Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU)

AMENDED ANNEX I
Work Plan 2015 – Part I
Operations

Adopted by the Governing Board on 30 April 2015

[Replaces version approved by the Governing Board on 18 December 2014]

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1. Introduction

This document establishes the second 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 2015, with a focus on research and demonstration activities prioritized for the second call for proposals, together with supportive actions required.

Fuel cell and hydrogen 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[1]. It is recognised that fuel cell and hydrogen technologies have an important role in this transformation and are part of the Strategic Energy Technologies Plan (SET) Plan[2-3], which was adopted by the European Council[4]. This is in line with recent strategic policies and directives[5-6], the European Commission's (EC) Communication "Energy for a Changing World – An Energy Policy for Europe", the goals of the Lisbon Strategy and the European Strategic Transport Technology Plan.

[1] Council of the European Union: Council Conclusions on the Commission Communication "Investing in the Development of Low Carbon Technologies (SET Plan)". Brussels, 12 March 2010

[2] A European Strategic Energy Technology Plan (SET Plan) – "Towards a Low-Carbon Future". COM(2007) 723 final

[3] European Commission: Investing in the Development of Low Carbon Technologies (SET Plan). COM(2009) 519 final

[4] Council of the European Union: Council Conclusions on the Commission Communication "A European Strategic Energy Technology Plan (SET Plan)." Brussels, 28 February 2008

[5] See: (1) A policy framework for climate and energy from 2020 to 2030 - COM(2014) 15 final, and (2) European Energy Security Strategy - COM(2014) 330 final

[6] Directive on the deployment of alternative fuels infrastructure - 2014/94/EU

2. The 2015 Call for Proposals

The 2015 Call for Proposals is jointly prepared by the major stakeholders, namely the NEW IG, the RG and the European Commission. It represents a set of prioritised actions, consistent with the objectives of the FCH 2 JU, and covers the Pillars identified in the Multi-Annual Work Plan: Transport, Energy and Cross-Cutting. In addition, Overarching projects, addressing objectives from the Transport and Energy pillars, are also included.

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

2.1 Strategic Scope

2.1.1 Transportation

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.

Further technological developments, especially in the field of fuel cell stacks, will be pursued in the 2015 call. In addition to those projects already funded in the first FCH JU in this field from 2008 to 2013, one bigger effort focussing on new materials and designs for next generation PEMFCs also considering lifetime issues is included in the 2015 call. Tools for prognostics/diagnostics on e.g. for monitoring degradation rates and further operating parameters of PEMFCs are key for a reliable fuel cell system supporting service and replacement strategies. Therefore one of the topics is dedicated to such tools. Advanced/Next Generation PEMFC systems and system components for road transport applications are still to be improved and therefore also included. Hydrogen storage on board of road vehicles is another issue which needs to be improved with respect to storage density and costs. Whereas compressed hydrogen storage is currently the only solution which is suitable for series produced road vehicles, new approaches considering hybrid solutions shall be investigated.

For other transport applications, the systems developed for road transport should be used as far as possible, making use of synergies between the different sectors. Therefore, the adaptation of road vehicle FC technologies (fuel cell systems/stacks and storage systems) to air, maritime and rail applications is another important topic. Auxiliary power units (APU) based on fuel cell technology have the potential to solve some of the problems of electricity supply in road and non-road vehicles. Thus, the development of technologies for achieving competitive solutions for APU applications for road vehicles, airplanes, ships and railway based on the existing technology for drive train applications from road transport and stationary applications is also included.

2.1.2 Energy

Special attention is given to the production of hydrogen from intermittent electricity sources like those generated from wind turbines and photovoltaic cells.

Large scale demonstration projects are needed to build up confidence/acceptance of the various stakeholders (electricity/heat producers, public, politicians, investors etc.) and applications to reduce the market entry barriers and to commercialize the technology. These demonstration projects are needed for confidence building to trigger volume scale-up with large orders, leading to higher installed capacity and therefore to lower cost.

To enable the electrolyser cost reduction targets in the MAWP a number of Research and Innovation topics are included in the 2015 call. These advances in technology have to be in the early calls to enable later demonstration.

The 2015 call includes a topic extending the potential application and impact of electrolysers in sectors where their use may be largely envisaged. There will be two projects supporting the development of decentralized production of hydrogen (on-grid electrolysers), scaling up the technology for the range 100 – 500 kW. A second project will be directed to the development of off-grid electrolysers, with the focus on components and system development for variable source management, linking electrolysers directly to a renewable energy installation (e.g. solar, wind).

A smaller budget is envisioned in 2015 for Research & Innovation to increase the scale of high temperature electrolysis and co-electrolysis of water and CO_2. The study “Development of water electrolysis in the European Union”[7] identified these as the only technologies where a step change in efficiency is possible.

In this specific topic of HT electrolysers, a demonstration of small size units (<20 kW) is proposed, to demonstrate the KPIs and targets envisioned from already funded initiatives.

For the hydrogen production line of action, topics related to biomass to hydrogen have been left for after 2015 to make use of the results of the study that has been commissioned in 2014[8]. From the remaining activities hydrogen separation from low concentration hydrogen streams (<30%) has been prioritized as an enabler for generating hydrogen from waste streams and syngas.

For handling and distribution of hydrogen the most important near term requirement is to ensure efficient distribution away from central production centres to customers. Building on earlier projects, high capacity compressed hydrogen trailers need to be demonstrated in the field, including permitting issues and integration / standardisation at the customer site. This could form part of an overarching project.

The maturity level of several stationary fuel cell technologies is ready to achieve a market entry. Fuel cell power plants will be demonstrated in several challenging market segments such as residential (micro-CHP) or industrial (sub-MW and multi-MW scale). This is a way to meaningfully reduce harmful emissions like GHG.

In addition, a topic is foreseen to support the development of cost effective manufacturing technologies for fuel cell components in order to achieve significant cost reductions.

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

[8] More information available at: http://www.fch-ju.eu/page/vacancies-procurement

2.1.3 Overarching Projects

There is a clear need to showcase projects addressing targets from both Transport and Energy pillars. This need is being supported through a topic, where the added value of such integrated solutions using hydrogen and fuel cell technologies is perceived to be highest.

After a call in 2014 for demonstration of central electrolysis to provide grid services while producing hydrogen, the 2015 call includes demonstration of a number of distributed electrolysers acting as a single capacity to provide the same grid services. Together these topics shall demonstrate the ability of electrolysers to provide services to the electricity grid if cost and efficiency targets are met. There is an opportunity to make this an overarching topic, coupled to the large-scale demonstration of FCEVs including the build-up of the necessary refuelling infrastructure for these FCEVs. Larger numbers of FCEVs and higher capacity hydrogen refuelling stations (HRS) will also be considered compared to the equivalent activity proposed under AWP2014.

The Hydrogen Territories topic formerly proposed in AWP2014 will be addressed again due to the long-term interest expressed by various stakeholders for such a demonstration topic.

In addition, addressing technology developments needed to support the integration of new hydrogen distribution systems in HRS is also needed.

2.1.4 Cross-Cutting Activities

Cross-cutting activities will support and enable the Energy and Transport Pillars and facilitate the transition to market for fuel cell and hydrogen technologies. Some of these activities should start in the very beginning of FCH 2 JU, to generate the knowledge and information essential for the content of future calls. These activities will be conducted through specific topics within AWP 2015 for the subjects: recycling and dismantling, education and training, best practice guidelines for emerging FCH applications.

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 commercialisation of FCH technologies education and training activities will focus on the requirements of the range of policy and decision makers in government, and for those individuals in administrative capacities who will be responsible for such aspects such as health and safety, regulations, codes and standards etc.

As fuel cell and hydrogen technologies are commercialised they will be required to meet environmental standards and minimise impact, and part of this will be the ability to recycle and dismantle products at the end-of-life. Safe recycling and dismantling technology should be envisaged and materials and components recycled as is the case for current conventional technologies. There may also be valuable opportunities to recycle critical and scarce materials, such as precious metals used in fuel cell stacks and fuel processing sub-systems.

Market penetration of FCH products and services can be enhanced and accelerated by the sharing of best practices and development of guidelines for use by projects and individual industry participants. Such best practices will ensure that commercialisation activities focus on the factors that drive success, whilst also avoiding issues that retard progress. Such best practices can be captured, compiled in guideline/guidance and disseminated.

2.2 General Approach

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

Participation in indirect actions funded by the FCH 2 JU should comply with Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006[9].

The General Annexes to this Work Plan shall apply with the following exception: pursuant to Article 9(5) of the Regulation (EU) No 1290/2013, it is required, for a number of specific topics of the Call, that at least one constituent entity of the Industry or Research Grouping must be amongst the participants in the consortia funded under the FCH 2 JU Call for Proposals. This additional criterion is introduced for some specific topics of the Call as identified and duly justified in §2.2.1 below.

Communication and open access to publications

Horizon 2020 overall, including FCH 2 JU, takes a new approach to communication and to the access provided publications.

First, actions shall develop and implement a comprehensive communication plan to ensure a high visibility of the funded actions and help to maximise the impact of results.

Second, the FCH 2 JU will follow the Horizon 2020 policy on "Open Access to Scientific Publications"; further information is available on the Participant Portal.[10]

Coordination with Member States, Associated Countries and Regions

The FCH 2 JU will aim at a better alignment and coherence between national and regional and its own programme. It will look at synergies with national and regional initiatives to leverage their action at the European scale, in particular through large demonstration projects. It will also aim to foster jointly funded actions (with other European Industry Initiatives (EIIs) or Key Enabling Technologies (KETs) for example), Smart Specialisation Platform (http://s3platform.jrc.ec.europa.eu/home) in regions and the complementary use of Structural Funds.

The European Structural and Investment Funds (ESIF) will invest up to EUR 90 billion in innovation and research in the period 2014-2020. Therefore, Article 20 of the Horizon 2020 Regulation and Article 37 Rules for Participation encourage synergies between Horizon 2020 and other European Union funds, such as ESIF.

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[9] OJ L 347 20.12.2013, p.81

[10] http://ec.europa.eu/research/participants/docs/h2020-funding-guide/grants/grant-management/dissemination-of-results_en.htm

Synergy does not mean to replace national or private funding by ESIF or to combine them for the same cost item in a project. Synergy means to expand the scope and impact of both Horizon 2020 and ESIF in terms of scientific excellence and place-based socio-economic development respectively. Examples for this could be the development and equipment of research and innovation infrastructures or the fostering of innovation skills through ESIF that enable the participation in a Horizon 2020 project, or the transfer of knowledge and technologies resulting from Horizon 2020 projects to firms that can, thanks to ESIF support, develop it further, test, prototype, etc. towards innovations fit for market take-up. ESIF can also be used to expand the support and advisory services for potential Horizon 2020 participants. ESIF can also help deploy innovative solutions emanating from Horizon 2020, e.g. through public procurement in the fields of fuel cells and hydrogen.

Applicants are therefore invited to identify the smart specialisation fields of their EU Member State or region (see: http://s3platform.jrc.ec.europa.eu/eye-ris3) and explore potential for synergies with the relevant Managing Authorities in charge of the ESIF in their territory (see: http://ec.europa.eu/regional_policy/indexes/in_your_country_en.cfm). More details on ESI Funds investments in research and innovation can be found in the following link: http://ec.europa.eu/regional_policy/activity/index_en.cfm.

In addition, synergies with other Horizon 2020 funding instruments will also be investigated by the Programme Office, in collaboration with EU services.

2.2.1 Conditions for the Call for Proposals 2015

Call identifier: H2020-JTI-FCH-2015-1

Total budget[11]: EUR 123 million[12]

Publication date: 5 May 2015

Deadline: 27 August 2015

Indicative budget:

Topic	Type of action	Indicative budget (million EUR)
1. TRANSPORT PILLAR		
FCH-01.1-2015: Low cost and durable PEMFCs for transport applications	Research & Innovation (RIA)	25
FCH-01.2-2015: Diagnostics and control for increased fuel cell system lifetime in automotive applications	Research & Innovation (RIA)	
FCH-01.3-2015: Development of Industrialization-ready PEMFC systems and system components	Research & Innovation (RIA)	
FCH-01.4-2015: Adaptation of existing fuel cell components and systems from road to non-road applications	Research & Innovation (RIA)	
FCH-01.5-2015: Develop technologies for achieving competitive solutions for APU transport applications based on existing technology	Research & Innovation (RIA)	
2. ENERGY PILLAR		
FCH-02.1-2015: Improved electrolysis for Off-grid Hydrogen production	Research & Innovation (RIA)	20
FCH-02.2-2015: Improved electrolysis for Distributed Hydrogen production	Research & Innovation (RIA)	
FCH-02.3-2015: Development of co-electrolysis using CO_2 and water	Research & Innovation (RIA)	

[11] 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.

[12] The 2015 Call for Proposals has a total indicative amount of EUR 122,601,223 (rounded up to 123M€) of which EUR 109,422,124 from 2015 Commitment Appropriations for operations and EUR 13,179,099 reactivated unused commitment appropriations from year 2014 resulting from the outcome of the Call 2014 evaluations (decision to amend FCH 2 JU AWP 2015 and FCH 2 JU 2015 Budget to be taken by end of April 2015).

FCH-02.4-2015: Proof of concept of HT electrolyser at a scale >70 kW	Research & Innovation (RIA)	
FCH-02.5-2015: Development of technology to separate hydrogen from low-concentration hydrogen streams	Research & Innovation (RIA)	
FCH-02.6-2015: Development of cost effective manufacturing technologies for key components or fuel cell systems	Research & Innovation (RIA)	
FCH-02.7-2015: MW or multi-MW demonstration of stationary fuel cells	Innovation (IA)	34
FCH-02.8-2015: Sub-MW demonstration of stationary fuel cells fuelled with biogas from biowaste treatment	Innovation (IA)	
FCH-02.9-2015: Large scale demonstration µCHP fuel cells	Innovation (IA)	
3. OVERARCHING PROJECTS		
FCH-03.1-2015: Large scale demonstration of Hydrogen Refuelling Stations and FCEV road vehicles - including buses and on site electrolysis	Innovation (IA)	39.5
FCH-03.2-2015: Hydrogen territories	Innovation (IA)	
FCH-03.3-2015: Hydrogen delivery with high capacity compressed gas trailer	Research & Innovation (RIA)	2
4. CROSS-CUTTING		
FCH-04.1-2015: Recycling and Dismantling Strategies for FCH Technologies	Coordination and Support (CSA)	2.5
FCH-04.2-2015: Novel Education and Training Tools	Coordination and Support (CSA)	
FCH-04.3-2015: Best practices guidelines on safety issues relating to current and emerging FCH Technologies	Coordination and Support (CSA)	
TOTAL		123

Through their participation in projects funded under this call, 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.

