrogen markets</p> <p>FCH-02-10-2016: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas</p>
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	Not applicable

Two topics are also addressing cross-cutting issues:

- FCH-04-1-2016: Novel education and training tools
- FCH-04-2-2016: Identification of legal-administrative barriers for the installation and operation of key FCH technologies

KPIs

For FP7 programme, the FCH JU follows the internal document “FCH JU – Objectives and Indicators” and reports on the achievement of the KPIs in the Annual Activity Report.

For H2020 programme, the FCH2 JU follows the objectives as defined in the MAWP, and reports on the related KPIs in the annex to Annual Activity Report.

Risk Assessment

In the annual risk assessment exercise, conducted in October 2015, the following significant risks & responses to those risks in terms on action plans were identified:

Risk Identified	Action Plan
FCH2 JU would fail to deliver on additional activities	Work closely with the stakeholders, attend meetings, and actively participate on preparation of the reporting & the plan for 2016. For the first certification year 2015, terms of reference and eligibility criteria for additional activities were defined in the close cooperation of the FCH2 JU and its members.
Unclear translation of strategic objectives as defined in MAWP into annual work plan (i.e. selection of grant topics)	In line with the findings and recommendations from the IAS report on evaluation and selection process of H2020 grant proposals, the internal procedure will be developed seeking an endorsement from the Governing Board.
Stakeholders losing confidence in the industry	Work closely with the industry, steering their actions to be in line with the strategic objectives of the FCH2 JU, active participations on meetings/ regular consultations. Ensure the access to relevant information to stakeholders.
Loss of control of important administrative processes in H2020 (e.g. ex-post audits) due to centralization (important processes taken over by CSC)	Liaise with the CSC at working and executive levels and active participation in meetings.
High dependency on the common H2020 IT tools – security & data quality issues	Close contact with the EC, regular reporting, implementation of the complete Information Security System
Risk of not getting clean audit opinion from ECA and subsequently the discharge from the EP	Close cooperation with ECA, close cooperation with EC, other stakeholders (EP)
High dependency on the key personnel, business continuity, back-up planning	Knowledge share and back-up planning, implementation of the talent management. Update of the business continuity plan based on the business impact assessment.

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)

1. Transport Topics:

The road sector will continue to be of highest priority because the reduction of energy consumption and greenhouse gas emissions from replacement of conventional fossil fuelled vehicles with fuel cell electric vehicles (FCEVs) is significantly higher than any other transport market mode.

Regarding Innovation Actions, large scale demonstration of fuel cell buses for urban transport will be the focus of the call 2016, following from the conclusions of the commercialization study recently concluded by the FCH 2 JU. In addition, demonstration of fuel cell trucks for urban uses is the focus of a separate topic.

Further developments, especially in the field of industrialization of fuel cells for transport applications, will be pursued in the 2016 call. Topics on manufacturing technologies, both at the fuel cell and at the system levels are included in the 2016 call. Likewise, the development of industrialization-ready components, with a focus on Balance-of-Plant components, and their possible standardization are the focus of 2 topics. Other topics, such as the composite tanks for on-board storage of compressed hydrogen, and innovative technologies for compression systems used in refuelling stations, further complement the identified needs, going beyond the fuel cell systems as such.

The call also includes support for 2 separate topics supporting development of marine and rail systems incorporating fuel cell systems that can meet the demands of the respective applications. In both of these cases, prototype systems are expected that validate the developed concepts.

2. Energy Pillar:

The production of hydrogen from intermittent electricity sources continues to be a priority for the FCH 2JU. Following a central electrolysis call in 2014 and a call on distributed electrolysis in 2015, further scale-up is requested in the 2016 call for proposals. This includes a topic for demonstration of electrolysers beyond 3MW capacity, whereby grid balancing services and/or power demand management are provided on a commercial basis. These projects are expected to demonstrate the feasibility of electrolysers to operate in these markets and make recommendations for policy makers and regulators on measures required to stimulate the market for these systems. The primary focus is therefore on part load operation and response times, while keeping the 2020 cost and efficiency targets in mind. The Innovation topic is open to PEM as well as pressurized alkaline electrolysers. Parallel to this there is a Research & Innovation topic aimed at developing standardized testing protocols for electrolysers performing electricity grid services. This includes definition of the performance indicators for different grid services as well as developing tests to benchmark electrolysers.

Based on the results of the renewable hydrogen study completed by the FCH 2 JU in 2015⁵ two R&I topics are included in the 2016 call for proposals. The first topic is aimed at improving distributed reformer technology for biogenic materials like biogas and bio-alcohols. It calls for design and construction of a system between 100 and 500 kg of hydrogen per day, with main focus on feedstock diversity, efficiency and footprint. Applications include farms, municipalities and small powerhouses. The second topic addresses the production of hydrogen by direct water splitting using sunlight, including the selection of an existing material and production of a prototype system with more than 10m² exposed surface. This prototype should produce at least 15 g/h of hydrogen or more than 10 kg of hydrogen during the project. The TRL of this promising technology is expected to reach level 5 during the project.

In addition to this, the call 2016 includes an R&I topic on co-production of hydrogen and electricity using solid oxide fuel cells. This is expected to lead to more efficient energy use (>65% efficiency based on LHV) and lower cost of hydrogen as well as provide new technology for stabilizing the electricity grid. The topic calls for design and construction of a 50 kW system as well as the operation for at least 1000 hours, bringing the technology level from 4 to 6.

SOFc stacks and modules performance will be improved by implementing advanced monitoring and diagnostic tools. A topic aims at supporting the research on techniques that will lead to increased durability. In addition, a topic deals with the development of cost effective manufacturing technologies in order to achieve significant cost reductions of fuel cell components and systems for industrial applications.

The need for distributed power production for base load in both commercial and industrial segment, including grid support, will be addressed by demonstration of fuel cell power plants in different power range: 20-100 kW, 100-400 kW, MW or multi-MW scale. Increase of energy efficiency and power security, reduction of CO₂, noise and other emission are the most significant challenges that will be addressed. Indeed, the maturity level of stationary fuel cell technologies in such power ranges is ready to initiate the drive to achieving economies of scale and hence significantly reduce costs enabling further roll-outs/deployment.

Hydrogen-based energy storage solutions for isolated micro-grid or off-grid remote areas, as stand-alone solution integrated with renewables via electrolyser need to be demonstrated in order to enable wind and solar power to act as stand-alone primary energy sources, solving the intermittency issue for a better security in power supply. Decreasing the use of fossil fuel and CO₂ emissions and decreasing the cost of energy are the key challenges that will be addressed by the proposing project.

3. Overarching Topics:

Under the overarching projects the need for improved small scale hydrogen purification systems is addressed, after no suitable project resulted from a similar topic in the 2014 call. The R&I topic is aimed at bringing membrane based purification technology from TRL level 3 to 5, focusing on low energy consumption and low investment cost. With further development this enables additional sources of hydrogen like hydrogen from biomass fermentation and underground caverns to be used in transport and stationary applications.

⁵ See: http://www.fch.europa.eu/sites/default/files/GHyP-Final-Report_2015-07-08_5%20%28ID%202849171%29.pdf

4. Cross-Cutting Pillar:

Cross-cutting activities are intended to support and enable activities under the Energy and Transport Pillars and also to facilitate the transition to market for fuel cell and hydrogen technologies. Within AWP 2016 these activities will be conducted through specific topics on two subjects, the first covering novel education and training tools and the second covering identifying and reducing legal-administrative barriers that inhibit the installation and operation of FCH technologies.

Education and training are critical activities needed to continuously support the FCH Community and should be executed in a continuous manner. To foster the deployment and commercialization of FCH technologies, education and training activities need to develop and incorporate 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 technologies and the fundamental processes behind these technologies. To cover this range of involvement the new tools (web based, e-learning platforms) are to be applicable as support to conventional student lessons as well as concepts for successful self-studies for a wider future technical audience.

Legal-administrative barriers are among the obstacles that currently impede deployment of FCH technologies. They often reflect a lack of awareness of key FCH technology features within national and local legal codes along with additional bureaucracy and complex sets of procedures and requirements for FCH technology implementation. Identifying and providing a comprehensive set of applicable requirements and procedures for FCH technology installation and operation and making the information readily accessible to both those who set or regulate processes and procedures and those installing and operating FCH technologies can assist accelerate deployment. Reducing the time and costs for compliance through recommendations aimed at simplification of requirements or facilitation of compliance will also assist with the commercialization of FCH technologies throughout Europe.

List of actions

For the implementation of the Work Plan, the following actions will be taken in 2016:

A. Call for proposals 2016

Topic descriptions are detailed starting from the next page.

Topic Descriptions

TRANSPORT PILLAR

FCH-01-1-2016: Manufacturing technologies for PEMFC stack components and stacks

Specific challenge:

Even though the development of PEMFC components and stacks for transport applications have reached a mature level in which the operational performance specifications are met, certain aspects like manufacturability, production efficiency and production cost have a large improvement potential since they have not been the focus up to this point. Currently, stack production is based on a number of well-established and time efficient processes, while others are still inefficient with respect to cycle time, cost, yield and reliability. To enable a cost efficient production and thereby marketable products in the transport sector it is of paramount importance to address manufacturing and production issues.

Moreover, there are several production steps that haven't been thoroughly investigated regarding cost reduction potential in a serial production and integration capability in automated lines.

Scope:

This topic is intended to include process development of critical steps of PEMFC stack manufacturing, including the production of component engineering samples. The topic is not intended to cover basic research on new materials nor fundamentally new cell and stack designs. Also demonstrations of full pilot lines are excluded. The fuel cell system manufacturing is explicitly excluded from this topic since it is addressed in topic FCH-01.3-2016. The overall process chain must be considered for the sake of the analysis of cycle time, covering the complete value chain including the development of inline non-destructive control tools in order to reduce the amount of defective components. Potential project proposals should have the main focus on the development of manufacturing technologies specific for PEMFC components and stacks for transport applications. The successful consortium must show evidence that critical bottlenecks specifically related to the stack and/or stack component manufacturing, including e.g. end-of-line testing and stack conditioning are addressed. The minimum TRL for stacks and stack components is 5.

Projects should achieve at least a manufacturing readiness level, MRL⁶, of 7 (Capability to produce systems, subsystems or components in a production representative environment) at project end, starting from a MRL of 5 (Capability to produce prototype components in a production relevant environment).

To demonstrate advancement with respect to the state-of-the-art on four critical parameters: cycle time, manufacturing cost, yield and reliability of the production process, project proposals are expected to cover the following top-level objectives:

- Development of manufacturing technologies, beyond state of the art, specific to the PEMFC stack production processes, equipment and tools

⁶ For more information on the use of MRL in this topic, please see Section 3.3 Call management rules

- Transpose established automotive industry best practices on production and quality to the manufacturing of PEMFC stack and stack components, such as (but not limited to) lean manufacturing, Kaisen, six sigma
- Identification of bottleneck processes in stack or stack component production lines
- Identification and revision of critical sub-processes (e.g. low yield/high cost)
- Improvement, modification, adaptation or even new development of at least two critical stack or stack component production steps
- Integration of inline non-destructive quality control tools
- Adaptation of stack and/or stack components design to optimize manufacturability
- Development of QA strategies relevant for the transport sector compatible with ISO/TS 16949

Duplication with already funded project VOLUMETRIQ (topic FCH-01.2-2014) should be avoided. Consortium should include at least one transport OEM and one or more stack component supplier(s), stack developer and manufacturer with existing cell/stack design and a partner specialized in manufacturing automation and production systems.

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: 3-4 years

A maximum of 2 projects may be funded under this topic.

Expected impact:

Expected impacts of the project include:

- Demonstrate that with the improvements in the production process and eventually some product changes, the stack production can be increased from few 100 stacks/year up to 50,000 stacks/year in 2020, for a total power range about 5 MW per year with a single line.
- Produce engineering samples of the improved design for manufacturability of at least two relevant stack components, including their product validation.
- Validate in hardware, with cycle time measurement, cost analysis and statistical evaluation, the performance of the improved stack production steps.
- Validate the performance of the full stack (or stack component) production in an existing production line upgraded with the optimized process steps.
- Achieve components yields > 95% for the improved stack component production steps
- Feedback and structure the project results into future stack and stack component development.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-01-2-2016: Standardisation of components for cost-efficient fuel cell systems for automotive applications

Specific challenge:

PEMFC system technology has demonstrated its maturity for automotive application, but still does not meet the cost requirements for a broad market introduction. The reasons are diverse, including proprietary system architectures and component concepts, low volume and lack of a competitive chain of suppliers. Standardisation of interfaces and system components is considered to be an efficient pathway to reduce cost, accelerate market introduction of automotive fuel cell technology. Moreover development and qualification of a capable European supplier base is of major importance to strengthen Europe's competitiveness in the emerging international market for fuel cell electric vehicles.

For the sake of clarity, by standardisation is meant the development of common components and their interfaces and not the developments of new standards and regulations.

Whereas standardisation of refuelling infrastructure is approaching maturity, on the fuel cell system component level the variance is still very high and needs more alignment. Each manufacturer of a fuel cell system typically develops and uses its own components and interfaces, mainly based on proprietary requirements, whereas the similarity of requirements appears to be high (compare with "Auto Stack"⁷ specification).

Scope:

Components suitable for OEM-wide standardisation include air supply, fuel supply, valves, sensors, cooling, water management, DC/DC converters, current connectors, etc. In addition, some of these components affect safety classification of fuel cell systems and must be qualified and tested in order to comply with Automotive Safety Integrity Level (ASIL⁸) standards. Differentiation between OEMs is expected with regard to fuel cell architecture, fuel cell stack and system controls and, therefore, these should not be the focus of the project.

Successful proposals must address the following objectives:

- identify and select a minimum of three components or subsystems suitable and relevant for standardisation
- align specifications and interfaces for each component and subsystem
- define and agree on standardized verification, validation and qualification test protocols
- benchmark components and subsystems in conjunction with their operating range with the state-of-the-art. This includes testing of available market components and engineering samples from project partners
- develop and build the selected components and test them against the agreed specifications
- generate inputs for further development of advanced PEMFC system components in order to fulfil broader requirements of OEMs
- if meaningful, liaise with relevant ISO and IEC committees and transfer of recommendations for standardized system components and subsystems to industry codes & standards

⁷ FCH JU funded project AutoStack; <http://autostack.zsw-bw.de>

⁸ ASIL is a risk classification scheme defined by the [ISO 26262](https://www.iso.org/standard/55861.html) - Functional Safety for Road Vehicles standard

- assess the cost impact upon standardisation

The consortium should include at least two automotive OEMs, a fuel cell system integrator, and relevant suppliers to the automotive industry capable of fulfilling automotive standards. To strengthen the industry consensus and acceptance of the proposed component standardisation, participation of further OEMs and main automotive suppliers is highly recommended, even if only with an observer role. The components to be standardized are expected to be at least TRL 4 at the start of the project and TRL 7 at the end of the project.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 3 million each 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

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

Expected impact:

The expected impact must include:

- Industry supported recommendations for aligned interfaces and specifications for key PEMFC system components
- At least three PEMFC system components or subsystems modified, adapted and built to the recommended specifications/interfaces, including the component validation in an existing complete PEMFC system
- A set of standardised verification, validation and qualification test protocols for selected components
- Transparency on the reduction of development and manufacturing costs leveraged by standardisation
- Clear added value for the competitiveness of the European component supplier base
- Reduced certification efforts based on dissemination of a white paper for industrial standards

Type of action: Research & Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-01-3-2016: PEMFC system manufacturing technologies and quality assurance

Specific Challenge:

Currently, most fuel cell systems and their key components are produced in small quantities, often with considerable manual input and not optimized for low cycle times implying the corresponding high production cost and quality deficits. The core components are currently niche products with high complexity to produce and industry has little at-scale manufacturing experience. In order to achieve cost levels allowing for market deployment, fuel cell systems need further significant cost reductions in several areas including development, manufacturing, tooling and assembling. However, today, low production volumes – sometimes on a prototype level – do not provide the economical drive for the identification, improvement and validation of all factors that influence the robustness and yield of the manufacturing processes at system level.

Scope:

This topic addresses process development of critical steps of PEMFC system manufacturing, including the production of component engineering samples. The fuel cell stack and stack component manufacturing is explicitly excluded from this topic since it is addressed in topic FCH-01.1-2016. The overall process chain must be considered for sake of the analysis of cycle time, covering the complete value chain including the development of inline non-destructive control tools in order to reduce the amount of defected components. Potential project proposals should have the main focus on the development of manufacturing technologies specific to PEMFC system and system components for transport applications. Demonstrations of full pilot lines are excluded.

The scope of this topic is to enable established PEMFC OEMs and component suppliers in the fuel cell industry to implement technologies enabling the step-up from small scale production towards higher volumes (50,000 systems/year in 2020) which will result in the reduced cost of PEMFC technologies. The topic should also develop simpler tooling/ manufacturing technologies, making it easier for other players to enter the PEMFC system component industry, thus expanding and making the component supplier base more robust and competitive.

The scope of this topic is, moreover, to focus on improving the system production processes with respect to cost, cycle time and quality. Proposals should focus on developing high volume manufacturing technologies, modifying system components for improved manufacturability as well as quality assurance. System components such as compressors, heat exchangers, actuators and sensors should be the focus of the proposal. Critical bottlenecks in the fuel cell system assembly, e.g. end-of-line testing can also be addressed.

The successful consortium must show evidence that critical bottlenecks specifically related to the fuel cell system and system component manufacturing are addressed. The minimum TRL for fuel cell systems and system components is 5.

Projects should achieve at least a manufacturing readiness level, MRL⁹, of 7 (Capability to produce systems, subsystems or components in a production representative environment) at project end,

⁹ For more information on the use of MRL in this topic, please see Section 3.3 Call management rules

starting from a MRL of 5 (Capability to produce prototype components in a production relevant environment).

To demonstrate advancement with respect to the state-of-the-art on four critical parameters: cycle time, manufacturing cost, yield and reliability of the production process, project proposals are expected to cover the following top-level objectives:

- Development of manufacturing technologies, beyond state of the art, specific to the PEMFC system production processes, equipment and tools
- Transpose established automotive industry best practices on production and quality to the manufacturing of PEMFC system and system components, such as (but not limited to) lean manufacturing, Kaisen, six sigma
- Identification of bottleneck processes in system or system component production lines
- Identification and revision of critical sub-processes (e.g. low yield/high cost)
- Improvement, modification, adaptation or even new development of at least two critical system or system component production steps
- Integration of inline non-destructive quality control tools
- Adaptation of system and/or system components design to optimize manufacturability
- Development of QA strategies relevant for the transport sector compatible with ISO/TS 16949

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: 3-4 years

A maximum of 2 projects may be funded under this topic.

