Adopted by the FCH JU Governing Board on

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING (FCH JU)

Multi - Annual Work Program 2014 - 2020

"**Not legally binding**"

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Introduction

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Background

- Fuel Cell and Hydrogen (FCH) technologies hold great promise for energy and transport applications from the perspective of meeting Europe's energy, environmental and economic challenges. The European Union is committed to transforming its transport and energy systems as part of a future low carbon economy. It is recognised that FCH technologies have an important role in this transformation and are part of the Strategic Energy Technologies Plan. (SET-Plan).

- Europe is a technology leader in certain FCH applications and very competitive in others. However, the scale and scope of the research and market entry agendas for developing and deploying FCH technologies across the spectrum of applications goes beyond the capacity of single companies or public research institutions in terms of financial commitment, resources and capability.

- The public and private sectors came together to form the first Fuel Cell and Hydrogen Joint Undertaking (JU) in 2008 to promote coordination and collaboration across Europe's FCH sector and accelerate the commercialisation of FCH technologies.

- The Members of the FCH JU are the European Union, New Energy World Industrial Grouping (NEW-IG) and the New European Research Grouping for Hydrogen and Fuel Cells (N.ERGHY), representing Europe's FCH private sector and research community respectively.

- Under Horizon 2020 the JU will continue as the FCH 2 JU to build on the success to date and to achieve more efficient and effective operations focused on a long term, integrated, pan-European research and innovation agenda, sector strategy and market approach.

State-of-the-art

- FCH technologies constitute a very diverse and versatile portfolio, with applications in transportation, energy and portable application sectors.

- In the transportation sector, FCH technologies are most advanced in propulsion applications for fuel cell electric vehicles (FCEVs), notably passenger vehicles and buses. Significant progress has been made since the millennium to address technical issues such as start-up, driving range, refuelling times. FCEVs are now very reliable with availability of 98% achieved, and as such they are on the threshold of market introduction, but costs must be reduced and lifetimes increased.

- A European wide network of hydrogen refuelling stations (HRS) has yet to be established, although numbers are now approaching 100. Refuelling interfaces have been successfully developed and refuelling times are competitive with liquid fuels, but further developments are necessary e.g compressors, metering and quality assurance.

- Non-road applications of FCH are primarily in the form of Auxiliary Power Units (APU) for aviation, maritime, rail and the off-road sectors. The levels of maturity are generally lower than for road propulsion, with further developments necessary.

- In the energy sector FCH technologies are used in a diverse range of applications and have great promise in the integration of intermittent renewable energy sources into the overall energy system. However, the key technologies of electrolysis, large scale storage and injection of hydrogen into the grid require development.

- Hydrogen production with low carbon footprint from other resources, including solar, biogas and waste streams is generally at a low level of maturity. Further development and demonstration of the range of methods for hydrogen production is required.

- Fuel cells for combined heat and power (CHP) and power only, for stationary industrial, commercial, residential and small applications are relatively mature and, like FCH for transport, are at the threshold of the commercialisation process.

- Hydrogen storage, handling and distribution are critical to its widespread use. Current distribution of gaseous hydrogen by trucks needs to be improved and costs reduced, and in the longer term liquid hydrogen storage and distribution may be developed.

Objectives of the FCH JU for 2014-2020

- The overall objective of the FCH 2 JU is to implement an optimal research and innovation programme at EU level to develop a portfolio of clean and efficient solutions that exploit the properties of hydrogen as an energy carrier and fuel cells as energy converters to the point of market readiness by 2020.

- This objective will be achieved by implementing an industry led integrated programme of applied research, development and demonstration activities, including prototyping, piloting, testing for FCH technologies.

- The main strategic objectives of the FCH Joint Technology Initiative are to:

    i) boost the share of FCH technologies in a sustainable, low-carbon energy and transport system;
    ii) ensure a world leading competitive European FCH industry; and
    iii) secure inclusive growth for Europe's FCH industry, increasing/safeguarding jobs.

- Specific objectives are to:

    i) reduce the production costs of fuel cells used in transport applications whilst increasing their lifetime to levels competitive with conventional technologies;
    ii) increase electrical efficiency and durability of the different fuel cells used for power production, whilst reducing costs for power and CHP applications to levels competitive with conventional technologies;
    iii) increase energy efficiency of the production of hydrogen from water electrolysis and renewable sources whilst reducing operational and capital costs so that the combination of the hydrogen and the fuel cell system is competitive with the alternatives available in the marketplace;

iv) demonstrate on a large scale the feasibility of using hydrogen to support the integration of renewable energy sources into energy systems including through its use as a competitive energy storage medium for electricity produced from renewable energy sources; and
v) reduce the use of EU defined ‘critical raw materials’.

Programme and content

- The FCH 2 JU programme of research and innovation is structured around two research and innovation Pillars dedicated to Transportation and Energy Systems. Overarching projects integrating both transport and energy technologies and a cluster of Cross-cutting research activities complement these two Pillars.

- The Transportation Pillar encompasses all aspects of hydrogen utilisation in transportation including FCEVs as well as non-road, train, maritime and aviation applications, in addition to the required Hydrogen Refuelling Station infrastructure for refuelling these vehicles and systems.

- Road transport will be the main priority addressed by the Transportation Pillar because it offers the greatest potential for addressing EU climate change and energy security objectives and is also critical for European competitiveness. In addition to passenger vehicles, the focus will initially be on captive fleets (buses, trucks, vans…), along with the specific refuelling infrastructure for these applications. As such the FCH 2 JU programme will support research & innovation and innovation actions projects.

- Applications for maritime, rail and aviation and other off-road applications require additional research efforts, for APUs and possibly propulsion applications.

- The Energy Pillar will support projects in four areas:

  i) Hydrogen production for energy storage and grid balancing from renewable electricity – including large ‘green’ hydrogen production, storage and re-electrification systems. The initial focus will be on the role hydrogen can play in the integration of renewable energy sources in the grid.
  ii) Hydrogen production with a low carbon footprint from other resources – whereby different hydrogen pathways will be developed and if appropriate demonstrated.
  iii) Fuel cell systems for CHP and Power only – covering the technical developments necessary to reduce costs, increase lifetime and improve performance.
  iv) Hydrogen storage, handling and distribution – to allow storage of hydrogen at central production plant and distribution to the customer base.

- It is envisaged that Overarching projects will be supported by the FCH 2 JU to demonstrate the inter-operability and the synergies between the two Innovation Pillars.

- Cross-cutting research and development projects will support and enable the Transportation and Energy Pillars and facilitate the transition to market for FCH technologies. Priority will be given to Safety and Pre-normative research

- The proposed activity distribution of the FCH 2 JU financial resources is:

    - Research and innovation actions should account for approximately 29% of the total contribution from the EC; approximately 14.5% each for the Transportation and Energy Pillars;
    - Innovation actions should account for approximately 66% of the EC contribution, with approximately 33% each to the Transportation and Energy Pillars;
    - Cross-cutting activities should account for approximately 5% of the EC contribution.

- Deliverables for both the Transportation and Energy Pillars will include, amongst others:

    - Development of technologies that reduce cost and improve efficiencies and performance of FCH applications.
    - FCEVs and HRS systems developed using the new generation technologies and demonstrated, for both passenger and commercial vehicles.
    - Participation in standards development and definitions necessary for market deployment.
    - Electrolysers at variable scales developed and demonstrated for use in renewable energy integration systems, and injection of hydrogen into the grid.
    - On-site hydrogen production systems using renewable fuels for decentralised hydrogen production; biological reactors with larger volumetric density & scale.
    - Fuel cell systems for CHP and power only applications that incorporate new technologies.
    - Hydrogen storage (large scale) and distribution systems developed and demonstrated .

- The primary deliverable from the Overarching projects will be to have developed and demonstrated a fully integrated energy chain, inclusive of fuel production, storage to distribution to end use by FCEVs or stationary CHP and power only fuel cell systems.

- Cross-cutting deliverables will be many and varied according to the projects supported by the FCH 2 JU, but will include: innovative safety strategies and safety solutions that protect lives and property and an industry led RCS co-ordination activity.

Inter-actions and coordination activities of the FCH 2 JU

- The FCH 2 JU will interact and co-ordinate its activities with other organisations at the European, Member State, Associated Country and regional levels, and also with other European bodies and activities under the SET-Plan for example, in order to maximise efficiency and effectiveness. These interactions will be undertaken either directly or via other bodies.

- Specific inter-actions and coordination activities will be on or with:

    - Regulations, Codes and Standards (RCS).
    - Life Cycle Assessment activity.
    - The Commission's Joint Research Centre (JRC).
    - Co-ordination undertaken with the Member States, Associated Countries and regions.
    - Small and Medium Enterprises (SMEs).
    - Liaison and work with international agencies to benefit from synergies in fields such as RCS and market deployment.

Other European initiatives and bodies, for example the SET-Plan, EIIs (European Industry Initiatves), EERA (European Energy Research Alliance), other JUs, EGVI (European Green Vehicles Initiative), Smart Cities and KETs (Key Enabling Technologies) and the European Structural and Investment Fund (ESIF),

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Implementation of the FCH 2 JU

- The FCH 2 JU is established for the period 2014 to 2024. It will be jointly funded by its Members. The running costs will not exceed 38€m and operational costs will be covered by a financial contribution from the Union of up to 646€m, plus an in-kind contribution from the Members.

- The FCH 2 JU will provide financial support mainly in the form of grants to participants following open and competitive Calls for proposals. Other instruments may be used.

- At least one Call for proposals will be published each year based on the Annual Work Plan. Three types of actions will be supported by the FCH 2 JU:

    1. Research and Innovation Actions consisting of activities aiming to establish new knowledge and/or to explore the feasibility of a new or improved technology, product, process, service or solution. The appropriate Technology Readiness Level (TRL) will be from 3 to 5.

    2. Innovation Actions consisting of activities aimed at producing plans and arrangement or designs for new, altered or improved products, processes or services, and will include prototypes, demonstrations or pilot, and market replication activities. Projects may include limited research & innovation activities primarily TRLs from 6 to 8.

    3. Coordination and support actions consisting, inter alia, of measures such as standardisation, dissemination, awareness raising and communication, networking, coordination or support services, and studies.

FCH 2 JU bodies

- Under Horizon 2020 the FCH 2 JU will continue to be an industry led private-public partnership. The private sector will be represented by the NEW-IG for the European FCH industry and N.ERGHY for the European FCH research community. The European Union will be represented by the Commission. Each of the Members will appoint its representatives within the Governing Board of the FCH 2 JU. The bodies of the FCH 2 JU will be:

    - The Governing Board – responsible for FCH 2 JU strategy and operations;
    - The Executive Director and Programme Office – responsible for day-to-day management of the FCH 2 JU and the implementation of the research and innovation programme;
    - The Scientific Committee – providing an advisory function on science & technology;
    - The States Representative Group – with an advisory role on Member States, Associated Countrie and /regions activity;
    - The Stakeholders Forum - open to all public and private stakeholders.

Programme reporting and control

- The Executive Director will present to the Governing Board for approval an annual report on the progress of the FCH 2 JU in the previous calendar year, identifying, amongst others, innovation activities undertaken, financial expenditures and indirect actions selected for funding.

1. Introduction

This document sets out the Multi-Annual Work Program (MAWP) for the second phase of the Fuel Cells and Hydrogen Joint Undertaking (FCH 2 JU) under the EU's new funding programme for research and innovation, Horizon 2020. It outlines the scope and the objectives of the research, technological development and demonstration activities for the time frame 2014-2020.

1.1 Background

1.1.1 FCH technologies today and their potential

Fuel Cell and Hydrogen (FCH) technologies hold great promise for energy and transport applications, but monetising their potential social and environmental benefits in the short term is extremely challenging. Indeed this increases the investment risk for early movers in the market place. Under the Fuel Cells and Hydrogen Joint Undertaking (FCH 1 JU). FCH technologies have made significant progress, especially in terms of reducing life-cycle cost and increasing overall performance. This has enabled the commercialisation process to begin within some specific market segments; for example passenger cars, buses, materials handling vehicles, back-up power, portable power. However, the levels of cost competitiveness and performance required for large-scale deployment have not yet been achieved. Furthermore, important framework conditions required to foster widespread commercialisation of these technologies, such as the infrastructure to sustainably produce, distribute and store hydrogen, end-user confidence and the availability of appropriate regulations, codes and standards have not yet been fully met.