<u>Additional Conditions:</u>

As justified below, the following topics have been identified as relevant for application of the additional condition described in §2.2 above *(at least one constituent entity of the Industry or Research Grouping must be among the participants in the consortia funded under the FCH2 JU 2015 Call for Proposal).*

a) Transport Pillar (**Topic FCH 1.3**)

Topic 1.3: Development of Industrialization ready PEMFC systems and system components (RIA):

This topic is considered as specific project of key significance for the FCH sector as:

A coordinated approach by NEW-IG and N.ERGHY members, who offer a long term vision and a commitment towards commercialisation, will ensure that the results of this topic are used in full continuity with past and future projects.

b) Energy Pillar (**Topic FCH 2.1, 2.2, 2.4, 2.6, 2.7 and 2.9**)

Topic 2.1: Improved electrolysis for Off-grid Hydrogen production (RIA):
This topic is considered as specific project of key significance for the FCH sector:

By nature, the topic definition (off-grid, remote/isolated areas) may result into project(s) being run in isolation mode without any informal discussion of the results obtained. Application of the additional conditions offers the opportunity to exchange over project(s) results during NEW-IG and/or NERGHY gatherings. It is expected that this will benefit the project(s) and improve the quality of the results.

Topic 2.2: Improved electrolysis for Distributed Hydrogen production (RIA):

The topic is a continuation of several activities and development already achieved or running through the FCH 2 JU programme. Considering the necessity of networking both for the technical targets and for the sharing of knowledge and results, the additional clause will be a relevant issue to track the project and its support to the MAWP and KPIs of the FHC platform.

Topic 2.4: Proof of concept of HT electrolyser at a scale >70kW (RIA):

This topic is considered to bring significant expertise already included in previous initiative(s) and project(s) supported by the FCH 2 JU community. Participation from a member of NEW-IG and/or NERGHY will allow for the proper networking and knowledge sharing from project results related to both technical and business activities.

Topic 2.6: Development of cost effective manufacturing technologies for key components or fuel cell systems (RIA):
This topic is considered as specific project of key significance for the FCH sector:

Participation of at least one member from NEW IG and/or NERGHY 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 2.7: MW or multi-MW demonstration of stationary fuel cells (IA):

This topic is considered of strategic importance of horizontal nature:

As for Topic 2.6 above.

Topic 2.9: Large scale demonstration µCHP fuel cells (IA):

This topic is considered of strategic importance of horizontal nature:

Participation of NEW-IG and/or N.ERGHY members will allow maximum sharing of information and experiences with other European demonstration activities. This is of key importance for EU competitiveness, especially in view of the large numbers of units having been already deployed in Japan.

c) Overarching Topics (**Topic FCH 3.1 and 3.3**)

Topic 3.1: Large scale demonstration of Hydrogen Refuelling Stations and FCEV road vehicles - including buses and on site electrolysis (IA):

This topic is considered of strategic importance of horizontal nature:

This topic is considered of major strategic importance for the success of the commercialization of FCEVs and HRS. Only a coordinated approach involving NEW-IG and N.ERGHY 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 3.3: Hydrogen delivery with high capacity compressed gas trailer (RIA):

This topic is considered of strategic importance of horizontal nature:

To maximize the likelihood of obtaining Industry agreement on the interface technology developed between high pressure trailers and HRS equipment/components, it is necessary to consult stakeholders outside the project consortium. This additional condition ensures that existing networks within FCH 2 JU are used for this consultation process.

2.2.2 RCS Strategy Coordination Group

As required by the MAWP under section 4.1 RCS Strategy Coordination, a new Working Group (WG) must be set up bringing together Experts in the field of RCS from Industry and from Research with the support of JRC according to the terms of reference hereafter taken from the relevant MAWP section:

As an important first step, the RCS Group will focus on two main tasks which have to be implemented in full agreement with both the NEW-IG and N.ERGHY and periodically reviewed and updated, namely:

1. Identification and prioritisation of RCS needs of strategic importance for EU. The following subjects will need to be examined for the Transportation Pillar, others will be necessary in the Energy Pillar:
    a. standard on purity of the hydrogen and its measurement
    b. metering of hydrogen
    c. protocol for vehicles refuelling
    d. RCS issues surrounding permitting for hydrogen stations (simplifying and harmonizing the authorisation process for refuelling stations)
2. Definition of the strategy to be put in place to pursue the priority RCS issues.

Based on the results of PNR tasks covered in completed and on-going FCH 1 JU funded projects, the need for PNR will be reviewed by the RCS Group every year in order to give inputs for the call for proposals.

In general, the RCS Group will coordinate the following FCH 2 JU activities on RCS and PNR:

- Follow RCS developments, and update and prioritize RCS needs of the sector through a continuous global watch function; interface with regulatory bodies (EC and UN), and international organizations for standardization (ISO IEC and CEN/CENELEC) for development/amendment of international standards and regulations; and coordinate the attendance of European representatives in the relevant standardisation and Regulatory Bodies.
- Tailor PNR activities in the FCH 2 JU programme to ensure that safety issues and needs for standardization and regulation are appropriately addressed and validated.
- Collect and evaluate RCS-relevant information from demonstration projects; monitor PNR activities.
- Maintain, consolidate and disseminate results of RCS and PNR activities (targeted communication actions, awareness workshops, development of training content, etc.).

As indicated in the recommendations of the Second Interim Evaluation of the FCH 1 JU, and as part of the JRC support activities to FCH 1 JU (see 4.3), the JRC will assist the RCS Group and the PO in their RCS tasks."

The terms of reference and scope of activities of the RCS Strategy Coordination Group will be drafted by a core group of experts on RCS issues within NEW IG Coordination Committees members with the support of JRC. It is foreseen to hold the kick-off meeting of the Strategy Coordination Group by April 2015.

2.3 Topic Descriptions

TRANSPORT PILLAR

FCH-01.1-2015: Low cost and durable PEMFCs for transport applications

Specific challenge:

The Membrane-Electrode Assembly (MEA) is at the core of the PEMFC. Improvements of MEA components and Bipolar Plates (BPPs) are required for further cost reduction and to increase performance and durability of next generation of PEMFC stacks. MEA components comprise membrane, ionomers, catalysts and their supports, conductive electrode agents, gas diffusion layers (GDLs) including microporous layers (MPLs). Development of lower cost and durable materials (substrate and coating) and including BPP stable coatings may contribute significantly to meet cost targets required for commercialization.

A wide range of MEA components have already demonstrated their maturity for automotive application and many of them are commercially available. Nevertheless, integrated in a stack, these components do not yet meet the performance and durability at low cost requirements for a broad market introduction despite very promising innovative results achieved during previous projects funded by the previous FCH JU calls. The main reason is that different competitive phenomena occur in a PEMFC stack such as electrochemistry at catalyst and active layer level, water management in all components between bipolar plates and membrane, and heat management without a global optimization of the fuel cell core component architecture.

Therefore, there is a continuing need to develop existing concepts for the key MEA components such as catalyst, membrane, and GDL, through MEA designs and products demonstrating consistently improved performance (high power density), stability (lifetime with acceptable decay rates), and cost reduction (lowered precious metal loadings) that meet commercialization targets for FCVs. This approach is complementary to that targeted in the topic FCH-01.2-2014 "Cell and stack components, stack and system manufacturing technologies and quality assurance" from the previous call as upstream developments.

In order to reach the OEMs' requirements for transport application, it is now necessary to design and evaluate strengthened component architecture based either on commercial or innovative components consistent with available industrial processes. To reach this goal, a special attention has to be paid to interface and interaction between all components with new integration concepts and designs.

Scope:

In order to demonstrate the validity of the individual component improvements despite the competing electrochemical phenomena, demonstration of a full sized stack is mandatory. The following key objectives must be addressed by the project collaboration:

- Validate performance and durability of single cells or small stacks with adequate cross section area for automotive applications (> 150 cm^2). Both experimental and modelling evaluation has to be taken into consideration
- Understand component and stack degradation mechanisms in real operating conditions using both experimental and modelling approaches

- Align specifications and interfaces for each component and architecture with special attention to interface optimisation between each component (GDL/electrodes, electrodes/membranes, BP/MEA…)
- Define, achieve and evaluate new architectures and prototypes optimizing electrochemistry, water and heat management
- Generate inputs for further development of advanced fuel cell system components in order to fulfil broader requirements of OEMs
- Transfer of proposals for optimization of Balance-of-Plant components development according to optimized component operating conditions.

The following optional objectives can also be addressed by the project collaboration:

- Select, modify and adapt components and associated production processes complying with the agreed operations conditions
- Develop new synthesis and manufacturing methods for MEA components (i.e. catalyst layers, gas diffusion layers…) with optimised structure consistent with operating conditions in order to increase catalyst utilization and durability
- Develop stack prototypes optimized for the assembling in the process chain Benchmark components and architectures respectively with respect to the operating conditions (passenger cars, buses, material handling equipment…)
- Identify the most suitable standardized protocols, to qualify components
- Improve mass manufacturing methods for sheet metal BPP, low cost coatings and sealing
- Investigate dismantling of components and recycling of the critical materials

Expected impact:

Identify and select PEMFC components suitable to reach the main followings KPIs as described in the MAWP:

  - Power density: 1 W/cm^2 at 1.5 A/cm^2 (at BoL= Begin of Life)
  - Durability: > 6,000 hours (with a nominal power loss < 10 %)
  - FC stack production cost: 50 €/kW at 50 000 units/year production rate

The following key results must be achieved by the project collaboration:

- Identification and selection of components and their architectures to reach OEM requirements correlated with degradation mechanisms in real operating conditions by means of combined virtual (simulation based) and experimental techniques
- Development of catalysts and electrode layers with higher mass activity and increased durability allowing for significant reduction in precious metal catalyst loadings or the use of low cost non-platinum group metal catalysts. These should be corrosion resistant, preferably compatible with higher temperature operation (about 120°C) and able to mitigate the consequence of fuel starvation events

- Development of GDLs and MPLs designed for increased diffusivity, improved water management and heat conduction. GDL thickness has to minimized but be compatible with production in high volumes
- Design of BPPs with optimised interface with new MEAs in terms of geometry, protective and conductive coating for long lifetime, corrosion stability and production process
- Design of high performance MEAs using above components. Development of membrane materials suitable for automotive applications (low RH, higher temperature and dynamic load cycling operation)
- Techno-economic assessment showing that material, design, components & prototypes are compatible with the stringent cost and durability targets for commercialization of FCEVs

The following optional results can be considered by the project collaboration:

- Demonstrate performances and durability using accelerated test protocols as defined in previous JTI projects (FCTESTNET, FCTESQA, STACKTEST) and the current harmonisation exercise
- Validate the full value chain of components from the manufacturing up to the stack integration. Proposed components and prototypes should be optimised for easy dismantling and recycling of materials at the end of their active life
- Develop low cost seals with low O_2 permeation rates
- Standardization potential of components consistent with higher production volumes

Other Information:
TRL at start: 4
TRL at end: 6

The consortium must include at least one automotive OEM and a fuel cell system integrator (not required if the OEM is itself a fuel cell system integrator), relevant suppliers to the automotive industry capable of fulfilling automotive standards with above optimized components and research institutions.

Project proposals wanting to address issues on the fuel cell system and system components should consider the topic FCH-01.3-2015: Development of Industrialization-ready PEMFC systems and system components.

Indicative funding: The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 6 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

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

Expected duration: 3-4 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-01.2-2015: Diagnostics and control for increased fuel cell system lifetime in automotive applications

Specific challenge:

The typical drive cycles of fuel cell electric vehicles (FCEVs) are discontinuous, characterized by steep and unscheduled load transients, leading to an increased degradation rate compared to fuel cells used for most stationary applications. Thus, the highly dynamic nature of the drive patterns shortens the lifetime of automotive fuel cells, and lifetime limitations remain one of the key challenges for FCEV commercialization by adding to high total cost of ownership (TCO). It is, hence, urgently needed to address the issues of diagnostics and control which are expected to have a major impact on the competitiveness of FCEVs compared to conventional propulsion technologies. Diagnostics include the detection of faults/problems as well as identification of what is causing the faults/problem. Control includes the scheduling of power production, management of hybridisation strategies, and management of ancillary units.

Scope:

The project will focus on reducing the degradation to a minimum by means of control actions guided by condition monitoring and diagnostics. Activities will be devoted to developing diagnostics and control-based solutions to extend the lifetime of the present generation of automotive fuel cell systems, based on one hand, on the current scientific knowledge in degradation of fuel cells and balance-of-plant (BoP) components and, on the other hand, on feedback from past and on-going projects with the potential application also for future generations of automotive fuel cells.

The project is aimed at addressing the following objectives:

- Enhanced understanding of component and stack degradation mechanisms in real operating conditions using both experimental and modelling approaches in order to define the most suitable and efficient monitoring and diagnostic tools
- Development of appropriate monitoring and diagnostic methods for observing degradation of automotive fuel cells and BoP components, requiring no or only minor modifications to existing systems to be implemented
- Development of cost-effective control methods for automotive fuel cell systems, with the ability of minimising the progress of degradation in fuel cells when integrated with the diagnostic methods mentioned above; Preferentially, these methods should be modular, easily portable to other systems and not tied to a specific technology or design
- Implementation of the developed diagnostics and control systems in a prototype with a special focus of power management between FC system and battery pack. The implementation will be chosen among the classes of FCEVs identified in the MAWP: passenger cars and buses
- Demonstration of the prototype in operation, preferably in relevant environmental conditions, for a length of time sufficient to quantify the gains in terms of system lifetime obtained by the implementation of the new diagnostics and control system
- Validation of the applicability of the developed methods on future generations of fuel-cell systems

The FC stack hardware may also be 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.