Expected Impact:

Expected impacts of the project include:

- Taking into account the KPIs achieved within the project, such as yield, cycle time and production capacity, demonstrate through simulation that with the improvements in the production process and product, the PEMFC system production can be increased from few 100 units/year up to 50.000 units/year in 2020, for a total power range about 5 MW per year with a single line.
- Produce and validate engineering samples of the improved design for manufacturability of at least one relevant component, including its product validation.
- Validate in hardware, with cycle time measurement, cost analysis and statistical evaluation, the performance of the improved system or system component production steps.
- Validate the performance of the full system (or system component) production in an existing production line upgraded with the optimized process steps.
- Achieve components yields > 95% for the improved system component production steps
- Feedback the project results into future system component development

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-01-4-2016: Development of industrialization-ready PEMFC systems and system components

Specific challenge:

Typical PEMFC systems still have important challenges before mass production in transportation may be realised, namely cost, reliability and durability. Some of these challenges can be tackled improving the system components as well as by introducing novel system configurations.

While the technical feasibility has been demonstrated in several configurations, a major challenge remains on the high cost of these solutions due to low production volumes, the use of expensive materials and designs not suitable for automated manufacturing. Moreover, the supply chain for some components is still not in place.

Some of the specific outstanding issues concern the freeze start that is still too long and not reliable for low cost stacks and the water management at low temperatures and subsequent freeze preparation. Some failure modes for key components such as compressor air bearings have still to be solved. Packaging in combination with cost effective solutions remain an issue in view of future integration in mass production of the automotive industry.

In addition, the fuel cell system, power degradation is still too high, caused by events such as start-up/shut-down, fuel starvation and potential cycling. With novel system architecture and component designs, the FC degradation can be reduced to levels equivalent to incumbent technologies.

The biggest cost-down leverage in a FC system is on the cathode side: the components are usually the most expensive and the ones with the highest parasitic power and strongest impact to FC performance.

Additionally, the automotive supply chain needs to be established for some of the components and should be further supported by bringing together OEM and potential n-Tier suppliers in development projects such as the present one.

Scope:

The project should focus on the improved industrialization-ready designs of high efficiency and low cost Balance-of-Plant (BoP) PEMFC system components on the cathode side (compressor, humidification, intercooler, valves, and turbine/expander). The FC stack is also within the scope to be funded, although it is not the focus of the innovation. The FC stack is required to demonstrate the system level performance and may therefore be adapted from existing technology.

Development of a new generation of systems using cost engineering to identify cost reduction potentials for each component and perform design-to-cost activities and trade-offs with other BoP components. As an example: low O₂ permeation valves can be used to reduce O₂ ingress into the stack and thus decreasing start-up (SU) degradation. The project must include durability testing of the components (or testing at the system level if meaningful) under automotive conditions.

The project must address the following key issues:

- Novel system prototypes that eliminate or reduce issues currently experienced with PEMFC systems such as voltage cycling, SU/SD corrosion which leads to increased degradation

- Freeze start design and system component layout to minimize water pooling and consequent ice blockages and reduction of thermal mass to enable faster start up at sub-zero temperatures
- Air compressor prototypes that simultaneously
 - provide higher efficiency at max load point to enable reduction of parasitic power while providing increased durability
 - meet automotive dynamic requirements (0-90% power in 0.5s)
 - improve flow vs. pressure operating window at low current densities

Optionally the project can also address the following issues:

- Turbine/expanders prototypes that reduce parasitic losses with high recovery efficiency.
- New humidification prototypes that simultaneously
 - improve water transfer rates between wet and dry side
 - improve durability to meet automotive requirements of 6,000h
 - minimize packaging space
 - reduce pressure drop
- Intercoolers (gas-to-gas or gas-to-liquid) that simultaneously
 - high thermal transfer efficiency
 - minimize package space
 - reduce pressure drop

To insure the usefulness of the results for the automotive industry, the following methodologies are required:

- Automotive development methods, design to cost, reliability and robustness methods
- Detailed component level simulation for analysis and optimization (e.g. of multiphase transport and phase transition processes including multi-component diffusion and mixing phenomena of humidifiers etc.)
- Sub-system and system level simulation for component specification and assessment of overall performance of different component configurations
- Automated-/hardware-in-the-loop-/accelerated testing methods

TRL at start: 4

TRL at end: 7

The consortium should include at least one automotive OEM or their subsidiaries and at least one fuel cell component manufacturer and/or relevant suppliers to the automotive industry. A higher number of suppliers is recommended but not mandatory.

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

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 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: 3-4 years

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

Expected impact:

By addressing design to manufacturing and cost engineering tools, further cost-down potential should be reached on the main BoP components, thus bringing costs in line with positive business cases at the system level, not only for OEMs but also for the entire supply chain.

The project must show that the proposed BoP solutions support the targets at the FC system level. Details on the trade-offs between stack and BoPs including cost estimation are expected. All projects must also produce validated evidence of lifetimes; cost targets and efficiencies throughout life.

The following KPIs are expected to be reached at the FC system level:

- FC system production cost: 100 €/kW at 50 000 units/year production rate
- Maximum power degradation of 10% after 6000 h for passenger cars
- Cold Start: Improved freeze start up performance and reliability closer to standard automotive conditions

Type of action: Research & Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-01-5-2016: Develop new complementary technologies for achieving competitive solutions for marine applications

Specific challenge:

Fuel cell technology is able to address powertrain electrification in the domains of marine propulsion. This market represents high potential for reducing energy consumption and emissions (especially for harbour boats and tugs), because the source of emissions is not as dispersed, i.e. significant energy/ emission savings can be achieved by replacing a single conventional powertrain on a large ship. However, despite all the potential benefits, existing fuel cell technology components face application specific challenges that need to be addressed in order to drive large scale adoption in the marine sector. Hence, in order to achieve competitiveness, additional research and demonstration efforts are required for such drive systems in order to become competitive with conventional technologies.

Scope:

The aim of this topic is to develop an emissions-free fuel cell hybrid based powertrain system, suitable for marine applications, and to validate it in the target marine vessel.

The project must address the following key issues:

- Identify the components that have specific marine application requirements (e.g. lifetime and resistance to shock, vibration, corrosion, power range, SU/SD, etc.) in comparison to automotive or other vehicular applications
- Select amongst the identified components those with highest impact for the marine application in cost and performance
- Develop improved, industrialisation-ready system components (including but not limited to: fuel cell stack, compressor, humidifier, intercooler, valves, or turbine/expander, etc.) for high efficiency and low cost Balance-of-Plant (BoP), focused on the specific needs of the marine application
- Demonstrate significant improvement of the complete fuel cell based powertrain efficiency and stack lifetime due to integration of improved fuel cell components
- Validate the system performance on a powertrain test bench and in a target marine vessel for a period of minimum 6 months
- Investigate the CO₂ performance (through Life Cycle Analysis techniques) of current marine powertrain solutions and demonstrate the specific emissions saving that can be achieved by replacing conventional technology

TRL at start: 4

TRL at end: 7

The consortium should include at least one marine OEM or their subsidiaries and at least one fuel cell component manufacturer and/or relevant suppliers.

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: 3-4 years

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

Expected Impact:

Expected impacts of the project include:

- Fuel to electric efficiency > 42 %
- Freeze start capabilities from -35°C
- Operational ambient temperature -30°C to +45°C
- Powertrain system cost below 6000€/kW
- Fuel cell system of at least 75kW
- Fuel cell stack life of >15,000 hours
- Ability of the system to withstand the shocks, vibrations, saline environment and ship motions commonly encountered on water as well as other marine application relevant requirements.
- Taking into account the project achievements (e.g. costs and lifetime), clearly indicate the current state of return on investment for a prospective customer. Out of the business model analysis extract the technological leverages that still have to be considered for future projects.
- Formulation of initial go-to market strategy with support from stakeholders from the marine industry.
- Potential for future demonstration 'innovation' actions once the project is completed

Type of action: Research & Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-01-6-2016: Develop new complementary technologies for achieving competitive solutions for rail applications

Specific challenge:

Electrification of railway network is high on the agenda of EU. Currently, only 60% of the track in EU is electrified and it is much less in the East European member nations. Fuel cell technology is able to address powertrain electrification in the domains of rail propulsion, both for regional trains and shunt locomotives. This market represents high potential for reducing energy consumption and emissions, because the source of emissions is not dispersed i.e. significant energy/ emission savings can be achieved by replacing a single conventional powertrain on a large train. However, despite all the potential benefits, existing fuel cell technology components face application specific challenges that need to be addressed in order to drive large scale adoption in the rail sector. Hence, in order to achieve competitiveness with conventional technologies, additional research efforts are required.

Scope:

The aim of this topic is to develop an emission-free fuel cell based powertrain system, suitable for rail applications, and to validate it in the target rail vehicle.

The project must address the following key issues:

- Identify the components that have specific rail application requirements (e.g. lifetime and voltage levels, load cycle, power range, SU/SD, etc.) in comparison with automotive or other vehicular applications
- Select amongst the identified components those with highest impact for the rail application in cost and performance
- Develop improved, industrialisation-ready system components (including but not limited to: fuel cell stack, compressor, humidifier, intercooler, valves, or turbine/expander, etc.) for high efficiency and low cost Balance-of-Plant (BoP), focused on the specific needs of the rail application
- Demonstrate significant improvement of the complete fuel cell based powertrain efficiency and stack lifetime due to integration of improved fuel cell components
- Validate the system performance both on a powertrain test bench and a target rail vehicle over a period of minimum 6 months
- Investigate the CO₂ performance (through Life Cycle Analysis techniques) of current rail powertrain solutions and demonstrate the specific emissions saving that can be achieved by replacing conventional technology

TRL at start: 4

TRL at end: 7

The consortium should include at least one rail OEM or their subsidiaries and at least one fuel cell component manufacturer and/or relevant suppliers.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected duration: 3-4 years

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

Expected Impact:

Expected impacts of the project include:

- Fuel to electric efficiency > 42 %
- Freeze start capabilities from -35°C
- Operational ambient temperature -30°C to +45°C
- Powertrain system cost below 6000€/kW
- Power range at least 200kW
- System lifetime > 15,000 hours (with one stack change permitted)
- Taking into account the project achievements (e.g. costs and lifetime), clearly indicate the current state of return on investment for a prospective customer. Out of the business model analysis extract the technological leverages that still have to be considered for future projects. Demonstration that the powertrain system and component lifetime will eventually allow for reasonable return on investment in each industry and make mass commercialisation an attractive option
- Formulation of initial go-to market strategy with support from stakeholders from the rail industry.
- Potential for future demonstration 'innovation' actions once the project is completed

Type of action: Research & Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-01-7-2016: Improvement of compressed storage systems and related manufacturing processes in the perspective of automotive mass production

Specific challenge:

Hydrogen tanks for automotive applications are already available but they do not yet fulfill all carmakers' expectations in the view of a mass production of hydrogen powered vehicles.

Four key challenges have been identified:

1. Achievement of the automotive cost targets for a broader market introduction. This is mainly due to carbon fiber costs, conventional manufacturing processes not developed for high productivity and architecture concepts that are not compatible with mass production. To tackle this challenge, significant advances with respect to mechanical reinforcement, architectural optimization and compressed overwrapped pressure vessel (COPV) manufacturing are required.
2. Vessel and ancillary component (tank valve, pressure regulator) integration in the vehicle in order to ease assembling procedures and maximize customer available volume.
3. Hydrogen refuelling times truly comparable to those of conventional fuels require an extended temperature range of the COPV. Likewise being able to extract the maximum hydrogen mass flow independent of the state of charge (SOC) calls for the ability of the COPV and the complete fueling system to operate at lower temperatures.
4. Increase the acceptance of COPVs for hydrogen storage in automobile applications by means of a higher safety level. It is 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 performances and providing an enhanced integration in the car space at comparable price.
- Define standardized interfaces and objects in order to gain from the economy of scales.
- Improve filling and venting tolerance of COPV (e.g. enhanced liner materials and multi-material assembling materials and techniques to increase mechanical and temperature tolerance (e.g. real -40°C H₂ filling, - 60°C cold filling, +100°C).
- Development and assessment of COPV innovative and flexible manufacturing processes for very large production capacity (objective to decrease the manufacturing time by a factor of 3)
- Development of a cost-reduction strategy (increased materials efficiency, weight and volume reduction, manufacturing optimization, cost-efficient storage geometries/designs)
- Miniaturization and integration of tank components, e.g. on-tank valve, pressure regulator
- Development and validation of numerical tools (probabilistic models) to optimize COPV performance and durability and reduce cost and manufacturing discrepancies
- Provide input to revised regulation codes and standards for storage tanks for compressed hydrogen.

- For the protection against the worst-case scenario of the failure of the TPRD, a leak-before-burst vessel design should be developed. In this connection the failure mechanism of the vessel has to be studied. Furthermore, systems for detecting local fires and efficient fire protection systems as additional security measures are to be evaluated.

TRL at start: 4

TRL at end: 6

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 higher TRL/MRL.

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

Expected duration: 3-4 years

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

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.
- Development of new automated and flexible manufacturing processes, equipment and tools in coherence with mass manufacturing 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.

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%

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-01-8-2016: Development of innovative hydrogen compressor technology for small scale decentralized applications for hydrogen refuelling or storage

Specific challenge:

The hydrogen refuelling stations currently being deployed worldwide are mainly based on common mechanical compressor technology. Mechanical compressors are proven technology, but lack the desired durability, efficiency and reliability. This results in high operational and maintenance cost.

Roughly half of the investment cost of common hydrogen refuelling stations consists of mechanical hydrogen compressors cascaded in series to meet the above 700 bar dispensing pressure for fuel cell cars.

Currently available hydrogen compressors are too costly and noisy for decentralized production and efficient storage of hydrogen. The noise level should not be higher than 60 dB at a distance of 5 meters. Additionally the lifetime of the utilized compressors should be at least 20 years. The unit should be able to perform well under frequent start and stop cycles and maintain robust seals.

The technology proposed for development is preferably applicable in both the current and future Hydrogen Refuelling Stations (HRS), reinforcing the HRS exploitation business case. It should maintain high efficiency over a wide range of compression- 1 bar to 1000 bars, in order to be able to take in hydrogen not only from high pressure electrolysis, but also from low pressure hydrogen sources like biomass conversion and steam-methane-reforming/Pd-membrane systems. The energy demand to pressurize the hydrogen from 1 to 1000 bars should be 6 kWh/ kg H₂ or less. Most important is that the compression system is sufficiently dynamic to follow the (variable) hydrogen production rate when coupled directly to renewable hydrogen sources.

Scope:

This topic calls for proposals to develop innovative hydrogen compression technology that is modularly scalable, intrinsically silent and low cost, with competitive compression energy demand and attractive investment cost. The proposed technology is benchmarked against the mechanical compressor technology commercially available today and should have higher reliability, with the potential of lower maintenance cost and less down time of compressor systems.

It is expected that the technology readiness level at the end of the project is at least 5, meaning that the compression technology has been tested in a relevant environment, for instance in a small scale refuelling station (10-100 kg H₂/ day), or in a hydrogen storage facility in an island situation.

Proposals should further plan to assess the economic feasibility of the proposed innovative hydrogen compression technology.

The project should include:

- Development of a modularly scalable, low noise hydrogen compression technology capable of compressing hydrogen at an energy demand of < 6 kWh / kg H₂ from 1 to 1000 bars (or equivalent) and aiming to achieve an installed system cost of < €2,000/ (kg H₂/day) on the long term.

- Long duration testing of a typical start-stop operational profile during 9 months with <10% performance decay.
- Validation of the hydrogen compression technology in a relevant simulated environment.
- Cost of ownership assessment of the developed hydrogen compression technology
- Recommendations supporting the technology development process, leading to large-scale manufacturing capability of lower cost, modular, compression systems.

TRL start: 3

TRL end: 5

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

Expected duration: 3 years

A maximum of 1 project may be funded under this topic

Expected impact:

The project will show realization of a cost effective hydrogen compression system that can be applied at variable scale, in distributed and island situations, for hydrogen refuelling and for dynamic storage needs, with the possibility to drop-in/replace the current compression sub-systems in HRS.

Concrete topic targets and related impact:

- Modular scalability and operation: modular scalability of compression capacity allows for flexible and lean small scale system construction and for continued operation during maintenance, eliminating down time.
- Low noise level: the noise level plays an important role especially at metropolitan areas. To satisfy the customer the noise level should not be higher than 60 dB at a distance of 5 meters.
- Low energy demand
- Hydrogen compression technology should be able to achieve 6 kWh/kg H₂ for 1 to 1000 bar compression
- Low cost:
 - CAPEX: The installed system cost target of hydrogen compression is < €4,000/ (kg H₂/day) on a short term basis with a target of <€2,000/(kgH₂/day) on a longer term.
 - OPEX: the installed system is expected to have significantly lower maintenance cost and lower down time compared to conventional technology

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-01-9-2016: Large scale validation of fuel cell bus fleets

Specific challenge:

The urban bus application has been identified as a priority value application for fuel cells and hydrogen, for a number of reasons: a political agenda supporting a shift from individual to public transport; stringent CO₂ and exhaust (CO, NO_x, PM) emissions as well as noise reduction objectives.

Hydrogen allows for the use of renewable energy, dramatic well to wheel emission reductions¹⁰ which are a primary driver for future urban traffic electrification plans in the EU and very high operational flexibility.

Earlier EU programmes (CHIC, High VLOCity, HyTransit and 3EMotion) have shown a 75% price reduction of the bus since 1990 with volumes remaining small, opening up different pathways to full commercialisation as of 2020.

To achieve this objective, the commercialisation study, conducted by Roland Berger Strategy Consulting contracted by the Fuel Cell and Hydrogen Joint Undertaking recommends that a first step change that needs to be made is through:

- an increase of volume by aggregating number of about 100 units
- increased number of vehicles serviced per station
- a coalition of cross the board cities and regions forming regional clusters throughout the EU member states, who are committed to deploying the technology in the H2020 time frame.
- joint procurement as modern investment tool shall be applied to improve terms & conditions for operators and stability of supply for producers

Commitments thereto have been made jointly by the supply side in November 2014 (5 bus OEM's) and by the demand side (30+ bus operators) in June 2015. Five bus OEM's are developing next generation bus models to show the cost down potential and take the technology from a current TRL 6/7 (demos) to TRL 8/9 (semi and full commercialisation) level from now through the end of Horizon 2020.