"First-mover disadvantage" together with the limited access to financial resources are amongst the remaining market introduction challenges. Consequently, the industry has not been able to engage in mass production, which would enable a significant reduction in costs and allow for visible market penetration. In most applications, FCH technologies are competing to replace more polluting and/or less efficient incumbent technologies, but which are mature, very cost competitive, accepted by the market and deployed at large scale. Given that the drivers for these emerging FCH technologies are mainly societal (e.g. reduction of Green House Gases (GHG) emissions, energy security, local emissions reduction) rather than economic, pooling private and public (both at national and EU level) resources in a coordinated and joint approach is critical to address and overcome these challenges, and to maintain and enhance the competitiveness of businesses in Europe's FCH sector.

The FCH 1 JU programme has improved the poisition of FCH technologies significantly, but the fact that the European FCH sector is fragmented in that it is geographically dispersed, covers many activity areas (energy, transport) and involves a wide range of organisations (academia, industrial companies, Small Medium Enterprises (SMEs)) compromises coordination within the sector, especially in the exchange and pooling of knowledge and experience. Futhermore the scale and scope of the research agenda for developing FCH technologies across the spectrum of applications goes beyond the capacity of single companies or public research institutions in terms of the financial commitment, the resources involved and the capabilities required. There continue to be opportunities to further focus the reseach activities, which would encourage industry, particularly innovative SMEs, to further commit more of their own resources. A long-term, integrated, pan-European research & innovation and nnovation strategy and market approach will improve this situation.

The European Union is committed to transforming its transport and energy systems as part of low-carbon economy by 2050, whilst decoupling economic growth from resource and energy use, reducing GHG emissions, increasing energy security and maintaining a strong competitive global position[1]. Recent studies[2] have concluded that hydrogen, together with electricity, sustainable bio-fuels and natural gas, will gradually become a much more significant component of the European energy mix. At the same time fuel cells are the most efficient means of converting various fuels, especially hydrogen, to clean/cleaner, efficient, reliable power and heat for a wide range of energy related applications; these include portable devices, combined heat and power (CHP), stationary power generation and road and non-road transport. A recent IEA report[3] has concluded that hydrogen, as an energy vector and storage medium, will substantially reduce the need for ever-greater quantities of renewable electricity, bio-fuels and bio-energy necessary to create a sustainable low-carbon energy system after 2030. Furthermore independent near to mid-term market projections worldwide indicate a substantial growth in the sector with positive impacts on direct industry and associated supply-chain jobs.

For these many reasons, fuel cells and hydrogen are part of the portfolio of technologies identified in the European Strategic Energy Technology Plan (SET Plan)[4]. They are expected to make contributions to a European sustainable and secure energy system in the medium to long-term. This is consistent with the goals of the EU2020 Strategy, the Energy 2050 Roadmap[5], the White Paper on Transport[6], the Communication on Research and Innovation for Europe's Future Mobility (Strategic Transport Technology Plan (STTP))[7], the Communication on Energy Technologies and Innovation of 2 May 2013[8] and the Communication on Clean Power for Transport[9] (CPT) which outlines the European alternative fuels strategy.

1.1.2 The support of the European Union for fuel cells and hydrogen technologies

Europe is a technology leader in certain FCH applications and very competitive in others. Notable technological progress has been made by European companies in all sectors, particularly road transport, due in part to consistent and long term public support for projects funded in by the countries, the European Research and Development Framework Programmes and the FCH 1 JU. However, other world regions are developing quickly and there is the risk that Europe will fall behind regions such as Japan, USA or Korea. Significant public intervention through substantial financial support and favourable policies for market pull measures (e.g. subsidies, feed-in-tariffs etc.) have placed these regions in the lead of commercialising certain applications such as residential and industrial CHP, fuel cell electric vehicles (FCEVs), and fuel cell back-up units.

The European Commission has supported research and development in fuel cells and hydrogen technologies since the early EU Framework Programmes (FP) with increasing

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[1] Communication COM(2009) 519 final

[2] "*Infrastructure for Alternative Fuels*" – Report of the European Expert Group on Future Transport Fuels, December 2011

[3] *Energy Technology Perspectives 2012: Pathways to a Clean Energy System* (ISBN: 978-92-64-17488-7)

[4] A European strategic energy technology plan (SET Plan) - Towards a low carbon future" COM(2007) 723

[5] Communication COM(2011) 885 final

[6] White Paper COM(2011) 144 final

[7] Communication COM(2012)501 final; SWD(2012)260 final

[8] http://ec.europa.eu/energy/technology/strategy/doc/comm_2013_0253_en.pdf

[9] Communication COM(2013) 17 final

funding levels over time (e.g. 145 M€ in FP5, 315 M€ in FP6). In the absence of a clear European strategy, these efforts were fragmented and uncoordinated across the different FP sub-programmes, i.e. Energy (the main one), Transport, Aeronautics, Materials and Environment, and between different stakeholders, notably the European private sector.

Recognising the fragmented nature of the sector, in May 2003, the Hydrogen and Fuel Cell High Level Group presented its vision report, "*Hydrogen Energy and Fuel Cells – A Vision of Our Future*". In this, the formation of a hydrogen and fuel cell public-private partnership was recommended in order to substantially accelerate the development and market introduction of these technologies.

In December 2003, the European Commission facilitated the creation of a European Hydrogen and Fuel Cell Technology Platform (HFP), bringing together all interested stakeholders. In March 2005, the HFP published a Strategic Research Agenda and Deployment Strategy, followed by an Implementation Plan in January 2007 – a comprehensive, long-term road map for Europe.

This process confirmed that a coherent, long-term approach at EU level is essential for achieving critical mass in terms of scale, excellence and potential for innovation. The Commission's proposal for a long-term public–private partnership in the 7th Framework Programme of the European Community (2007-2013) in the form of a Joint Undertaking (JU) on Fuel Cells and Hydrogen was a consequential step to address the challenge.

In May 2008 the Council adopted a Regulation[10] setting up a Joint Undertaking for the implementation of the JTI on Fuels Cells and Hydrogen on the basis of Article 171 of the EC Treaty, now replaced by Article 187 of the TFEU (Treaty on the Functioning of the European Union). The aim of the FCH JU under FP7 was to accelerate the development and deployment of fuel cells and hydrogen technologies by executing an integrated European programme of Research Technology Development (RTD) activities for the period 2007-2013.

The FCH JU members were the New Energy World Industry Grouping (NEW-IG), representing Europe's fuel cell and hydrogen industries, the New European Research Grouping for Hydrogen and Fuel Cells (N.ERGHY) representing the European research community, and the European Commission representing the European Union (EU). The total budget of the FCH JU for that period was €940 million divided equally between the European Commission (FP7 funding) and the industry and research communities. The FCH JU became an autonomous legal entity on 15 November 2010.

The initial phase of the FCH JU (FCH 1 JU) enabled the development of a strategic programme of activities, comprising long-term, breakthrough-oriented research, applied research and technology development, demonstration and supporting actions, including strategic studies, pre-normative actions and technology assessment. However, taking to market those applications with the strongest potential for addressing energy security and climate change (e.g. road transport, public urban transport, stationary power generation, combined heat and power, hydrogen from renewable energy sources and electricity storage) requires further key technical developments. These key technical developments, such as prototyping, piloting, testing and demonstrations, should accelerate the achievement of large scale production volumes, taking into account issues around simplifying and harmonizing regulation (for example in authorisation processes for refuelling stations), standardization, consumer awareness and public procurement. All

[10] (EC) N° 521/2008 (EU Official Journal 2008 - L 153)

research & innovation and innovation actions should document progress beyond state-of-the-art.

As a public-private partnership, the FCH 1 JU has enabled a range of businesses and industry, in particular SMEs, and research communities to commit to longer term developments. It has fostered an impressive level of collaboration between the research and industry community. The current members of the FCH JU represent a major share of Europe's stakeholders from across the fuel cells and hydrogen value chain. The NEW-IG gathers over 60 companies of all sizes (50% SMEs), including car manufacturers, oil and gas companies, utilities, industrial gas companies and highly innovative SMEs developing and integrating FCH technologies. N.ERGHY consists of more than 60 reputable research institutions and universities.

The new phase of the FCH JU under Horizon 2020 will build on the experience gained in the period 2008-2013 to allow for a leaner governance structure, involvement of a broader range of stakeholders, more efficient operations and an optimal management of the human and financial resources. In this respect, the FCH 2 JU will aim at a better alignment and coherence between national and regional and its own programmes (part 4.4). 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 in regions and the complementary use of Structural Funds.

1.1.3 Integration of the recommendations from the second interim evaluation of the FCH1 JU

The success of FCH 1 JU was greatly acknowledged in its Second Interim Evaluation undertaken in 2013[11]. In its report the evaluators recommended a number of actions and adjustments to make the FCH 2 JU even better. These recomendations were taken into account in the definition process of this MAWP. In particular the following improvements result from these recommendations.

1.1.3.1 Programme governance, design, and management

The autonomy of the Executive Director has been underlined to strengthen his position (see Chapter 6), although the Governing Board remains the body that will take the strategic decisions.

The strategy of the FCH 2 JU is adapted to the main principles of Horizon 2020 as described in the technical part of this MAWP (see Chapter 3). The structure of the FCH 2 JU further reflects the recommendations with the development of an energy pillar that includes storage and cost-efficient end-use of renewable energy in the form of electricity and hydrogen (see Chapter 3).

Closer cooperation with all stakeholders is planned, enabling the FCH 2 JU to realize its long term strategy most efficiently in the European context (see Chapter 4).

[11] http://www.fch-ju.eu/sites/default/files/2nd%20interim%20evaluation.pdf

It is widely acknowledged that regulations, codes and standards (RCS) will need an increased importance in FCH 2 JU. This is reflected in the new structure of the MAWP with a stronger Cross-cutting part emphasizing RCS (see Chapters 3and 4).

Participation of SMEs in FCH 2 JU is seen as crucial for the achievement of its goals (see Chapter 4.6). The position of SMEs will be strengthened by the application of the Horizon 2020 Rules for Participation. Additionally a connection to venture investment funding may be established. However, a tool to enable researchers to establish new companies based on their innovations has yet to be implemented because such an action does not fit with the grant system of the FCH 2 JU. Further negotiations with other bodies are necessary to define a solid framework for this.

1.1.3.2 Technology monitoring and policy support

Technology monitoring will be implemented, largely based on the TEMONAS tool developed under the FCH 1 JU[12]. Additionally a knowledge management activity has been added to the tasks of the Programme Office (PO). To boost the start of the FCH 2 JU a joint working group formed by the NEW-IG and N.ERGHY will support the PO by evaluating the state-of-the-art based on the outcome of projects carried out under the FCH 1 JU. The result of this activity will be a major input for defining and detailing the technical tasks within updates of the MAWP and the forthcoming AWPs.

To measure progress of the research & innovation and innovation activities of FCH 2 JU Key Performance Indicators (KPI) are to be implemented and these form part of the MAWP (see Chapter 3). These KPIs together will help improve the monitoring of the activities and outcomes of the projects supported by FCH 2 JU.

An exchange between the FCH 2 JU and the policy DGs will be established to implement the strategic goals of Europe within the MAWP, such as those defined in the SET Plan[13] or the Clean Transportation Systems initiative (CTS)[14] amongst others. At the same time, the technology monitoring activity of the FCH 2 JU will serve as a tool for EU policy making, by providing upto date information on the state-of-the-art and the achievements of the JU.

1.1.3.3 Engagement with Member States, Associated Countries and Regions

An important strengthening of the relationship with Member States, Associated Countries and regions (see Chapter 4) is foreseen. Additionally efforts to link other stakeholders such as local authorities and European associations, to the development of the FCH 2 JU should be made.

Capacity building is very important for the growth of the fuel cell and hydrogen economy in Europe. This is reflected in the cross-cutting activities described in Chapter 3. New financial arrangements will need to be negotiated between, the EC, other European institutions and the Member States, Associated Countries and regions to broaden the possibilities of the FCH 2 JU in this respect, and this should be supported by the PO where possible.

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[12] http://www.temonas.eu/

[13] http://eur
lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=COMfinal&an_doc=2007&nu_doc=723

[14] http://ec.europa.eu/transport/themes/urban/consultations/doc/cts/cts-hardcopy.pdf

1.1.3.4 Communication and dissemination

Given that the FCH 2 JU is the leading organization for fuel cells and hydrogen in Europe strengthening the communication and dissemination of results, outcomes of the projects, etc. (including, but not limited to, knowledge management) is a key issue (see Chapter 4). This challenge is reflected in improvements to the structure of the PO (see Chapter 6), whilst better disclosure and dissemination by projects will be reflected in the grant agreements. These actions will improve the dissemination of information within and beyond the FCH community, and enable a larger impact of the FCH 2 JU on European society.