Expected impact:

- Reduce the fuel cell system cost including the additional cost of the diagnostics and control system, below the following thresholds, corresponding to the 2020 FCH2 JU targets:
    - 100 €/kW for passenger cars at 50,000 units
    - 1000 €/kW (or 500 €/kW)[13] for buses at 200 units
- Attain the FCH 2 JU targets for lifetime of automotive fuel cell systems for 2020; since several of these targets would require one or two years to validate in real time, while validation with real time operation is preferred, they may also be validated with proven accelerated protocols or proven prognostic methods:
    - 6,000 h for passenger cars
    - 15,000 h (or 2 x 8000 h)[14] for buses

Other information:
TRL at start: 3
TRL at end: 5-6

The focus should be on automotive applications (passenger cars and buses).

The consortium must include at least one automotive OEM and a fuel cell system integrator (not required if the OEM is itself a fuel cell system integrator), relevant suppliers to the automotive industry capable of fulfilling automotive standards and research institutions.

Indicative funding: 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.

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

Expected duration: 3 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

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[13] Depending whether the bus system will be composed by one larger bus fuel cell stack or two passenger car stacks

[14] Depending whether the bus system will be composed by one larger bus fuel cell stack or two passenger car stacks, and hence will have to be replaced once during the lifetime targets.

FCH-01.3-2015: 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 O_2 permeation valves can be used to reduce O_2 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
    - o provide higher efficiency at max load point to enable reduction of parasitic power while providing increased durability
    - o meet automotive dynamic requirements (0-90% power in 0,5s)
    - o 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
    - o improve water transfer rates between wet and dry side
    - o improve durability to meet automotive requirements of 6,000h
    - o minimize packaging space
    - o reduce pressure drop
- Intercoolers (gas-to-gas or gas-to-liquid) that simultaneously
    - o high thermal transfer efficiency
    - o minimize package space
    - o 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

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:

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

Other information:
TRL at start: 4
TRL at end: 7

The consortium must 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.

Project proposals wanting to address issues on the fuel cell stack itself should consider the topic FCH-01.1-2015: Low cost and durable PEMFCs for transport applications.

Indicative funding: 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.

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

Expected duration: 3-4 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-01.4-2015: Adaptation of existing fuel cell components and systems from road to non-road applications

Specific challenge:

The low temperature PEMFC technology for road applications are gaining more and more traction and investment, and these activities can have a very positive impact on other segments by making available components and systems of lower cost and more robustness to the market – along with increased sales volumes. The goal of this topic is to facilitate that these benefits are transferred to early niche markets within other applications. It is important to dedicate specific focused activities to make this happen.

An advanced level of technology readiness has been achieved for specific non-road transport applications, within material handling vehicles. These are close to market introduction in Europe, although in other markets about 6,000 vehicles are reported to be in operation, with significant public financial support for demonstration before market introduction. These are a not priority for this Pillar in view of their limited contribution to meet key transport policy objectives. The low temperature PEMFC technology and components developed for road transport may be used as the basis for other non-road applications. This could lead to a significant cost reduction, improved affordability and reliability. These systems and components from road transport need to be adapted to the specific non-road special needs. Identification of the needed adaptation of specific FC road vehicle drive train components for main propulsion for any vehicles but passenger cars and buses should be addressed in this topic.

On-road FC drive train components and systems are designed, developed and tested for on-road use in Europe's climatic conditions spanning from high summer temperatures to sub-zero winter temperatures. Non-road applications will benefit from the implementation and adaptation of the knowhow and different applications from on-road FC drive trains in order to operate also in European out-door climate including more severe operating conditions with a higher lifetime.

Scope:

The overall objective of the projects in this topic is to bring non-road vehicles from TRL 4 to TRL 6. The achievement will be based on adaptation of road LT PEM Fuel Cell system components to non-road vehicles, heavy duty vehicles, airport ground vehicles, trains, harbour taxies and smaller ships as substitutes to battery systems and ICE systems on pre-existing vehicles/vessels and non-road vehicles/vessels. Any kind of applications could be addressed such as ships, trains and aircraft. Material handling vehicles are considered outside the scope of this topic.

Examples of adaptation of pre-existing components devoted to cars and buses could be:

- The size and/or the catalyst loading of MEA,
- Alternative high resistant coating on metallic bipolar plates used for automotive application,
- Power management and hybridization technology

but produced with the same processes as used for cars and buses in order to increase the scale effect but taking into account specific size restriction with more severe operating conditions (corrosion, temperature…)

The achievements should be validated on the economic and environmental model versus reference battery vehicles and ICE solutions.

- The on-road vehicles EU outdoor capabilities can be implemented in non-road vehicles
- Hydrogen storage technology transferred to the non-road segment
- Low temperature PEMFC stacks and components can be shared between several applications
- BoP components from on-road can be adapted
- Power and control strategies adapted

Expected impact:
The technical goals of this topic are:

- Identify components and systems where the development, learning and volume from road vehicles can be transferred to non-road vehicles
- Identify ways to adapt components and systems for specific non-road applications
- Identify value proposition of each component and sub-system and prioritize efforts to implement or redesign components for implementation in non-road vehicles
- Implement chosen components and sub-systems in non-road fuel cell power unit

The project should meet the technical milestone from the MAWP in 2020:

- Specific FC system cost: < 1200 €/kW @ 10kW
- Hydrogen storage system cost: < 750 €/kg H2
- Lifetime: > 10 000 h
- Efficiency: > 52%
- Availability: > 98%
- Power Range <250kW

Other Information:
TRL at start: 4
TRL at end: 6

The consortium must include at least three actors in the value chain for FC non-road vehicle and should involve relevant experience from the automotive industry. International cooperation is recommended. The project should include end users providing specifications and test of at least 3 FCH vehicles. The purpose of this project is to share knowledge and components across applications.

Indicative funding: 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.

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

Expected duration: 3 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-01.5-2015: Develop technologies for achieving competitive solutions for APU transport applications based on existing technology

Specific Challenge:

Fuel cell APUs can contribute not only additional electric power vehicles but also heat for cabin temperature control. Possible applications include hybrid and electric passenger cars, vans and trucks as well as other manned commercial off-road vehicles such as for municipal, airfield-, agricultural- (etc.) use. Later on, a carryover of these fuel cell systems to non-road applications such as airplanes, electric boats etc. can be easily achieved. Further, such systems could also be the basis for range extender concepts as explicitly addressed in the MAWP.

The main specific challenge to be tackled is also addressed in the techno-economic objective 1 of the MAWP of the FCH 2 JU: reduce the production cost of the fuel cell system to be used in an APU transport application, while increasing its lifetime to levels competitive with conventional technologies and also reducing weight and volume where space is at a premium.

Scope:

The overall objective is to design, develop and test APU fuel cell systems against realistic specific requirements covering the main application field, i.e. on- and off-road vehicles. Requirements of other applications have to be collected and considered as far as possible. The project should also address auxiliary subsystems optimization on the basis of automotive FC systems for road propulsion.

In more detail, the objective of this project is to develop low cost fuel cell APU systems for transport application by means of latest system and component level RTD methodologies and tools. Also all balance of plant components need to be addressed. After key component and system testing, the components and systems shall be further developed towards the target system for the surface transport APU application. Design-to-cost methodologies shall be applied to analyse cost and to identify cost reduction opportunities for further improvements of the respective components.

Project proposals should focus on development of APU systems which can be integrated in (already existing) vehicles. Consortia shall define and identify all external operating conditions which are specific to the particular application. All transport applications are eligible under this topic.

Projects are expected to cover the following top-level objectives:

- Electric power output relevant for real life operations depending on the actual application.
- Significant improvement of the complete powertrain efficiency due to integration of a fuel cell APU
- Integration of fuel cell APUs into final application with the coupling to pre-existing electric (e.g. battery) systems in order to optimize the whole energy chain on board.
- Advanced hybrid operating strategies enabling elimination of idling or warm-up losses etc.
- Validation of the results in a prototype APU systems in applications under real world operating conditions including monitoring for operating feedback analysis for further developments
- Prototype testing in a relevant end user environment
- Proof of the safety of the FC system for embedded applications due the integration and system architecture with regards to safety needs

Expected Impact

Overall impacts of the results of the project have to be:

- Tank-to-electricity efficiency of at least 35%
- Cost reduction of the APU system enabling a return of investment period of the APU system of below 2 years
- Lifetime to be compatible with the selected vehicle application
- Minimized fuel cell APU system packaging volume/weight to be compatible with the selected vehicle application

All projects must produce validated evidence of lifetimes, cost targets, performance and efficiency throughout laboratory- and field tests.

Other Information

TRL start: 4

TRL end: 6

The consortium must be led by industry and include a fuel cell system manufacturer and cell/stack developer or manufacturer with an existing cell/stack design. It may include research institutes and material developers/producers and equipment manufacturers. Projects must include fuel cell APU end users such as system integrators and vehicle/system manufacturers.

The consortium has to prove the ability to make use of advanced methodologies for fuel cell APU development:

- Design to cost techniques, reliability and robustness analysis in order to provide the basis for later large scale industrialization.
- Detailed component level simulation for analysis and optimization based on full consideration of physical processes involved.
- Sub-system and system level simulation for component specification and assessment of overall system performance by means of multi-physics (co-)simulation.
- Utilization of automated-/hardware-in-the-loop-/accelerated testing methods

Indicative funding: The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 3.5 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

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

Expected duration: Up to 4 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

ENERGY PILLAR

FCH-02.1-2015: Improved electrolysis for Off-grid Hydrogen production

Specific challenge:

It is estimated that 1.2 billion people will be without electricity access globally by 2025. A further 1 billion people are connected to unstable networks and are regularly exposed to power outages. It may thus be considered that 2.4 billion people (i.e. around 35% of the global population) are "under electrified".

When the connection of a major distribution network to the transport network is not a feasible option from a technical and economic perspective, *onsite* energy is generated off-grid.

Islands are particularly concerned by this type of situation. Indeed, electricity generation there is guaranteed by diesel generating units, despite their high production costs and pollutant emissions simply due to the absence of simple and feasible alternatives.

This is a significant market, part of which is represented by installed diesel production capacity of 600GW, whose half is installed on off-grid sites.

Hydrogen is envisioned as a potential solution for completely off-grid remote areas in Europe (e.g. villages, alpine refuges, etc.). These locations cannot be isolated of the global hydrogen development due to their off-grid characteristic and need to be part of the hydrogen technologies development coupled to renewable systems taking into account their intrinsic characteristics, applications and business case scenarios. The potential use of the hydrogen produced is varied, such as mobility applications, industrial use, stationary heat, large back-up systems, telecommunications, etc. and it increases the potential access to hydrogen technologies to these areas.

The newly proposed solution of off-grid electrolysers can pave the way to efficient hydrogen production systems optimized for a given region. Indigenous off-grid hydrogen generation may occur at highly distributed level close to the point of use (e.g. dc-dc PV-electrolyser systems). It could be used also as an energy system able to assure the energy independence of small locations in a municipal area or industry park, relying as much as possible on renewable sources locally available.

Current electrolysers must be improved in order to match the operation conditions linked to an off-grid and stand-alone scenario (dynamic operation, unpredictability of operation profiles, high robustness and reliability, low maintenance, etc.). Electrolyser manufacturers still need to improve some systems of the technology in order to work at variable load profiles efficiently, high efficiency at broad operating range and cost competitiveness. Proper design of these electrolysers in the range of 50-100 kW for off-grid applications must focus on developments at stack level, power electronics and balance of plant components and system engineering.

Scope:

Proposals must address the following objectives:

- Development of off-grid electrolysers (alkaline or PEM technology) optimized at component and system levels, supplied by renewable energy sources - RE (e.g. solar PV and small wind energy), achieving MAWP 2017 target for electrolyser systems of 6M€/tpd capacity, high efficiency consistent with MAWP targets (<55kWh/kg by

2017 for electrolyser systems), high annual hydrogen yield and capacity factor with respect to the RE considering the constraints of dynamic operation

- Development of power conversion and balance-of-plant hardware adapted to operate electrolysers in variable power mode, necessary for the off-grid system to perform efficiently, taking into account system topology (DC-DC, AC-DC, etc.) and grid constraints
- Development of a control system with the capability of smart integration in off-grid installations and RE generation forecasting
- In-field testing in relevant environment (TRL 6) is required (relevant environment is understood as existing renewable systems in off-grid conditions – e.g. PV system, small wind energy - in the range of 50-100 kW) for at least 6 months

Proposals could address the additional following objectives:

- Developments at stack level in order to operate properly the electrolyser in a broad operation load profiles taking into account each installation and at high dynamic operation
- System engineering in order to decrease the maintenance costs and frequency and increase reliability, robustness and lifetime
- Identification of eventual RCS barriers between the technology and the business cases identified
- Potential uses of hydrogen should be explored

Expected impact:

- Electrolyser efficiency consistent with MAWP targets by 2017 for electrolyser systems (<55kWh/kg), when converted from solar or wind power to hydrogen (with respect to Lower Heating Value - LHV)
- Design to integrate solar and/or wind resources
- Address business cases and applications where the specific off grid approach may have a significant impact
- As reported in the MAWP, target KPIs on cost per nominal power for alkaline and PEM electrolysers will be considered

Other Information:
TRL start: 4
TRL end: 6

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

Indicative funding: 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.

Number of projects: A maximum of 1 project may be funded under this topic,

Expected duration: 3 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-02.2-2015: Improved electrolysis for Distributed Hydrogen production

Specific challenge:

Implemented energy policies have the objective of producing 65% of electricity from renewable energy sources by 2050, and of reducing emissions of CO_2 linked to energy production by 50%.

The rapid deployment of wind power and solar energy sources contribute to reducing the carbon footprint of the electricity grid. However, wind power and solar energy are resources dependent on meteorological conditions and their instability poses a number of problems for functioning of the electrical grid, in terms of stabilisation mechanisms, regulation and offsetting. The bottlenecks in the electricity supply system result from an excess of renewable energy which cannot be transferred to the grid and that is consequently curtailed by the operators of the supply grid, in order to balance the power produced and demand for energy and/or to permit the allocation of electricity deriving from other sources

Considerable investments in transport and distribution infrastructure will be necessary in the forthcoming years. In its global energy prospects, the International Energy Agency forecasts that total investments in transport and distribution (T&D) infrastructure will amount to US$ 6.817 billion during the period 2014-2035.