The purpose of this bus validation topic is therefore to establish a committed coalition that can achieve the aggregate volume and a demonstration scale that is necessary to meet further cost reductions required for a full commercialisation of fuel cell bus technology and the associated infrastructure by 2020. FC bus manufacturers have indicated that a cumulative production volume of 500 to 1000 buses is required to trigger full commercial roll-out. This is a challenge both in terms of acquisition of the buses (large enough numbers to reduce costs) and their operation, and also the HRSs needed for such yield of hydrogen and its supply.

Scope:

This topic calls for simultaneous deployment and demonstration of larger scale FC bus fleets in line with the recommendations of the FCH JU's bus commercialisation roadmap in Europe until 2020¹¹. The project will cover the roll-out of a set of fleets amounting to at least 100 FC buses consisting of at

¹⁰ See: Well-To-Wheels Report Version 4.a JEC Well-To-Wheels Analysis: Well-To-Wheels Analysis of Future Automotive Fuels and Powertrains in the European Context

¹¹ See: <http://www.fch.europa.eu/publications/fuel-cell-electric-buses-%E2%80%93-potential-sustainable-public-transport-europe>

least 3 locations with minimum 20 buses per depot. The minimum number of buses per location/depot for additional locations should be 10. Concrete statements should be provided in the proposals regarding the willingness of operators to further expand the fleets after the project. The project will serve to analyse the operation of large fleets of buses and their impact on everyday heavy usage bus operation, including the specific purchasing mechanisms like e.g. joint procurement to efficiently commercialise innovative technology.

FC buses

The buses deployed within the project should have a high level of standardization and learning from previous projects shall reflect significantly in the availability of the buses. The buses are considered to be close to commercial readiness from both a technical maturity and an economic perspective.

The generation of FC buses deployed in this project shall at least have been tested in prior projects (EU & non-EU, minor system changes to improve availability are acceptable) in order to assure a reliable operation of the bus fleets leveraging existing experience and leading to more operating uptime.

Buses are expected to comply with the following requirements:

- Buses can be FC-hybrid or full power FC (FC system as the dominating power source), but at least half of the energy required for performing their expected duty cycle should be provided from hydrogen.
- The minimum operational period for any bus demonstrated in the project is 24 months, whereas in all cases arrangements for extending operation after the end of the project are expected and should be documented in the proposal as a matter of key importance. A minimum of 50% of all buses should be introduced in the first 2 years of the project and should be 36 months or 100,000km in operational service
- Maximum funding: The funding per vehicle cannot exceed 200.000€ per standard bus¹² (12/13.5 m), 250.000 € per articulated bus (>18m), provided they are equipped with a full power FC system of at least 50kW. In addition, for range-extender units or other alternative solutions complying with the given requirements, the funding is limited to 1500€/kW installed FC system
- Maximum price (for the customer): 650,000€ for a standard bus and less than 1,000,000€ for articulated buses
- >20,000h vehicle operation lifetime initially, minimum 25,000h lifetime as project target
- The key energy source of vehicles must be hydrogen in a fuel cell dominated or range extender architecture. At least half of the power requirement should be provided by the fuel cell
- Fuel cell system MTBF¹³ >2,500 km
- Availability >90% on a fleet basis after an initial 6 month ramp-up phase (to be measured in available operation time excluding scheduled preventive maintenance)

¹² Basic 12m low entry, class 1 city bus, with 2 doors, air conditioning, min. 30 seats, traction batteries for operation on flat terrain, all IT equipment (except destination signs) delivered by the operator, manually operated ramp, delivered ex-factory OEM. Extra for special equipment excluded.

¹³ MTBF: mean time between failure, failure means any incident caused by the vehicle which interrupts the operation of the vehicle

- Tank-to-wheel efficiency >42%, for buses measured in the SORT 1 & 2 drive cycles.
- Series production ability as well as the cost reduction potential as a result of the project have to be demonstrated.

HRS

This topic focuses on the demonstration of larger hydrogen refuelling station for large bus fleets based on previous engineering research projects (min. > 20 buses and 400 kg refuelling capacity per day). The challenge is to maintain high levels of station availability, specify the right level of system redundancy and ensure fuel availability during the entire operation.

For the location(s) that begin testing fuel cell buses at a smaller scale, a pathway towards larger fuel cell bus fleets (>50) needs to be provided as a result of the project. Projects and cities with a clear strategic goal to increase their hydrogen bus fleet and projects with a higher buses/station ratio will have priority as the impact for the commercialisation will be bigger.

HRS are expected to comply with the following requirements:

- HRS are to be designed to allow for cost effective operation in each location, including plans for scaling up as fleets expand
- A target availability of the station of 98% (measured in usable operation time of the station providing redundancy for service and maintenance) excluding scheduled preventive maintenance
- Inclusion of the HRS designs developed under earlier programmes (in particular the NewBusFuel project from the 2014 call) to show integration of concept and cost down potential of hydrogen production and storage for larger fleets as well as the potential to scale up capacity
- 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 (target at the pump < 9 €/kg excl. taxes)
- Hydrogen purity has to be at least 99.999 %

A maximum funding per large HRS (20 buses) is 1,200,000 € and smaller stations (10 buses) is 600,000 €, excluding on-site production equipment.

Overall

Beyond demonstration of the technology the participating cities shall engage in communication of their efforts to partner cities/regions in Europe and beyond through appropriate channels to share their experience within the project (e.g. UITP meeting/city conferences, etc.)

This topic includes funding caps which are clearly below the maximum funding rates applicable in the framework programme Horizon 2020 and the FCH 2 JU. This is done on purpose as beneficiaries are expected to obtain co-funding.

In order to facilitate co-funding and compliance with all the rules applicable to the different funding sources, beneficiaries are allowed to shift the capped budget from one cost item to another as long as (1) they comply with the rules applicable in the framework programme Horizon 2020 and the FCH 2 JU and (2) they remain under the budget defined by the funding caps.

Example: a beneficiary deploying 1 HRS and 20 12meter buses. The maximum reimbursement for this deployment is $1 * \text{€}1.200.000 + 20 * \text{€}200.000 = \text{€}5.200.000$. To facilitate co-funding, said beneficiary can shift the budget from the HRS to the buses or vice versa as long as the budget remains under 5.2M€ and complies with the reimbursement rules of the FCH 2 JU and all other applicable rules.

It is necessary that the project shows evidence for co-funding by 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 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.

Any event (accidents, incidents, near misses) that may occur during the project execution shall be reported into the European reference database HIAD (Hydrogen Incident and Accident Database) at <https://odin.jrc.ec.europa.eu/engineering-databases.html>.

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

To be eligible for participation a consortium must contain at least one constituent entity of the Industry or Research Grouping Proposals should clearly demonstrate the commitment of OEMs to supply vehicles to the project. The involvement of SMEs is encouraged.

The following TRLs are at least required:

- 7 for FC buses at start of project
- 7 for the HRS at start of project.

The maximum FCH 2 JU contribution that may be requested is EUR 32 million. This is an eligibility criterion – proposals requesting FCH 2 JU contribution above this amount will not be evaluated.

Expected duration: 4-6 years

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

Expected impact:

FC buses

According to previous investigations on fuel cell buses it is expected that the project leads to further cost reduction of FC-buses and the necessary power train components. The envisaged cost level for a standard 12m FC-bus (equipped with a full power FC-system) produced in larger numbers in 2020 is 600,000 Euro¹⁴. Further, the project needs to trigger uptake of FC-buses by European cities. In addition it is anticipated that larger fleets of buses create higher public awareness of the technology increasing interest in hydrogen and fuel cell solutions for public transport in general, stimulating further demand.

HRS

¹⁴ See: Fuel Cell Electric Buses – Potential for Sustainable Public Transport in Europe, A Study for the Fuel Cells and Hydrogen Joint Undertaking

Hydrogen refuelling stations for larger fleets of fuel cell buses will be heavily utilised and therefore generate a bigger learning effect in comparison to underutilised stations for other applications. It shall increase the confidence of bus operators in reliable fuel supply and demonstrate the viability of fuel cells in public transport even in a full role out scenario, i.e. all buses at a depot run on hydrogen. Furthermore, fuel cell bus stations can occasionally be combined with refuelling points for other applications that might trigger awareness, understanding and demand for applications. Previous engineering research will contribute to successful implementation and execution of this project.

Overall

The project should deliver:

- Lessons learnt from implementing and operating large hydrogen bus fleets for follower cities
- Identification of bottlenecks – technical, organisational, structural, financial including RCS and formulation of recommendations on how to address these
- 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 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 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-01-10-2016: Validation of fuel cell urban trucks and related infrastructure

Specific challenge:

European urban areas are increasingly facing deterioration of their air quality. Among other contributors, urban trucks performing a number of services are emitting local pollutants (CO, NO_x, 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 of people and public authorities.

At the same time a drastic GHG reduction of emissions in the growing road freight sector is needed to meet long term climate and energy targets..

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. However, this strategy risks to increase the number of conventional light commercial vehicles circulating in city centers, generating traffic congestion and, consequently, worsening tail-pipe emissions of toxic pollutants.

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.

In this context, the first “all-electric” truck prototypes (powered exclusively by batteries) have been evaluated in Europe. The main conclusion of such experimentation trials is that these vehicles 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.

Fuel Cell technologies may dramatically improve the driving range of these vehicles providing the operational attributes necessary to replace diesel trucks. A fuel cell truck should have the same daily operation behavior and payload as its diesel version (e.g. refuelling time), while proposing an acceptable payload in comparison with an “all-electric” vehicle.

Scope:

The topic calls for deployment and demonstration of Fuel Cell urban truck fleets, where urban truck stands for a truck having a Gross Vehicle Weight between 3.5 tons and 20 tons, which performs daily back-to-base mission within an urban area.

The project should cover the manufacturing, deployment and evaluation by real end-users in a real operating environment of a series of at least 10 urban trucks and the related infrastructure. The trucks should be deployed in at least two major European cities willing to improve their urban logistics via the utilization of innovative transportation solutions.

FC trucks

The fuel cell truck 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 in order 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 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:

- >20,000h vehicle operation lifetime initially, minimum 25,000h 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 range extender
- 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 trucks will be able to fulfill requirements for urban delivery, assuring one day of operation without refill.

- The funding per truck should be the lesser of 1500€/kW installed FC system or 300,000 €
- The minimum operational period for any truck demonstrated in the project is 24 months.

HRS

The project should also include hydrogen refuelling stations with suitable capacities to meet the operational requirements of an urban truck fleet of at least 5 units.

The challenge is to maintain high levels of station availability, identify the right level of system redundancy and ensure fuel availability during the entire year.

HRS are expected to comply with the following requirements:

- HRS are to be designed to allow for supply of at least 5 urban trucks daily for cost effective HRS operation.
- A target availability of the station of 98% (measured in usable operation time of the station providing redundancy for service and maintenance) should be adopted
- Inclusion of the HRS designs developed under earlier programmes (including the 2014 call) to show integration of concept and cost down potential of hydrogen production and storage for larger fleets as well as the potential to scale up capacity.
- 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 (target at the pump < 9 €/kg excl. taxes)

The maximum funding per HRS is 400,000 €, excluding on-site production equipment.

Overall

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.

Any event (accidents, incidents, near misses) that may occur during the project execution shall be reported into the European reference database HIAD (Hydrogen Incident and Accident Database) at <https://odin.jrc.ec.europa.eu/engineering-databases.html>.

It is recommended that the project is co-funded by national, regional or private sources in order to demonstrate a strong commitment towards clean propulsion and emission free public transport. Co-funding needs to 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 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, refuelling infrastructure operators, fuel retailers, industrial players, local and regional bodies, as appropriate and relevant to the effective delivery of the programme. The involvement of SMEs is highly encouraged. To be eligible for participation a consortium must contain at least one constituent entity of the Industry or Research Grouping.

The following TRLs are at least required:

- 6 for the mid-range trucks at start of project
- 7 for the HRS at start of project.

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: 4-5 years

A maximum of 1 project may be funded under this topic

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 other road transport applications, like trucks and vans, the uptake of FC technology and cost reduction of FC and FC system components is significantly increased.

Hydrogen refuelling stations for larger fleets of will be heavily utilised and therefore generate a bigger learning effect in comparison to underutilised stations for other applications. This is a precondition on the pathway towards commercial operation of refuelling infrastructure. It shall increase the confidence of fleet operators in reliable fuel supply and demonstrate the viability of fuel cells for trucks. Furthermore it is expected that the new fleet stations contribute to the build-up of a European-wide hydrogen refuelling network.

The project should identify and disseminate:

- Lessons learnt from implementing and operating urban 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 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

ENERGY PILLAR

FCH-02-1-2016: Establish testing protocols for electrolyzers performing electricity grid services

Specific challenge:

Initial implementations of fuel cells and hydrogen infrastructures are required in the EU to demonstrate the potential of these technologies to decarbonise energy and transport sectors. A wide portfolio of research and development actions have been carried out to reduce costs and increase efficiency, but it still remains unclear in which direction incremental improvements should move to. Then, to achieve cost reduction in the operation of electrolyzers, efforts are needed to align them with the provision of specific electricity grid services, which are going to be required by EU transmission and distribution grids due to the foreseen high penetration of renewable energy sources (RES).

Based on the study “Development of Water Electrolysis in the European Union”¹⁵ providing grid services is expected to require start-stop and dynamic operation and high efficiency across the load curve. On the other hand, future technological targets- as stated in the MAWP 2014-2020 – have overlooked the different services brought to the grid, specifically when regarding flexibility of operation and cold-hot start features.

Although the importance of dynamic operation to provide grid services is clearly stated in both documents, no special indication has been made to consider or segregate the performance of the systems depending on the specific services to be provided, the scale of the electrolyser or the load to be covered (depending on end uses for the generated hydrogen). The technical innovations required for electrolyser systems to be able to perform grid services are clearly pointed out, but also there is a requirement for economic analyses for identifying the business case advantages if electrolyzers are able to offer higher levels of response, or various combinations of service, to the electricity grid.

The challenge is not only for efforts focused on developing better components and systems able to meet the already proposed KPIs, but also to further develop and prepare benchmarks at component and system levels. Additionally, set up standardized tests to study which are the specific indicators and performance requirements for each grid service to be provided, considering the feedback from Transmission/Distribution system operators (TSO/DSO). The grid needs balancing at all levels within the electricity high, medium, low voltages network (HV, MV, LV) and with reference to the distinct variabilities caused by solar PV and/or wind power. And further that the aggregation of individual electrolyser loads can make a large contribution to grid services in a region.

Scope:

Proposals should aim to achieve the following advances:

- Benchmarking of components and assessment of improvements through a specific testing methodology specially defined to evaluate the ability of the electrolyser to provide response suitable for each possible grid service (e.g. power quality and harmonics, primary and secondary reserve, frequency regulation, voltage management and provision of VARs, RES balancing, peak shaving, avoidance of curtailment)
- Standardization of a testing protocol to evaluate the ability, regarding features, of electrolyzers to provide grid services, taking into account the design consideration of the

¹⁵ Available at: http://www.fch-ju.eu/sites/default/files/study%20electrolyser_0-Logos_0.pdf

impact of safety requirements (safety check and start-up routines) upon response times from cold and warm starts

- Establishment of power curves to be introduced for the emulation of T&D grids for electrolysers providing each grid service in relation to their features (e.g. depending on nominal and maximum power, type of technology). Characterization of different operation modes to provide each different grid service
- Benchmarking and comparison of components at state of art stack level, tested according to the standardized procedures for the provision of grid services, identifying potential improvements opportunities
- Testing power electronics, stack and balance of plant aiming at providing flexibility and rapid response to the whole system without compromising overall efficiency, safety and cost
- Defining indicators aligned with previous studies and 2020 KPIs from the MAWP, updating them to be consistent with minimum part load and dynamic targets expressed for each technology paving the way to include these capabilities in target scales for 2020 with further consideration of electrolysers of >3MW
- Defining and providing experimental evidence through the protocols tested and from feedback from end users to better define the future targets related with flexibility and/or reactivity as a function of the service provided, considering also potential degradation of the efficiency and lifetime duration (e.g. 1.5% efficiency degradation/year). Targets to be tested and proposals to redefine them will be aligned with the actual indicators of flexibility/reactivity:
 - Power factor >0.95
 - Operating range from 5 to 200% Nominal power
 - <2 seconds from minimum to maximum power
 - <2 seconds from maximum to minimum power
 - Cold start (from 0 to minimum power) in 30 seconds
- Assessment of CAPEX and OPEX considering the provision of each different, and a combination of, grid services for electrolyser components and systems (to include revenues, electricity costs, replacement and maintenance of the proposed solutions, and balancing services payments). Although proposals will contribute to update KPIs on CAPEX, OPEX to consider revenues, electricity costs, replacement, maintenance of the proposed solutions, and balancing services payments (this is, considering the case and specificities of grid services provision), applicants are expected to consider and build on MAWP targets for efficiency (48 kWh/kg for PEM and 52 kWh/kg for alkaline electrolysers) and production cost (2.0 M€/t/d for 1000 kgH₂/day of production) with no significant deviations
- Definition of a business model showing the stakeholders (including DSO/TSO, generators, consumers, electrolysers operators/owners), the interrelations and the economic flows and incentives to foster introduction of electrolysers for grid operation to provide services at different scales of the electrical network. Technical, economical, legal, environmental and social aspects will be considered to define a suitable business model, considering the differences and particularities in relation to each member state and impacting this project
- Assessment of the services with the highest potential (considering economic, technical, legal and environmental aspects) to compete or be a strong alternative in relation to other existing energy storage systems (ESS) and/or smart grid approaches considering the electrolyser size, and features as well as the possible end uses of hydrogen

- Market potential assessment to determine the best cases and countries for introduction of electrolyzers providing grid services and roadmap for implementation at EU level

The consortium should have 1 manufacturer as a partner, and both TSOs and DSOs representation in an advisory board. Preferably the advisory board should also include further electrolyser manufacturers and organisations relevant to grid services or hydrogen applications". To be eligible for participation a consortium must contain at least one constituent entity of the Industry or Research Grouping.

Projects are expected to start at TRL 4 and to reach TRL 6 regarding protocols development (not electrolyser development).

Proposals should build upon experience and results from previously funded projects both on national and/or European levels, including results from previous FCH JU projects.