1.1.4 Horizon 2020

The Europe 2020[15] strategy and in particular the Innovation Union[16] flagship initiative aim at securing EU global competitiveness by, amongst other activities, providing a better environment for innovation. The Horizon 2020 Framework Programme for Research and Innovation, the financial instrument that implements the Innovation Union, covers the period 2014-2020. By coupling research and innovation, Horizon 2020 aims to achieve the Europe 2020 strategy goals of smart, sustainable and inclusive growth and jobs through emphasis on excellent science, on industrial leadership and by tackling societal challenges.

In this context, Horizon 2020 targets strengthening EU industry through supporting research and innovation actions across a range of sectors by providing funding along the entire value chain, from fundamental research through to market introduction. In particular, it supports public-private partnerships that will contribute to tackling some of the key challenges that the EU is facing. The Commission Communication 'Public-private partnerships in Horizon 2020: a powerful tool to deliver on innovation and growth in Europe'[17] contains legislative proposals to establish public-private partnerships in a number of areas (the “innovation investment package”). Collectively, these partnerships will implement major elements of the Innovation Union and the EU Industrial Policy[18], the strategy on Key Enabling Technologies (KETs)[19], and make substantial contributions to a number of EU policies, including amongst others, in climate, energy, transport. One of the proposals[20] provides for a prolongation of the Fuel Cells and Hydrogen Joint Undertaking launched under Seventh Framework Programme.

The present MAWP takes into consideration and builds upon information and documents prepared for the launch of the second phase of the Joint Undertaking, complying with the requirements of the Horizon 2020 Framework Programme, in particular the Impact Assessment[21] accompanying the legislative proposal.

1.2 State of the Art

Fuel Cell and Hydrogen technologies constitute a very diverse portfolio with different levels of technology maturity. The versatility of these technologies has been demonstrated in transportation as well as in portable and stationary power applications, covering a wide range of power outputs.

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[15] COM(2010) 2020
[16] COM(2010) 546
[17] COM(2013) 494
[18] COM(2012) 582
[19] COM(2012) 341
[20] COM(2013) 506
[21] SWD(2013) 260

Transportation technologies:

- *Road applications*

Fuel cell and hydrogen technologies in the transportation sector are at various stages of maturity, depending on the application. The most mature fuel cell (FC) systems for propulsion are found in vehicles for road transport, notably passenger cars and buses. A significant number of FCEVs has been deployed in a range of demonstration projects throughout the world. The technological challenges which at the turn of the millennium were identified as critical for the successful implementation of FC in vehicles have all been resolved: start-up and operation in temperatures down to -30^{o}C has been demonstrated; the driving range of today's FCEVs is now 400-600 km; and refuelling times reduced to 3-4 minutes for passenger cars and ~20 minutes for buses. A range of developments over the last 20 years mean that FCEVs are now very reliable, with availability of 98%[22] achieved. In terms of performance these passenger vehicles are on the threshold of market introduction. However, to become fully commercially viable, costs for FCEVs still need to be reduced and lifetimes increased.

The total number of FCEVs on the road has already reached several hundreds. The majority of large car manufacturers throughout the world are working on the development and market introduction of fuel cell passenger cars, while multiple bus manufacturers are developing and deploying fuel cell electric buses (FCEBs). Additionally, some smaller manufacturers have developed two-wheel and four-wheel FCEVs and demonstrated their maturity in different demonstration projects. Costs have fallen from more than a million Euros per fuel cell powered passenger car at the beginning of the millenium to less than a few hundred thousand Euros in 2013, whilst lifetime has increased from a few hundred operating hours to several thousand operating hours. Some car manufacturers have already announced the market introduction of FCEVs 2015 and thefollowing years.

Integration of the fuel cell system and on-board hydrogen storage into a passenger vehicle remains a challenge, taking into account the competing requirements of long range mobility, high performance and minimal impact on the passenger and luggage space. The current approach for on-board storage focuses on high pressure hydrogen storage, but alternative storage technologies available after 2020 may reduce storage pressure, thereby easing certain safety issues and potentially cutting storage system costs.

A European wide network of hydrogen refuelling stations (HRS) has yet to be established, but the numbers have grown significantly, and are now approaching 100. At the same time the cost of HRS has fallen, whilst reliability and lifetime of HRS technology has increased. HRS have been demonstrated at different sizes from stations that supply small demonstration fleets, to HRS that are capable of supplying highly frequented public locations. The 700 bar refuelling technology is established as the predominant refuelling pressure level for passenger cars, whilst 350 bar is used for buses and forklifts. With a standardized refuelling interface, the inter-operability of emerging HRS networks is already advanced. The targeted refuelling time (3-5 minutes) has been reached by pre-cooling the fuel and applying infra-red communication between the vehicle and the filling station meeting the SAE J2601 standard.

[22] Availability of FCEVs (including Daimler's F-Cell and Hyundai's iX35) demonstrated in the FCH JU-supported H2movesScandinavia project over more than a year. (

The major remaining technological / standardization issue for refuelling is the metering accuracy of dispensers. Current technology for metering hydrogen can achieve at best +/- 3% accuracy; higher accuracies will be needed for public billing purposes, for example + / - 1% is required for dispensing natural gas.

Additionally, hydrogen compressors are still a barrier; compressors are both too expensive and not reliable enough for commercialisation purposes. Similarly hydrogen gas quality assurance at the nozzle still constitutes a challenge, due to the very stringent requirements for fuel gas impurity levels for automotive fuel cell applications. Currently, no simple methodology nor single instrumentation is available for low cost qualification of hydrogen fuel. Moreover, the maximum impurity levels allowable by standards should be revised to take account of the trade-off between cost of cleaning the hydrogen produced at the HRS and the associated lifetime expectancy for the PEM fuel cell stack on board the FCEV.

- *Non-road applications*

Applications of FCH technologies in non-road propulsion and Auxiliary Power Units (APUs) applications are less mature than for road propulsion. Functionality, performance and operational lifetime need to be improved and costs reduced. Relatively few FCH systems have reached a formal demonstration stage and market introduction by OEMs has typically been indicated from 2018-2020 onwards.

An advanced level of technology readiness has been achieved for material handling vehicles. These are close to market introduction in Europe; although in other markets up to 4,000 vehicles are reported to be in operation, often with public financial support. Over 400 material handling vehicles, equivalent to 25% of the MAIP EU-level 2015 target, are due to be deployed through FCH 1 JU projects.

In the commercial **Aviation** sector, FCH APU technologies are a pathway toward meeting increased on-board power demands from more electric aircraft architectures (rather than diverting power from main engines in flight) and can be used for ‘hotel loads’ on the ground and runway taxiing. Fuel cell systems are being evaluated for replacing conventional tailcone APUs and/or as multi-functional systems providing ~200kW electric, plus thermal, water generation and oxygen depleted air outputs (the latter for use in wing tank and cargo hold inerting) for future commercial aircraft implementation. They are also being evaluated (<20kW) for replacement of mechanical Ram Air Turbine systems. Flight testing of representative systems is anticipated from 2016 onwards. There are no formal FCH system standards and requirements across the aviation sector for APU requirements as yet and the critical issues that need to be addressed are weight reduction along with high levels of reliability and availability (the certainty of in-flight reliability and availability at altitude are more significant than overall lifetime). On-board hydrogen storage and replenishment also needs to be addressed. FCH technologies are also being evaluated for unmanned air vehicles, where small scale (<1kW) FCH systems have been used in hybridised and range extender applications for military and civil unmanned air vehicles.

In the **Maritime** sector, there has been long term experience of FCH systems used in submarine applications. Elsewhere, FCH based APUs are being evaluated for providing power (250kW upwards) to cover in-port operations and ‘hotel’ loads for ferry and larger vessels and thereby reduce CO_2 and other emissions from main engines operating on heavy fuel oil and marine diesel. FCH systems have also been trialled for propulsion of smaller passenger and tourist/leisure vessels. There are no formal standards and requirements across the maritime sector as yet and the critical issues that need to be addressed for APUs are reliable performance, lifetime and cost – with criteria largely similar for mid-sized stationary power generation, after allowing for weight and packaging/space issues.

In the **Rail** sector, FCH systems have already been trialled for niche mining and shunting locomotive applications and are being considered as (200kW+) APUs for diesel powered rail units to cover 'hotel' loads and eliminate main engine idling while in stations for CO_2 and emissions reduction purposes. There are no sector specific standards and the critical issues to be addressed are reliable performance, lifetime and cost – again with criteria similar to mid-sized stationary power generation, accepting weight and packaging/space issues. Hydrogen storage systems are also an issue where hydrogen is being considered for direct fuel use.

Energy

- **Hydrogen production from renewable electricity for energy storage and grid balancing** (including system integration, large scale hydrogen storage, re-electrification, blending into the natural gas grid and the business model development).

The increase of intermittent renewable energy sources, such as solar and wind energy, in Europe's power systems is causing operational challenges, such as grid stability, and has led to calls for a greater use of energy storage amongst other measures. Hydrogen is identified as one of the key solutions for large scale and long term energy storage. In order to fulfill this promise several technologies need to be further developed.

C**onversion of electricity to hydrogen** is possible via electrolysis. Electrolyser systems that are commercially available have an energy consumption around 60 kWh/kg, or just below, and further improvement is still possible. However, commercial systems for hydrogen production are small (around 100 kg/day) and not currently optimised to produce hydrogen from intermittent electricity. Key challenges are electrolyser systems able to respond to dynamic intermittent renewable power and lower capital cost to compensate for lower utilisation. The impact on the lifetime of such dynamic operations is still unknown.

Large scale **storage** of hydrogen is feasible and has been commercially proven in at least one case where hydrogen is stored in an underground salt formation. However, integration with intermittent production of hydrogen has not yet been demonstrated, whilst a suitable business case whereby the location of the storage is dictated by wind/sun patterns and geological conditions has yet to be defined. It is also unclear if alternative large scale hydrogen storage methods, such as liquid, gaseous and solid means, can attain the required technology level in the near future. To exploit the large scale storage capacity of the Natural Gas (NG) grid, the first demonstrations of blending hydrogen into the natural gas grid are starting right now. These are still small scale and inject at a relatively low-pressure entry point.

The business case for hydrogen as a renewable energy storage medium depends on the **value generated by its use,** and although some cases are proven, others are not. Converting hydrogen back into electricity for the grid, using fuel cells, suffers from low efficiency (30% to 35% power-to-power) and high capital cost of fuel cell systems. Commercial viability is as yet uncertain. Other conversion technologies such as gas turbines are available, but do require further development. As such future commercial viability is uncertain and will depend on technology progress.

- **Hydrogen production with low carbon footprint from other resources** (grid electricity, gas, solar energy, biogas, waste streams) **and waste hydrogen recovery**

Today most hydrogen is produced by centralised steam reforming of natural gas. For the introduction of a hydrogen economy a reliable, and affordable hydrogen supply with low carbon emissions is crucial. Only with such a hydrogen supply will FCEVs realize their potential to become low carbon or carbon emission neutral when compared to the current state of the art gasoline or diesel engines. The objective of the FCH 2 JU is to further reduce the carbon footprint of hydrogen production to contribute to the 2020 goals.

The challenge of using other resources for hydrogen production is to provide a reliable and low cost fuel. To do so the activities in this section will focus on development of new and demonstration of near commercial hydrogen production technologies from other resources: electrolysis, high temperature water splitting, reforming, photoelectrochemical water splitting, biological production (fermentation, biophotolysis), and purification of hydrogen rich gas streams. The various pathways display different TRLs. In this sense, near term improvement should be favoured, as well as the most promising long term pathways, to show pilot scale plants at substantial size.

The objectives of the innovation activities will be focused on improving the efficiency of hydrogen production and reducing costs, increasing the yield of purification methods and reducing these costs, and improving carbon dioxide removal from production pathways.

This section has strong links with hydrogen transport and stationary fuel cell technologies. If hydrogen is produced centrally the hydrogen will need to be distributed, preferably with a low carbon footprint. The production, purification and distribution methods will need to be optimized for efficiency in both energy use and costs. Decentralized production pathways can reduce emissions, distribution needs and costs in more remote areas in Europe. The clean up of waste hydrogen streams can also provide low cost and low-carbon footprint hydrogen for both automotive and stationary fuel cell use.