The postponement over time of transport and distribution infrastructure is possible by using storage resources to absorb power exceeding the capacity of a T&D line and returning it at a subsequent point, when the available T&D capacities permit. The upgrading of T&D resources generally translates into high fixed costs, while relatively limited storage resources allow a delay in (or even avoidance of) the investments which would otherwise be necessary.

Hydrogen can play a significant role for the support to the electricity grid, for peak shifting and demand response.

Current electrolysers are designed for high efficiency at their operating design point, at typically close to 100% load, and to run continuously. Providing energy services is expected to require start-stop and dynamic operation and high efficiency across much of the load curve. The electrolyser would have to follow the variable generation profile of renewable sources locally available and be adapted to the intermittent profile of electricity supply. It could be used also as an energy system able to maximize the energy self-consumption of entire districts in a municipal area or industry park, relying as much as possible on renewable sources locally available, while being grid connected for security of supply.

Scope:

Proposal must address the following objectives:

- Development of electrolysers from 100 to 500 kW to provide grid services. Fact based assessment of specifications, supported by experimental evidences (i.e. from existing facilities, especially interaction with the grid and renewable electricity sources), is highly valuable
- System and component optimization for partial load operation, from 20% (with a minimum efficiency of 50%) to 120%
- System and component optimization for highly dynamic operation
    - ramp-up rates of less than 2 seconds going from 20% to 100% of nominal power,
    - warm start-up

    - cold start-up
    - standby behaviour, i.e. maximum of 5% of nominal power in standby mode
- Control system designed to enhance interaction with the grid and renewable sources

Proposals could address the additional following objectives:

- System engineering and improvements in manufacturing process for decreasing costs down to 3.7M€/tpd, contributing to system simplification, cost reduction, material use minimisation or that put in place a path to volume manufacturing
- Technology to be tested in the field for at least 6 months to validate the development achieved. The method utilized should be illustrated in the proposal

Expected impact:

- Address business cases and applications where the Distributed Hydrogen Production may have a significant impact
- As reported in the MAWP, target KPIs on cost per nominal power for alkaline and PEM electrolysers will be considered
- Contribution to achieve KPIs of the "Electrolysis Study" from FCH 2 JU, decreasing electricity consumption to 52 kWh/kg H2 for alkaline electrolysers and 48 kWh/kg H2 for PEM electrolysers, and capital cost to 630 EUR/kW for alkaline electrolysers and 1,000 EUR/kW for PEM electrolysers)
- Setting up innovative solutions and configurations for grid and renewable energy integration, implemented of control systems fully adapted to provide grid services
- Involvement of policy makers to develop regulations for grid services provided by electrolysers in the EU member states

Other Information:

TRL start: 4
TRL end: 6

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

Indicative funding: 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.

Number of projects: A maximum of 1 project may be funded under this topic

Expected duration: 3 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

<u>FCH-02.3-2015: Development of co-electrolysis using CO2 and water</u>

<u>Specific challenge:</u>

The establishment of the hydrogen economy is constrained by different factors, such as handling and storage. On the other hand, hydrogen could be used in large amounts to synthetize gas and liquid hydrocarbons, whose system of storage and distribution are well established. Co-electrolysis of water and CO_2 to produce H2 and CO is one of the most promising ways to convert electricity into a syngas. Water plus CO_2 co-electrolysis constitutes the corner point of power-to-chemicals and power-to-fuel strategies, for green chemicals, CO_2 recovery and electricity storage at large scale. Indicatively, Power to Gas, by means of the methane as energetic carrier, is a good example and the co-electrolysis process to produce hydrogen and CO as hydrocarbon precursors, is a very promising way on that.

The main challenge here addressed is to store excess renewable electricity in the form of hydrogen and CO. By producing syngas, co-electrolysis would enable various storage options like methanation and storage in liquid organic carriers. Alternatively the CO in the syngas can be easily converted to hydrogen via water-gas-shift. Co-electrolysis could therefore become a more efficient way of producing hydrogen from electricity. This topic will contribute to hydrogen carriers, using CO_2. The produced syngas, CO plus hydrogen, is again in the scope for multiple ways of conversion, including filtration and utilization of hydrogen for transport and combustion / conversion of CO for stationary applications.

Specifically, Solid Oxide Electrolysis (SOE) co-electrolysis towards liquid fuels offers advantages over an electrolysis plus methanation process, in case where hydrocarbon (H/C) fuels are the desired final products. Moreover, co-electrolysis can be fed with recycled CO_2 towards the progressive reduction of GHG emissions, where the produced H_2 can be used for the synthesis of light-H/Cs as H_2 carriers. The commercialization of co-electrolysis will provide a simpler and cost efficient way for the production of light-fuels compared to the mainstream technologies, whereas it is advantageous that the expected technology development can be based on the on the existing status of Solid Oxide Cells.

To commercialize this technology improved component design and system optimisation are required to increase efficiency, as well as a clear understanding of the integration of the technology in the energy system.

<u>Scope:</u>

Solid Oxide Electrolysis Cells (SOEC) promise high efficient conversion of renewable electricity into hydrogen and, via hydrogen, into other products. The current state-of-the-art makes use of materials and designs developed for solid oxide fuel cells and improvements in efficiency can be achieved by optimising these materials and designs for SOEC.

The topic therefore asks for:

- Novel cell structure and design, including novel electrolyte products and/or new developed electrodes
- Design and development of the co-electrolysis process (materials, reactor, operating conditions) towards direct fuel production
- Validate the co-electrolysis operation for different targeted outlet H2/CO compositions depending on the synthetic fuel to be produced
- Validate its operation with durations over 1,000 hours targeting and defining adapted designs and/or operating conditions to achieve degradation rates below 1% efficiency and 1,000h lifetime

Optionally projects can also:

- Develop concepts of co-electrolyser for coupling with downstream catalytic reactors for gas or liquid fuels synthesis
- Asses the techno-economic benefits of co-electrolysis for gas or liquid fuel synthesis in comparison to other water electrolysis technologies
- Perform a life cycle assessment on the CO_2 to prove the recycling potential of this technology

Further there is a need for a techno-economic assessment of the technology. An important problem concerns the variability in prices of CO_2 coming from different processes, as well as prices of electricity from different sources, such as nuclear, geothermal, hydroelectricity and wind. Other economic factors should be considered taking into account the whole supply chain, i.e. costs of distribution, transportations, taxations and subsidies.

The proposal has therefore to clearly indicate the system engineering of the complete process in which the co-electrolyser will be considered as well as the strategy of operation, including:

- Process for CO_2 recovery and reutilization in the co-electrolysis
- Integration with the methanation process
- Upgrade of the produced synthetic fuel to reach grid specifications

Expected impact:

Proposals addressing the described technology should carefully justify the current state of the art and the potential evolution of the technology until 2025, to be commercially available and competitive *ex-aequo* with the conventional syngas production technologies.

The project is finally expected to assess that co-electrolysis may offer a competitive advantage against state-of-the-art technologies for syngas production. The related business case should be part of the project results. The technical performances required to have a profitable business case together with low GHG emission shall be identified.

The proposal is expected to have the following impacts:

- Achieve near 50% conversion efficiency from electricity to syngas
- prove the concept of co-electrolysis in representative conditions (system scale and power range) as well as identification of real life application areas including the CO_2 sources
- increase the durability of the co-electrolyser to at least 1,000 hours, from the actual results of lab scale proof of concept systems
- decrease the production cost of synthetic gas or liquid fuels with respect to the actual processes. Proposals should present some data on methodology applied and targets proposed
- select the most suitable technologies involved in the co-electrolysis process (from CO_2 to electricity and fuel production/distribution) and assess the most cost effective route for the production of synthetic fuels.

Other Information:

TRL start: 3

TRL end: 5

Indicative funding: 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.

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

Expected duration: 3 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-02.4-2015: Proof-of-concept of HT electrolysers at a scale > 70 kW

Specific challenge:

HT electrolysis has great advantages in terms of thermodynamics and transport phenomena, good possibilities of thermal optimization (through system integration), and so high potential of high value efficiency. Necessarily it has to demonstrate its potential.

HT electrolysis allows reaching much higher efficiencies compared to water electrolysis, which makes this process of prime interest for hydrogen production for different applications (hydrogen production for transportation or other direct industrial usages and renewable energies integration and storage). In this case, materials selection and/or development is necessary.

Considering economic factors, some studies exist with CAPEX and OPEX analysis, leading to a levelized cost of hydrogen for the size of installation considered[15]. For units producing 100 kg of H2 per day, the CAPEX of HT electrolysis is close to the one of PEM water electrolysis, but higher than for alkaline electrolysis. However, thanks to its better efficiency, the levelized cost of hydrogen is below the one of PEM electrolysis whatever the price of electricity, and that it becomes competitive with alkaline electrolysis for an electricity price above 100 €/MWh. These elements highlight the potential of this technology compared to the other electrolysis technologies, and give lots of sense for demonstration project to demonstrate this expected benefit in real environment.

High performances have been validated over the last years (former Relhy and Adel projects) and major improvements have been achieved in terms of durability at stack level, both contributing to an increase of the maturity of the technology. Only few tests have been performed at the system level.

Therefore, there is a strong interest to prove the potential of this technology at the system level and at a scale above 70 kW. A single module or a sum of several modules can realize the target higher power range, to support different market applications with the same technology.

Scope:

Proposals should address:

- The design and construction of a HT electrolyser including all balance of plant components for thermal, gas and electrical management, with:
    - Minimum capacity of 70 kW
    - Overall electrical efficiency on or above 68% based on higher heating value
    - Lifetime of at least 2,000 hours.
- In-field tests of the HT electrolyser system in a relevant environment for at least 6 months

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[15] M. Reytier, S. Di Iorio, A. Chatroux, M. Petitjean, J. Cren, J. Mougin, "Stack Performances in High Temperature Steam Electrolysis and Co-Electrolysis", WHEC2014, June 15th-20th 2014, Gwangju, Korea (2014)".

- Assessment of the techno-economic performance of HT electrolysis in comparison to other water electrolysis technologies

Expected impact:

The proposal is expected to have the following impacts:

- Contribution to achieve a target efficiency as indicated in the "Electrolysis Study" from FCH-JU, decreasing electricity consumption to below 40 kWh/kg H2
- In-field tests of HT electrolysis under representative conditions and scale as reported in the scope section and validation of the target performances
- Identification of business cases where HT electrolysis is more cost competitive than PEM and alkaline electrolysis

Other Information:

TRL start: 4

TRL end: 5

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

Indicative funding: 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.

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

Expected duration: 3 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-02.5-2015: Development of technology to separate hydrogen from low-concentration hydrogen streams

Specific challenge:

Common hydrogen separation systems and technologies are developed for hydrogen rich streams. Recovery of hydrogen from streams with only a low concentration of hydrogen is currently expensive and inefficient, or reduces the pressure of the bulk gas and therefore its value. Separation technologies need to be developed or improved to make recovery of hydrogen from such gas streams economically attractive and energy efficient.

A main application would be the separation of hydrogen from the natural gas grid, thus enabling its use for the storage and distribution of hydrogen. Further applications could be found in separating hydrogen from mixtures produced in chemical or biological processes, where it otherwise would be used to generate heat or even be vented.

This topic calls for proposals to separate hydrogen from the natural gas grid with typical hydrogen concentrations below 10% by volume. Technology proposed for development is preferably also suitable for separation of hydrogen from other gas mixtures. The energy used for separation of hydrogen should not exceed 5 kWh/kg H2 separated.

Scope:

This topic calls for proposals to develop hydrogen separation technology and to validate the system by separating hydrogen from natural gas/hydrogen mixtures. It is expected that the technology readiness level at the end of the project is at least 5, meaning that the function of system has been tested in a relevant environment (for example a resident environment in case the hydrogen is used for a residential fuel cell system, or a refuelling station if fuel cell vehicles are targeted). Validation should be done at least 25% scale for the application (for example above 25 kg/d of hydrogen separated for retail stations). Proposals should justify that the scale of validation is relevant and indicate how the system can be scaled up.

Proposals should further aim to address the economic feasibility of the system by comparing the cost of hydrogen obtained from the separation system with alternative sources of hydrogen, like reformation of a natural gas hydrogen mixture as well as with state of the art separation methods. This analysis should include the full chain and all aspect relevant for the application (examples could be the loss of energy in the NG pipeline or pressure losses for filing stations).

The project should include:

- Development of a hydrogen separation technology that can separate hydrogen from gas mixtures below 10% of hydrogen
- Validation that the technology can separate hydrogen from natural gas/hydrogen mixtures with the specified hydrogen concentration giving hydrogen quality that can be used for hydrogen operated fuel cells, for example ISO14687 or updates thereof. The system should be in operation for a minimum of 800 hrs and enable extrapolation of findings to full scale and to a lifetime relevant for the application
- Cost assessment of hydrogen separation at full scale. As a guideline maximum cost of €1.50/kg of hydrogen separation are expected for full scale application. This would make distribution of hydrogen via the NG grid competitive other ways of distributing hydrogen and would make it economic to separate the hydrogen instead of converting it with the natural gas. Higher expected separation cost would have to be justified in the proposal

- Compensation for pressure loss of the hydrogen as well as the bulk gas should be included in the cost analysis if relevant for the application. For example, if the technology removes hydrogen containing gas from the natural gas grid, the cost of recompression and re-injection of the remaining natural gas into the NG grid has to be included
- A recommendation for the next steps for the development of the technology

Expected impact:

The project will show the feasibility of cost (<1.5€/kg) and energy effective (<5 kWh/kg) extraction of hydrogen from very low hydrogen concentration streams, in particular the extraction of hydrogen that has been blended into the natural gas grid at a scale that is relevant for the final application.

The developed technology will provide a route to:

- Increase the value of hydrogen blended into the natural gas grid, improving the economics of central hydrogen production from excess renewable energy couples with natural gas grid injection
- Reduced cost, and therefore increased use of hydrogen from very dilute hydrogen streams in energy and transport applications

Other information:

TRL start: 3

TRL end: 5

Indicative funding: 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 at a scale of validation around 25 kg/d or higher. For smaller scales a lower amount would be considered appropriate.