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

Expected Duration: 3 years

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

Expected impact:

The project should achieve the following impacts:

- Contribute to a better understanding of the expected transient behaviour and features of electrolyzers when providing grid services and of efficiency across the load curve to manufacturers. This effort should lead to further definition of specific KPIs for dynamic operation to provide grid services
- Development of standardized tests and protocols for assessing the capability of electrolyzers to provide grid services, providing a way to compare and assess improvements for manufacturers
- Paving the way to achieve a standard performance of electrolyzers to provide grid services (using hydrogen for different end uses), showing their potential against/combined with other ESS or approaches to reinforce electrical networks and allow wide penetration of RES
- Specific performance indicators for the provision of each grid service will be defined from a clear understanding of the technical performance and economic factors
- Contribution to develop a regulatory framework for energy storage at EU and member state level including electrolyzers. Recommendations to promote the introduction of electrolyzers in grid services in RCS at EU and member state level. Contribution to develop a regulatory framework for including electrolyzers in grid services and energy storage at EU and member state level, collaborating with standardisation groups and regulators
- Provide input towards the development of a regulatory framework for energy storage at national/regional level including electrolyzers. Recommendations to promote the

introduction of electrolysers in grid services in RCS at EU and member state level. Provide input towards the development of a regulatory framework for including electrolysers in grid services and energy storage at national/regional level, collaborating with standardisation groups and regulators

- Assessment of economic quantifications of savings in operational costs for final hydrogen energy and transport infrastructures when generating hydrogen by means of electrolysers that provide grid services (e.g. generating hydrogen from curtailed energy from RES) to engage public and private financiers/operators of these installations, fostering investments in FCH installations

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-2-2016: Development of compact reformers for distributed bio-hydrogen production

Specific challenge:

There is a need to increase the share of renewable resources in final energy consumption and achieve increases in energy efficiency. In the objectives and vision of the FCH-JU, hydrogen production from low carbon sources represents a valuable possibility to promote the decarbonisation of the energy system in a sustainable way. Thus, there is a need to in the near term identify pathways leading to low-cost hydrogen production technologies with near-zero net greenhouse gas (GHG) emissions from highly efficient and diverse renewable sources.

The distributed production of hydrogen ($d/dt \text{ H}_2 < 500 \text{ Nm}^3/\text{h}$) is one of the interesting approaches to introduce hydrogen as an energy carrier in the near term. This approach requires less capital investment for the smaller capacity of hydrogen, and it does not require a substantial hydrogen transport and delivery infrastructure. Such hydrogen production will use locally available feedstock and power in compact systems.

The specific challenge is to demonstrate the potentials of alternative and sustainable utilization of biogas, bio-alcohols and other biofuels as renewable fuels for a decentralized bio-hydrogen production in the form of more compact and efficient reforming technologies.

The objective of generating renewable hydrogen from biofuels is proving different possible options for the fuel cell industry, especially for application in the distributed energy market. There is a need to have many energy sources as possible to feed different types of FC (especially SOFC, MCFC, HTPEM) with renewable hydrogen to reduce the dependence on fossil fuels and to improve the air quality (through the production of clean energy) in different parts of a country (cities, farms, industry, remote areas, etc..) with availability of biofuels.. In addition, the development of small-scale units, easily integrable with FCs, can help to revitalize the clean energy market that is of interest, i.e. for energy providers, companies that deal with materials (catalysts, components), software and hardware (control and monitoring systems).

Scope:

This topic calls for proposals to develop compact reformers that can be applied cost-effectively at small scale in the distributed production of hydrogen from biofuels. In general, the efficiency, the start-up time and the durability should be improved as well as the thermal management and the reduction of the thermal mass of the reformer. Moreover, the use of less pure renewable feedstock (e.g. clean biogas containing CO_2 and or other pollutants and contaminants) directly in the reformers is a technological aspect that can be considered to indirectly reduce the feedstock purification cost and consequently the H_2 production cost.

The reformer technology should address the following aspects:

- range: 100 – 500 kg/day H_2 , for distributed applications in farms, municipalities, small power houses
- hydrogen purity: 99,9%

- demonstrate the technical and commercial feasibility of small units (100-500 kg /day H₂) able to process renewable raw materials derived from biomass feedstock
- improve the efficiency of hydrogen production through a better heat integration of the different reformers components; flexibility to process less clean biofuels

In addition, projects should support development of optimized and more compact systems, tolerant to variable amount and typology of raw materials. Thus, the proposals should demonstrate a high degree of process/reactor improvement to decrease the total required systems volume, increasing bio-fuels conversion and hydrogen yields, moreover, achieving higher overall energy efficiencies, as well as overcome heat and mass transfer limitations to increase the H₂ production rate.

The project should demonstrate the economic feasibility of producing hydrogen to support integration of renewable biomass energy sources into the energy systems at distributed level.

The following objectives should be addressed:

- Design and construction of bio-fuels reforming units, including BoP for thermal, gas and electrical management, demonstrating the following:
 - Min - max H₂ production capacity: 100 - 500 kg/ day
 - H₂ quality : 99.9%
 - Load variation : 20-100%
 - Min cold starts: 50 / year
 - Cold start up time: < 2 h
 - Start up after stand by : 15 min – immediately
 - Reactor & system modularity
 - System size and weight: Process intensification by integration of reformer catalysts and heat exchangers and burner
 - Control hardware, protocol/algorithms improvements for stand-alone operation
- Assessment of the techno-economic performance in comparison to other state-of-the-art technologies
- Demonstration of a business plan and service strategy during the project that will be replicable and validated in the chosen market segment after the project
- Projects are expected to start at TRL 3 and to reach TRL 5.

Proposals should indicate the specific business case and development steps planning to reach higher TRLs > 6. Proposals should indicate the specific business case and development steps planning to reach higher TRLs > 6.

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

Expected duration: 4 years

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

Expected impact:

Expected outcomes from the project are to develop reactor and system design for renewable H₂ produced on-site with the following features:

- Total cost of H₂ (including CAPEX, OPEX) between 0.3-0.5 €/Nm³
- Design lifetime of at least 10 years
- Demonstration of reformer of at least 4,400 hours
- Overall efficiency on or above 80% based on higher heating value

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-3-2016: Development of processes for direct production of hydrogen from sunlight

Specific challenge:

The direct conversion of solar energy to hydrogen remains a fundamental goal for the forthcoming energy economy based on renewable sources. It is therefore important to develop new and less expensive technologies for obtaining hydrogen by water photo splitting using sunlight. These aims are fully based on the recommendations from the ongoing Green Hydrogen Study.

To bring photo-electrolysis to a commercially viable level, main efforts have so far been focused on the development of new photo-catalytic materials with high efficiencies at lower costs. Systems with relatively high efficiency are usually composed by expensive and often chemically unstable materials, while other less sophisticated systems do not yet have satisfactory yields. While benchmark materials have been established over the past few years, none of the materials is close to being optimised yet. In fact, a basic problem remains to be solved which is the development of both novel semiconductors with superior electronic properties and optimal potentials, additionally showing a high capability of absorbing the visible components of sunlight.

In order to further advance the technology towards the market, the materials research must be accompanied by development of reliable and highly flexible photo-electrolysis devices that operate at high solar-to-hydrogen-efficiencies and exhibit lower production costs. Advanced device engineering is required to maximise electrode performance, optimise the mass and current transfer characteristics, and prevent corrosion and photo-corrosion. An operative prototype with significant hydrogen production, able to consider the effect of variable solar illumination, has not been developed yet.

Scope:

Aim of the project is the development of full technology (i.e. materials selection, prototype development, techno-economical evaluation) for direct water splitting from sunlight, followed by a demonstration of up scaling and the set-up of a prototype production equipment. A photo-electrochemical approach, employing either single-photo-electrode cells or tandem cells should be followed for this purpose. A pure photocatalytic approach cannot be excluded a-priori, but it should be clearly demonstrated to be applicable for the developed system.

Goals should be obtained considering a wide variety of solids, with particular attention to cheap and chemically robust systems (e.g. metal oxides, nitrides, Si-based materials). A preliminary screening using both theoretical (band gap and band energies calculations) and experimental tools (photosensitivity, charge separation capability) is required in order to identify suitable system to be tested in a true photocatalytic apparatus.

Proposals should also aim at the development of an innovative device that is able to overcome the limitations occurring in current state-of-the-art technologies. The new cell concept should be development based on optimized photo-catalysts to be suited for large-scale production processes, as demonstrated by a prototype system.

The proposals should put their main emphasis on following topics:

- selection of materials with optimised photocatalytic properties
- proof-of-concept for a new photo-electrolysis device concept for decentralised hydrogen production
- demonstration of solar-to-hydrogen reliable and efficient conversion at demonstrator scale
- investment cost for the new technology estimated by a socio-techno-economical assessment

Projects are expected to start at TRL 3 and to reach at least TRL 5.

Proposals should build upon experience and results from previously funded projects both on national and European level on component and system development.

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

Expected duration: 4 years

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

Expected impact:

A real proof of concept and not a simple benchmarking is mandatory as a result of the project.

Expected outcomes from the project are the following:

- Full analysis (e.g. definition of materials, project of the system, BoP, effect of a variable solar irradiation, thermal management) of photocatalytic systems for direct hydrogen production from sunlight
- A prototype system with an exposed surface higher than 10 m² has to be developed with selected material, including full gas control (i.e. hydrogen and oxygen collection, purification, online analysis, storage, etc.) Optimized management of the prototype should be demonstrated
- Specific targets to be obtained by the prototype system are the following:
 - H₂ production demonstrated > 15 g/h or 10 Kg_{H₂} over the complete running time
 - Efficiency > 5 %
 - Running time > 6 months with a degradation lower than 10% under harsh operating conditions
 - H₂ cost < 5 €/kg H₂
- The materials selected and most promising should be upscaled and proved through in-field testing
- A cost analysis of the developed technology must be performed

Type of action: Research and Innovation Action.

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-4-2016: Co-generation of hydrogen and electricity with high-temperature fuel cells

Specific challenge:

High temperature fuel cells are typically used to produce power and heat from natural gas or bio-methane at high efficiency. In this process, a hydrogen containing syngas is often produced as an intermediate step.

The specific challenge of this topic is to convert part of this syngas into a hydrogen stream, while maintaining the high efficiency of the overall system. The system would thus supply power, hydrogen and possibly heat, with flexibility to modulate between these products to cope with changing demand.

The results of a project should enable the development of a distributed hydrogen production system and stationary applications.

Scope:

This topic calls for the development of a solid oxide fuel cell based system to produce hydrogen and electricity from methane rich sources (natural gas or bio-methane) with high efficiency.

- Design and construction of a prototype system, with a fuel cell stack capable to produce at least 20kg/day of hydrogen from for example natural gas;
 - with efficiency of at least 65% at the design point calculated as (kWh of DC power out + kWh H₂ out based on LHV)/(kWh NG in based on LHV);
 - With hydrogen to power modulation between 0 (only electricity produced) and 1 (50% electricity and 50% hydrogen produced).
- Testing of the system for at least 1000 hours producing electricity and hydrogen at a purity of 99.9%, including at least 5 cold starts;
- Perform a lifecycle analysis to provide CO₂ and energy footprint of the system and compare these to other relevant ways of hydrogen and power generation;
- The design, on paper, of a full-scale production unit that could supply hydrogen to a hydrogen station with 200 kg/day capacity at cost below 4.5 €/kg (fossil base) or 7.0 €/kg (renewables based);
- An investigation of how potential heat output could be used in a distributed hydrogen production situation, for example to provide cooling of hydrogen.

Consortia should include at least one SOFC technology provider with proven experience with SOFC systems, at least an equipment producer and at least one partner with experience in hydrogen station operation to ensure the whole value chain of this technology is present in the project.

Project proposals should show a clear route to market.

Projects are expected to start at TRL 4 and to reach at least TRL 6.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 4 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected duration: max 4 years

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

Expected impact:

The project is expected to demonstrate the potential for high temperature fuel cells to produce hydrogen and power at higher efficiency than conventional technologies (on-site SMR and grid power) and to bring this technology close to the demonstration stage. This is expected to lead to:

- more efficient energy use and lower cost of hydrogen production
- more energy efficient electricity grid stabilisation compared to existing technologies (mainly gas turbines)
- lower cost of grid stabilisation compared to existing technologies (mainly gas turbines) because the system is used continuously and not only as back-up

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-5-2016: Advanced monitoring, diagnostics and lifetime estimation for stationary SOFC stacks and modules

Specific challenge:

Solid oxide fuel cell technology for stationary applications is approaching the market. More and more demonstration systems are installed. One important cost aspect is the SOFC unit and its lifetime and durability, which still determine large part of the total costs. While durability studies on SOFC stacks or modules have been carried out comprehensively using advanced methodology, there is only limited monitoring of the state of the SOFC during operation in the field available or not even existing at all. That is a costly problem as the systems cannot counteract properly if a SOFC stack starts to malfunction or to degrade fatally. A stack monitoring and diagnostic methodology is therefore needed to evaluate the state of health of a working SOFC, to detect and identify critical operation, and to counteract appropriately on a system level before fatal damage has occurred on the SOFC stack.

Previous projects have proposed monitoring and diagnostic techniques for their implementation in real systems. Balance of Plant faults and stack malfunctions detection methodologies based on conventional approaches are available after the project GENIUS, which concentrated mostly on the system's component faults identification. A further advancement has been achieved by the project DESIGN towards the development of passive signal-based techniques for the identification of high fuel utilization and slow degradation phenomena. A step forward is now being accomplished by the project DIAMOND to merge conventional monitoring and diagnostics with control techniques to improve reliability and performance of SOFC. However the state-of-the-art of EU research lacks solutions and instruments dealing with SOFC degradation and prognosis for on-field advanced monitoring that may support diagnostic and lifetime tools. A step forward is required to lift laboratory oriented techniques along with theoretical and modeling studies towards a practical implementation in real SOFC systems. Moreover, several solutions developed for PEMFC (already at TRL 4) are based on advanced monitoring and diagnostic methodologies that may be applied for SOFC as well.

Scope:

The overall objective is to develop advanced, robust and cost efficient monitoring and diagnostic tools for stacks/modules in working SOFC, which are to be integrated into the system. The challenge of advancing laboratory application and complex experimental or modeling tools towards their embedding in SOFC system must be clearly addressed. Achieving these objectives will lead to improved durability and reduction of TCO (Total cost of ownership) of SOFC systems thus fostering fuel cell market penetration.

Activities will be devoted to build a new framework for monitoring and diagnostics with high accuracy and reliability. Therefore the methodologies to identify and quantify degradation phenomena are the main scope of the topic. All available knowledge on degradation, mostly exploited for laboratory use and theoretical studies, should be used to perform on-field condition monitoring analysis (e.g. state of health) for easy-to-implement and fast lifetime prediction algorithms. The proposal should also leverage the outcomes of past and on-going projects to address the following objectives:

- Enhanced understanding of stack degradation mechanisms in real operating conditions using both experimental and modelling approaches
- Identify suitable monitoring parameters at stack and system levels that indicate critical state of the SOFC stack/module within the system
- Define the most suitable and efficient monitoring and diagnostic tools with lifetime forecast functions embedded that do not add more than 3% to the total system manufacturing costs
- Development of cost-effective monitoring methods to discover fatal degradation in time to start appropriate protective actions, thereby prolonging SOFC lifetime by 5% and increase availability by 1%
- Implement the proposed algorithms in a SOFC system and perform relevant tests to demonstrate on-line the effectiveness of the developed tool

All methodologies and tools must comply with industry standards for a straightforward implementation within SOFC system monitoring and control equipment.

The activities should build on existing, available results from previous or on-going projects. SOFC systems used are expected to be at TRL 6 or higher.

TRL at start: 3

TRL at end: 5

The TRLs refer to the concerned tools for monitoring, diagnostics and lifetime estimation.

The consortium should include at least one SOFC stack/module manufacturer, research institutions and academic groups. To be eligible for participation a consortium must contain at least one constituent entity of the Industry or Research Grouping.

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

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

Expected Impact:

Proposals are expected to achieve a substantial improvement over the state-of-the-art by achieving most of the following targets:

- The most relevant degradation mechanisms in SOFC systems for specific stationary market segments have to be identified based on data for system testing and analysed with respect to impact on lifetime, such as fatal impact or slow decrease of power output (for example: redox failure, corrosion, poisoning, etc.)

- Monitoring parameters have to be identified that reveal state-of-health of SOFC stacks regarding those identified critical mechanisms
- Counter measures to prevent fatal SOFC stack failure have to be proposed, including possible regular treatments that prevent or slow-down long-term degradation
- Integration and validation of the method into a system
- It has to be shown that the added cost of the monitoring/diagnostics approach does not increase the overall system manufacturing costs by more than 3%

Type of action: Research & Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-6-2016: Development of cost effective manufacturing technologies for key components or fuel cell systems for industrial applications

Specific challenge:

Most fuel cell systems, key components like stacks, and BOP components like inverters, heat exchangers, etc., are produced in small quantities with considerable manual input. In order for mass deployment, stationary fuel cells must now achieve significant cost reductions underpinned by robust/high yield manufacturing processes at the cell, stack and system level. To reduce costs and increase quality, cost effective manufacturing technologies are required, and there is a high demand within the European stationary fuel cell sector for this type of activity to secure EU fuel cell competitiveness. This topic focuses on fundamental actions to improve production processes and scaled production for stacks, stack components, key components like BOP components, system integration, and whole systems. The aim is to develop/apply novel manufacturing technologies for industry, including for example: laser welding, coating, 3D printing, molding and casting of materials for fuel cell system components and/or stacks.

Scope:

Proposals should support development and use best in class manufacturing technologies, production processes, equipment and tooling with cost impact on, for example, stacks or key BOP components for the industrial segment. Optimised mass manufacturing processes can include automated assembly, shortened cycle times, continuous production and lean manufacturing, compatible with environmental and health standards. Thus development of production processes with fewer steps, tolerant to varying quality of raw materials, and with lower-cost materials or materials with reduced environmental or health impacts are important, as well as advanced quality control methods. Innovative technologies could also be considered to provide complex design solutions with increased performance while allowing for lower costs compared to conventional production technologies. Pilot plants are excluded.

To achieve cost reduction the project may also aim at developing industry-wide agreements for standard BoP components for FCs, including heat exchangers, reformers, converters, inverters, post-combustors, actuators and sensors. To reach this target it is necessary to establish a resilient supply chain with respect of REACH Regulation (EC) No. 1907/2006, OJ L 396, 30.12.2006, p.1 and other regulations impacting on manufacturing.

TRL at start: 4

TRL at end: 6

Consortium should include at least two manufacturers along the considered value chain, a partner specialized in manufacturing automation and/or production systems and a research institution.

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

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

Expected impact:

Projects should demonstrate how players in the fuel cell industry will enable the step-up from high cost small scale production towards lower cost higher volumes. Increased manufacturing capacity by elimination of slow processes and automation of highly manual intensive processing steps will lead to lower manufacturing costs which are the most critical factor towards real market competitiveness. Innovative manufacturing technologies could also contribute for cost reduction and reduced time to market.