- **Fuel cell systems for CHP and power only** for industrial, commercial, residential scales and small **applications**

The state-of-the-art of stationary fuel cell systems for distributed or centralised CHP and power only generation needs to be segmented by the different technologies and applications. Fuel cells are becoming established in a number of markets where they are now recognised as good as or a better technology option than some of incumbent technologies. Increasing customer awareness of enhanced products and economics wil lead to improved market penetration and a larger total market. These larger markets will generate the economies of scale necessary to reduce capital, operation and maintenance (O&M) costs.

The residential market for mCHP installations (0.3 - 5 kW), primarily for single family homes, but also multi-family homes and small buildings is rapidly developing in Japan. More than 90,000 units were installed at the end of 2013, reflecting both unique circumstances and generous public sector financial support. In comparison in Europe about 800 units have been installed as part of projects supported by both the FCH 1 JU and Member States, with further units planned. A number of European manufacturers are starting the scale-up process towards mass manufacture. Within this power range a large market of hundreds of thousands installations is expected by 2023. This market is expected to develop quickly due to the European political strategy until 2020[23]

[23] European Parliament resolution on microgeneration - small-scale electricity and heat generation- http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+MOTION+B7-2013-0388+0+DOC+PDF+V0//EN

Covering residential and commercial applications, SOFC technology is an excellent choice for some markets; in other markets PEM technology is a viable option. However, for both technologies further progress on specific issues must be made to reduce costs, improve device performance and durability as well as to improve manufacturing processes.

Mid-sized installations (5-400 kW) for commercial and larger buildings have been successfully demonstrated in a number of European locations, with an estimated installed base of 13 units, with 2MWe power output. In comparison elsewhere in the world hundreds of units have been deployed, usually with substantial public sector support. The longer term market potential is for thousands of units annually.

Fuel cell based cogeneration systems in mid and large scale installations for industrial use (0.3 - 10 MW) are being deployed globally based on lower capital and operating costs, and reduction in GHG achievable through high overall fuel efficiency. Under demanding environmental and efficiency legislations these units provide an attractive option as demonstrated in South Korea and North America, where the business case benefits from substantial public sector financial support.

Use of baseload power (1 - 30 MW) fuel cells for grid support and district use have yet to be demonstrated in Europe, although such untis are in operation in North America and South Korea. This situation reflects very different market conditions in Europe where the business case is hindered by lack of financing models and a low levelized cost of eletricity (LCOE). Compared with large conventional technology baseload systems, capital and maintenance costs are currently higher than can be sustained by the market. More market exposure and confidence is needed, and this is best achieved through demonstrations of pilot installations. This will lead to an increasing number of units and a cost reduction because of manufacturing scale up.

- **Hydrogen storage, handling and distribution:** compressed gas, cryogenic liquid, solid or liquid carriers, pipelines

Currently, large scale hydrogen handling, storage and delivery of hydrogen are limited to localized areas connected by hydrogen pipelines. Extension of this infrastructure to cover even just a relevant part of Europe would cost many €billions, an investment which will only be feasible in a fully mature market.

In the short term, distribution of hydrogen will be achieved by expanding the existing merchant market for truck distribution. A capacity of 400kg for compressed hydrogen trucks is standard for industrial applications, but demonstrations of higher pressure and higher capacity trailers are now on Europe's roads. These require further development prior to roll-out. An initial analysis of this requirement is on-going in the FCH 1 JU DeliverHy project.

In the medium term it will be necessary to develop liquid hydrogen storage and distribution to be able to expand the area supplied by central hydrogen production sites and for this to be commercially viable. Liquid hydrogen is currently transported in trucks and containers of around 3,500 kg capacity. For large scale storage of liquid hydrogen and transport by ships or rail, innovative solutions need to be developed. In addition, the energy consumption of existing liquefaction plants is high at 12 kWh/kg hydrogen. The FCH 1 JU IDEALHy project concluded that it is possible to halve this.

Compression at the large scale of many tonnes per day, is most efficiently done via turbo-machinery. This type of machinery, as well as other compression technologies, still needs to be developed for hydrogen, because standard machinery is not optimised for the low molecular weight of hydrogen.

Other forms of hydrogen storage and/or delivery, in particular via hydrogen carriers, are at an early stage of development, but promise improved performance compared to compressed gas and liquid hydrogen. The FCH JU will only support these technologies if the minimum starting TRL of at least 3 is proven.

1.3 Vision and Ambition for 2020

The FCH 2 JU will contribute to fulfilling the European vision of a low-carbon Economy as declared in the SET-plan. In line with the the *Financial and technology outlook issued by NEW IG*[24] and with the *Europe 2020 Strategy*[25] the current ambition agreed by the NEW IG, the N.ERGHY and the European Union, represented by the European Commission, is to "develop by 2020 to the point of market readiness, a portfolio of clean, efficient and affordable solutions that fully demonstrate the potential of hydrogen as an energy carrier and of fuel cells as energy converters, as part of a system that integrates sustainable and secure energy supply with low carbon stationary and transport technologies".

In addition, FCH technologies also have the potential to contribute to Europe's energy independence, by allowing storage and integration into the grid of energy from renewable sources.[26]

By 2020, fuel cell and hydrogen technologies will be demonstrated as one of the pillars of future European energy and transport systems, making a valuable contribution to the goals of the SET Plan[27], the European Strategic Transport Technology Plan (STTP)[28] and Clean Power for Transport[29] package (CPT), contributing significantly to the transformation to a low carbon economy by 2050. At the same time, the development and exploitation of advanced technologies in Europe will contribute to the Union's competitiveness.

The overall commitment of all of the stakeholders remains strong as evident in a recent survey performed by the FCH 1 JU[30]. This is the case even with the economic crisis and reduction in investment in longer term research made by some larger industry and research players. Indeed as a result of partnering and joint programming, co-operation between research and industry is strong across most FCH 1 JU projects. Furthermore with research topics being driven by industry needs, the results should feed into improvements to industrial technologies or processes, and thereby contribute to smart, sustainable and inclusive growth in the Union

[24] *Fuel Cell and Hydrogen technologies in Europe 2011, Financial and technology outlook on the European sector ambition 2014- 2020 issued November 2011*

[25] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF

[26] A Communication is being prepared by the Commission in response to the Council request, see, http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/141749.pdf

28 SET Plan

[28] Communication COM(2012)501 final; SWD(2012)260 final

[29] http://ec.europa.eu/transport/themes/urban/cts/doc/2011-12-2nd-future-transport-fuels-report.pdf

30 *Study on the trends in terms of investments, jobs and turnover in the European Fuel cells and Hydrogen sector*, McKinsey & Company and FCH JU, 2012.

2. Objectives of the FCH JU for 2014-2020

2.1 Strategic programme objectives

The overall objective of FCH 2 JU is **to implement an optimal research and innovation programme at EU level to develop a portfolio of clean and efficient solutions that exploit the properties of hydrogen as an energy carrier and fuel cells as energy converters to the point of market readiness[31]**. This will enable support for EU policies on sustainable energy and transport, climate change, the environment and industrial competitiveness as embodied in the Europe 2020 strategy, job creation, and also help achieve the EU's over-arching objective of smart, sustainable and inclusive growth.

The programme will comprise industry-led applied research (TRL of at least 3 at the begining of the project), development and demonstration activities, including prototyping, piloting and testing, for fuel cell and hydrogen technologies, over the period 2014 - 2020. All these activities should demonstrate advancement of the state-of-the-art. The FCH 2 JU, as described hereafter, will provide a stable, long-term instrument supporting the necessary investments required to introduce FCH technologies into the market place.

The main strategic objectives of this Programme are:

- To boost the share of FCH technologies in a sustainable, low-carbon energy and transport system, as well as fostering deployment of integrated solutions accross these sectors.
- To ensure a world leading, competitive European FCH industry.
- To secure inclusive growth for the European FCH industry, increasing and safeguarding jobs.

In addition to the activity of the FCH 2 JU the achievement of these objectives will also be dependent upon activities supporting research and innovation of the Member States, Associated Countries and regions. Consequently, the FCH 2 JU will need to coordinate its activities with these other initiatives and national or regional programmes, for example in the field of H2 Mobility.

2.2 Specific objectives

The specific objectives of the FCH 2 JU are in line with those of the "*Hydrogen technologies in Europe - Financial and technology outlook on the European sector ambition 2014- 2020"* document, published in October 2011 by the NEW and with N.ERGHY. This roadmap describes the pathway and by 2020 the necessary actions to ensure that the performance of the technologies will allow for their progressive deployment and their full integration within a low carbon economy, through to 2050. The research & innovation and innovation action Programme to be implemented in the FCH 2 JU during the period 2014-2020 will in particular contribute to the following ***techno-economic objectives***. These objectives are presented with more details in part 3.

- <u>Techno-economic objective 1</u>: reduce the production cost of fuel cell systems to be used in transport applications, while increasing their lifetime to levels competitive with conventional technologies,

[31] Market readiness is defined as technologies achieving the Technology Readiness Level 8.

- Techno-economic objective 2: increase the electrical efficiency and the durability of the different fuel cells used for CHP and power only production, while reducing costs, to levels competitive with conventional technologies;

- Techno-economic objective 3: increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system is competitive with the alternatives available in the marketplace;

- Techno-economic objective 4: demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems, including through its use as a competitive energy storage medium for electricity produced from renewable energy sources;

- Techno-economic objective 5: reduce the use of the EU defined "Critical raw materials", for example via low platinum resources, and through recycling or reducing or avoiding the use of rare earth elements.

In addition, the following ***operational objectives*** have been defined, :

- Operational objective 1: Leverage private and public (including Member States and AC) investment for research, innovation and early deployment activities on FCH technologies in Europe by 2020.

- Operational objective 2: Maintain, and if possible increase, SME participation in the FCH 2 JU's activities at or over 25%.

- Operational objective 3: Unlock the excellence and innovation potential in less-performing regions by increasing their participation in the activities of the FCH 2 JU, thereby contributing to closing the research and innovation divide in FCH technologies and to the realisation of the European Research Area.

- Operational objective 4: Ensure the efficient implementation of the FCH 2 JU programme by substantially shortening the time-to-grant (<240days) and time-to-pay (<90days) (see Chaper 5 for definitions of time-to-grant and time-to-pay)

3. Programme and Content

3.1 Programme structure

The implementation of the FCH 2 JU programme of research & innovation, and innovation ctions for fuel cell and hydrogen technologies for the period 2014 – 2020 is structured around **two Innovation Pillars**, dedicated respectively to **Transport** and **Energy** Systems. **Overarching** projects integrating both Transport and Energy technologies, and one cluster of **Cross-cutting research activities**, complement the two Innovation Pillars.

3.1.1 Innovation Pillar 1: FCH Technologies for Transportation Systems

As one of two Innovation Pillars of the FCH 2 JU the Transportation Pillar encompasses all aspects of hydrogen utilization in transportation, including FCEVs, non-road mobile vehicles and machinery, trains, ships, aeroplanes, and fuel cell based APUs as well as the required infrastructure for refuelling these vehicles and systems.

The projects within the Transportation Pillar deal with all fuel cell (system) and hydrogen related activties. For electric drive train components, such as electric motors and batteries, and vehicle and electric architectures an alignment with the EGVI is needed and joint activities will have to be defined and co-funded to ensure maximum synergies.

The main areas where research & innovation, and innovation actions will be undertaken are the following:

- Road vehicles
- Refuelling infrastructure
- Non-road mobile vehicles and machinery/equipment
- Maritime, rail and aviation applications

Scientific and technical progress has brought FCH technologies for transportation systems to various levels of maturity. In particular, the present generation of FCEVs, including buses, benefit from developments that have been supported in several demonstration projects co-funded by FCH 1 JU. These projects aim to deploy 150 cars (33 to date) and 45 buses (30 to date). These applications have proven their technology readiness in terms of performance, safety and reliability, and already meet public expectations for mobility. However, affordability requires large scale production volumes and this cannot be achieved without suitably phased and progressive roll-out of vehicles and hydrogen refuelling infrastructure, plus other transportation applications. This implies very substantial and sustained effort and investment in order to further improve performance and reduce costs of the next generation of road vehicles and the necessary hydrogen infrastructure, both critical aspects for mass market introduction by 2020.