Number of projects: A maximum of 1 project may be funded under this topic

Expected duration: 3 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-02.6-2015: Development of cost effective manufacturing technologies for key components or fuel cell systems

Specific challenge:

Currently most fuel cell systems and key components like stacks, BOP components, system integration, inverter, heat exchanger etc. are produced in small quantities, often with considerable manual input. In order to achieve cost levels allowing for mass deployment, stationary fuel cells need further significant cost reductions in their manufacturing. The currently still low production volumes do not allow identifying, improving and validating all factors that influence the robustness and yield of the manufacturing processes on cell, stack and system level. To reduce costs and increase quality cost effective manufacturing technologies are required for the medium term. This topic focuses on actions to improve production processes and scaled production for stacks, and stack components (cell & cassettes), key components like BOP components, system integration, inverter, heat exchanger etc., and whole systems. The aim is to develop/apply novel manufacturing technologies, including for example: laser welding, coating, 3D printing, molding and casting of materials that are used for fuel cell system components and /or fuel cell stacks.

Scope:

Projects should support development and use best in class manufacturing technologies, production processes, equipment and tooling with cost impact on, for example, stacks, reformers, pre-heaters, BOP and heat exchangers. Optimised production processes for mass manufacturing can include automated assembly, shortened cycle times, continuous production and lean manufacturing with little waste and should be compatible with environmental and health standards. Thus development and adaption of production processes with fewer steps, more tolerant to varying quality of raw materials and with lower-cost materials or materials with reduced environmental or health impacts are important tasks as well as advanced quality control methods.

Innovative manufacturing technologies could also be considered to provide complex design solutions with increased performance while allowing for lower cost levels compared to conventional production technologies.

Pilot plants are excluded.

To achieve cost reduction projects may also aim to develop industry-wide agreements for standard BoP components for FCs, including heat exchangers, reformers, converters, inverters, post-combustors, actuators and sensors. Reaching this target it’s 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.

- Residential (0.3 – 5 kW): start TRL 5, end TRL 8
- Commercial (5 – 400 kW): start TRL 4, end TRL 6
- Industrial (0.4 – 10 MW): start TRL 4, end TRL 6

Expected impact:

Projects will enable important players in the fuel cell system segment to implement technologies enabling the step-up from small scale production towards 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 competiveness. Innovative manufacturing technologies could also contribute for cost reduction and reduced time to market.

The project should focus on the following impact:

- 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
  - Max. 12,000 €/kW as KPI target for residential micro-CHP for single family homes and small buildings (0.3 - 5 kW, residential) in the MAWP less than 7,500 €/kW for systems of 5-400 kW (commercial)
  - Less than 3,000 €/kW for the 0.4-10 MW (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

Other Information:

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

Indicative funding: 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.

Number of projects: A maximum of 3 projects may be funded under this topic, preferably 1 project for each segment: residential, commercial, industrial. These segments have absolutely different manufacturing technologies.

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-02.7-2015: 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/technologies[16] 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

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:

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[16] Advancing Europe's energy systems: Stationary fuel cells in distributed generation: A study for the Fuel Cells and Hydrogen Joint Undertaking, Roland Berger, 2014

- 1 MW up to several MW capacity production of power and heat from methane (natural gas or natural gas quality gas) or power from 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, stake holders and end users may benefit from the experience gained throughout the value chain
- Develop and reinforce business plan and service strategy during the project so that they will be replicable and validated in the chosen market segment after the project

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 CO_2 emissions with respect to the 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

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.

Other information:

TRL start: 7

TRL end: 8

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

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

Indicative funding: EUR 9 million for the first MW plus proportionally EUR 1.5 million for every additional MW. Maximum budget is expected to be in the range of EUR 10-12 million.

Number of projects: A maximum of 1 project may be funded under this topic

Expected duration: 5 years

Type of action: Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-02.8-2015: Sub-MW demonstration of stationary fuel cells fuelled with biogas from biowaste treatment

Specific challenge:

It is a key goal to have the same drivers as those for FCH technologies (reduction of GHG emissions, energy security, distributed generation, local emissions reduction) generated a firm foothold in the societal landscape as well as in the portfolio of investors. Commercial success of FC's and increasing numbers in the field of distributed generation is needed in order to leverage the awareness and deployment of stationary fuel cell systems. Organic waste processing plants producing methane-rich biogas are highly successful examples of enterprise in the renewable energy sector. Furthermore, of the worldwide biogas plants operational in 2012 (just over 13,000 excluding landfill sites), more than 12,500 are situated in Europe[17]. On the contrary, stationary FC power exploiting this resource coming from wastewater is currently situated almost exclusively in California, US. The fact that such installations are operating well and continuously growing in number proves the feasibility of the concept and outlines a clear opportunity for Europe in particular.

Indeed, direct conversion of biogas from organic waste to end-use power and heat, rather than intermediate upgrading to methane, maximizes round-trip efficiency and cost-effectiveness of the waste-to-energy chain. The aim is to develop fully integrated solutions for bio waste to power. To jump-start the commercial exploitation of these integrated plants, the industry needs dedicated demonstrations with selected promising suppliers/technologies[18].

This should allow to pick up on the growing need for an deployment of efficient organic waste treatment plants, which already provide attractive value propositions in the framework of European legislation.

Scope:

This innovation activity will focus on demonstrating the technical and commercial feasibility of sub-MW stationary FC's directly fuelled by biogas produced from bio-waste treatment processes, aiming at full process integration of heat use in the digester process or the digestate treatment. In this way confidence shall be established for the further application of FC systems for the exploitation of this resource, which could radically leverage the deployment of stationary FC across Europe, allowing the achievement of further reductions in product cost and development of the value chain.

Core features of the FC such as efficiency, cost, emissions, durability and lifetime must comply with relevant MAWP targets and the global competition; these values have been compiled on the expected impact chapter.

The projects will target primarily demonstration of a sub-MW FC solution in the biogas/-waste market segment addressing the following:

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[17] IEA Bioenergy: "Biomethane – status and factors affecting market development and trade" (2014), http://www.iea-biogas.net

[18] Advancing Europe's energy systems: Stationary fuel cells in distributed generation: A study for the Fuel Cells and Hydrogen Joint Undertaking, Roland Berger, March 2015

- Between 100 kW and 1 MW capacity production of power and heat from bio gas, provided by bio waste treatment processes
- Full, steady-state process integration of the FC system with the biogas producing process, in terms of power requirements and heat management
- Raw biogas processing and upgrading for durable conversion in the FC stack including the needed clean-up and detection equipment

The scope or the technology should have a clear difference or a clear progress relative to the wastewater project of the AWP2014-2.11.

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 replicated and can be financed through various sources. Therefore the project should:

- Validate real demonstration units in representative applications in order to enable suppliers, various stake holders and end users to gain experience throughout the value chain
- Assess the technical opportunities and bottle-necks across the sector of biogas producing facilities for an accurate mapping of feasibility of the FC integrated system in Europe
- Develop and reinforce business plan and service strategy during the project that will be replicable and validated in the chosen market segment after the project

Expected impact:

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, waste management or other industry accessing biogas from biowaste. The project could 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 project should focus on the following impacts:

- Supplier and user experience of installation/commissioning, operation and use of power generation in the bio-waste sector, also relative to tailored biogas cleaning
- Clear awareness among the current investors in biogas producing plants of the added value of FC integration
- Demonstrate a viable solution and a replicable business case

and possibly address in addition to that also:

- Validated references to build trust among the stakeholders
- Active participation of consumers in order to bring the fuel cells technology closer to their daily business
- Reduction of the CO_2 emissions with respect to the national grid by > 10%
- Reduction of the use of primary energy by
    - Electrical efficiency > 45%
    - Total efficiency > 70% (heat cycle: 45°C/30°C, LHV)
- Reduction of the FC-system CAPEX (no transport, installation, project management, no heat use and biogas clean-up equipment) towards 3,000 – 3,500 €/kW for systems near 1 MW and towards 6,000-6,500 €/kW for systems near 100 kW
- Reduction of the maintenance costs (full service including stack replacement) of the FC-system (without heat use and biogas clean-up equipment) towards < 0.035 €/kWh (near 1 MW) and towards < 0.050 €/kWh (near 100 kW)

Increase the fuel cell system lifetime towards 20 years of operation (stack replacement included, as referred on the cost reduction goals). It is envisaged that the proposals will also bring societal benefits such as:

- Improved round-trip efficiency and sustainability of processing organic waste streams
- Economic growth and new jobs at the local level, including supply-chain jobs
- Great basis for further growth of the industry providing FC systems tailored to the rapidly growing sector of biogas producing plants
- Energy security and improved reliability

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.

Other information:

TRL start: at least 6

TRL end: 7

Indicative funding: The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 5 million (at the level of 12.5 k€/kW) would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Number of projects: A maximum of 1 project may be funded under this topic

Expected duration: 5 years

Type of action: Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-02.9-2015: Large scale demonstration of µCHP fuel cells

Specific challenge:

According to COM(2015) 80 final, 25/02/2015 on the Energy Union Package, the vision of the Energy Union is a sustainable, low-carbon and climate-friendly economy that is designed to last; the vision is of strong, innovative and competitive European companies that develop the industrial products and technology needed to deliver energy efficiency and low carbon technologies inside and outside Europe (the European Council set in October 2014 an indicative target at the EU level of at least 27% for improving energy efficiency in 2030, and the agreement on the 2030 climate and energy framework has defined the EU commitment of an at least 40% domestic reduction in greenhouse gas emissions compared to 1990); most importantly, the vision is of an Energy Union with citizens at its core, where citizens take ownership of the energy transition, benefit from new technologies to reduce their bills, participate actively in the market, and where vulnerable consumers are protected (e.g. facilitating the participation of consumers in the energy transition through smart grids, smart home appliances, smart cities, and home automation systems).

It is in this context necessary to fundamentally rethink energy efficiency and treat it as an energy source in its own right, representing the value of energy saved. As part of the market design review, the Commission will ensure that energy efficiency and demand side response can compete on equal terms with generation capacity, in particular in the transport and buildings sector.

All above Energy Union main challenges (especially those on energy efficiency and emissions targets) can be partially addressed by the distributed Combined Heat and Power, CHP technology, in particular micro-CHP based on fuel cells technology (for residential applications area)[19] which can reduce CO_2 emissions by more than 30% compared to the condensing boiler (normal conventional technology), while NOx emissions can be eliminated entirely; and can be more efficient than central generation due to superior technologies and avoidance of transmission losses for a potential mass-market of more than 2.5 million units annually in core European countries.

In general, the fuel cell system has the best net energy performance and can further improve its competitiveness by decreasing capital costs; however, to become economically competitive, capital costs must be reduced substantially by increasing production volumes, while improving the technology through similar learning curve: many production steps are still manually performed and learning effects from Japan cannot be adopted. Larger volumes (of at least 500 units per manufacturer) will allow for automation and bundled sourcing strategies; in addition, standardisation must increase within and across technology lines; finally, further research on how efficiency can be improved by next generation system design is needed (increase of electrical efficiency to 65% and total efficiency to 95-99%) and further optimisation of running modes and operating models should be done (durability increase to 15 years for the stack and up to 20 years for the entire system).

[19] Advancing Europe's energy systems: Stationary fuel cells in distributed generation: A study for the Fuel Cells and Hydrogen Joint Undertaking, Roland Berger, March 2015

The first demonstration stage of such applications (about 50-150 units per manufacturer) has started in Europe around 2007-2008 with National initiatives on field trials and demonstration programmes (e.g. Danish µCHP-demonstration, and Callux, FuelCell@Home in Germany) and it has been continued at European scale with the projects SOFT-PACT and ene.field (after 2010), in order to first try to build a European value and supply chain, but also experiment the different routes-to-market in about 10-12 EU Member States; overall around 10 major European manufacturers have successfully demonstrated the technology readiness by installing and operating approximately approx. 1,300 systems (800 units only in Germany). It is therefore expected that the customer requirements such as very high efficiency, significant CO_2-reduction and competitive operating costs could be achieved.

The second stage demonstration/field trials should also continue to demonstrate the technology at least in the main markets identified by the first demonstration/field trials, but also try to identify new markets opportunity, depending on the energy spark-spread of each region or Member State.

Scope:

The main focus of this topic is to initiate a second generation large scale demonstration of µCHP fuel cells destined for the residential and small commercial applications (0.3-5 kW); it will require further improvements of units/system concepts demonstrated in previous initiatives and build upon those results. This represents the second step of demonstration for the manufacturers (incl. all types of FC technologies) at a more advanced phase of the learning curve (i.e. ramp-up phase) which will ensure ramp-up in the range of 2.500 units in one/two-family homes (eventually small commercial applications in Europe).

The technology and system integration aspects in the <5kW part of topic 2.6 are closely linked to this topic and synergies between these topics should therefore be sought within the scope of these projects. This topic puts significant focus on the further development of the FC stack, being the main innovative element in a FC system and a prerequisite for the success and competitiveness of the European µCHP sector in future. The project scope should also address the practical functionality of the system, with the synergies from topic 2.6, including further improved and validated BoP components in terms of concept, robustness and increased lifetimes, while exploring the possibility for standardisation; the integration in Europe's energy system with higher rates of RES (e.g. as VPP), stabilisation/standardisation of supply chains; innovative marketing and sales strategies, innovative business models, implementation of financial facilities; finally, the upgrading of already developed solutions such as monitoring, control, diagnosis, lifetime estimation should be addressed too.