The project should have the following impacts:

- Confirmation of KPI of the MAWP of at least 97% availability due to implemented quality systems in established production lines, availability shown in relevant environment
- Potential cost reduction of key components to achieve overall system CAPEX of Less than 3,000 €/kW for the industrial segment.
- Demonstrate manufacturing flexibility, by allowing reduction of time to market for new concepts by 20-30%, compared to traditional manufacturing lines and possibly address in addition to that also:
 - Demonstrate potential for cost reduction of at least 50%, compared to state of the art, once mass production is achieved

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-7-2016: Demonstration of large-scale rapid response electrolysis to provide grid balancing services and to supply hydrogen markets

Specific challenge:

The penetration of intermittent renewable electricity based on solar and wind energy increases the need to match supply and demand for power. Electrolysis is a means to convert excess electricity into hydrogen that can be stored and re-electrified at a later time, or used for other energy consuming or industrial processes. As a flexible load the electrolyser can also offer grid balancing services provided that it is of sufficient capacity and responsiveness to participate in the power industry's balancing markets.

This topic aims to demonstrate services that electrolysis can provide to the grid operator and electrolyser operation in relation to the power market price. Electrolysers need to be developed so that they are suitable for participating in grid balancing markets. For example, innovation is required to develop PEM electrolysers of much greater capacity (by approximately one order of magnitude) than the largest versions in use today. When market prices are low, extra hydrogen can be economically produced. In addition, income can be earned by electrolyser operators for providing grid services, while selling the hydrogen (and potentially oxygen) produced on the market.

The challenges are:

- Demonstration of large electrolysis units (>3 MW) using the latest available PEM or pressurized alkaline technology
- Providing grid balancing services/power demand management on a commercial basis

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 multiple grid services are required and where hydrogen can be distributed and offered for high value markets, such as e.g. industrial gases, transport fuel and power-to-gas. 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 receiving revenue by providing grid balancing services and demand management, whilst distributing and receiving revenues from hydrogen (and potentially oxygen) for high value markets.

The objective of the project is to deploy and monitor improved electrolyser systems configured to attract revenues from grid services and leveraging timely power price opportunities, in addition to providing hydrogen (and potentially oxygen) for high value markets.

The scope of the project is:

- To develop a large scale electrolyser in excess of 3MW of sufficiently rapid response time (of the order of a few seconds), to participate in the existing primary and secondary grid balancing markets. 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 fulfil, when possible, the required pressure for the hydrogen application targeted - including buffer storage needs if any - and reduce as far as possible the need for dedicated hydrogen compression units downstream. Storage and compression are not in the scope of this topic.

- To focus on the inclusion of 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 52 kWh/kg @1000+/kg for alkaline technology and 48 kWh/kg @1000+/kg for PEM technology at nominal power.¹⁶
- To demonstrate a CAPEX for the electrolyser consistent with 2020 expectations of 630 €/kW for alkaline technology and 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 benefits from grid services revenue streams and power price opportunities, as foreseen in the ongoing implementation and revision of the electricity markets. Here, the consortium will demonstrate that they are able to obtain these revenues by entering into commercial contracts with the grid operators or utilities who value these services. The value could be demonstrated also by other means that confirms the revenue potential.
- A comprehensive operation plan must be put in place. 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 grid services 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 grid operators.

The proposal will indicate the operating scenarios, the duration of production, the quantities of hydrogen produced and the use foreseen. Consortia will preferably build upon outcome from previous projects funded by the FCH-JU and on already feasible business cases, so that potential customers (transport use, industry or utility) 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.

TRL is expected to go from 6 (technology demonstrated in relevant environment) or 7 (system prototype demonstration in operational environment) to 8 (system complete and qualified).

Eligible consortia will analyse and compare the value chains for the business cases considered, such as for instance electrolyser and hydrogen technology developers, electricity grid operators, gas companies, HRS network operators, industrial hydrogen customers, utilities and energy companies. Specifically, the partnership must include strong links to:

- the necessary contractual and commercial expertise to access revenues from the grid services and/or power price opportunities

¹⁶ Water Electrolysis in the European Union (2014) (<http://www.fch.europa.eu/node/783>, reference: page 11-13)

- 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 for high value markets such as industrial gas, transport fuel or power-to-gas

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

The maximum FCH 2 JU contribution for this topic is EUR 16 million. This funding is to be allocated to 2 projects:

- One project demonstrating PEM technology of at least 6 MW. This must be achieved with either two electrolysers of at least 3 MW or one single electrolyser of at least 6 MW. The maximum FCH 2 JU contribution of this topic is 12 M€.
- One project demonstrating pressurized alkaline technology of at least 3 MW. The maximum FCH 2 JU contribution of this topic is 4 M€.

The funding includes the additional activities suggested under the scope of the topic. 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 and the electricity costs for the test phase are eligible for the funding. On the contrary, electricity costs during business operation are not eligible.

Expected duration: 4-5 years

Expected impact:

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 hydrogen for high value markets.

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

- Demonstrate feasible operation of large scale rapid response electrolysis
- Implement the necessary grid interfaces to provide grid balancing services
- The environmental performance of the system will be evaluated in alignment with the recommendations of the CertifHy project – with a particular attention to the CO₂ intensity of the hydrogen produced, which should include an understanding of the CO₂ impact of the grid services mode selected and CO₂ footprint impact in the addressed hydrogen end-user markets
- Techno-economic analysis of the performance of these systems
- Projections of the value and size of the markets addressed by provision of the grid balancing services and supply to multiple hydrogen markets
- Assessment and operation experience of the contractual and hardware arrangements required to access the balancing services and operate the electrolyser systems
- Assessment and operation experience, including safety, of the contractual and hardware arrangements required to distribute and supply hydrogen to multiple markets such as industrial gas, transport fuel and/or power-to-gas

- 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

Public-facing versions of these 'lessons learnt' reports 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 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-8-2016 Large scale demonstration of commercial fuel cells in the power range of 20-100kW in different market applications

Specific challenge:

The European energy market has to face the growth of power demand in the industrialized countries.

There are special challenges in each market applications for the commercial sector in the range of 20-100 kW where fuel cell systems can play a key role:

- Alternative power supply for these applications is mostly diesel powered and produces CO₂, noise and other emissions;
- Distributed electricity systems need more flexibility for safe operation;
- Need for high energy efficiency and power security and possible integration of renewable energy.

The Roland Berger study “Advancing Europe’s energy systems: Stationary fuel cells in distributed generations” (2015) also mentions “Whilst European power grids are still amongst the most reliable in the world, critical infrastructure providers and businesses with sensitive applications are becoming increasingly interested in decoupling the availability of electricity from the grid and becoming more independent.”

Indeed, the investment costs, availability and lifetime of the system should be comparable to conventional alternatives.

The key markets for 20-100 kW FC technology in the commercial sector are base load operations, also in CHP configuration, for small data centres, commercial and public buildings, telecommunication switching centres, signalling technique for trains and motorways, small industries, security networks and public infrastructure that need to improve power security and energy efficiency. Additionally, in the waste hydrogen segment FCs can play a key role of improving energy efficiency and additional usage of hydrogen that otherwise would not have been used.

So far, no European or national projects funded demonstration of FC systems in such power range and in such market applications.

Scope:

It is the main scope of the project to demonstrate that the FCH technology in the power range of 20-100 kW is ready to contribute to European energy challenges as energy efficiency and power security combined with significant reduction of emissions. Several European industries are active in this power range and are ready to initiate the drive to achieving economies of scale and hence significantly reduce costs enabling further roll-outs/deployment.

In such context of distributed power generation, the main objectives of the topic are to strengthen the performance and reliability of fuel cell systems in various sites in Europe. Such decentralized base load power generation with FCH technology will be implemented while respecting the European industrial requirements of related applications in commercial sector: CHP in apartment building, small industry, critical loads in small industry, security networks etc., also addressing public sector with highly controlled and conservative procurement processes.

This project includes fuel cell systems from minimum 3 different fuel cell system manufacturers in the power range of 20-100kW in order to demonstrate in minimum three countries the different technological products and compare maturity. The installed capacity will be at least 400kW in order to proof concept of scale with regards to allowing progress on standardisation, cost reduction and will address different requirements and applications to compare solutions coming from different European industries. The project will demonstrate at minimum 20 sites with one unit per site in order to demonstrate each of the manufacturers' technology in a replicable scale. Different power level units in the range of 20-100 kW will be demonstrated in the project. This will also help to increase the public awareness of fuel cell systems as a valuable alternative compared to conventional systems across Europe.

Further objectives:

- Demonstration, evaluation and optimization of new solutions and components especially at the FC stack level and/or on systems levels through field tests with improved product concepts e.g. pre-serial status as compared to previous field trials, by validating next generations of product designs.
- Demonstration through field applications of the advantages of innovative technologies (hardware or software) including, but not limited to, monitoring, control, diagnosis, lifetime estimation, new BoP components.
- Online monitoring of operating conditions, load demands and system output will provide initial data to determine the overall efficiency of the system within the project period.
- Establishment of a demonstration/commercialization pathway for European SMEs innovating in the development, manufacture and supply chain of fuel cell products by involvement of customers including distributors and end users.

Field demonstration usage data, efficiency, reliability are to be reported. Any event (accidents, incidents, near misses) that may occur during the project execution shall be reported into the European reference database HIAD (Hydrogen Incident and Accident Database) at <https://odin.jrc.ec.europa.eu/engineering-databases.html>.

The project can address one or several application segments. The project will be open to all fuel cell technologies. The project is also open for different fuel sources for the fuel cells, but hydrogen from renewable sources should be considered where possible. Electrolyser costs are not included.

TRL at start: 6

TRL at end: 7-8

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

The consortium should include at least three fuel cell manufacturers providing minimum two and maximum ten units per manufacturer and additionally relevant customers from the industrial and or commercial sector. Research institutions and academic groups could be also included. The total installed power should be at least 400kW.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 7.5 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: 3-5 years

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

Expected impact:

The suggested topic embodies the opportunity to connect substantial research (scaling models, prediction of energy needs combined with fuel-cell performance) with innovative industrial practices (system development and engineering against actual configurations). Moreover, it has high social impact, thus opening the fuel-cell research and innovation world to sectors industry or disaster recovery.

Moreover, significant attention should be paid to improvements in the technical and economic performance of the FC products including stacks, BoP components and their manufacturing.

- Reduction of CAPEX at a level of less than 6,000€/kW
- Increase of system lifetime of more than 15 years and increase of maintenance interval
- Improve of electrical efficiency of all possible applications in this topic in the range of 42-55% or CHP efficiency of more than 90%.

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.

Type of Action: Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-9-2016 Large scale demonstration of commercial fuel cells in the power range of 100-400kW in different market applications

Specific challenge:

The electrical demand in the European countries is estimated to increase to be three times the level of the year 2000 by 2020. Utility companies are facing already increasing difficulties to accommodate escalating power demands and fluctuating loads from renewable electricity sources.

The main challenges to be addressed are:

- The need for distributed power production for commercial and industrial applications for base load and redundant energy supply and as a supporting alternative to conventional central power plants.
- Need for high energy efficiency and reduction of emissions, because the alternative power supply for these applications is mostly emitting high amount of CO₂, noise and other emission
- The need for flexible power solutions supporting the further integration of renewable energy in the energy system
- Increase of energy efficiency and power security

The Roland Berger study “Advancing Europe’s energy systems: Stationary fuel cells in distributed generations” (2015) also mentions “Whilst European power grids are still amongst the most reliable in the world, critical infrastructure providers and businesses with sensitive applications are becoming increasingly interested in decoupling the availability of electricity from the grid and becoming more independent.”

The key markets are base load operations, also in CHP configuration, for data centres, commercial buildings, industries, logistics and security networks that need to improve energy efficiency and power security, and grid support.

Scope:

The goal of this topic is to provide an overarching connection in the energy landscape, based on integration of available FCH technologies for distributed power production in the evolving grid infrastructure. The project shall explicitly strengthen the European value chain for critical components such as fuel cell stack, power electronics in connection with fuel cells and remote control.

This demonstration in 100-400 kW power range will make fuel cell based distributed power production more visible in the European countries. It demonstrates that several European manufacturers of FC systems in the 100-400 kW power range are ready to initiate the drive to achieving economies of scale and hence significantly reduce costs enabling further roll-outs/deployment.

In such context of distributed power generation, the main objectives of the topic are to support the performance and technical viability of fuel cell systems implemented in various sites in Europe. Such decentralized base load power generation systems will be implemented while respecting the European industrial requirements of related applications in commercial sector: CHP in commercial buildings, industries, hospitals, airports; grid support for offering balancing services for safe

operation of electricity system as alternative to conventional power plants, in pilot plant configuration.

This project includes fuel cell systems in the power range of 100-400kW with a total installed capacity of at least 1MW. Such numbers will allow progress on standardisation, cost reduction and will address different requirements and applications to compare solutions coming from different European industries. The project also helps to increase the public awareness of fuel cell systems as a valuable alternative compared to conventional systems across Europe.

The project can address one or several customer segments. The FC system applications will be demonstrated at minimum 3 different sites in three different European countries in order to contribute to introduction of the FC technology across Europe. The project demonstrates solutions from minimum 3 different manufacturers of FC products in order to demonstrate the technological capabilities and to cooperate on mutual challenges such as standardisation and communication. The project will be open to all fuel cell technologies. The project is also open for different fuel sources for the fuel cells, but hydrogen from renewable sources should be considered where possible. Electrolyser costs are not included.

Heat and/or cooling from the CHP should also be utilized where possible to drive up the overall energy efficiency.

Project proposals should prove the readiness of fuel cell solutions for CHP applications and the possibility to roll out the fuel cell technology in that large market segment for power supply solutions, also considering eco-efficiency principles for value added and the applicability to grid support.

Further objectives:

- Demonstration, evaluation and optimization of new solutions and components especially at the FC stack level and/or on systems levels through field tests with improved product concepts e.g. pre-serial status as compared to previous field trials, by validating next generations of product designs.
- Demonstration through field applications of the advantages of innovative technologies (hardware or software) including, but not limited to, monitoring, control, diagnosis, lifetime estimation, new BoP components.
- Development of scaling models, prediction of energy needs combined with fuel-cell performance including demand side management (DSM) for dispersed energy production system including FC systems and supporting the increased share of RES
- 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.
- Establishment of a demonstration/commercialization pathway for European SMEs innovating in the development, manufacture and supply chain of fuel cell products by involvement of customers including distributors and end users.

Field demonstration usage data, efficiency, reliability are to be reported. Any event (accidents, incidents, near misses) that may occur during the project execution shall be reported into the European reference database HIAD (Hydrogen Incident and Accident Database) at <https://odin.jrc.ec.europa.eu/engineering-databases.html>.

TRL at start: 6

TRL at end: 7-8

The consortium should include at least three fuel cell manufacturers providing each a minimum of 100kW and additionally relevant customers from the commercial and or industrial sector. Research institutions and academic groups could be also included. The total installed power should be at least 1MW.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 7.5 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: 3-5 years

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

Expected impact:

The suggested topic embodies the opportunity to connect substantial research (scaling models, prediction of energy needs combined with fuel-cell performance) with innovative industrial practices (system development and engineering against actual configurations). Moreover, it has high social impact, thus opening the fuel-cell research and innovation world to industrial and utilities.

Moreover, significant attention should be paid to improvements in the technical and economic performance of the FC products including stacks, BoP components and their manufacturing.

- Reduction of CAPEX at a level of less than 6,000€/kW
- Increase of system lifetime of more than 15 years and increase of maintenance interval
- Improve of electrical efficiency of all possible applications in this topic in the range of 42-55% or CHP efficiency of more than 90%.
- The fuel cell systems should demonstrate smart grid operation – modulating power output; sales to grid at peak prices and reduction of power output at lower grid prices.
- The fuel cell systems should demonstrate heat and/or cooling utilization to drive up overall efficiency of the systems, modulating heat/power output

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. It should also confirm the readiness of the technology in the CHP market or to adjust power generation in response to grid signals from a Smart Grid and thereby provide improved stability to the grid.

Type of Action: Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-10-2016: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas

Specific challenge:

It has been estimated that 1.2 billion people globally will be without electricity access by 2025¹⁷, in addition 1 billion people are connected to unstable networks and are regularly exposed to power outages¹⁸. It may thus be considered that 2.2 billion people (i.e. around 35% of the global population) are “under-electrified”¹⁹ with a massive use of diesel generation. Indeed, with an installed diesel production capacity of 600GW²⁰, for which it has been estimated that half is installed on off-grid sites²¹, the need to reduce dependence on fossil fuels and CO2 emissions is mandatory.

Isolated areas in Europe (e.g. villages, alpine refuges or 1000s of islands) where micro-grid are present in general have high electricity generation cost. Since the production of electricity generally derives from thermal plants powered by fossil fuels, like combined cycle plants or diesel electrical plants, the cost of electrical energy is heavily dependent on the cost of these fossil fuels, their logistics and their transport. Thus, the cost per kilowatt-hour delivered to the end user is definitively higher than that associated with connection to the main network.

The need to reduce dependence on fossil fuels and to reduce energy costs has guided the investment policies of certain isolated territories in recent years so that, as an example, today numerous islands have significant renewable energy capacity or plan to invest in this sector.

However, most of these isolated territories have not yet been able to guarantee their independence from fossil fuels mainly because of renewables intermittency, thus exploitation of the full potential for energy production by their renewable energy plants is still missing.

Ultimately, RES electricity generation cost is very low. In these conditions of very cheap RES electricity, positive business cases can be built using excess or additional RES to power electrolyzers, use hydrogen as energy storage medium and reconvert hydrogen into electricity with fuel cell technology when requested by end-users.

The specific challenge of the topic is to promote in isolated micro-grid and/or off grid sites the implementation of reliable and clean integrated power solution based on fuel cell technology for:

- decreasing the use of fossil fuel and CO₂ emission;
- decreasing the cost of energy;
- adoption of RES electricity storage in chemical form (hydrogen) thus enabling wind and solar power to act as stand-alone primary energy sources, solving the intermittency issue for a better security in power supply; and
- increasing the energy supply independence.

¹⁷ McKinsey Global Institute: Disruptive technologies: Advances that will transform life, business and the global economy, p. 98

¹⁸ A.T Kearney report in collaboration with GOGLA, Investment and Finance Study for Off-Grid Lighting, June 2014

¹⁹ IEA (2012); IEA (2013)

²⁰ The Boston Consulting Group, Revisiting Energy Storage, There is a Business Case, February 2011, p. 10

²¹ Siemens Corporate Technology, June 2014, p.58

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 renewables via electrolyser.

Fuel cell technologies in the power range of 5-200 kW will be demonstrated in minimum 2 sites. Minimum 200 kW total capacity production of power will be demonstrated. Such large power range will allow to address different load requirement of isolated sites (e.g. from single homes to schools).