Significant progress has also been achieved on refuelling infrastructure by the FCH 1 JU from 2008 to 2013, with 20 refuelling stations expected to result from the programme, of which seven have been installed to-date. A number of different technologies have been demonstrated according to the specific needs of locations (i.e. close to the hydrogen production facility or to the point of use) and customers. However, efforts must be sustained to reduce capital purchase costs and operational cost to reach the highest international levels in terms of modularity, refuelling time, reliability, safety and availability. These developments will be accompanied by demonstration activities.

Although standardisation of the interface between FCEVs and the HRS as well as filling protocol standards are already agreed on the basis of applicable standards, such as those developed by SAE and ISO, it is still necessary to complete the standardisation work for HRS. Examples of this work include the purity of the hydrogen delivered by the HRS, the accuracy of the measurement of the amount of hydrogen dispensed to the FCEVs and its temperature level. This work will be crucial in building up a sufficient refuelling infrastructure network for hydrogen, e.g. as reflected in the Clean Power for Transport Package[32], and the Alternative Fuel Infrastructure directive.[33] The coordination of efforts between Member States, Associated Countries and related stakeholders should be ensured in order to facilitate a coherent roll-out.

Road transport will be the main priority of the Transportation Pillar since it offers the highest potential for addressing the EU climate change and energy security objectives and is also critical for EU economic competitiveness. The highest priority will be given to development and demonstration of road vehicles (passenger cars, vans, buses, trucks and two-wheeled bikes), for which the fuel cell system is the main power source for propulsion, and the corresponding refuelling infrastructure for these applications. Range extender concepts may also be considered.

Some European regions,Member States and Associated Countries have already, or are developing strategic initiatives to build-up HRS infrastructure and roll-out FCEVs. These H2Mobility initiatives have a strong potential to initiate large scale FCH technology roll-out and to bring these technologies to the point of market readiness. Synergies exist between the actions promoted at the national or regional level by these initiatives (with the deployment of an HRS infrastructure, with the production and distribution of green hydrogen, social acceptance etc) and the actions of the FCH 2 JU at the EUlevel. These synergies will be examined to find ways to leverage the impact of these separate national or regional initiatives at the European level through large demonstration projects. Such actions can be an important step towards the economic success of FCH technologies, and hence reduce GHG-emissions and energy consumption, as well as creating jobs in Europe.

An advanced level of technology readiness has also been achieved for specific non-road transport applications, including material handling vehicles. These are close to market introduction in Europe, although in other markets about 4,000 vehicles are reported to be in operation, often with public financial support. Over 400 material handling vehicles, or 25% of the MAIP EU-level 2015 target, are due to be deployed through FCH 1 JU projects. These are not a high priority for this Pillar in view of their limited contribution to meet the key transport policy objectives. However, it might be possible to have limited additional research projects to increase the performance and reduce the cost of the FC systems to be integrated into material handling vehicles, along with demonstration projects. A decision on such demonstrations will be taken in accordance with propsoed studies of the opportunities.

Applications for maritime, rail and aviation and other transport modes still need additional research efforts to achieve competitiveness with incumbent technologies. These applications include propulsion for boats, APUs and in-port power supply for ships; traction motors for trains on non-electrified tracks in sensitive locations (e.g. stations, suburban trains, protected areas); and APUs for aeroplanes. Furthermore, greater use of FCH technologies in non-road applications will stimulate and leverage additional

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[32] Communication COM(2013) 17 final

[33] Commission Proposal for the Directive on the deployment of alternative fuels infrastructure: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0018:FIN:EN:PDF

economies of scale in adjacent supply chains for fuel cell and hydrogen infrastructure related components.

Consequently, development and adaptation of components and demonstration of fuel cell propulsion systems for non-road applications (e.g., materials handling, ships, trains and aeroplanes),related infrastructure and APUs for all applications will also be covered. Where possible synergies will be pursued by using and adapting suitable components between application areas. Development activities are foreseen for non-road applications only where there are specific requirements for these applications in accordance with the Directive on alternative fuels[34].

Close links to the Innovation Pillar Energy for supply and storage of hydrogen and generic aspects related to fuel cell development (e.g. lifetime issues etc.) will be pursued to maximize the potential of hydrogen as an energy vector in a sustainable energy system.

Table 3.1.1.1 shows state-of-the-art in 2012 and the targets for the particular applications of FCH technologies in the Transportation Pillar for 2017, 2020 and 2023. The activities of the FCH 2 JU, especially the projects, will be prioritized to maximise the contribution towards achieving these targets. All FCH 2 JU supported projects will be expected to demonstrate that they are capable of moving beyond the state-of-the-art towards these targets. The values for the targets result from a consultation of experts within the NEW-IG and N.ERGHY. They were revised in 2014 and will be updated when necessary.

During the revision of the targets it became clear that some of the formertarget values were either too challenging (e.g. cost for passenger car fuel cell systems) or not challenging enough (e.g. lifetime for bus fuel cell systems). Thus, these have been adapted.

For the bus fuel cell system two principal approaches will be pursued. The first is to use one large fuel cell system, developed specifically for bus applications, which takes account of the lifetime requirements for the total operation time of the bus. These are demanding requirements and as such the cost of these fuel cellsystems are high. The second approach is to use two fuel cell systems initially developed and used for passenger cars. This will enable synergies with passenger car systems, with notably significantly lower costs than the first appoach, but, due to lower lifetime requirements of passenger car systems, this approach will result in the need to exchange the fuel cell system once during the operational life of the bus. However, even in this case the particular operational requirements of public transport are such that when used in buses these FC system will have a longer life than when used in passenger cars. It is expected that many of the developments for buses can also be transferred to trucks and vans.

In order for material handling vehicles to be competitive with incumbent technologies cost reduction of the fuel cell and storage systems will be a major focus for this application area. This may be achieved through the implementation of larger fleets and corresponding economies of scale.

For hydrogen refuelling infrastructure cost reduction at constant performance can be anticipated provided that a stable regulatory framework is in place, and a roll-out of vehicles and infrastructure is built-up and the momentum maintained.

[34] Communication COM(2013) 17 final wrong reference

Targets

Table 3.1.1.1 shows the state-of-the-art in 2012 and the main targets to be achieved for the transportation technologies presented:

Table 3.1.1.1 State-of-the-art and future targets for Transportation

Application	Parameter	Unit	2012	FCH-JU target		
				2017	2020	2023
Fuel cell electric passenger cars	Specific FC system cost *Assumed number of units (per year) as cost calculation basis*	€/kW	>500	150 *20 000*	100 *50 000*	75 *100 000*
	FC Vehicle cost (C-segment)	k€	200	70	50	30
	Tank-to-wheel efficiency (vehicle in New European Drive Cycle)	%	40	42	45	48
	Availability	%	95	98	98	99
	FC system Lifetime	hours	2500	5000	6000	7000
Fuel cell electric buses	Specific FC system cost	€/kW	< 3500	< 1800 750	1000 500	800 400
	FC Bus System Lifetime	hours	10000	15000 2 x 8000	20000 2 x 10000	25000 2 x 12500
	FC Bus cost	k€	1300	700	650	500
	Fuel consumption (vehicle, average of SORT1 and SORT2 cylce)	kgH2/100km	9	8.51	8	7.59
	Availability	%	85	90	95	99
	Assumed number of units (per year) as cost calculation basis			< 50	200	> 500
Hydrogen Storage	Hydrogen storage system cost	€/kg H2	>3000	800	600	500
	Volumetric capacity (H2 tank system)	Kg/l	0.02	0.022	0.023	0.025
	Gravimetric capacity (H2 tank system)	%	< 4	4	5	6
Material handling	Specific FC system cost	€/kW @10 kW	4 000	< 1500	< 1200	< 1000

vehicles FC system	Hydrogen storage system cost	€/kg H2	> 3000	< 1000	< 750	< 500
	Lifetime	h	<5000	<10000	>10000	<15000
	Efficiency	%	>45%	>50%	>52%	>55%
	Availability	%	>90%	>95%	>98%	>99%
Hydrogen Supply	Cost of hydrogen delivered to HRS *	€/kg	5.0[35] - >13[36]	5.0- 11	5.0 – 9.0	4.5 – 7.0
	Hydrogen refuelling stations cost[37]	M€	1.5 -3.5	1.0-2.5	0.8–2.1	0.6 - 1.6
APU for truck applications (3 kW)	Specific FC system cost	€/kW	> 10,000	< 5,000	< 3000	< 1500
	Lifetime	hours	2000	5000	8000	12000
	Efficiency	%	25[1]/35[2]	30[1]/40[2]	32[1]/44[2]	35[1]/50[2]
	Availability	%	60	80	90	95
APU for aircraft applications (100-400 kW)	Specific FC system cost	€/kW	> 10000	10000	3000	1500
	Lifetime	hours	2000	10000	20000	40000
APU for maritime applications (100-400 kW)	Specific FC system cost	€/kW	> 10000	10000	3000	1500
	Lifetime	hours	2000	10000	20000	40000

* Source: Based on the data from the report 'A portfolio of power-trains for Europe: a fact-based analysis, McKinsey 2010'.
1: Hydro-carbon fuelled systems
2: Hydrogen fuelled systems

Note: For aviation, maritime and rail APU applications there are as yet no sector specific targets for lifetime, efficiency and availability. In aviation, reliability and availability are currently considered more critical than lifetime and overall cost, while mass reduction and future component adherence to aviation safety requirements is also critical. Maritime and rail APU systems will have similar requirements to mid-sized stationary power systems, allowing for weight and packaging/space considerations, but configured for their specific operating environment. This also applies to two-wheel FCEVs.

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[35] Hydrogen from centralized SMR. Achieving these targets will be influenced by the evoution of the cost of natural gas. This parameter should be taken inot account when assessing progress against this KPI.
[36] Renewable hydrogen, either on site or centralized
[37] 700 bar HRS with 200 to 1000 kg/day capacity including on-site storage.

3.1.2 Innovation Pillar 2: FCH technologies for Energy Systems

The main areas where innovation activities will be undertaken for Energy Systems are described below. In each part, a table shows the targets for the particular applications of FCH technologies for three years 2017, 2020 and 2023. The values for the targets are the result of a consultation of experts within the NEW-IG and N.ERGHY. They were revised in 2014 and will be updated when necessary. During the revision of the targets it became clear that some of the target values needed to be adjusted (e.g. CAPEX of H2 production unit from biogas or micro CHP), and adaptations have been made.

The activities of the FCH 2 JU, primarily the Research and Innovation Actions and Innovation Actions, will contribute to the achievement of these targets. All projects will be required to show how they will advance beyond the state-of-the-art towards these targets.

> **1.a - Hydrogen production from renewable electricity for energy storage and grid balancing** (including system integration, large scale hydrogen storage, re-electrification, blending into the natural gas grid and the business model development[38].)

The objectives of this area are;

1. Market deployment of affordable and reliable large green hydrogen production systems from renewable energy power which are designed for integration in smart grids. These systems should have the following capabilities:

   - off-peak over-production: capacity to utilise electricity when there is excess available and when the price is low
   - on-peak shaving: capacity to reduce or defer electricity consumption when the demand for electricity by other users is high
   - grid balancing: low / fast dynamic behaviour replacing fossil energy (e.g. gas power plants) to provide grid balancing services: using momentary electricity over-capacity to produce hydrogen.
2. Position hydrogen as a cost effective and safe storage medium of renewable electricity, for grid services and long term energy storage (including blending into the natural gas grid).

3. Develop affordable, reliable and efficient systems to convert hydrogen (or hydrogen blended into natural gas) into electricity and heat.

4. Demonstrate the business model via integrated projects of hydrogen production for grid balancing, peak shaving, energy storage and other possible applications.

Large green hydrogen production systems compatible for (smart) grid integration

Water electrolysis will be the main technology supported, specifically for the production of hydrogen from renewable energy sources, thereby enhancing their integration into the grid. It can be either enhanced alkaline, or PEM, or novel technologies with a sufficient level of maturity (as measured by TRL). FCH 1 JU projects in distributed production of hydrogen

[38] could include syngas production or direct methane production

from electrolysis demonstrate efficiencies to-date of 66%, and continue to demonstrate progress towards the MAIP EU-level 2015 target of 68%.

Hundreds of MW and GW scale, together with several GWh storage, is necessary to address the benefits for the transmission grid at the energy system level. Smart grid integration aspects are important for the distributed generation or district level, at the 1-10s MW scale and 10-100 MWh storage. The prinicpal criterion for success remains the cost of hydrogen production, and as such a cheap system may not be flexible or have a slow dynamic response behaviour and thus not capable of meeting the needs of the energy system. For large scale electrolysis the value of the oxygen by-product shall be, as far as possible, captured alongside the value of the heat.