The project should mainly:

- Demonstrate in the field in the range of 2,500 µCHP units with at least 500 units or 500 kW_{el} per manufacturer and a minimum of 3 manufacturers; these manufacturers should have been successful in first generation field-trials (successful operation of min. 250,000 kWh produced cumulated and fleet availability of at least 90% in previous field-trials for at least 100 units or 100kWel is a pre-requisite)
- Demonstrate, evaluate and optimize new solutions and components especially at the FC stack level but also 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
- Increase lifetime of stack and other components of BoP; each manufacturer has to double the stack lifetime during the project as compared to the state-of-art figures

- Test and demonstration of new models, among the 2500 units, which should minimize installation efforts and installation failures
- Increase robustness of fuel cell system to achieve availability of at least 99% in the fleet to be demonstrated
- Test and demonstration of remote control models with regards of grid stability support of Virtual Fuel Cell Power Plants as part of Europe's future renewable energy system
- Establish a demonstration/commercialisation pathway for European SMEs innovating in the development, manufacture and supply chain of fuel cell µCHP components
- Verification of heat and power contracting business models for applicable markets by the manufacturers present in the project
- Specifically identify further installation sites as base for large scale deployment; Establish a "technical label" assuring the financial viability for system installation for further installation sites
- Establish the basis and further develop, if possible marketing and sales strategies of European µCHP manufacturers; qualify to open the access to conventional financing for customers, be it private households, utilities or other kinds; proven solid business model in practical manner for a significant number of systems providing pathways to allow full commercial deployment
- Increase awareness in European markets for µCHP fuel cells

It is expected that the applicants in the consortium will have significant experience of manufacturing, installing and testing fuel cell µCHP units; participating manufacturers have to present a clear strategy on how to grow their installed base, this demonstration presenting a stepping stone for growth beyond. This strategy needs to be in line with the corporation's strategic targets and is expected to be part of bigger additional activities plan. Marketing, sales and deployment plans need to be approved on strategic level of the company, i.e. by senior executive management of the sales and after-sales organisation of the manufacturer. Each manufacturer has to show recent value created in a European member state in at least 3 EU member states, e.g. by creation and protection of jobs in Europe, strengthening of existing or establishment of new competitive key suppliers for the FCH industry.

The project will also demonstrate through field applications the advantages of innovative technologies (hardware or software) including, but not limited to, monitoring, control, diagnosis, lifetime estimation, new BoP components. Furthermore, any methodology that may improve the knowledge and the quantification of those processes causing lifetime and performance reduction may be considered as a valuable solution to be tested and demonstrated in the field. The project will implement each solution on a limited scale basis for the purpose of demonstrating their feasibility and the advantages brought to the on-board application.

The project is linked with topic FCH.02.6-2015 (Development of cost effective manufacturing technologies for key components or fuel cell systems) to enable demonstration in the field of new developed components and manufacturing processes. Data gained in the project should be fed into the HIAD database.

The project is encouraged to look for additional/complimentary funding from regional or National funding bodies which should result in demonstration of additional number of units, up to the necessary total number of units for this second generation stage (about 10.000 units, according to the Roland Berger Study, before starting the deployment phase).

Expected impact:

The project shall explicitly strengthen the European value chain in particular for the critical components such as fuel cell stack, reformers (incl. desulphurization), special heat exchangers, inverters, etc. Proposals have to explain which of these issues can be addressed by scaling up in order to strengthen European industry competiveness. This large scale demonstration will as well initiate the drive to achieving economies of scale and hence significantly reduce costs enabling further phase roll-outs/deployment stage to be funded at lower rates by Member States after 2020.

The proposals are expected to have the impacts described below:

- The main objective of this topic is to achieve significant improvements in the technical and economic performance of the FC stack and its manufacturing:
    - Reduction of the FC stack production cost with at least 30%
    - Application of innovative production methods, demonstrated through increase of production capacity with at least 30% and an increased share of automation
    - Improving the lifetime of the stack and demonstrate the durability in relation to thermal cycling
- The above is expected to contribute, together with progress in the system integration to a capital cost (CAPEX) reduction of at least 30% on FC system level compared to today's average system costs, aiming at a level of less than 10.000 €/kW which can provide the right level of competiveness for large deployment phase after 2020
- Increased system lifetime to more than 15 years and maintenance interval by new/improved components (e.g. in case of new desulphurisation component: new solutions should be found and demonstrated to provide maintenance free over lifetime, which would lower the maintenance costs, OPEX significantly and therefore improve LCOE/RoI for the customer side)
- Contribute to significant further capital cost reduction enable to tightened start investments in European production facilities for further ramp-up in European markets
- Reinforce European supply chain of critical key components by e.g. a higher range of common/standardised parts to be produced in Europe
- Stimulate private investments in production lines and facilities in Europe from today's yearly 'hand-made' volumes (50 – 100) to a capability of minimum yearly 1,000 systems
- Generate cost decreases on core components potentially transferable to other product families and enabling accelerated product deployment in the commercial size FC market segment in principle
- Explore the implementation of financial facilities that provide capital for the next step of µCHP deployment, e.g. through the European Investment Bank, market incentive schemes in addressed EU markets, etc.

Other Information:

The consortium must include at least three manufacturers, if necessary fuel cell system integrators, relevant suppliers for BoP components and relevant energy utilities. Research institutions and academic groups may also be included. Collaboration with any national initiatives is recommended, in order to leverage additional funding for the necessary level of this second demonstration step.

Improvement of TRL from level 7 to 8 or even 9 for advanced technologies and new technical solutions; upgrading of already developed solutions such as monitoring, control, diagnosis,

lifetime estimation, new BoP components in previous funded FCH JU projects by achieving at least TRL 7.
At least one constituent entity of the Industry Grouping or Research Grouping should be among the participants in the consortia in order to align new European demonstration activities with previous/existing projects and to maximize impact towards commercialisation of hydrogen and fuel cell technology.

Indicative funding: The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 30 million would allow the specific challenges to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

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

Expected duration: 5-6 years

Type of action: Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

OVERARCHING PROJECTS

FCH-03.1-2015: Large scale demonstration of Hydrogen Refuelling Stations and FCEV road vehicles - including buses and on site electrolysis

Specific challenge:

While fuel cell transport applications have recently moved into the early commercialization stage a number of challenges still need to be resolved before hydrogen can be widely implemented as a transportation fuel. These challenges include improved performance and lower costs of both fuel cell electric vehicles (FCEVs) and hydrogen refuelling infrastructure and thereby a strengthened customer acceptance. This requires a large scale “market test” with HRS located on a network basis in different regions showing various geographical and demographical characteristics; and with sufficient vehicle numbers, and types, per station to generate relevant data based on demonstration of the HRS under high load conditions. The learnings obtained are specifically intended to trigger further technological improvements of both stations and vehicles and to provide the necessary experience and confidence on the part of investors and policy makers in the business plans for the multi-billion euros of investments needed to establish the HRS infrastructure required for mass market roll-out.

For the purpose of this topic, it is expected that use of electrolysis integrated into fuelling stations will demonstrate a capability to assist the penetration of renewable power in electricity grids by taking excess electricity and converting it into hydrogen. Concurrently, as FCEV fleets increase, the aggregate electrical load constituted by onsite electrolyser based H2 production coupled with HRS facilities could also provide valuable balancing services to the power industry in addition to strengthening the economic case for decentralized electrolysers. A techno-economic framework and control hierarchy is required to ensure appropriate electrolyser-infrastructure is developed for providing balancing services and sufficient low carbon footprint hydrogen is available for FCEV refuelling. Consideration is required of how to design and operate suitable production and refuelling infrastructure, both for wind-dominated and solar-dominated regions, including how central, regional and forecourt electrolysers are operated within the electricity grid. In this topic the focus is on decentralised electrolysis integrated into fuelling stations.

Scope:

This topic calls for a large scale demonstration project covering FCEVs and HRSs, coupled to decentralized electrolysers, to be deployed in alignment with and in cooperation with national or/and regional roll-out activities. Demonstration of electrolyser integrated HRS operating in grid balancing mode in a selection of the new HRS installed will also be covered.

Vehicles

For vehicles, the project will cover the roll-out of a fleet of at least 200 FCEVs. This should comprise multiple OEM supplied passenger cars, utility vehicles (light duty vans, medium duty trucks) and buses. Other vehicles can be included provided they can demonstrate a strong business case a significant market potential (10,000’s per year) and have reached a TRL of 7 or above.

The majority of FCEV's are expected to be using a fuel cell system as the key power source, and 70MPa storage in the case of passenger cars or 35 MPa for buses. Storage systems lower than 70MPa can be allowed if relevant and there is a business and customer case for inclusion in the proposal. Range extenders using FCs are also eligible if relevant and can show a clear advantage over all-electric drivetrains for the same vehicle type.

The minimum operation for passenger cars is 36 months or 45,000 km. For buses it should be 36 months in operational service at minimum 10h/day (unless regulatory restrictions prohibit 10h). The minimum operational period for vehicles introduced in the last 15 months of the project is 12 months or 10,000 km for passenger cars and 12 months or 50,000 km for buses, though in both cases arrangements for extending operation after the end of the project are expected.

HRS

In this topic, the focus is on demonstrating at least 20 HRS in operation and on investigating the specific problems arising from the need to provide high volumes of hydrogen per day while offering satisfactory service to HRS customers in terms of refuelling duration per vehicle (back to back refuelling performance). It is expected that HRS will prove performance under high load. In addition, proposals are expected to address reliability, metering accuracy, purity and station efficiency.

When addressing the passenger car market, HRS facilities need to be accessible for private customers/users and should preferably be integrated in forecourts of conventional refuelling stations. When addressing the utility vehicle market or local fleets, HRS facilities might be located on private forecourts, with or without public access, as long as several customers are already identified as long term users of the HRS. The first HRS need to be operational at the latest 24 months after the start of the project. The majority of the HRS have to be operational no later than 36 months after project start. The minimum operation for the HRS is 5 years (operation beyond the project life is expected.

The project should aim at benchmarking and establishing links between existing regional and national initiatives in order to synchronize actions and maximize impact Europe wide. The demonstration sites for passenger cars, buses, utility vehicles and vans must be located in more than one EU member state where H2 Mobility initiatives, or similar initiatives (like HIT) aiming at deployment of hydrogen based mobility programmes are in place, to leverage the activities already underway. HRS should be sited to provide interconnectivity with existing initiatives to create a plausible driving experience both within and between the networks. In view of the requirement to evaluate HRS under high load, consideration should also be given to locations with a high number of users, addressing both privately owned or fleet vehicles.

Different options for the ownership and investment in HRS should be analysed and tested.

On-site hydrogen production & grid support

The project should demonstrate the use of fluctuating renewable energy sources for hydrogen supplied to the HRS:

- Develop a model of the required electrical behaviour of various penetrations of electrolysers and HRS for grid balancing in a range of future scenarios of renewable power penetration and mobility hydrogen demand. The model should provide the most economic favourable scenarios based on a multi-market service strategy
- Identify preferred electrolyser and HRS design, including control configurations, for providing the required balancing services and match the local hydrogen demand on the stations and for other applications

- Identify operational frameworks (including pooling when needed) for grid operators to utilise electrolysers for balancing services and quantify the associated remuneration. The extent to which electrolysers can assist with meeting energy storage requirements in the EU for the period 2020-2050 should be determined.
- Demonstrate cost effective and optimised running strategies for a cluster of electrolysers acting as a single capacity in the energy market. This includes electrolyser load decisions based on electricity cost, electrolyser efficiency at different loads and hydrogen demand at individual stations
- The electrolysis technology must demonstrate an electricity consumption below 60 kWh/kgH2 and a capital cost @ rated power including ancillary equipment and commissioning of 6 - 8 M€ / (t/d) for PEM technology and 4 – 6 M€ / (t/d) for alkaline technology
- The forecourt electrolysers must demonstrate an optimized integration of the electrolysis with the refuelling station including buffer tanks sizing consistent with the operating modes selected

Safety assessment shall include the social acceptance dimension.

Overall

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

Ensuring that the knowledge acquired throughout the project will help to provide the confidence to underpin future investment and policy decisions in favour of hydrogen vehicles is of key importance. Therefore priority will be given to proposals presenting a comprehensive programme to gather new learning from the project in terms of: customer acceptance, techniques for the operation of a station network, business models for national HRS roll-out, technology performance (and requirements for improvement, using the HyLights methodology) and the impact of different national policies on roll-out effectiveness. A formal, inclusive and creative dissemination programme is required which ensures that the lessons learnt by the project are made available to wider public. In particular, it should be ensured that countries considering development of similar FCEVs/HRS roll-out initiatives should have an easy access to information generated by the consortium.

Expected impact:

Vehicles

At least 80% of the vehicles to be deployed in the project should be “next” generation and based on model platforms made available / released in Europe after 1st January 2015). A number of older vehicle models can be accepted where these are introduced in the early stage of the project to help improve HRS loading levels.

Technical targets for passenger cars:

- >6,000h vehicle operation lifetime
- The key power source of vehicles must be a fuel cell system (except for light duty vans, medium duty trucks and other vehicles proposed based on a range extender concept or optimized combinations of hybrid drives)

- Vehicle range > 400 km
- Fuel cell system MTBF >1,000 km
- Availability >98% (to be measured against available operational time)
- Tank-to-wheel efficiency >42%, measured in the New European Drive Cycle (NEDC)
- Pilot series production ability has to be shown

Technical targets for buses:

- >15,000h / 2 x 8,000h[20] vehicle operation lifetime initially, minimum 20,000h lifetime as program target
- The key power source of vehicles must be a fuel cell system
- Fuel cell system MTBF >2,500 km
- Availability >90% (to be measured in available operation time)
- Tank-to-wheel efficiency >42%, for buses measured in the SORT 1 & 2 drive cycles.
- Pilot series production ability has to be shown

Utility vehicles (light duty vans and medium duty trucks) and other vehicles must demonstrate that their specifications meet the requirements of a mainstream customer for the vehicle type included. They should also demonstrate that the vehicles will have reached a TRL of 7 or above by the time of deployment in the project.

For vehicles deployed early in the project the funding contribution will not exceed 500 € per kW of installed power in passenger cars and other vehicles where the fuel cell is the key power source, and will not exceed 2000 € per kW where the fuel cell acts as a range extender. For buses, the funding per vehicle cannot exceed 3500 € per kW of installed power. For vehicles deployed 3 years after project commencement and to reflect cost reductions brought by new vehicles the funding contribution will not exceed 200 € per kW for passenger cars, 1800/750 €/kW[21] for buses and 700 €/kW for FC-range extenders (limited to 30 kW). Overall, a minimum of 80% of the FCEVs funded will be at the lower of the funding contribution levels indicated.