Existing source of renewable energy will be used, while demonstration of electrolyser of at least 500 kW and storage equipment is in the scope of the project.

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 the fuel cell-based energy storage solutions with respect to alternative technologies in terms of economics, technical capabilities and environmental benefits.

Further objectives:

- Demonstration through field applications of the advantages of innovative technologies (hardware or software) including, but not limited to, monitoring, control, diagnosis, lifetime estimation, new BoP components.
- 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 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. Any event (accidents, incidents, near misses) that may occur during the project execution shall be reported into the European reference database HIAD (Hydrogen Incident and Accident Database) at <https://odin.jrc.ec.europa.eu/engineering-databases.html>.

TRL at start: 6

TRL at end: 7

The consortium should include EU fuel cell manufacturers, relevant suppliers for BoP components and research institutions or academic groups.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 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: 3-5 years

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

Expected impact:

Following support to development of electrolysers for off-grid applications in AWP2015, this topic will focus on demonstration of integrated fuel cell-based energy storage 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 CO₂ emissions
- Reduce CAPEX towards 5,000€/kW for fuel cell systems and 2M€/(t/d) for electrolysers following the KPIs of the MAWP
- Increase system lifetime of more than 15 years and maintenance interval by new/improved components according the MAWP
- Demonstrate a viable solution and a replicable business case
- Improvement of energy security and reliability
- Supplier and user experience of installation/commissioning, operation 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 operating in reversing configuration during the duration of the Innovation Action.

Type of Action: Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-02-11-2016: MW or multi-MW demonstration of stationary fuel cells

Specific challenge:

The global development of large stationary FC goes towards multi-MW installations: examples are a 15 MW FC park in US or 60 MW FC park in South Korea as well as the announced 360 MW FC park there. Europe has a total of only 2 MW of such fuel cells installed.

Such large installations demonstrate the capability of the technology, raise needed volume for cost reduction and provide best of class total cost of ownership (TCO).

To jump-start this first commercialisation phase, the industry needs dedicated demonstrations with selected promising suppliers/technologies¹⁶ in order to clear the way for a volume increase in the market, which is concomitant to the required decrease in capital costs. This should open pathways to allow full commercial deployment with shrinking public funding, taking into account the full added values of what large FCs can offer to the European energy system.

Scope:

This demonstration activity will focus on MW or multi-MW demonstration in order to:

- Demonstrate the feasibility (technical and commercial) for MW or multi MW stationary FC's in a commercial/industrial application, also relative to the use of heat, for which the needed heat recovery equipment is included
- Demonstrate the feasibility (technical and commercial) for MW or multi-MW stationary FC in large commercial or industrial applications, also relative to process integration of heat or heat/cold.
- Establish confidence for further market deployment actions in other sectors, e.g. next demonstration of MW or multi-MW solutions for grid support
- Prepare the ground for successful implementation of European stationary MW-class fuel cell industry (technology and manufacturing settlement) and to achieve further reductions in product cost and development of the value chain
- Demonstrate the technical performance as required in a grid with large share of variable renewables.

Core features of the FC such as efficiency, cost, durability and lifetime must comply with relevant MAWP targets and the global competition; these values have been compiled on the expected impact chapter. This demonstration must not only raise public awareness; it should be used to establish confidence in technology, business models and market readiness with key customers in the food, pharma, chemical industry or other sectors. The project should be advanced with market enablers (such as utilities, leading project developers in construction and energy business) to achieve volume contracts and with financiers to assure access to project financing.

The selected project will target primarily demonstration of MW-class FC solutions in the commercial/industrial market segments integrating both of the following:

- 1 MW up to several MW capacity production of power and heat from methane (natural gas or natural gas quality gas) or hydrogen

- Integration of a FC power plant in commercial/industrial processes

The project should aim at creating partnerships between end users, industry, local SMEs, financiers and local authorities, in order to ensure that the solutions are replicable and can be supported or financed by various public or private organizations.

Therefore the project should:

- Validate real demonstration units in commercial/industrial applications with adequate visibility so that suppliers, stakeholders and end users may benefit from the experience gained throughout the value chain
- Develop and reinforce business plan and service strategy for the specific demonstrated application during the project so that it will be replicable and validated in the chosen market segment after the project

Any event (accidents, incidents, near misses) that may occur during the project execution shall be reported into the European reference database HIAD (Hydrogen Incident and Accident Database) at <https://odin.jrc.ec.europa.eu/engineering-databases.html>.

TRL start: 7

TRL end: 8

Preference will be given to proposals that demonstrate higher power levels.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 6 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: 5 years

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

Expected impact:

The project should focus on the following impacts:

- Reduce the overall energy costs
- Building and validating references to build trust among the stakeholders
- Reduction of the use of primary energy by
 - Electrical efficiency > 45%
 - Total efficiency > 70% (as an example heat cycle: 45°C/30°C, LHV)

and possibly address in addition to that also:

- Supplier and user experience of installation/commissioning, operation and use of distributed power generation
- Enable active participation of consumers in order to bring the fuel cells technology closer to their daily business
- Reduction of the CO₂ emissions with respect to the average national grid by > 10%

- Reduction of the CAPEX (no transport, installation, project management, no heat use equipment) towards < 4,000 €/kW for systems ≥1 MW 3,000-3,500 €/kW for systems ≥ 2 MW
- Reduction of the maintenance costs (full service including stack replacement) towards to < 0.05 €/kWh for systems < 2 MW and towards < 0.035 €/kWh for larger systems
- Increase the fuel cell system lifetime towards 20 years of operation (stack replacement included, as referred on the cost reduction goals)
- Demonstrate a technically and financially viable solution, including the identification of hydrogen sources (if applicable), and a replicable business case

It is envisaged that the project will also bring societal benefits such as:

- Economic growth and new jobs at the local level, including supply-chain jobs
- Great basis for further growth of the industry providing MW-class FCs
- Energy security and improved reliability

Type of action: Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

OVERARCHING TOPICS

FCH-03-1-2016: Development of innovative hydrogen purification technology based on membrane systems

Specific challenge:

Each year about 50 M ton of hydrogen is produced in majority at refineries by steam methane reforming. Most of it is purified using large pressure swing absorption systems. For a continuous flow of pure hydrogen, multiple units are required, operating in out-of-phase duty cycles, demanding a substantial investment for refineries and producing a waste fraction, normally used for heat generation. Especially at lower scale, PSA systems are not meeting cost targets (CAPEX & OPEX). For new hydrogen production methods without heat demand like biomass fermentation and for hydrogen from industrial hydrogen pipelines and underground caverns, innovative and lean hydrogen purification technologies, alternative to conventional purification technologies like PSA or cryogenic evaporation are needed.

This topic calls for proposals to develop innovative membrane based hydrogen purification methods fit for dynamic hydrogen demand at lower scale and high hydrogen purity requirements. NCNG applications are excluded from this topic.

Scope:

The scope of this topic comprises the proof-of-concept and optimization of hydrogen purification technologies that meet the purity requirements for fuel cells used in stationary and transport applications. These systems should be optimized for stand-alone operation with minimum H₂ concentration in the feed gas of 50%, used for purification from the new hydrogen production methods, delivery and storage sources.

Proposals for projects are expected to address small-scale clean-up steps of H₂ produced from new production methods.

The project(s) shall take into account the following overall technology objectives:

- Low overall energy consumption. This includes energy input, H₂ losses and energy required for re-compression to input pressure. The operational cost of purification is expected to be a small fraction of the final hydrogen cost
- Low investment cost. This includes small-scale gas clean-up and purification processes

The project should include:

- Development of a stand-alone hydrogen purification system
- Validation of the hydrogen purification technology in a relevant simulated environment
- Cost assessment of the developed hydrogen purification technology, addressing operational and installation cost of the system including the required cleaning up processes and benchmarking with the conventional PSA

Projects are expected to start at TRL 3 and to reach TRL 5.

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

Expected duration: 3 years

A maximum of 1 project will be funded under this topic

Expected impact:

A step change in installation and operational cost for a membrane based, small scale stand-alone hydrogen purification system is expected:

- The purification technology needs to show a hydrogen recovery of above 90%
- Hydrogen purity must comply with the SAE2719 or ISO 14687-2/3 standards on hydrogen quality for fuel cell vehicles, reaching a minimum of 5 N
- Output capacity (depending on H₂ purity and feed gas flow) should range between 2-5 kgH₂/day
- Energy consumption of Hydrogen purification technology should be able to achieve 5 kWh/kg H₂
- Reduction of CAPEX compared to state of art (e.g. PSA purification) to 1500€/kg H₂/day

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

CROSS CUTTING PILLAR

FCH-04-1-2016: Novel education and training tools

Specific challenge:

Education and training in the fuel cells and hydrogen sector is critical for the current and future workforce and thereby supports indirectly the commercialisation of the technology. Knowledgeable and capable workforce that understands the functioning of both technology and underlying fundamental processes, but knows also about obstacles and technological restrictions, is essential for successful development, planning and implementation of FCH plant and system technology. Apart from conventional education and training methods, education and training on FCH technology and its fundamental processes should turn towards digital based e-education and e-training methods, which become more and more used fruitful and successful in modern education methods. In addition, e-science practised by modelling and simulation of very different technological problems and issues is increasing over the past years and knowledge, and results originated by modelling and simulation are available via digital means and should be transferred to be used for education and training on FCH technologies. An envisaged challenge is the presentation of conventional technological content through modern information technology concepts, serviceable for higher education (undergraduate and graduate students) in case of educating engineers but also focusing on industry, especially SMEs, to educate and train permanent employees, or by self-study through new e-education methods and concepts.

Scope:

The scope on this topic encompasses the development of new digital based methods to educate and train undergraduate and graduate students but also technical workforce on FCH technologies and fundamental processes behind. The e-learning concept shall include new methods based on figurative language and representations to explain detailed physical and mathematical principles and FCH technique in its complex structure. Opportunities to support conventional student lessons shall be included as well as concepts for successful self-studies.

The needed IT-structure shall be built on a web-based e-learning platform backed by open access software, and shall provide free access as a minimum during project lifetime. As several e-learning platforms, databases and digital education material already exist, the e-learning platform shall link others and include comprehensive information on educational and scientific activities in FCH-thematic area to profit from. In addition, user interfaces shall be envisaged to expand the e-learning platform also to e-science, e.g. through modelling and simulation of fundamental processes but also process modelling and simulation of technological and safety aspects. International collaboration with similar activities ongoing in US, Canada and Asia will be an advantage and can 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.

Expected duration: 3 years

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

Expected impact:

- Development of new digital based methods and concepts to educate and train engineers and technicians on FCH technologies
- Inclusion of figurative language and representations to support and/or explain detailed physical and mathematical principles behind the technologies (e.g. thermodynamics of hydrogen behaviour, electrochemical behaviour of fuel cells)
- Inclusion of digital opportunities to transpose self-study on FCH technologies on different levels
- Inclusion of virtual practicing measures to educate and motivate candidates, e.g. e-learning by doing (e.g. through virtual practicing and simple demonstration tools)
- Interconnections with already existing e-learning platforms and digital training materials (e.g. digital lessons scripts, digital training materials, databases to specific data)
- Provision of freely accessible e-learning platform (e.g. web-based) implementing education and training methods and concepts developed based on open access software
- Provision of tools to maintain and update e-learning platform
- Development of a business model and structure to ensure that the e-learning platform remains a valuable asset and continues to grow after the initial project(s) is/are completed
- Supporting FCH industry by e-education and e-training of permanent staff in general
- Strengthen the community by building networks for educational and informational reasons

Type of action: Coordination and Support Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

FCH-04-2-2016: Identification of legal-administrative barriers for the installation and operation of key FCH technologies

Specific challenge:

Legal-administrative barriers are among the obstacles currently impeding a quicker deployment of fuel cell and hydrogen (FCH) technologies. These barriers, which often reflect a lack of awareness and/or acknowledgement of the key features of FCH technologies within national legal codes and local planning by-laws, along with additional bureaucracy and complex sets of procedures and requirements, can significantly hamper FCH installation and operational processes.

Promoters of projects and activities using FCH technologies are obliged to allocate substantive time and effort on overcoming legal-administrative barriers related to:

- Planning and installation / operations processes for FCH technologies (i.e. notification, registration, licensing, safety and environmental impact assessment, etc.)
- Electricity grid connections (for consumption, storage or injection of electricity derived from FCH installations)
- Gas grid connections (either for consuming natural gas for FCH power output or for injecting hydrogen into natural gas networks for load balancing and subsequent energy abstraction)
- Certification, registration, use and parking/storage of fuel cell electrical vehicles (FCEVs)
- Fuel definition – particularly related to H₂ as a transport fuel and for the dispensing of H₂ at Hydrogen Refuelling Stations (HRS) or use of H₂ in other transport related or stationary applications

Compliance is complex and time consuming and the information on the applicable procedures is difficult to identify for businesses wishing to install, operate and use FCH systems locally, nationally and internationally. In some cases rules are inexistent or uncertain as it is not clear whether rules or procedures developed for other gases and technologies will be applied to hydrogen and fuel cells by the authorities. Regulators and administrative authorities themselves have limited information about procedures and practices applied in other countries.

As a result, the development and the sustainable establishment of markets for applications using fuel cells and hydrogen technology in many European countries is unnecessarily delayed.

Scope:

There are two key objectives under the scope of the project and these should relate to barriers where a region or a Member State has a direct mandate to address the identified barrier(s). The first objective is to provide a comprehensive set applicable requirements and procedures for FCH technology installation and operation – and to make the information readily accessible and available to both those who set / regulate the requirements, processes and procedures and those wishing to install and operate the FCH technologies. It also requires measuring their impact in terms of delay and costs. Further, it is necessary to facilitate the comparison of the requirements and procedures applied in the different states and regions of Europe.

The second objective is to reduce the time and costs for compliance by preparing recommendations aiming at simplification of the requirements and procedures or facilitation of compliance.

To achieve both objectives, the action should be organised around three successive steps:

- Research and analyse administrative processes in European countries by means of both desk research and interactive industry surveys.
- Formulation of concrete recommendations, whether based on observed 'best practices' or new procedures, to be prepared in the format of an advisory paper for each country (or region). The recommendations should be publicly discussed, in particular with industry stakeholders and public authorities before being finalised
- Promotion of recommendations and improvement of the administrative framework: policy papers should be presented to relevant public authorities, utilities and other involved bodies at the national, regional and EU level. Dissemination workshops should also be organised.

In terms of geographical scope, it may not be possible to cover all EU countries and associated countries, the action should cover at least 12 of these countries and focus on those countries with largest capacity and potential for RES, linked to green and waste hydrogen production and use, providing best opportunities for deployment of FCH technologies. In countries where regions play an important role in defining administrative requirements and procedures applicable to FCH technologies, the analysis and the recommendation should include the regional level.

The consortium should include a strategy to ensure the continuity of the activities after the end of the FCH JU funded action. This strategy should ensure that the database continue to be available and be updated after the end of the action. It should also ensure that the policy papers and the associated recommendation continue to be promoted.

The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 1.0 million allow the specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Expected Duration: 2 years.

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

Expected Impact:

- An online and publicly available database of legal and administrative processes in main EU countries with a focus on those countries where the deployment of FCH technologies are the most advanced .and, to the extent possible, on all 12 selected EU and associated countries. The database should also enable the comparison of the different administrative frameworks and their implication in terms of costs and delays. Reference example databases include <http://www.pvgrid.eu/database.html>; <http://www.pvlegal.eu/>; and <http://www.pvgrid.eu>
- Policy papers country by country in English and the relevant national language describing the administrative barriers and their effect in terms of delay and cost as well as recommendation for removing/reducing these barriers
- Constitution of a network a national associations/experts, well-coordinated and equipped with the necessary information and able to support maintenance and update of the database and promotion of policy papers

Type of Action: Coordination and Support Action

The conditions related to this topic are provided in the chapter 3.2 and in the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

B. Collaboration with JRC

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 is under finalization and subject to approval by the Governing Board. 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 2016, 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, to be approved by the Governing Board of the FCH 2 JU, will list the activities, the expected outcomes/deliverables and the estimated resources necessary for each activity. The activities will be subject to monitoring against agreed key performance indicators.

The rolling plan 2016 constitutes the structure for all future rolling plans. Therefore it is expected that the planned resources as well as the interaction mechanisms with the FCH 2 JU Programme Office will be reviewed, improved and refined during its implementation.

Conditions for the Call

Call identifier: **H2020-JTI-FCH-2016**

Total budget²²: EUR 117.5 million²³

Estimated Publication date: 19 January 2016

Estimated Deadline: 03 May 2016

²² 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.

²³ The 2016 Call for Proposals has a total indicative amount of EUR 117.5 M€ of which EUR 103,9 M € from 2016 Commitment Appropriations for operations and EUR 13.6 M€ reactivated unused commitment appropriations from year 2015 resulting mainly from the outcome of the Call 2015 evaluations.

Indicative budgets:

Topic	Type of action	Indicative budget (million EUR)
1. TRANSPORT PILLAR		
FCH-01-1-2016: Manufacturing technologies for PEMFC stack components and stacks	Research & Innovation (RIA)	20
FCH-01-2-2016: Standardisation of components for cost-efficient fuel cell systems for automotive applications	Research & Innovation (RIA)	
FCH-01-3-2016: PEMFC system manufacturing technologies and quality assurance	Research & Innovation (RIA)	
FCH-01-4-2016: Development of industrialization-ready PEMFC systems and system components	Research & Innovation (RIA)	
FCH-01.5-2016: Develop new complementary technologies for achieving competitive solutions for marine applications	Research & Innovation (RIA)	
FCH-01-6-2016: Develop new complementary technologies for achieving competitive solutions for rail applications	Research & Innovation (RIA)	
FCH-01-7-2016: Improvement of compressed storage systems and related manufacturing processes in the perspective of automotive mass production	Research & Innovation (RIA)	
FCH-01-8-2016: Development of innovative hydrogen compressor technology for small scale decentralized applications for hydrogen refuelling or storage	Research & Innovation (RIA)	
FCH-01-9-2016: Large scale validation of fuel cell bus fleets	Innovation (IA)	37
FCH-01-10-2016: Validation of fuel cell urban trucks and related infrastructure	Innovation (IA)	
2. ENERGY PILLAR		
FCH-02-1-2016: Establish testing protocols for electrolysers performing electricity grid services	Research & Innovation (RIA)	16
FCH-02-2-2016: Development of compact reformers for	Research &	

distributed bio-hydrogen production	Innovation (RIA)	
FCH-02-3-2016: Development of processes for direct production of hydrogen from sunlight	Research & Innovation (RIA)	
FCH-02-4-2016: Co-generation of hydrogen and electricity with high-temperature fuel cells	Research & Innovation (RIA)	
FCH-02-5-2016: Advanced monitoring, diagnostics and lifetime estimation for stationary SOFC stacks and modules	Research & Innovation (RIA)	
FCH-02-6-2016: Development of cost effective manufacturing technologies for key components or fuel cell systems for industrial applications	Research & Innovation (RIA)	
FCH-02-7-2016: Demonstration of large-scale rapid response electrolysis to provide grid balancing services and to supply hydrogen markets	Innovation (IA)	40
FCH-02-8-2016 Large scale demonstration of commercial fuel cells in the power range of 20-100kW in different market applications	Innovation (IA)	
FCH-02-9-2016 Large scale demonstration of commercial fuel cells in the power range of 100-400kW in different market applications	Innovation (IA)	
FCH-02-10-2016: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas	Innovation (IA)	
FCH-02-11-2016: MW or multi-MW demonstration of stationary fuel cells	Innovation (IA)	
3. OVERARCHING PROJECTS		
FCH-03-1-2016: Development of innovative hydrogen purification technology based on membrane systems	Research & Innovation (RIA)	2
4. CROSS-CUTTING		
FCH-04-1-2016: Novel education and training tools	Coordination and Support (CSA)	2.5
FCH-04-2-2016: Identification of legal-administrative barriers for the installation and operation of key FCH	Coordination and	

technologies	Support (CSA)	
TOTAL		117.5

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.