The technical requirements for emerging dynamic systems and integration in smart grids shall be defined to serve the most profitable use cases. To date technology developers have no clear picture of those requirements. The outcomes from the FCH 1 JU energy storage commercialisation study (due to be availabile at the end of 2014) should provide the basis for the definition of generic specifications.

When electrolyser systems are connected to the grid, the CO_2 footprint of the electricity used will directly impact the CO_2 footprint of the hydrogen produced. However, the CO2 benefits created by providing grid balancing services and surplus energy storage need to be reflected and the approach developed.

Large scale hydrogen storage and injection of hydrogen in the natural gas grid

The large scale storage of electricity in the form of hydrogen depends on the amount of renewable energy deployment:

- Until the renewable energy electricity reaches a sufficiently high share, hydrogen will be stored for direct end use, rather than for electricity storage.
- Demonstration will be valuable to support integration of higher shares of renewable energy in the energy system and support the inter-operability of electricity and gas networks. At the same time the benefits of hydrogen as an energy carrier come from the variety of end-use options.
- In the medium to long term the market needs for energy storage in the form of hydrogen will need to be identified. The FCH 1 JU storage study outcomes should provide information and data for this.

Injection of renewable hydrogen into the natural gas grid increases the renewable energy content of the gas, thus integrating renewable electricity in the energy system. It also provides a way to match hydrogen production and demand, preventing venting of hydrogen in cases where hydrogen storage capacity is exhausted because of sustained availability of excess renewable electricity. Work will be completed to define the maximum percentage of hydrogen that can be injected into the natural gas grid and identify the paths to increase this percentage.

Re-electrification

Highly efficient and cost effective electricity production (re-electrification) from hydrogen can be a key element of future energy systems. Multi-MWe fuel cell power plant technology has the potential to re-electrify previously stored excess renewable electricity (as hydrogen). This enables a more efficient and greater user of energy generated from wind and solar and thus contributes to the decarbonisation of the energy system as a whole.

Large stationary fuel cells will be the main technology supported. Within this activity heat recovery and capturing its value is also important for efficiency and an enhanced business model

Business model development

This topic is treated in the section: Overarching projects.

Targets

Table 3.1.1.2 shows the state-of-the-art in 2012 and the main targets to be achieved for the technologies presented in part 1a:

Table 3.1.1.2 State-of-the-art and future targets for Hydrogen production from renewable electricity for energy storage and grid balancing

		State-of-the-art	**2017**	**2020**	**2023**
KPI 1	H2 production electrolysis, energy consumption (kWh/kg) @ rated power	57-60 @100kg/d	55 @500kg/d	52 @1000+kg/d	50 @1000+kg/d
KPI 2	H2 production electrolysis, CAPEX @ rated power including ancillary equipements and comissioning	8.0 M€/(t/d)	3,7 M€/(t/d)	2.0 M€/(t/d)	1.5 M€/(t/d)
KPI 3	H2 production electrolysis, efficiency degradation @ rated power and considering 8000 H operations / year	2% - 4% / year	2% / year	1,5% / year	<1% / year
KPI 4	H2 production electrolysis, flexibility with a degradation < 2% year (refer to KPI 3)	5% - 100% of nominal power	5% - 150% of nominal power	0% - 200% of nominal power	0% - 300% of nominal power
KPI 5	H2 production electrolysis, hot start from min to max power (refer to KPI 4)	1 minute	10 sec	2 sec	< 1 sec
	H2 production electrolysis, cold start	5 minutes	2 minutes	30 sec	10 sec

Notes:
(*) KPI 4 and KPI 5 shall be considered as optional targets to be fulfilled according to the profitability of the services brought to the grid thanks to the addition of flexibility and (or) reactivity (considering also potential degradation of the efficiency and lifetime duration).
"H2 Production . . . @ rated power *"- * corrected for 30 bar hydrogen output pressure

1.b - Hydrogen production with low carbon footprint from other resources and waste hydrogen recovery (this includes hydorgen from renewable energy where this is not part of grid balancing or energy storage in Part 1a).

Hydrogen production from diverse sources is essential for a future hydrogen system. Different low carbon footprint production routes need to be developed that meet the special needs of applications, but also the availability of different renewable energy sources, such as wind solar and biomass, in different European regions. The development of new and demonstration of near commercial hydrogen production technologies is required. This line of action will include feedstock preparation and hydrogen production as well as hydrogen purification.

The FCH 2 JU will focus on reducing cost and improving efficiency of hydrogen production with the main effort on technologies that support the primary objectives of deployment and reduced carbon reduction emissions when compared to the state-of-the-art steam reforming of natural gas. Electrolysis is one of the pathways that will be pursued..

New production pathways also require new purification solutions. Existing methods such as Pressure Swing Adsorption (PSA) and membranes split hydrogen into a pure hydrogen stream and a smaller hydrogen stream where the contamination is concentrated. The latter stream is commonly burned to provide heat for the hydrogen production process. For innovative hydrogen production gas treatment is necessary at different stages of the process. Therefore purification technologies need to be developed that reduce the contaminated waste streams which might not be reusable in the process. The FCH 2 JU will focus on improving efficiency and on reducing cost of cyclic adsorption technologies and membranes, where those are directly linked to market introduction needs. Such focus will also include pre-normative research into efficiency and performance of purification.

Other options for hydrogen production such as reforming of carbonaceous feedstock, high temperature water splitting, photoelectrochemical and biological, and innovative purification technologies, e.g elecrtochemical or ionic liquids will be considered if aminimum TRL is demonstrated and there is the potential for a business case.

A study will be launched in 2014 to assess the potential and prioritisation of the different pathways.

Methodologies for accurately assessing the carbon emissions from hydrogen produced by these different technologies may need to be developed.

Targets

Table 3.1.1.3 shows the state-of-the-art in 2012 and the main targets to be achieved for the technologies presented in part 1b:

Table 3.1.1.3 State-of-the-art and future targets for Hydrogen production with low carbon footprint from other resources and waste hydrogen recovery (these figures are indicative and will be revised and verified in forthcoming studies)

Topic	Parameter	Unit	SoA	Sector target	FCH-JU target		
					2017	2020	2023
Distributed H2 production from biogas, CAPEX			4.2 M€/(t/d)		3.8 M€/(t/d)	3.1 M€/(t/d)	2.5 M€/(t/d)
Distributed H2 production from biogas, efficiency (HHV)			64%		70%	70%	72%
Hydrogen production: High temperature water splitting	Efficiency	% HHV	33	45	36	39	42
	OPEX	€ / kg	5.8	2.6	5.0	4.5	3.0
	CAPEX	€ / ton/d	4.0	1.4	3.5	2.5	1.7
	Total costs of H2	€ / kg	12	5	10	8	6
	Pressure of H2	Bar	1	20	2	20	20
	Life-time	Y	0.5	10	1	2	10
	High temperature water splitting can be achieved with solar or nuclear power. Improved stability of the catalysis/redox materials is needed to increase life-time and reduce operational costs Improvement of internal heat recovery needed to reduce operational cost and						

	capital cost Improved interfaced to the energy source needed to reduce capital cost Efficiency due to different definitions not comparable to other H2 production technologies ? TRL=3						
Hydrogen production: High temperature electrolysis	Efficiency	% HHV	65	72	68	70	72
	OPEX	€ / kg	-	6.2	7.1	6.9	6.7
	CAPEX	€ / ton/d					
	Total costs of H2	€ / kg	8.2	6.6	8.0	7.3	7.1
	Pressure of H2	Bar	1	30	5	10	30
	Life-time	Y	-	15	1	2	10
	? High temperature electrolysis reduces costs of electricity needs. ? Improved stability of the stack and materials is needed to increase life-time and reduce operational costs ? Prototyping and demonstration will be needed to develop interfaces ? HT Electrolysis offers opportunity to in-site have produced hydrogen be converted to methane for storage of energy ? TRL = 3						
Hydrogen production: biological means	Production rate	g H2 / l reactor	2	200	10	40	100
	Carbon Yield	(H2/Carbon)	0.6	0.65	.62	.64	.65
	Production scale	L reactor	50	10.000	500	1000	10.000
	? Different technologies are in development. Fermentation, anaerobic digestion, akgae and combinations thereof ? It will give increase of potential feedstock for hydrogen production ? There is a high potential to combine biological hydrogen production and other societal changes and programmes (BRIDGE) for simultaneous production of bio-chemicals and hydrogen ? TRL is 4-5						

Targets for electrolyser technologies are given in line of action 1a and those for other production technologies will be given in the "Energy Pillar topic list".

2. Fuel cell systems for CHP and power only for industrial, commercial, residential scales and small **applications**

Stationary fuel cell systems for distributed or centralised flexible baseload power and heat generation and back-up power at different levels need sustained innovation activities to reduce capital and operational costs, and improve system durability. The focus should be on those applications with the greatest potential to contribute to the achievement of the EU energy policy objectives for power, CHP and CCHP production by stationary fuel cells through:

- Improved efficiency
- Reduced degradation
- Reduction of total cost of ownership (TCO in €/kWh)
- Development of European fuel cell markets and competitiveness of the industry
- Reduction of harmful emissions (CO_2, SOx, NOx, Particulate Matter,) noise, vibrations, etc
- Improved power supply security.

This includes stationary fuel cell systems for decentralized power generation operating on natural gas, biogas and hydrogen for

- Residential: mCHP for single family homes and small buildings (0.3 - 5 kW)
- Commercial: Mid-sized installations for commercial and larger buildings (5 - 400 kW)
- Industrial: Large scale installations for industrial use (0.3 - 10 MW)
- Grid support and district use (1 - 30 MW)

The main focus of this area will be on reduction of use of primary energy by efficient conversion of chemical energy into power (hydrogen, biogas, natural gas and other hydrocarbons, power to gas , industrial waste gases etc.), for decentralized production, which reduces efficiency losses experienced in the transmission and distribution grids, and for CHP, CCHP, hydrogen and power production.

In order to increase competitiveness against incumbent technologies, including grid and other energy systems, such as combustion based CHP systems, there is a need to reduce the total cost of ownership (TCO in €/kWh) towards grid costs and competitive total costs of energy in different applications. Demonstration projects are needed to prove the performance and costs, which will build the end-user confidence necessary for larger scale market demand. Higher orders and installed capacity will generate the economies of scale required to lower costs through automation of production processes, consolidation of supply chains and standardization of components.

Efforts should made to develop markets through innovative financing structures and business models, marketing and policy measures which also build stakeholder confidence and acceptance; for example through funding schemes; lowering costs and standardisation of siting and grid connection authorisations; project risk reduction through use of bonds and/or guarantees; and further strengthening of emissions reductions for new plant amnd buildings.

There will be a focus on the reduction of harmful emissions such as GHG (through improved energy efficiency and utilisation of renewable fuels including biogas and green hydrogen) NOx, SOx and PM. In this regard, HTFC (High Temperature Fuel Cells) potentially provide CO_2 concentration and capture. This will be considered when realistic scalable market deployment can be demonstrated.

Improved power supply security will be achieved by on-site generation for critical loads, Back-up power, improved grid stability by controllable dynamic load balancing solutions and high quality decentralized base load power production. Enhanced island operation capability (reliability and duration) will be achieved with fuel cells providing integrated solutions. Applications of stationary fuel cells together with energy storage can furthermore contribute to improve grid stability in the future.

The development required to meet these goals differs per technology, so market related targets need to be set. The basic technologies for stationary fuel cells are:

1. PEMFC
2. SOFC
3. MCFC
4. AFC

Other fuel cell technologies are welcome provided that they have reached the minimum TRL required to become applicable in this market segment within the life span of the FCH 2 JU.

Targets

Table 3.1.1.4 shows the state-of-the-art in 2012 and the main targets to be achieved for the technologies presented in part 2. This table provides ranges for KPIs for generic applications, rather than absolute figures because of the different technologies which are being developed across Europe. This reflects the fact that across Europe there are multiple different markets with specific conditions, determined by climate and culture for example. Ultimately the success of fuel cells will be driven by costs, notably the TCO reaching grid parity. An on-going study, commissioned by FCH 1 JU, of the market requirements for stationary fuel cells will report in Autumn 2014 and will provide further and more detailed guidance on the target KPIs, including TCO.

Table 3.1.1.4 State-of-the-art and future targets Fuel cell systems for CHP and power only for stationary applications (these figures are indicative and will be revised and verified in the short term).