HRS

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

- Metering of hydrogen: As current standard dispensing technology is offering a level of metering accuracy of circa 5%, improvements leading to a level of accuracy reaching circa 1% should be considered
- Quality Assurance issues around hydrogen purity: Progress towards definition of an industry acceptable hydrogen quality compliance system is targeted
- Integration of hydrogen into conventional vehicle fuel forecourts: 2 options for integrating HRS are to be considered: semi-integration with separate hydrogen

[20] Depending whether the bus system will be composed by one larger bus fuel cell stack or two passenger car stacks, respectively, and hence will have to be replaced once during the lifetime targeted

[21] Depending whether the bus system will be composed by one larger bus fuel cell stack or two passenger car stacks, respectively

dispensing unit from the main conventional fuels distribution versus full integration within the existing distribution system

- Achieving a high level of availability for HRS: Improvements towards 98% HRS availability
- Optimization of HRS layout and reduction of safety distances for HRS integrated in service-stations
- Improved efficiency/performance for HRS:
    - level of back to back vehicle performance to be defined as function of HRS utilization factor (minimum of 5 for passenger cars / LDVs)
    - energy consumption targeted at 4kW/kg H2
    - optimization of compressor management
    - optimization of cold temperature process management
- Key RCS issues for HRS such as those related to optimized safety distances and fuelling protocol to be addressed in order to facilitate permitting/approval
- Standard Operation procedures for refuelling
- Increased availability of hydrogen from renewable sources: level of targeted decarbonization of the hydrogen fuel must be defined according to the national/regional sustainable on-going production roadmap(s)

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

- For passenger cars, provide a clear and configured HRS network, with practical FCEV driving distances between HRS (in the order of 200 km). For utility vehicles based on the captive fleet model, a realistic fleet of vehicles (up to 30 per station) must be demonstrated together with a vision of how the business model for these HRS installations will lead to their integration into a wider, publically accessible, HRS network for multiple vehicle types
- For buses, HRS be designed to allow for supply to a realistically scaled bus fleet of up to 20 buses for cost effective HRS operation. Both passenger car and bus categories should comply with the requirements of the directive on the deployment of alternative fuel infrastructure package (as published particularly as regards its standardization requirements. Exceptions may be allowed, if justified by the vehicle application (e.g. the captive fleet model for utility vehicles)
- The majority of the HRS for non-fleet, public operation shall deliver 70MPa H2 for private cars and 35 MPa for buses and should be sized consistently with the deployment and business planning strategy for the country / H2Mobility programme HRS targets. Higher capacity HRS facilities are encouraged for highly frequented HRS sites. The minimum refuelling capacity should be 200 kg of daily refuelling capacity for all stations. Moveable or mobile stations can be proposed, adding flexibility and reliability in regional clusters comprising several fuelling stations
- Some 35MPa HRS (maximum 10) can also be proposed if they are associated with a significant fleet of vehicles (passenger cars, vans, other vehicles, buses) TRL 7 or above) and can demonstrate a clear commercial plan. In this case, an up-grade strategy to 70MPa, or a bi-pressure station (35MPa and 70MPa) should be proposed if coherent with the foreseen customer(s) requirement(s) ideally before the end of the project and consistent with the business case for the station
- A target availability of the station of 98% (measured in usable operation time of the whole filling equipment) should be adopted and bidders should demonstrate how this will be achieved
- 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 <10€/kg excl. taxes)

- Hydrogen purity has to be at least 99.999 %. Vehicle refuelling process must comply with SAE J2601 (2014) and IR communication needs to comply with SAE J 2799. Exceptions may be allowed, if justified by the application
- Reliability of filling process under high throughput situations, i.e. 6 vehicles being filled in 1 hour

An average maximum funding per HRS is 700,000 €, excluding electrolysis.

On-site hydrogen production & grid support

- Deployment of at least four electrolysers operated as a single system to demonstrate on-site production of hydrogen, while providing services to the electricity transmission and/or electricity distribution network operators. A central electrolyser may be included as part of this system, but terminal and distribution facilities from the central electrolyser to the hydrogen customer cannot be funded under this topic The choice shall take into account the following parameters:
    - For the forecourt electrolysers priority is set to the HRS with the highest forecasted demand of hydrogen (e.g. bus depots)
    - need to pool several electrolyser systems for grid services

Linking existing or otherwise funded electrolysers to this system is encouraged.

- Total installed capacity of electrolysis funded by this project at least 1 MW (with at least 50% of the capacity in decentralised mode).
- Confirm and validate feasible operation of distributed electrolysis on the HRS, including the necessary grid interfaces that capture revenue from grid balancing and (or) energy storage services
- Optimise a system containing forecourt and central electrolysers to provide electricity grid services while producing hydrogen. Storage options at the HRS should also be envisaged.
- The environmental performance of the system shall be foreseen including an understanding of the GHG emission impact of the grid services mode selected and mobility WTW (well to wheels) roundtrip efficiency and WTW CO2 emission assessment. Demonstration of how the 50% reduction of carbon intensity targeted is met
- Confirm that there is a viable business model for electrolysis to deliver hydrogen at the dispenser at a maximum price of 10€/kg

Overall

The proposal should identify:

- Customer profiles in order to establish HRS utilization patterns in an early market
- Definition of best practices for mass market roll-out
- Analysis of network planning decisions and in particular the customer reaction to the network, with a view to influencing future network planning activities

The learning from the project will be widely disseminated to improve the overall investor/policy maker confidence in the infrastructure roll-out and support other actors in the hydrogen mobility sector in evaluating their strategies. It should address the following points:

- The techno-economics of the HRS facilities and vehicles deployed in the project vs. the targets identified in the national or regional roll-out strategies as well as the MAWP

- Customer acceptance and the willingness of local populations to switch to FC vehicles when a minimum HRS coverage is in place
- Determination of any new obstacles on the way to hydrogen mobility, particularly from a customer perspective
- Customer profiles in order to establish likely early adopters and HRS utilization patterns in an early market

Other information:

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.

Proposers should provide a clear evidence of:

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

The consortium should include multiple vehicle OEMs, refuelling infrastructure providers and operators, fuel retailers, and other actors as appropriate and relevant to the effective delivery of the programme. The composition of the consortium should facilitate the establishment of strong links with "H2Mobility" initiatives.

It shall also reflect the value chain of the power to hydrogen process, for instance including electrolyser and hydrogen technology developers, electricity grid operator(s), utilities and electricity market trader(s).

To be eligible for participation, a consortium must contain at least one constituent entity of the Industry and/or Research Grouping.
The following TRLs are at least required:

- 7 for FCEVs at start of project and 7 - 8 at the end
- 6 for the HRS at start of project and 7 – 8 at the end.
- 6 for electrolysers to start the project and 7 – 8 at the end.

Indicative funding: The maximum FCH 2 JU contribution that may be requested is EUR 35 million per project. This is an eligibility criterion – proposals requesting FCH 2 JU contributions above this amount will not be evaluated.

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

Expected duration: 6 years

Type of action: Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH-03.2-2015: Hydrogen territories

Specific challenge:

Hydrogen and fuel cell technologies are often described as very promising solutions that will help to reshape a new society model as it would guaranty secure, clean and efficient energy solutions while also offering smart, green and integrated transport solutions. However, transport and energy are often treated separately within the FCH JU funding framework programme, thereby reducing the opportunities to demonstrate pioneer hydrogen economy models at territories levels.

Therefore, this topic aims to support territories where there is a strong political commitment to deploy ambitious and innovative hydrogen-integrated transport and energy demonstration projects in European Territories.

This particular “Hydrogen territories” topic is focused on the deployment of hydrogen technologies in European isolated territories in order to prove the viability and feasibility of hydrogen economy concept in off-grid areas.

Scope:

To develop and deploy replicable, balanced and integrated fuel cell and hydrogen solutions in both energy and transport fields through strong partnerships between municipalities, industries and academia in European isolated territories disconnected to the main or national electrical grid.

These solutions will demonstrate an integrated hydrogen economy concept focused on small off-grid areas. The hydrogen territory proposals should primarily target transport and energy replicable demonstration applications such as vehicle fleets powered by hydrogen for public and/or private transport, including logistics and/or freight-distribution, MW capacity production of green hydrogen, hydrogen storage for balancing the grid and supply to a hydrogen refuelling station as well as large stationary fuel cell systems for distributed generation and other relevant commercial or industrial applications.

The proposals should address the following main areas:

- Near/fully autonomous hydrogen buildings/quarters/districts: through the integration of hydrogen energy storage chain coupled with renewable energy sources and including heat valorisation, backup power solution, and when applicable, supply to a vehicle hydrogen refuelling station (retail, public transport, or fleets)
- Zero emission mobility: through the integration of hydrogen refuelling infrastructures and provision of vehicle fleets powered by hydrogen for public and/or private transport, including logistics and/or freight-distribution. The project shall focus on hydrogen mobility applications such as public transport buses, passenger vehicles, taxi fleets, boats but also scooters or bikes to ensure a greater public visibility and awareness. The vehicles included must be designed in a way that allows producing them in large series

To be eligible, the proposals should prove a strong commitment from local authorities that reveals a long-term hydrogen-integrated urban plan strategy.

Isolated hydrogen territories should seek to create partnerships between industries, academics and cities, demonstrate replicability of the solutions and ensure funding from various sources.

Therefore each project should:

- Be realised in at least one European isolated territory
- Include industry, city planning authorities, research community, local Small and Medium Size Companies (SMEs)
- In addition the project should co-involve at least one follower territory i.e. an off-grid territory willing to contribute to the process though the replication of solutions at the end of the project and having access to the know-how and results of the project and a privileged contact with the project's partners. The involvement of the follower territory should be relevant (e.g. participating in definition of user requirements and methodology of transferability of solutions, data collection etc.). The follower territory should commit to replicate, improve and follow up integration of hydrogen energy vector solutions in the urban planning. The follower(s) territory(ies) will not be eligible for FCH 2 JU funding to deploy integrated hydrogen and fuel cell solutions in the frame of the project proposals. At least one follower territory should come from a Member State or Associated Country
- Ensure that all proposed activities will be integrated in an ambitious urban plan. The urban plan shall integrate buildings planning, energy networks, and transport/mobility planning; additional issues may be addressed as well if relevant for the territory. These plans shall be submitted with the proposal as a supporting document(s)
- In order to ensure the success of the project, the funding for some parts of the programme or initiative in which the isolated territory project is embedded should be secured from other sources, preferably private ones, but also other EU funding sources, national or regional funding
- Projects should develop and reinforce business plans during the project and Life Cycle Analysis that will be replicable and validated in other territories after the project
- Consortia must have a clearly defined structure with roles and responsibilities properly spelled out for all involved entities

Proposals must also commit to scientific and technical requirements:

- Create a "Hydrogen Territory Platform" to share smart hydrogen solution proposals, best practices, project ideas, collect data from operating systems, measurement and disclosure methodology, in order to facilitate a common footprint calculation methodology and other metrics (especially for energy saving; CO_2 reductions, financial savings, number of jobs created, environmental impact etc.)
- The performance monitoring should last for a period of long-term commitment such as 5 years. Consortia should develop an integrated and common protocol for monitoring energy, infrastructure, mobility and governance practices in the hydrogen territories, enabling documentation of improved performance over short and long term periods. The monitoring protocol should be robust and viable also after the end of the project, supporting and increasing municipal capacity over time

Projects should be co-funded by national, regional or private sources in order to demonstrate a strong commitment towards the 2020 European Energy Policy. This should be explained in the budget justification and supported with a Letter of Intent.

Expected impact:

The proposals are expected to have the following impacts:

- deploy and demonstrate wide-scale, innovative replicable and integrated hydrogen energy solutions in both energy and transport

- increase the energy efficiency of isolated territories and valorise the use of renewables for integration of hydrogen-energy solutions and enable active participation of consumers
- demonstrate the positive impact of electrolysis on grid balancing
- increase mobility efficiency with lower emissions of pollutants and CO_2. The proposals will have to specify key objectives and indicators such as gCO_2/km for Well to Wheel analysis
- reduce the energy costs; The consortium will have to commit itself to reaching targets for energy cost reduction
- respect Key Performance Indicators described in the MAWP for both hydrogen transport and energy applications and technologies used in the project
- conclude on a business model for the use of hydrogen in isolated territories
- decarbonise the energy system while making it more secure and stable; clear targets shall be expressed in terms of, for example, gCO_2/MWh electrical and/or g CO_2/MWh heat
- create stronger links between isolated territories in Member States with various geographical and economical positions through active cooperation

It is envisaged that the proposals will also bring societal benefits:

- Reduction of energy bills for all actors and especially for public authorities with clear objectives for both energy applications (e.g. €/MWh elec and/or heat) and for transport applications (e.g. €/km)
- Increase quality of life by creating local jobs (that cannot be delocalised) in the isolated territories
- Increase air quality

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.

Other Information: The project will be using very near to market hydrogen technologies (TRL 7 and more at the start or maximum one year after the start of the project) and should be replicable in other territories.

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

Indicative funding: 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.

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

Expected duration: 5 years

Type of action: Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH.03.3-2015: Hydrogen delivery with high capacity compressed gas trailer

Specific challenge:

Current industry practice for the distribution of gaseous hydrogen from central production plants is by means of trailers equipped with approximately 200 bar compressed gas storage cylinders. The maximum effective payload of these trailers is around 400 kg.

The FCH 2 JU aims to fund development and demonstration projects to increase the payload to 1000 kg, while keeping cost and unloading time acceptable. The aim is to reduce distribution cost, reduce the number of distribution trucks on the road and minimize the impact of delivery at hydrogen retail stations, thus enabling road transport of hydrogen on a larger scale than is currently possible.

The recently completed DeliverHy project concluded that the MAWP target for high pressure trucks (1000kg capacity at investment cost of 450 €/kg in 2023) is feasible. Further conclusions were that improvements are needed for filling the truck and for emptying it at the hydrogen retail station; as well as to standards (EN/ISO on cylinder design) and regulations (ADR for transport of dangerous goods by road).

This topic calls for proposals to enable high pressure hydrogen delivery by proposing changes to regulations and the interfaces between the truck and hydrogen supplying and receiving equipment. The proposal should describe activities to obtain acceptance by hydrogen retailers and distributors as well as regulators. It is possible that the results of the project will be used in a future full scale demonstration project.