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.

Dissemination and information about projects results

Activities will progress 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).

Data collection both within and beyond the activities of the FCH 2 JU will enable to obtain a global view of FCH-related activities and advances, such as mapping and updating of FCH facilities worldwide and collecting credible figures of the number of vehicles deployed.

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.

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– 2017²⁴ (with the exceptions introduced in this work plan, see below).

Evaluation criteria, scoring and threshold: The criteria, scoring and threshold are described in part H of the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

Evaluation Procedure: The procedure for setting a priority order for proposals with the same score is given in part H of the General Annexes to the Horizon 2020 Work Programme 2016– 2017.

As part of the Panel Review, hearings will be organised for Innovation Actions (IA) proposals.

The full evaluation procedure is described in the relevant H2020 **guide for participants**²⁵ as published on the Participant Portal.

Eligibility and admissibility conditions: The conditions are described in parts B and C of the General Annexes to the Horizon 2020 Work Programme 2016– 2017. The following **exceptions** apply:

- 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 members²⁶ 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

²⁴ http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016-2017/annexes/h2020-wp1617-annex-ga_en.pdf

²⁵ http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/pse/h2020-guide-pse_en.pdf

²⁶ 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.

Grouping is among the participants in the consortium. These topics should relate to topics of strategic importance of horizontal nature: Large demonstration and overarching 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:

Topic FCH-01-4-2016: Development of Industrialization-ready PEMFC systems and system components

The topic presents a major milestone on the FC system cost reduction roadmap to 2020. It is fundamental that the findings, challenges and successes reached during the project are continuously fed back to the industry and research groupings such as to validate (or contradict) the initial hypothesis of the roadmap, thus allowing the necessary adjustment.

A participating member of the industry and/or research groupings will take over the task of transmitting this feedback to the yearly discussion of the AWP, thus allowing a better match between allocations of resources for the specific technology challenges.

Topic FCH-01-9-2016: Large Scale Validation of fuel cell bus fleets

This topic is considered of major strategic importance for the success of the commercialization of FC buses and successful introduction of FC technology in the transport sector. A coordinated approach involving Hydrogen Europe members will ensure that lessons learned from previous projects are taken into account, as well as provide a clear pathway for incorporation of the innovation into the commercial deployment members have committed to.

Topic FCH-01-10-2016: Validation of fuel cell urban trucks and related infrastructure

Topic 1.10 is considered to bring a great deal of experience in a strategically important segment of the H2 transportation sector. Participation from at least one member of Hydrogen Europe and of N.ERGHY will enable the proper exploitation of results related to both business and technical activities thus creating the background necessary to trigger and support the full commercialization phase.

Topic FCH-02-1-2016: Establish testing protocols for electrolysers performing electricity grid services

The topic is a continuation and integration of several activities and development already achieved or running through the FCH 2 JU programme. Specifically it is linked to both technology improvements and standardization issues.

Compliance with technical 2020 KPIs in MAWP and the study “Development of water electrolysis in the European Union” in what concerns to the provision of grid services (e.g. ramp-ups, warm start-up, cold start-up, standby, etc) is a necessary condition.

Considering the necessity of networking both for the technical targets and for the sharing of knowledge and results, this additional condition for participation, will be a relevant issue to track the project and its support to the MAWP and KPIs of the FCH JU. Support to the development of a

European regulatory framework for energy storage at EU and member state level including electrolysers will be eased.

Topic FCH-02-5-2016: Advanced monitoring, diagnostics and lifetime estimation for stationary SOFC stacks and modules

The topic shall leverage results achieved for SOFC by projects ran within the FCH JU programme. It aims also at transferring to SOFC systems key methodologies already developed for PEMFC and available from previous initiatives and projects supported by the JU. Participation of a member of Hydrogen Europe and/or N.ERGHY shall maximize the exchange between different application areas by sharing technical know-how and can guarantee the proper vision as well as a commitment towards implementation of results on the next generation of SOFC.

Topic FCH-02-7-2016: Demonstration of large-scale rapid response electrolysis to provide grid balancing services and to supply hydrogen markets

The proposed project is in direction of upscaling action. The proposal will indicate the operating scenarios, the duration of production, the quantities of hydrogen produced and the use foreseen. Consortia will preferably build upon outcome from previous projects funded by the FCH JU and already feasible business cases, so that potential customers (transport use, industry or utility) do not discontinue the use of the installation after project end, but on the contrary support continued market roll-out efforts.

Participation of at least one member from Hydrogen Europe and/or N.ERGHY will allow a sound continuity across the developments concerned in this area. Furthermore, it will also contribute to strengthen the efforts aimed at improving the competitiveness of the European stakeholders.

Topic FCH-02-8-2016: Large scale demonstration of commercial fuel cells in the power range of 20-100kW in different market applications

Technology assessment, business and market readiness, public awareness and authorities' actions are central issues to establish a proper demonstration of stationary fuel cell technologies. The participation of Hydrogen Europe and/or N.ERGHY representatives shall maximize those achievements through the strengthened exchange of information between the sector players (through presence of members). Moreover Hydrogen Europe and N.ERGHY participation shall help avoiding duplication of effort with other activities performed outside the FCH 2 JU and can contribute to a maximum coherence of the overall European technology investment and a maximum impact of the EU funding.

For innovation activities in the transport applications, an additional eligibility criterion has been introduced to limit the FCH 2 JU requested contribution, as follows:

Topic FCH-01-9-2016: Large Scale Validation of fuel cell bus fleets

The maximum FCH 2 JU contribution that may be requested is EUR 32 million. This is an eligibility criterion – proposals requesting FCH 2 JU contribution above this amount will not be evaluated.

Topic FCH-01-10-2016: Validation of fuel cell urban trucks and related infrastructure

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.

Technology Readiness Level (TRL) definitions are provided in the part G of the General Annexes to the Horizon 2020 Work Programme 2016– 2017. 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)²⁷ requirements have been also introduced.

There is no derogation from the H2020 Rules for Participation.

²⁷ 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](http://www.nrel.gov/hydrogen/pdfs/45406.pdf)", [National Renewable Energy Laboratory, United States Department of Energy](http://www.nrel.gov/hydrogen/pdfs/45406.pdf), available at <http://www.nrel.gov/hydrogen/pdfs/45406.pdf>

3.4. Support to Operations

Communication and events

A. Communication objectives

In line with the FCH2 JU new Communication Strategy to be adopted by the Governing Board by year-end 2015, the communication activities aim at 2 main objectives as follows:

1) Raising the FCH 2 JU Programme's profile

OBJECTIVES	Increasing the visibility and reputation of the organisation for stronger support amongst European and national decision makers; and to mobilise applicants. Facilitating access to complementary public funding resources (European and National levels) to bridge the gap between research and deployment
TARGET GROUPS	European and National decision-makers (Parliament, EC, Permanent Representatives, CoR COTER and CoR ENVE), FCH 2 JU members, potential applicants, and new stakeholders, European and national funding bodies
FOCUS AREA FOR MESSAGES	<ul style="list-style-type: none"> • Benefits of the public -private partnership model in the FCH sector as an effective way for European intervention to overcome current obstacles and to coordinate R&D activities • FCH JU achievements and successes • Benefits of participations in FCH JU projects • FCH 2 JU funding rules • Benefits of joining forces for complementarity of calls
CHANNELS	<p>High-level meetings with national and European policy-makers; participation to specific events and organisation of info-days. Joint-workshops with EU programmes, workshop on Smart Specialisation for regional involvement, meetings with financial actors.</p> <p><i>Weekly updating of the Website with events calendar, projects updating etc.</i></p>

2) Highlighting technology potential and market readiness

OBJECTIVES	Demonstrate the added value of hydrogen and fuel cell technologies in addressing economic, social and environmental concerns of EU citizens.
TARGET GROUPS	Specific audiences will be selected depending on the sub-sector (public transport authorities, bus operators, renewable and energy associations, utilities, decentralised heating operators, NGOs)
FOCUS AREA FOR MESSAGES	<ul style="list-style-type: none">• Success of FCH JU demonstration projects• Potential of the technology to address specific societal and environmental challenges• New studies outcome (three hot topics will be highlighted through publication of new studies: energy storage, Micro CHPs and FCE buses)
CHANNELS	New channels (specifically social media), active mailings and taking contacts with newly identified audiences (mailings, press releases to specific blogs and media), attendance to specific events and exhibition organisation to highlight the tangible aspect.

B. 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 2016, the FCH 2 JU will develop a communication plan including a detailed event list.

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) International Transport Forum Summit 2016 – Leipzig

Being the only global body that covers all transport modes, this intergovernmental organisation will organise its 2016 Summit under the theme “Green and Inclusive Transport” and will focus on three elements: economic growth, inclusiveness, and the environment.

2) European Sustainable Energy Week

The FCH 2 JU will reiterate its participation to the EUSEW 2016 to tap into crucial Energy topics by demonstrating the added value of its program, while building on the 2015 experience.

FCH 2 JU Stakeholder Forum (SF)

The SF is a body of the FCH 2 JU (see section 4.5 Governance). In 2016 an analysis will be carried out aiming at assessing the feasibility to develop the role of the SF as a communication vehicle by considering reshaping its format and attracting new audiences as appropriate.

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 2016 edition, the sixth edition of the PRD, will be organized in Q4.

Events targeting regional authorities

In 2016, communication activities focusing on smart specialisation with regions will build on the knowledge acquired and the output of first Smart Specialisation workshop, organised in May 2015 by the FCH 2 JU.

C. Concrete actions

For the channels

The FCH 2 JU will further develop its existing channels for a better reach-out and efficient information dissemination. In that respect, new material will be made available on its website and a strategic use of social media will be done with the purpose of increasing circulation to the FCH 2 JU website.

The FCH 2 JU website will develop specific pages for the purpose of informing on the technology advantages.

Achievement will be measured by the following indicators:

- Adoption of the 2016 communication plan
- Level of implementation of the plan

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 2016 special focus will be put on the following:

- Development and implementation of procurement plan for administrative activities;
- Join new interinstitutional procurement procedures planned among others in the field of IT;
- Launch procurement procedures in the field of communication activities;
- Follow-up on implementation of ongoing administrative contracts and operational studies;
- Financial and administrative management of procurements;
- Improvement of internal monitoring system (contract database);
- Update the templates and model contracts to take into account new legal base and financial rules;

- Procure a contract for an independent auditor for the annual accounts (see also section on ECA audits).

The table below provides a summary of the tenders planned for 2016 (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 <i>Indicative</i>
Team building/training activities	10,000	Negotiated procedure for low-value contracts	Q3
Catering (for meetings, local workshops...)	10,000	Negotiated procedure for low-value contracts	Q2
Event organisation support (such as SF, PRD...)	134,000	Negotiated procedure	Q3

Achievement is measured by the following indicators:

- Level of implementation of the procurement plan

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.

Main activities include the following:

- Ensure adjustment of IT tools (ABAC/ FP7 and H2020 IT tools) to the FCH 2 JU needs (expansion, upgrade, etc...);
- Participate in coordination meetings with the CSC and other JUs and take action on the adjustments needed to allow and ensure smooth functioning of Horizon 2020 tools;
- Support to the internal and external users, in particular through the following services:
 - Technical support on the FCH 2 JU technology monitoring and assessment platform TEMONAS;
 - Assistance in public communication channel (communication campaign, events, and website);
 - Follow-up and monitor implementation of the contract with IT supplier, notably service delivery plan for the JUs' shared infrastructure and the FCH 2 JU IT specifics;
 - Monitor stability of the dedicated IT system M-Files (document management system) and ISA (information system for absences);

- Ensure maintenance, upgrades and security of the FCH 2 JU equipment's;
- Chair the common IT Governance committee of the JUs

In 2016 special focus will be put on the following:

For the JUs common infrastructure

- Ensure the smooth handover of the telephony services with the new service provider under the EC framework contract;
- Prepare a strategy and business case for the replacement of the equipment of the JUs common IT infrastructure;
- Implementation of a backup-as-a-service (BaaS) solution, i.e. online backup system, in order to improve the backup strategy of the JUs and the recovery point objective serving the requirements of the business continuity planning;
- Transfer of the TESTA network infrastructure to the new provider under the corresponding EC framework contract (postponed from 2015 linked to contractor's constraints);
- Alignment of software licenses (initially purchased in 2011) with the actual situation of headcount and repartition key.

For the FCH 2 JU

- Further enhance in-house tools for reporting and monitoring (TEMONAS and contract database);
- Continue to deploy the full set of workflows offered by COMPASS/SYGMA in combination to the specific FCH 2 JU document management system;

Achievement is measured by the following indicators:

- Compliance by contractors/ service providers with the service level agreements and overall stability of all systems;
- Users' feedback through satisfaction survey

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.

In 2016 the new Executive Director is expected to be appointed by the GB (see governance section).

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.

Main activities include the following:

- Contribute to the overall FCH 2 JU staff strategy and planning processes;
- Develop/update HR policies, rules and procedures (including implementation, monitoring and review);
- Monitor adequacy of staff resources in relation to activities;
- Launch and follow-up recruitment procedures efficiently to ensure filling of full establishment plan;
- Identify training needs and promote professional development through learning and development opportunities;
- Carry out annual Reclassification Exercise;
- Facilitate social contact between staff;
- Promote internal communication;
- Inter-JU (Joint Undertakings) cooperation in HR field.

In 2016 special focus will be put on the following:

- Develop and implement the learning and development plan taking into account the outcome of the appraisal dialogues and aiming at ensuring adaptation of staff skills and competences to efficiently implement the Programme office mission and tasks;
- Revise HR policies and procedures to align them to the new legal environment, in particular to the new implementing rules;
- Continue to promote good internal communication and positive team atmosphere;
- Election of a new staff committee;
- 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);
- Improve together with the other Joint Undertakings internal tool for time-recording (ISA);
- Regularly review and maintain up to date the manual of procedures.

Achievement is measured through the following indicators:

- Vacancy rate;
- Performance against work plan;
- Coordination level with other JUs;
- Feedback from staff.

Administrative budget and finance

The main objective for **Finance and Budget** is to ensure a sound financial management of the Programme Office resources. In addition, **financial engineering** will provide support to the deployment of FCH technologies by facilitating the access of the FCH industrial and research community to other sources of funding.

Main activities include the following:

- Allocate budget resources in line with planned activities; Establish the necessary commitments to ensure the timely availability of resources for the smooth implementation of all operational and support activities; Execute the necessary payments for services and goods delivered; Provide financial analysis and financial management support to the operational unit;
- Monitor budget execution and report to the Executive Director and Governing Board;
- Revise the FCH 2 JU Financial Rules to align them to the revised model of Financial Rules for PPP and submit them for GB approval;
- Update multi-annual budget forecast and report to the Governing Board;
- Monitor changes in the Financial Regulations and related rules and implement them as required.

In the context of raising FCH 2 JU Programme's profile (see strategic objective of communication under section 4.4.A.1):

- Development of the **financial engineering** function

In 2016 activities will focus on the following:

- Preparation of 2017 estimate of revenues and expenditure in liaison with Commission services;
- Ensure efficient budget monitoring through optimal use of tools and close follow-up with operational initiators;
- In liaison with the Programme Unit, closely monitor projects' implementation to ensure that deadlines are respected;
- Ensure efficient implementation of new financial procedures adopted in 2015.

In relation to financial engineering:

- Map more systematically the FCH activities and identify most active regions with which closer partnership can be developed;
- Draft a guidance note on combination of FCH 2 JU and other funding;
- Use FCH 2 JU studies (e.g. ongoing studies on FC buses joint procurement, H2 for energy storage and stationary FC) as platform to discuss combination of funding (public-public or public-private);
- Providing customised support to consortium partners for setting up complex project and/or combine FCH 2 JU funding with other sources of funding.

Achievement is measured through the following indicators:

- Level of budget execution;
- Timeliness of payments;
- Number of exceptions (deviations from rules and procedures) recorded;
- Feedback on quality of input and advice;
- Recognition by stakeholders of FCH 2 JU role in financial engineering.

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 45/2001, “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 2016 the following actions will be taken:

- Continuation of the awareness raising and training for staff 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;
- Ensure cooperation with the EDPS: In 2015 the FCH 2 JU was asked by the EDPS to provide its input in the general monitoring exercise 2015. This input will be used to help compile a general report on the level of compliance with the Regulation by all institutions and bodies. The FCH 2 JU data protection officer will take note of the said report and ensure any necessary action is implemented;
- Ensure continuous update of the legal basis and provisions of FCH 2 JU’s data protection notifications and privacy statements;
- 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 as well as any change in the regulatory framework

3.5. Governance

The **Governing Board (GB)** is the main decisions-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 NEW Industry Grouping and 1 representative of the NEW European Research Grouping. The GB is planning to hold three meetings during 2016. In addition, monthly briefings by teleconference between GB members and the FCH 2 JU Programme Office will be held for information purposes.

The key activities of the GB for the 2016 are listed below:

Key activities in 2016 – timetable	
Appoint the new FCH 2 JU Executive Director	Q1
Approve the lists of proposals to be selected for funding	Q3
Adopt the AAR 2015 and its assessment by the GB	Q2
Adopt an opinion on the final accounts 2015	Q2
Adopt the AWP & Budget/SEP 2017	Q4

Approve the 2017 Additional Activities plan	Q4
Approve the 2014-2015 Additional Activities report	Q2

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 2016.