Topic	**Key performance indicator (KPI)**	**Unit**	**SoA**	**FCH-JU target**		
			2012	**2017**	**2020**	**2023**
Residential: mCHP for single family homes and small buildings (0,3 - 5 kW)	CAPEX	€/kW	16,000	14,000	12,000	10,000
	Durability	years of plant operation	10	12	13	14
	Availability	% of the plant	97	97	97	97
	Electrical efficiency	% LHV	30-60	33-60	35-60	35-60
	Thermal efficiency	% LHV	25-55	25-55	25-55	25-55
	LCOE	€ Ct/kWh	3*grid parity	2.5*grid parity	2*grid parity	<2*grid parity
	Emissions	mg/kWh	NOx < 2 ppm, no SOx	NOx < 2 ppm, no SOx	NOx < 2 ppm, no SOx	NOx < 2 ppm, no SOx
Commercial: Mid-sized installations for commercial and larger buildings (5 - 400 kW)	CAPEX	€/kW	6,000 - 10,000	5,000 - 8,500	4,500 - 7,500	3,500 - 6,500
	Durability	years of plant operation	2 - 20	6 - 20	8 - 20	8 - 20
	Availability	% of the plant	97	97	97	97
	Electrical efficiency	% LHV	40-45	41-50	42-55	42-55
	Thermal efficiency	% LHV	24-40	24-41	24-42	24-42
	LCOE	€ Ct/kWh	3*grid parity	2.5*grid parity	2*grid parity	2*grid parity
	Emissions	mg/kWh	NOx < 40	NOx < 40	NOx < 40	NOx < 40
Industrial: Large scale installations for industrial use (0.3 - 10 MW)	CAPEX	€/kW	3,000-4,000	3,000 - 3,500	2,000 - 3,000	1,500 - 2,500
	Durability	years of plant operation	20	21	22	22
	Availability	% of the plant	98	98	98	98
	Electrical efficiency	% LHV	45	45	45	45
	Thermal efficiency	% LHV	20	20	22	22
	LCOE	€ Ct/kWh	1.8*grid	1.3*grid	grid parity	< grid

			parity	parity		parity
	Emissions	mg/kWh	NOx < 5, SOx < 0.05, CO_2 < 5k	NOx < 5, SOx < 0.05, CO_2 < 5k	NOx < 5, SOx < 0.05, CO_2 < 5k	NOx < 5, SOx < 0.05, CO_2 < 5k
Grid support and district use (1 - 30 MW)	CAPEX	€/kW	3,000-4,000	3,000 - 3,500	2,000 - 3,000	1,500 - 2,500
	Durability	years of plant operation	20	21	22	22
	Availability	% of the plant	98	98	98	98
	Electrical efficiency	% LHV	45	45	45	45
	Thermal efficiency	% LHV	20	20	22	22
	LCOE	€ Ct/kWh	1.8*grid parity	1.3*grid parity	grid parity	<grid parity
	Emissions	mg/kWh	NOx < 5, SOx < 0.05, CO_2 < 5k	NOx < 5, SOx < 0.05, CO_2 < 5k	NOx < 5, SOx < 0.05, CO_2 < 5k	NOx < 5, SOx < 0.05, CO_2 < 5k

Based on the identified targets the sector aims to reach a TCO which allow grid parity in the different market segments at the end of the program.

More detailed targets on fuel cells by technologies will be given in the Energy Pillar topic list document.

3.- Hydrogen storage, handling and distribution:

Storage, handling and delivery are essential components of any future hydrogen infrastructure system. FCH 2 JU priorities will be based on the need to store hydrogen at a central production plant and to transport from the plant to its customers.

More specifically:

- Industrial scale storage is required to deal with imbalances between supply and use of hydrogen, in particular those caused by fluctuations in availability of renewable electricity.

- Compression is required for most hydrogen systems, whether underground storage, gaseous truck distribution, liquefaction or pipeline injection. Innovation activities on large scale hydrogen compression would improve efficiency and cost effectiveness of compression of volumes of hydrogen to the various pressure stages required for commercial introduction.

- Improved delivery concepts are needed to increase the area of potential customer base around central facilities. Delivery encompasses those processes needed to transport hydrogen from a central or semi-central production facility to the final point of use. Hydrogen delivery has three aspects: loading of hydrogen into a transportation system, transport of this hydrogen and unloading of hydrogen at the point of use.

The basic technologies for delivery of hydrogen are tube trailer transport of gaseous hydrogen, transport of liquid hydrogen, pipeline transport and carrier transport of hydrogen. Carrier transport of Hydrogen is meant as “gaseous, liquid or solid carriers” (i.e hydrogen bound physically or chemically to another substance). The FCH 2 JU will focus on gaseous truck transport and liquid delivery. Support of hydrogen carriers will only be considered once the technology is of sufficient TRL level and has reasonable likelihood of providing benefits when compared to gaseous or liquid delivery. Pure hydrogen pipeline transport is not in the scope of the FCH 2 JU because the technology has little need for further development. Research and innovation could include the preparation of hydrogen for these delivery methods (i.e compression and liquefaction). It is expected that permitting will be an essential aspect for all these technologies.

A study has been commissioned by FCH 1 JU on energy storage, including hydrogen storage. Thes results of this study will be used to clarify the opportunities and priorities for research & innovation and innovation actions in this part of the Energy Pillar.

Specifically the FCH 2 JU will focus on the following innovation activities:

- Demonstrate a representative number of gaseous hydrogen trucks with capacity of 1,000 kg of hydrogen and reduced unloading times.

- Demonstrate innovative liquid hydrogen storage and delivery systems that support the main objectives.

- Develop and demonstrate the use of hydrogen carriers to efficiently store and/or deliver hydrogen.

- Improve handling and buffer storage related components and systems.

Targets

Table 3.1.1.5 shows the state-of-the-art in 2012 and the main targets to be achieved for the technologies presented in part 3:

Table 3.1.1.5 State-of-the-art and future targets for Hydrogen storage, handling and distribution

Topic	Parameter	Unit	2012	FCH-JU target		
				2017	2020	2023
Tube trailer transport	Trailer Capex	M€/t capacity	0.55 (@400 kg)	-	0.55 (@ 800kg)	0.45 (@1000kg)
Liquid H2 storage	Container Capex	M€/t	0.30		0.25	0.20
Gasous Hydrogen storage	System Capex	M€/t	0.5		0.45	0.40

Notes: For hydrogen carriers, no KPI is specified, reflecting the uncertainty in the market readiness of these technologies in the near future. Meaningful targets for 2017 have yet to be identified.

3.1.3 Overarching projects

One important mission of the FCH 2 JU over the period 2014–2020 will be to demonstrate the inter-operability and the synergies between the technologies of the two Pillars. This will demonstrate that fuel cells and hydrogen are able to act together in systems and demonstrate the full potential to deliver stationary power, mobility, and (portable) convenience products to the consumer whilst substantially reducing the GHG emissions.

Consequently, projects will be supported for "integrated technologies" applicable to both energy and transport sectors, and research and innovation projects supporting at the same time energy and transports technologies. These projects will need to adress the objectives of both Pillars.

Such projects will include activities where hydrogen production from renewables is combined with FCEVs, distributed generation and selected consumer appliances into a 'grand picture'. Field testing FCH technologies and showcasing their possibilities to the public will be pursued.

In order to develop such potential across the activity Pillars, selected projects will need to collect contributions from these Pillars and combine them into 'integrated projects' that will display several aspects of power supply, storage and interaction of FCH technologies.

3.1.4 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. They will comprise projects that transcend the two Pillars, for instance educational, safety, regulatory, dissemination and pre-normative research activities.

These activities will be conducted through dedicated projects for the folowing subjects, with priority given to the first two points:

- **Safety:** This is of paramount for public acceptance of FCH technologies, for provision of health and safety, as well as safeguarding property, and special attention will be paid to the technology transfer from the professional community to the general public.. Emphasis will be on technical safety, including, but not limited, to pre-normative research. Actions may include technology projects on safety, development of best practice guidelines, development of data bases of incidents/accidents for use in education and training, and development of intervention techniques for first responders at an incident/accident scene.

- **Pre-Normative Research**. Building upon the work started in the FCH 1 JU this will among other actions include harmonisation of testing procedures and of reporting templates, as well as establishment of commonly agreed representative loading profiles (stressors) for different applications of FCH technologies, such as automotive and stationary fuel cells. Particular emphasis will be placed on aligning with international efforts in this area eg USA and Japan. Where pre-normative research activities are specific to one Pillar they will be funded under that specific Pillar.

- **Education and training.** This action will provide education and training for both the FCH sector, including but not limited to scientists, engineers, technicians and for decision/policy makers outside the sector. These activities will be coordinated with those in the SET Plan and combined where additional funding can be leveraged. In particular, it will encourage the consolidation of European technical training by helping to build networks of educational activities between academia, industry and research. Emphasis will be on consolidation and establishment of pan-European education activities in the area of safety and RCS to provide knowledge and safety technology transfer to all interested stakeholders (ideally under joint funding by public and industry).

- Building **databases** for environmental, economical, socio-economic subjects as part of the Knowledge Management activity, but only where it doesn't duplicate activities covered by Temonas.

- Identification and development of **financial mechanisms** to support market introduction.

- Activities to increase **social acceptance and public awareness**: general public conferences and workshops, brochures, public 'show rooms', e.g. museum displays; adressing and informing local authorities, certification bodies, first responders, etc.

- Support **portable applications and other niche market** fuel cell solutions for market dissemination to prepare the introduction into the market of other FCH technologies and build a competitive European supply chain of necessary components. The technologies supported will need to be near industrialisation (at least a TRL of 6 and with a real business case.

- Conduct **socio-economic research** to determine the environmental and societal impact of FCH technologies, their effect on European GHG emissions and primary energy use, and their effect on the economy. This will be done in order to identify and/or support new business cases and feasible models.

- Conduct projects on **recycling** and dismantling of FCH technologies such as fuel cell and electrolyser components (stacks & system components), composite tanks etc…

A number of important Cross-cutting activities should also be conducted outside of financed projects through the PO including the following subjects (the first three points being a priority):

- Informing EU policies with relevant FCH 2 JU projects results by specific activities addressing the European Parliament, Commission Services, Member States and Associated Countries representatives etc.
- Regulations, Codes and Standards (RCS) observatory and coordination of **strategy definition.**
- Maintain **international connections** in order to monitor hydrogen energy evolution outside Europe and be able to suitably interact with relevant developments.
- Provision of knowledge and technology transfer through research infrastructures and test facilities to the FCH community.
- Information exchange and neworking regarding European and national/regional/international FCH associations, industrial groupings and municipalities; hosting a web site dedicated to general technical and deployment information.
- Monitor the RTD programme implementation.

3.2 Activity distribution

To allow a more flexible implementation of the Programme, priorities and budget-distribution among the various Pillars will be agreed each year by the Governing Board, upon proposal of the PO, after consultation of the members of the FCH 2 JU.

The proposed distribution of FCH 2 JU financial resources is set out below. It is anticipated that, over the whole FCH 2 JU period duration from 2014-2020, "research and innovation" actions should account for 29% of the total contribution from the EC in projects, 14.5% for the Transportation Pillar and 14.5% for the Energy Pillar: while 66% of the contribution from the EC is expected to be devoted to "innovation" actions (demonstration and pilot activities), with 33% for the Transportation pillar and 33% for to the Energy Pillar, reflecting the fact that hydrogen and fuel cell technologies are approaching market introduction. Some flexibility is given around this share of the budget, for slight adaptation depending on the interest and the impact of the subjects proposed in the different categories, in particular at the end of the period 2014-2020.

Finally, In line with the current FCH 2 JU characteristics, it is proposed to dedicate 5% of the JU total contribution from the EC for projects for complementary Cross-cutting activities.

The share of funding proposed recognises that research and innovation is required to develop second-generation FCH technologies and to make current generation of technologies 'market' ready, and that both small and large scale demonstrations and pilots are required as part of the market readiness proving process.

Table 3.1.1.6 Proposed distribution of funding with the FCH 2 JU

Funding distribution	Research and Innovation		Innovation		Total	
Transports Systems	94 (±5)	14.5%	213 (±10)	33%	307	47.5%
Energy Systems	94 (±5)	14.5%	213 (±10)	33%	307	47.5%
Cross-cutting activities					32	5%
Total	192	29%	426	66%	646	100%

The total contribution from the EC for projects in the above table account for 646M€.

The Overarching projects (sections 3.1.3 and 3.3.3) will be funded from the budget allocated to in the two Pillars. The amount to be dedicated to this type of projects will be agreed each year by the Governing Board.