Scope:

Projects should focus on industry agreement on standard equipment (connections, pipe-diameters, etc.) and procedures for loading and off-loading trucks and aim at bringing standardised high-pressure (≥450bar) hydrogen trailer delivery from TRL level 3 to TRL level 7. Projects should start with a review of the public conclusions of the DeliverHy project. The project should include:

- Building of a consortium with sufficient critical mass to enable standardisation of equipment and procedures to load and unload high pressure gas trucks
    - Stakeholders include hydrogen suppliers, hydrogen retailers and standardisation/regulation bodies. These are encouraged to participate in the project, but could also participate in other forms for example as advisors or steering committee members
- Define standard equipment and procedures for the interfaces between the high pressure truck and the truck filling station and the high pressure truck and the hydrogen retail station
- Design and build, or adapt an existing high capacity trailer on a relevant scale with the interfaces defined before
    - The volume and weight of the system should be on the same scale so that it is clear that full system would meet EU trucking regulations regarding these
    - The system pressure should be at the full intended (optimum) pressure and at least 450bar
    - The capacity of the system should be at least 200kg
- Integrate as far as possible technologies and tank components (liner, mechanical reinforcement, valves…) used for on board hydrogen tank for transportation in order to

optimize the production process and lower production cost. Size effect will have to be taken into consideration

- Design and adapt the interface to a hydrogen retail station to receive hydrogen at high speed according to the standards defined; and optionally: design and build or adapt a high pressure hydrogen truck filling station according to the standards defined (otherwise find an alternative way to fill the truck)
- Demonstration of trailer delivery at a filling station using the agreed equipment and procedures“. Data (filling times, hydrogen losses, incidents and other relevant aspects) from at least 10 deliveries should be documented and published
- A cost analysis of the trailer when produced at full scale as well as the cost impact on the hydrogen terminal and filling stations of transitioning to high pressure trailers
- Initiation of the process to certify high-pressure trucks for operation on European roads

Expected impact

- Industry agreement on the interfaces between high pressure hydrogen trucks and truck filling points as well as hydrogen refuelling stations regarding equipment and procedures has been obtained and published
- The agreed interface equipment and procedures have been demonstrated at relevant scale and in a relevant operating environment and results have been published
- The process to amend EU legislation to allow high pressure hydrogen trucks on the road has been initiated and a pathway to certification of high-pressure, high-capacity trucks is visible
- The feasibility of the 2023 cost (≤450€/kg) and capacity (≥1000kg) targets have been validated or changes have been proposed based on adequate reasoning.
- Offloading time has been optimised within safety constraints to allow as fast as possible offloading at the filling station. A minimum target is ≤60min for 200 kg, but consortia are expected to aim for quicker offloading.

Other Information:

Successful proposals will bring together at least two industrial players from each part of the value chain (central production, distribution and retail), either as participants in the consortium or in a consultation role.

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

Indicative funding: 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. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Number of projects: A maximum of 1 project may be funded under this topic

Expected duration: up to 2 years

Type of action: Research and Innovation Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

CROSS-CUTTING PILLAR

FCH.04.1-2015: Recycling and Dismantling Strategies for FCH Technologies

Specific challenge:

As fuel cell and hydrogen technologies are commercialised they will be required to meet environmental standards and minimise impact, and part of this will be the ability to recycle and dismantle products at the end-of-life. For example FCEVs will be required to be safely dismantled, and materials and components recycled as is the case for current conventional vehicle technologies. Until alternative materials are found, it is important to recycle critical and scarce materials, such as precious metals used in fuel cell stacks and fuel processing sub-systems.

Scope:

Research and technological development is required on the recycling and end-of-life treatment of materials and components. An initial action assessing the existing and proposing new recycling and dismantling technologies and application specific requirements will be necessary to provide guidelines for the recycling on FCH technology components. This is also an important precursor to further development and demonstration work. Besides, it is fundamental to involve stakeholders to harmonize procedures and prove the economic feasibility of the concept as early as possible.

To achieve these goals, the activities under this call should contribute to:

- Evaluation of existing recycling and newly developed technologies and their applicability to FCH materials and components
- Identify critical raw and rare materials and components for which new strategies and technologies have to be developed and the technological challenges related to this, taking existing EU initiatives into account (e.g. SETIS reports and activities within the European Partnership for Innovation)
- Compliance with European and national regulations about recycling, specially the Ecodesign Directive (2009/125/EC)
- Harmonization and regulatory proposals of new strategies and technologies for the phase of recycling and dismantling considering all the actors involved in the lifetime of the product (from manufacturers to dismantling, reuse and recycling entities including end/industrial users)
- Development of Life Cycle Assessment models for fuel cells and hydrogen technologies (considering the International Reference Life Cycle Data System, ILCD, Handbook on LCA and following the HyGuide recommendations) looking for and quantifying possible energy and cost reductions linked to the proposed new strategies and technologies in the phase of recycling and dismantling
- Business model on how to motivate, regulate, promote and make economically feasible the use of the new strategies and technologies proposed, especially considering the manufacturing industry
- Recommendations for introduction of new processes (e.g. recovery of critical materials from FCH products) and re-adaptation of recycling centres so that the new strategies and technologies proposed can be effectively implemented
- Event/showcase in a recycling centre showing the implementation of the new strategies and technologies proposed for at least one FCH product

Expected impact:

- Provide guidance on the future need and focus of recycling strategies in common for both the stationary and the transport sector
- Establishing a road map for recycling and dismantling strategies within FCH technologies
- Harmonize procedures for the phase of recycling and dismantling at EU level
- Pave the way for future large demonstration projects validating the business model proposed

Proposals should build upon the experience of previous projects on LCA (including activities covered under the European Green Vehicle Initiative) and consider the application of LCA methodologies developed in FC-HyGuide project.

Other Information:

Indicative funding: The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 0.5 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

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

Expected duration: 2 - 3 years

Type of action: Coordination and Support Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH.04.2-2015: 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.

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

Other Information:

Indicative funding: 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.

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

Expected duration: 2 - 3 years

Type of action: Coordination and Support Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

FCH.04.3-2015: Best practices guidelines on safety issues relating to current and emerging FCH Technologies

Specific challenge:

There has been considerable overall progress with fuel cell and hydrogen (FCH) technology development and market deployment in the past. To keep this trend successful and to foster on further market entry, it is essential that the safety of all FCH technologies and plant can be assured – particularly as public and end-user acceptance depends on actual and perceived safety levels. Today's FCH technology comprise many different techniques and components and the safety coefficient of each FCH component affects the overall safety coefficient of each assembled plant and packaged system. Best practice guidelines are therefore required on current and emerging FCH Technologies including information at the component level and, if relevant, the weakest component(s) in the assembled system for which definition of fail-safe modes and/or restrictions on use might reasonably apply during early deployment and pre-commercialisation stages of the applicable FCH technology.

Scope:

For the further successful deployment and market entry of FCH technologies is essential to ensure the safe operation of FCH applications. Contemporary FCH technology is based on integrating and assembling a mix of technical components, e.g. electrolysers, finishing devices, storage tanks, fuel cell stacks, sensors, etc. depending on the particular application the system is intended for. Each of the components bears its own critical failure aspects and safety standard. The overall safety standard of an assembly can be increased through improving safety coefficients of individual components within the assembly. The improvement of safety coefficient in general supports both the safe and harmless operation of FCH technology together with plant endurance.

Apart from safety coefficient of single components, the best practice in assembling and installing components to extensive plants is as well essential and should be based on known practical issues and safety standards. The accumulated knowledge base concerning past failures for the installation, for the operation and for the maintenance of the specific FCH technology can influence and complete best practice guidelines.

It is expected that the consortium would create comprehensible and specific best practice guidelines based on already identified practical issues arising from all kind of FCH industry including knowledge transfer of past and ongoing projects and specific research results facing that issue:

- Best practice guidelines based on already identified practical issues
- Implementation of new standard operating procedures and safety standards as far as available
- Implementation of restrictions according the assembly of materials, components and interfaces
- General procedures in order to define the best compromise of cost-reduction, safety and industrialization
- Identification of further requirements to technical components common to both the energy and transport sectors

Expected impact:

- Increase fail-safer of several assembled plant technology
- Raising public confidence in FCH Technologies

- Improvement to the operation and maintenance of FCH plant technologies by best practice guidelines
- Influences the necessities to standardization/harmonization of materials used, components, interfaces and testing procedures in order to define the best compromise of cost-reduction, industrialization and safety aspects

Other Information:

Indicative funding: The FCH 2 JU considers that proposals requesting a contribution from the EU of EUR 0.5 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

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

Expected duration: 2 - 3 years

Type of action: Coordination and Support Action

The conditions related to this topic are provided in the previous chapter and in the General Annexes.

3. Public Procurement

The activities described in this section are implemented by call for tenders (i.e. public procurement) and fall outside of the call for proposals (i.e. grants, which constitute the main means of implementation of the Annual Work Plan.). Implementation of this section is subject to an additional Governing Board decision.

Subject (Indicative title)	**Indicative distribution of the funding between the studies**
1. Business model and financing arrangement for the commercialisation of micro-CHP Fuel Cells	400,000 EUR
2. Alternative stationary storage for Hydrogen	150,000 EUR
3. Vision implementation planning and requirements	300,000 EUR
4. Early business case for energy storage through Hydrogen	300,000 EUR
5. Joint Procurement Strategy for Fuel Cell Buses.	300,000 EUR
6. Coordination of the implementation of European FC Car activities	300,000 EUR
7. Assessment of the impact of increased support for clean H2 in transport EU legislation	150,000 EUR
Total FCH 2 JU Funding	**1,900,000 EUR**

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

The AWP 2014 foresaw a list of topics for studies. For these topics an intensive preparatory work has been done in 2014. However as the regulation creation the FCH 2 JU entered into force in June and the AWP 2014 was approved in June, it was not possible to finalise the procurement of all these studies before the end of the year. It is therefore planned to finalise the implementation of this part of the AWP 2014 in 2015. This will not require new appropriations from the budget 2015.

4. Cooperation 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 FCH JU was structured under a Framework Agreement that covered support activities that JRC provided in-kind to FCH JU, as well as possible funded JRC participation to FCH JU projects.

For the Horizon 2020 period, a new Framework Agreement between FCH 2 JU and JRC is under finalization and subject to approval by the Governing Board.

This Framework Agreement will include activities at programme level to support the Strategy Formulation, as well as some specific research and innovation activities related to standardisation and pre-normative research. These activities will be provided free of charge to the FCH 2 JU Programme Office and to the FCH 2 JU funded projects.

Other activities, at programme and project level, including support to the implementation of the MAWP and the consecutive AWPs, will be funded from the FCH 2 JU operational budget. These activities will be discussed and agreed on an annual basis between the JRC and the Program Office and will be included in a rolling collaboration plan, to be approved by the Governing Board of the FCH 2 JU. These activities will be subject to annual monitoring against agreed key performance indicators. The collaboration plan will list the activities, the expected outcomes/deliverables and the estimated necessary resources for each activity.

For 2015, a maximum budget of EUR 1 million from the 2015 FCH 2 JU operational budget is foreseen.

5. Abbreviations and Definitions

Term	Definition
APU	Auxiliary Power Unit
AWP	Annual Work Plan
BoP	Balance of Plant
CAPEX	Capital Expenditure
CEN/CENELEC	European Committee for Standardization, European Committee for Electrotechnical Standardization
CHP	Combined Heat & Power
Demonstration	Activities for a given technology and/or infrastructure comprising all or some elements of: 1) Validation/field testing of prototype/pilot systems including feedback to RTD, proof of safety aspects, functional and endurance testing under real-life conditions. 2) Market preparation demonstrating relevant numbers of application ready products, aiming at infrastructure development and expansion, customer acceptance and development of RCS, economic assessment, attraction of capital investment and achieving target costs for commercial deployment
Deployment	Activities for a given technology and/or infrastructure from its market introduction to its widespread use
EC	European Commission
EFTA	European Free Trade Area
ESIF	European Structural and Investment Funds
FCEV	Fuel Cell Electric Vehicle. This includes passenger cars, buses as well as vans and two-wheelers
FCH	Fuel Cells & Hydrogen
FCH JU, FCH 2 JU	The FCH Joint Undertaking: name used to refer to the legal entity established as the public & private partnership. It may also be referred to as the JTI
GDL	Gas Diffusion Layer
Horizon 2020	EU Research and Innovation programme over 7 years for the period 2014 to 2020
HRS	Hydrogen Refuelling Station
HT	High Temperature
IEC	International Electrochemical Commission
IG	European Industry Grouping for a Hydrogen and Fuel Cells JTI also referred to as "Industry Grouping" or NEW IG".
ISO	International Standardization Organization
JRC	Joint Research Centre of the Commission
JTI	Joint Technology Initiative - referring to the political research

	initiative introduced by the EC in the FP7. The Term JTI may also be used to referred to the legally established structure implementing the initiative (cf. above FCH JU)
KET	Key Enabling Technologies
KPI	Key Performance Indicator
LCOE	Levelized Cost of Electricity
MAWP	Multi Annual Work Program
MEA	Membrane Electrode Assembly
Members	The term "members" refers to the founding members of the FCH 2 JU (EC & IG) and the Research Grouping, as the case may be.
MS **Member States**	The "Member States" shall be understood as the EU-27 Members States. If not stated clearly in the document, the term "Member States" can also refer to countries associated to the FP7 (named "Associated Countries" in the current document). It may also be referred to as "MS"
OPEX	Operational Expenditure
PEM	Proton Exchange Membrane
PNR	Pre-normative Research, R&D work that addresses technical knowledge gaps in the development of RCS
RCS	Regulations, Codes and Standards
RoI	Return on Investment
RG	European Research Grouping for a Hydrogen & Fuel Cells JTI, also referred to as " Research Grouping" or "N.ERGHY"
SET Plan	Strategic Energy Technology Plan, see COM(2007) 723 Final
SME	Small and Medium size Enterprise
SOEC	Solid Oxide Electrolysis Cells
SRG	States Representative Group, advisory body of the FCH 2 JU gathering representatives from Member States and Associated Countries
Stakeholders	The term "Stakeholders" embodies any public or private actors with interests in FCH activities from the MS or third countries. It shall not be understood as “partners" or "members" of the FCH 2 JU
T&D	Transmission and Distribution
VPP	Virtual Power Plant