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 two meetings in 2016.

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 SF will take place in Q4 2016 (see also communication section 4.4.B).

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.

Main activities include the following:

- Ensure awareness and implementation of internal control processes and standards;
- Assess the effectiveness of the internal control system;
- Report on compliance and effectiveness in the mid-year management report and annual activity report;
- Carry out periodic review of risks at least yearly in the context of preparing the annual work programme;
- Ensure coordination of the drafting of the Annual Activity Report;
- Coordinate visits of the European Court of Auditors;
- Liaise with the IAS auditors;

- Follow-up on implementation of action plans on audit recommendations and on observations of the discharge authority.

In 2016 focus will be put on the following:

- Further to the risk management exercise carried out in October 2015 ensure a specific follow up of the actions to mitigate/reduce the main risks identified;
- Following the internal control awareness session of December 2015, follow up on requirements stemming from the Internal Control Standards (ICS) update and monitor the timely implementation of the action plans;
- Carry out the annual assessment on the level of implementation of Internal Control Standards;
- Monitor the implementation of the actions plans on audits and of the measures and responses to the observations of the discharge authority.

Financial procedures

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

In 2016 focus will be put on the following:

- Effective implementation of the newly developed procedure on the technical reviews for FP7, including considerations for procedure on the technical reviews for H2020;
- Active communication and cooperation with the Common Support Centre (CSC) for the H2020 newly developed financial procedures with focus on their adaptation to FCH 2 JU environment;
- Ensure implementation of the common anti-fraud strategy of the Research family adopted on 18 March 2015 by the CSC.

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 a desk review (performed by FCH 2 JU project, finance and legal officers); mid-term review 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.

Main activities include the following:

- Generate and check grant agreements;
- Initiation, check and verification of invoices for administrative expenditure;

- Assessment of periodic reports from grants -if necessary with the assistance of external experts (mid-term reviews)- verification and payment of cost claims.

In 2016, specific attention will be placed on:

- 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;
- Strengthen cooperation with CSC concerning information campaigns for H2020 rules for FCH2 JU beneficiaries;
- Organize a financial workshop on H2020 financial reporting;
- Further implement the FP7 communication campaign on how to avoid errors in cost reporting by organizing one dedicated session.

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 FP7 grants include financial audits which are carried out by external audit firms.

Main activities include the following:

- Management of FP7 ex-post audits of beneficiaries through a Framework Contract with external audit firms;
- Implementation of the FP7 ex-post audit strategy - new 'representative' and 'risk-based' audits will be launched to ensure appropriate audit coverage of cost claims validated.

In 2016 focus will be put on the following:

- Liaise with CSC on the recent developments of the methodology for the H2020 (audit strategy, audit programmes 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 establishment of working arrangements "FCH 2 JU – CAS" for the effective management of H2020 ex-post audits;
- Signature of a new specific contract for FP7 with external audit firms, launching new batch(es) of representative and risk-based audits, ensuring sufficient coverage for the declaration of assurance.

Audits

IAS audits

Internal audits are carried out by Internal Audit Service of the European Commission (IAS) in liaison with Internal Audit Capability (IAC).

In 2016 focus will be put on the following:

- Follow up on the action plan regarding IAS audit report on evaluation and selection process of H2020 grant proposals (report expected in November 2015);
- Coordination of the internal audits launched by the IAS as per the strategic internal audit plan for 2015 – 2017.

In particular, regarding the action plan on the IAS audit report, in 2016 a procedure for the selection of the grant topics will be developed and formal approval by the GB will be sought.

ECA audits

In 2016, the FCH JU will:

- Contract, following a procurement procedure, an independent auditor to audit FCH 2 JU accounts as required by the revised General Financial Regulation (after adoption of FCH 2 JU revised Financial Rules);
- Liaise with ECA on the smooth transition from the annual audits performed by ECA to audit performed by an external firm, as per requirements of the new procedure;
- Follow up and implement the recommendations made in ECA reports on the FCH 2 JU annual accounts.

Achievement is measured by the following indicators:

- Degree of implementation of action plans (on audit recommendations, on effective implementation of ICS);
- Compliance with JU's deadlines established in the framework contract for ex-post audits;
- Auditee's feedback.

4. BUDGET YEAR 2016

4.1. Budget information

The draft budget 2016 is in line with the preliminary budget presented in the Fiche Financière, with the draft budget sent to GB members on 18 May 2015 and with the FCH 2 JU multi-annual budget 2014-2024 presented to the Governing Board in April 2014 except for the following two elements:

- 1) Due to the impact from the adjustment of the EFTA contribution from 2.94 % (initial assumption in the Fiche Financière) to 2.73 % (final EFTA rate for 2016), there is a total reduction of:
 - i) 216,460 € in commitment appropriations (214,549 € from operational expenditure and 1,911 € from administrative expenditure²⁸) and
 - ii) 101,333 € in payment appropriations (99,422 € from operational expenditure and 1,911 € from administrative expenditure).
- 2) Reactivation of 13,684,458 € of unused commitment appropriations from operations from year 2015, resulting from the outcome of the call 2015 evaluations. These appropriations will be used for 2016 operational activities.

An amount of 1,491,547 € is proposed to be re-introduced in the 2016 budget. This amount refers to unused appropriations from EC contribution for administrative costs under FP7. This introduction will have no impact on the remaining EC cash contribution under FP7 for which the total amount agreed remains unchanged, except for a different breakdown between 2016 and 2017 as reflected in the following table:

	2016	2017	Total
EC	272, 620	1,744, 619	2,017,239
Adjustment	1,491,547		1,491,547
IG	2,200,384	2,009,579	4,209,963
RG	366,731	334,931	701,662
Total revenues	4,331,282	4,089,129	8,420,411
Total expenses	4,331,282	4,089,129	8,420,411

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 2016 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.

²⁸ EC contribution to administrative costs I reduced by 955 €.
IG contribution to administrative costs is reduced by 822 €.
RG contribution to administrative costs is reduced by 134 €.

Title Chapter Article Item	Heading	Budget 2014 CA (executed)	Budget 2014 PA (executed)	Budget 2015 CA (amended budget 2)	Budget 2015 PA (amended budget 2)	Budget 2016 CA	Budget 2016 PA	Remarks
2001	European Commission subsidy for operational expenditure (FP 7)		67,364,463	0	34,672,477		55,455,900	Council Regulation of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking
2002	European Commission subsidy for administrative expenditure	2,014,780	2,014,780	2,293,402	2,292,250	739,988	739,988	Council Regulation of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking includes EFTA (2.94% in 2015 and 2.73% in 2016)
2003	Industry Grouping contribution for administrative expenditure	2,315,244	2,025,881	2,588,692	2,587,701	2,602,321	2,602,321	Council Regulation of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking
2004	Research Grouping contribution for administrative expenditure	384,870	336,643	429,847	429,685	432,163	432,163	Council Regulation 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)	96,154,620		112,322,123	29,915,275	104,955,460	48,637,500	Council Regulation of 6 May 2014 on the establishment of the Fuel Cells and Hydrogen 2 Joint Undertaking includes EFTA (2.94% in 2015 and 2.73% in 2016)
2006	JTI revenues	849,363	849,363	0	0	1,491,547	1,491,547	Interest, income from liquidated damages & others
	sub total title revenues	101,718,877	72,591,129	117,634,064	69,897,389	110,221,478	109,359,418	
3003	C2 reactivation of appropriations (2011)	97,562		0	0			FCH Financial rules articles 10 and 11- de-committed CA for operational activities re-entered to be used for operational activities
3004	C2 reactivation of appropriations (2012)	10,663,113	23,822,819	0	0			FCH Financial rules articles 10 and 11- de-committed CA for operational activities re-entered to be used for operational activities
3005	C2 reactivation of appropriations (2013)	384,800		0	0			FCH Financial rules articles 10 and 11- de-committed CA for operational activities re-entered to be used for operational activities
3006	C2 reactivation of appropriations for administrative expenditure (2014)			0	861,996			FCH 2 JU Financial rules article 6 - unused PA for administrative costs re-entered to be used for running costs
3007	C2 reactivation of appropriations for operational expenditure (2014)			13,948,227	23,328,170			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)							FCH 2 JU Financial rules article 6 - unused PA for administrative costs re-entered to be used for running costs
3009	C2 reactivation of appropriations for operational expenditure (2015)					13,684,458		FCH 2 JU Financial rules article 6 - de-committed CA for operational activities re-entered to be used for operational activities
	sub total reactivation	11,145,475	23,822,819	13,948,227	24,190,167	13,684,458	0	
	TOTAL REVENUES	112,864,352²⁹	96,413,948	131,582,290	94,087,555	123,905,936	109,359,418	

²⁹ Compared to FiFi2016, JTI budgeted revenues (50,000 €) and carried forward from 2012+2013 (698,821.43 €) are not included, whereas liquidated damages and bank account interests (73,386.29 €) are included.

The FCH 2 JU 2016 budget amounts to a total of 123,905,936 € in CA and 109,359,418 € in PA with the following breakdown:

Title Chapter Article Item	Heading	Executed 2014		Financial year 2015		Financial year 2016		Ratio 2014/2016	Ratio 2014/2016	Comments
		Commitment appropriations (committed)	Payment appropriations (paid)	Commitment appropriations (amended budget 2)	Payment appropriations (amended budget 2)	Commitment appropriations (CA)	Payment appropriations (PA)	Commitment appropriations (CA)	Payment appropriations (PA)	
1	STAFF EXPENDITURE									
1 1	STAFF IN ACTIVE EMPLOYMENT	2,365,170	2,310,136	3,056,085	3,111,119	3,032,773	3,032,773	78%	76%	Salaries
1 2	EXPENDITURE RELATED TO RECRUITMENT	21,219	21,219	47,000	47,000	20,000	20,000	106%	106%	Miscellaneous expenditure on staff recruitment: installation and travel expenses
1 3	MISSIONS AND TRAVEL	102,620	91,920	132,350	143,050	134,912	134,912	76%	68%	Mission expenses
1 4	SOCIOMEDICAL INFRASTRUCTURE	43,731	13,776	54,390	84,346	55,864	55,864	78%	25%	Training, medical service and mobility costs
1 7	ENTERTAINMENT AND REPRESENTATION EXPENSES	6,492	4,992	5,200	6,700	5,400	5,400	120%	92%	Representation and receptions
	TOTAL TITLE 1	2,539,233	2,442,043	3,295,025	3,392,215	3,248,949	3,248,949	78%	75%	
2	INFRASTRUCTURE									
2 0	INVESTMENTS IN IMMOVABLE PROPERTY RENTAL OF BUILDINGS AND ASSOCIATED COST	337,105	311,247	393,700	419,558	318,400	318,400	106%	98%	Rent, works, insurance, common charges (water/gas/electricity), maintenance, security and surveillance
2 1	INFORMATION TECHNOLOGY	176,083	93,651	177,800	260,232	181,660	181,660	97%	52%	IT purchases, software licences, software development
2 2	MOVABLE PROPERTY AND ASSOCIATED COSTS	19,944	18,319	10,175	11,800	10,368	10,368	192%	177%	Purchases and rental of office equipment, maintenance and repair
2 3	CURRENT ADMINISTRATIVE EXPENDITURE	23,755	16,739	41,140	45,852	40,589	40,589	59%	41%	Office supplies, library, translation service, bank charges and miscellaneous office expenditure
2 4	CORRESPONDENCE, POSTAGE AND TELECOMMUNICATIONS	9,873	3,757	16,200	22,316	16,500	16,500	60%	23%	Telephones, video conferences and postal services
2 5	EXPENDITURE ON FORMAL AND OTHER MEETINGS	48,965	45,945	62,000	65,019	63,240	63,240	77%	73%	Official meetings such as SRG, Scientific Committee, Governing Board
2 6	COMMUNICATION COSTS	422,433	291,619	400,000	530,814	400,000	400,000	106%	73%	External communication and events
2 7	SERVICE CONTRACTS	254,995	12,664	477,500	719,831	545,000	545,000	47%	2%	Studies and audits
2 8	EXPERT CONTRACTS AND MEETINGS	375,681	110,085	438,400	703,995	441,312	441,312	85%	25%	Costs related to expert contracts (evaluations, mid-term reviews)
	TOTAL TITLE 2	1,668,834	904,027	2,016,915	2,779,418	2,017,069	2,017,069	83%	45%	
	TOTAL TITLE 1+2 (ADMINISTRATIVE EXPENDITURE)	4,208,067	3,346,070	5,311,941	6,171,633	5,266,018	5,266,018	80%	64%	
3	OPERATIONAL EXPENDITURE									
3 0	IMPLEMENTING THE RESEARCH AGENDA OF FCH JU	104,175,580	68,804,585	126,270,350	87,915,922	118,639,918	104,093,400	88%	66%	Grant agreements (pre-financing, cost claims)
3 0 0	Implementing the research agenda of FCH JU	104,175,580	68,804,585	126,270,350	87,915,922	118,639,918	104,093,400	88%	66%	
3 0 0 1	Implementing the research agenda of FCH JU: FP7	8,020,960	68,804,585	769,128	58,000,647		55,455,900	N/A	124%	This appropriation shall cover the operational costs of the JU regarding FP7 grants.
3 0 0 2	Implementing the research agenda of FCH JU: H2020	96,154,620	0	125,501,222	29,915,275	118,639,918	48,637,500	81%	0%	This appropriation shall cover the operational costs of the JU regarding H2020 grants.
	TOTAL TITLE 3 (OPERATIONAL EXPENDITURE)	104,175,580	68,804,585	126,270,350	87,915,922	118,639,918	104,093,400	88%	66%	
	TOTAL EXPENDITURE	108,383,647	72,150,655³⁰	131,582,290	94,087,555	123,905,936	109,359,418	87%	66%	

³⁰ Refers to payments against 2014 commitments only. FiFi 2016 contains in addition 523,452.24 € as payments against 2013 commitments.

In more details:

Title 1 – Staff

Title 1 (staff costs) represents 62 % of the administrative costs in the 2016 budget. It mainly covers salaries (93%) and other chapters cover missions, training & socio-medical costs, recruitment costs and representation expenses.

The decrease in title 1 in 2016 compared to 2015 (-1.4% amounting to 46,076 €) is explained by the following:

- *in staff in active employment (-23,312 €)*
due to the replacement as of 2015 of staff in higher grades with lower ones as reflected in the staff establishment plan
- *in recruitment (-27,000 €)*
a lot of recruitments were done in 2015 which is not expected to be the case in 2016
- The increase in chapters missions, sociomedical infrastructure and representation expenses is due to indexation (foreseen at approximately 2%).

Title 2 – Infrastructure

Title 2 represents 38 % of the administrative costs in 2016.

The budget of this title is slightly increased by 154 € compared to 2015. At chapter level, the following changes are noted:

- Decrease in chapter 20 due to the fact that the last tranche from 2011 refurbishment was paid in 2015.
- IT, office equipment, correspondence and telecommunication costs are indexed to inflation (foreseen at 2%) whereas experts' contracts and meetings at 1%.
- There is no change in the budget for communication costs.
- The adjustment of the EFTA contribution from 2.94% (initial assumption of the 2016 draft budget) to 2.73% that will apply in 2016 is absorbed by the current administrative expenditure budget line.
- The increase in service contracts is due to an increase in the audit services budget line since it is assumed that more audits will be carried out in 2016 to maintain the coverage level.

Title 3 – Operational

Commitment appropriations amounting to 118,639,918 € (including EFTA at 2.73%) correspond to H2020 programme and will cover the 2016 operational activities as described in section 3.2 of the AWP 2016.

Payment appropriations correspond to estimated needs to cover (1) payment obligations under FP 7 projects (interim & final payments) for 55,455,900 € and (2) payment obligations under H2020 projects (mainly pre-financing payments of call 2015) for 48,637,500 €.

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 (2016-2017 and following years) to meet budget commitments entered into earlier financial years (before 2015).

FCH 2 JOINT UNDERTAKING

Budget 2016

SUMMARY SCHEDULE OF PAYMENTS (Operational)

2014 Outturn		Budget 2.1 2015		2016 Budget		Difference (2016/2015)	
CA	PA	CA	PA	CA	PA	CA	PA
90,996,481	68,804,585	111,816,764	85,751,224	118,639,918	104,093,400	6%	21%

DETAILS OF PAYMENT SCHEDULE (Operational)

FP7

Commitments		Payments				Total
		2015	2016	2017	Outstanding amount	
Pre-2014 commitments still outstanding (RAL)	153,250,018	28,418,901	55,455,900	32,266,597	37,108,620	153,250,018
2014 commitment appropriations	-	-	-	-	-	0
2015 commitment appropriations	-	-	-	-	-	0
TOTAL	153,250,018	28,418,901	55,455,900	32,266,597	37,108,620	153,250,018

H2020

Commitments		Payments				Total
		2015	2016	2017	Outstanding amount	
2014 commitment appropriations (RAL)	57,207,615	3,160,630	6,933,333	17,116,050	29,997,602	57,207,615
2015 commitment appropriations	111,816,764	100,000	40,704,167	-	71,012,597	111,816,764
2016 commitment appropriations	118,639,918	0	1,000,000	58,819,959	58,819,959	118,639,918
TOTAL	287,664,297	3,260,630	48,637,500	75,936,009	159,830,158	287,664,297

Remarks

State of play on 23/09/2015 - RAL refers to open commitments on 23/09 - payments for 2015 refer to forecasted payments for the period 24/09 - 31/12/2015

2014 CA outturn refers to the L2 commitments in 2014 and 2015 (the latter against L1 commitment of 2014)

The amount shown as outstanding represents:

4.2. Staff Establishment Plan

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

The 2016 Staff Establishment Plan is shown below:

Temporary Agents

Grade	2015 authorized	2015 filled	2016 budget
AD 16			
AD 15			
AD 14	1	1	1
AD 13			
AD 12			
AD 11	3	2	2
AD 10			
AD 9	1	1	3
AD 8	4	5	5
AD 7	2	2	
AD 6			
AD 5	4	4	4
Total AD³¹	15	15	15
AST 11			
AST 10			
AST 9			
AST 8	1	1	2
AST 7	3	1	
AST 6		2	2
AST 5			
AST 4	1	1	3
AST 3	4	4	2
AST 2			
AST 1			
Total AST³²	9	9	9
TOTAL	24	24	24

Staff resources also include 2 contract agents, 1 in Function Group (FG) III and 1 in FG IV.

³¹ AD stands for Administrator
³² AST stands for Assistant

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
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
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