3.3 Expected deliverables

The European FCH sector has detailed its technology and industry objectives for the period 2014-2020 in the document "Hydrogen Technologies in Europe - financial and technology outlook and the European sector ambition 2014-2020" issued in 2011. The cumulative efforts in research and innovation and innovation activities needed to achieve these objectives are estimated by the industry to be €6.4 billion. The projects granted and funded within the FCH 2 JU Programme will contribute to the scientific and technological progress still required to reach the levels of performance and reliability necessary for introducing FCH technologies into the market. The FCH 2 JU Programme will be developed in a consistent way with other public and private research and technology programmes in Europe, made possible by the involvement of European industry and research communities. Although it is obviously not possible to isolate the FCH 2 JU Programme from the rest of FCH research and innovation activities in Europe, which will form a consistent pool of actions, the FCH 2 JU is expected to contribute particularly to the deliverables listed in section 3.3.

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In order to achieve the main deliverables described in the following sections, the activities need to be broken down in groups of topics and subtopics. The general topic list is provided in a separate document, the FCH 2 JU topic list. More detailed descriptions of the topics for the Calls will be compiled for each individual Call.

Different types of projects can be adressed under the calls of FCH 2 JU:

- Research and innovation,
- Innovation,
- Coordination & support actions.

The definition of these types of projects is given in part 5.2.2.

3.3.1 Innovation Pillar 1: FCH Technologies for Transportation Systems

- Demonstrate a sufficiently large fleet of next generation FCEVs, which incorporate new or enhanced technologies with the following properties:
    - Reduce by a factor ten from 2012 the costs of the the fuel cell in passenger cars.
    - Increase lifetime towards 6,000 operational hours whilst performance is maintained or increased for passenger cars
    - Bus FCEVs meeting reduced cost and enhanced lifetime requirements will also be taken through final stage development and demonstrated at sufficient volume to meet pre-commercialisation targets
    - Two-wheel FCEVs and light commercial vehicles are to be taken through development, validation and demonstration at the pre-commercialisation level.

- Develop and demonstrate truck APU options in a formal operational environment, and develop and demonstrate a set of APUs, in single or several units, in the relevant applications e.g aviation, rail and maritime, plus others where there is sufficient industry commitment. This may also include fuel cell systems for propulsion where there is suffiicent industry commitment in appropriate market segments.

- A representative number of modular, turnkey HRSs demonstrated in the field, which are of progressive and scalable capacity, and are competitive and efficient, in terms of refuelling time and frequency (back-to-back), availability and cost.

- A series of HRS and FCEVs demonstrated through different projects as part of nationwide or regional roll-out initiatives. These demonstrations are expected to be embedded in a wider European refuelling infrastructure in a number of Member States and Associated Countries to support the large-scale market introduction of FCEVs in the EU by 2020.

- The standards still to be defined or modified and which are necessary to bring the technologies to the market (H2 quality, cooling temperature, standard operating procedures) will not be developed within the FCH 2 JU, but the participation of the members in their definition will be actively sought.

- The delivery of a study defining the needs and opportunities for fuel cell technologies in material handling applications. Depending on the results of the study, the development of a new generation of technologies capable of achieving competitive solutions for materials handling applications (e.g. forklifts and other material handling systems at warehouses, airports, docks, etc.) at full market deployment scale.

3.3.2 Innovation Pillar 2: FCH Technologies for Energy Systems

1.a The following deliverables are identified for **Hydrogen production from renewable electricity for energy storage and grid balancing**:

- Multi-MW electrolysers for power to gas and large-scale consumers, focusing on the integration of renewable energy sources.. These electrolysers may use novel electrolysis concepts: high temperature, co-electrolysis for increased energy efficiencies. Other power to hydrogen processes with potentially alternative feedstocks shall be investigated.

- A report on the requirements of Transmission and Distribution System Operators (TSO/DSO) for the design of suitable hydrogen production systems, to include both technical and economic needs.

- Electrolysers with reduced TCO (in €/kg H2), reflecting both lower CAPEX and increased reliability and lifetime. Flexibility and dynamic behaviour will enable greater benefit from opportunity costs of electricity. In addition, the specific flexibility parameters (e.g. start-up time, ramp rates, etc) required by grid codes to participate in provision of anciliary services.

Downstream, most of the uses of the hydrogen produced require pressure: storage, transport, or injection in a natural gas grid. Consequently, the pressure at which the hydrogen is produced is important: typically 30 to 50 bar and up to 80. For better technology comparisons, the cost of an additional compressor (where required for redundancy purposes) shall be added for low pressure production systems.

Large scale hydrogen storage and injection of hydrogen in the natural gas grid

Very large scale underground storage exceeding GWh in a salt cavern is being undertaken on commercial scale in a few locations. Further work on suitable geological formations and links with renewable H2 production methods as well as uses of hydrogen needs to be done..

One large scale hydrogen based energy storage system. Single or several MWh scale storage systems for smart Grids, and which demonstrate competitiveness, and 10s-100s kWh capacity for stationary applications. Systems may include comprssed gas in large pressure vessles, solid hydrogen storage solutions, cryogenic storage or other solutions as long as they meet the scale requirements and show that they are comeptitive.

- For the injection of renewable hydrogen in the natural gas grid based on the results of demonstration projects:
    - A number of electrolyser systems integrating large amount of renewable power (GWHs) mainly from intermittent sources into the natural gas distribuition systems in the range of 2-5%.

- Studies and tests that demonstrate the feasibility of 20% vol of hydrogen in the natural gas grid. This will acknowledge and build upon the outcome of NaturalHy.

- When working with other organisations on RCS the following will have been targeted:
    - Regulations, specifications and tariff systems fro hydrogen storage system.
    - Scheme of renewable certificates, such as for bio-methane.

Re-electrification

- A MW scale PEM (main technology targeted) fed with hydrogen with a characteristic reaction time of 10s to 100s, with electrical efficiencies (H2 HHV) up to 50% (with the use of heat and water produced, achieve 85%.) MCFC, SOFC and othertechnologies using hydrogen are possible.

1.b The deliverables for **Hydrogen production with low carbon footprint from other ressources and waste hydrogen recovery** are:

For hydrogen production and synthesis pathways:

- A number of on-site electrolysis systems that show reduced operational and capital costs while increasing the electrical efficiency from 65% up to 77%. . All electrolysis technologies, low and high temperatures, will be acceptable for this deliverable.

- Co-electrolysis of CO_2 and Hydrogen developed and demonstrated.

- Small scale, on-site hydrogen production systems fromrenewable fuels (biogas, bio-(m)ethanol) for decentralized hydrogen production with Capex reduced by 40% and Opex by 10% when compared to current state-of-the-art.

- Catalysts and materials with increased life-time for direct solar pathways such as high temperature water splitting and photoelectrolysis to produce low cost and low carbon footprint hydrogen. Pre-commercial demonstrator powered by sunlight. This technology will demonstrate improved system design and reduced costs.

- Biological reactors with increased volumetric productivity 50 times and scale 200 times the current state-of-the-artwhile maintaining or increasing (by 10%) the carbon yield of biomass input.

For hydrogen purification methods:

- New adsorbent materials (e.g. Metallic Organic Frameworks, enzymatic adsorbents) plus improved and optimized designs and cycle times that, together, improve yield and reduce costs of PSA systems.

- Low cost systems for hydrogen recovery of waste streams and other hydrogen containing streams. Many new biological and current waste streams contain low concentrations of hydrogen. New system designs will need to be developed to economically and efficiently (energy) purify such streams.

- Membranes with new alloys or other materials for membrane separation systems to reduce minimum operation temperatures (from 300 down to 180°C), reduce of costs and increase of hydrogen flux (100%).

2. The following technical deliverables will be achieved by 2023 for **Fuel cell systems for CHP and power only**on industrial, local, domestic scales **and small applications**.

- A number of products at a level of maturity with improved energy (electrical or total) efficiency and lower capital and maintenance costs, such that they can build up confidence which enables opportunities for private investors to support the volume scale-up to fully open the market.

- A European value chain for fuel cell systems for CHP and power only applications.

- Improved fuel cell systems capable of providing integrated solutions for distributed on-site generation and island mode.

The commercial competitiveness can be achieved through mass manufacturing created by complementary capital investments.

3. The deliverables expected for **Hydrogen storage, handling and distribution** (compressed gas, cryogenic liquid, solid or liquid carriers, pipelines) are:

- High pressure truck trailers with increased capacity of 1000 kg/truck at an investment cost of 500 €/kg H2 capacity. Validated and pertinant permitting processes for Europe. The trucks will have an unloading time below 60 minutes, including the time needed to connect to the customer facility.

- A transport and storage system for liquid hydrogen for truck transport as well as shipping and/or rail transport. Such a system will have a capacity of 3500kg of hydrogen or more and cost less that 200 €/kg H2.

- A minumum 10 tonne industrial scale hydrogen storage system with an investment cost at or below 400 k€/tonne.

The objectives for potential calls on hydrogen carriers (whether in gaseous, liquid or solid form) relate to reduction of the cost of hydrogen storage while increasing its efficiency. The cost target of 850 k€/ton in 2023 is a system target, so includes the measure of a number of cycles that are possible (for example for Liquid organic hydrogen carriers, part of the carrier is lost with each transport). The carriers should have charge/discharge efficiency above 88% in 2023 and a discharge energy use below 5 kWh/kg Hydrogen.

In order to achieve these main deliverables, the activities will be broken down into groups of topics and subtopics. The general toptic descriptions are described in a separate document. More detailed descriptions of the topics for the Calls will be compiled for each individual Call.

3.3.3 Overarching projects

- A whole integrated energy chain from fuel production, storage (including large scale or power to gas) through distribution to end use by vehicles or stationary fuel cell systems in different Member States and Associated Countries with smart grid integration by coordinating and combining with national or regional projects. Specific business models in an industrial and commercial environment in the context of at least two full scale demonstrations. This will verify and evaluate the suitability of current theoretical concepts and move the technology, including the business side, towards full-scale roll-out and be replicable across Europe. As far as possible, the system(s) will be operated after the demonstration phase to further supply customers (green power, green gas, smart grid services…etc).

Further deliverables may be achieved depending on the common needs identified between the two Pillars during the FCH 2 JU programme.

In order to achieve these main deliverables, the activities will be broken down into groups of topics and sub-topics. The general topic descriptions are provided in a separate document. More detailed descriptions of the topics for the Calls will be compiled for each individual Call.

3.3.4 Cross-cutting activities

The following deliverables are expected ftom the Cross-cutting activities:

Information, education and dissemination activity (preferably in all Member States) that builds **political support and societal acceptance** for hydrogen and fuel cell technologies throughout the Union. Information will include description of the benefits of fuel cell and hydrogen technologies, but also how possible risks have been addressed, and how any potential negative impacts should be mitigated.

- **Training activities** on FCH technologies developed for students (technicians, engineers and scientists) and for programmes of continuous improvement of qualification for professionals (for example FCEV repair, safety training…).

- Innovative **safety** strategies and safety solutions that support both Pillars and protect lives and property at levels not below that for fossil fuel technologies, and allow commercial deployment of the FCH technologies (e.g. separation distances where appropriate, mitigation measures etc). Best practices and guidelines for various emerging FCH applications. Intervention techniques and procedures for first responders for different situations (outdoor, tunnels etc.) and different technologies. New safety culture at the customer levelestablished.

- Implemented an **industry-led RCS coordination function** (cf. part 4.1) that meets the needs of European stakeholders regarding international and European standards, and supports the establishment of an efficient regulatory framework requiring these standards where appropriate. Identify and address pre-normative research (PNR) needs in conjunction with the research community with the results are fed back into standardisation activities.

- Analysis and identification of **financial support mechanisms for market introduction.**

- Increased the social acceptance of fuel cell and hydrogen technologies through assistance to **portable fuel cells** to reach the market.

- Improved **public acceptance and risk perception.**

- **Socio-economic research** studies that clearly identify the economic and infrastructure framework through which FCH technologies can play a significant role and proposed new frameworks that might also lead to new business models and cases.

- An investigation of the effect of FCH technologies on energy consumption and emissions (GHG and regulated emissions), well-to-wheel analyses at the level of Member States, Associated Countries and regions in order to properly identify transition strategies for the European regions.

- The **socio-economic, environmental** and **energy impact of FCH technologies**,including impact on infrastructure (gas & electricity) will be demonstrated.

- Demonstrate that FCH technologies are compliant with the European directive[39] about **recycling**. Produce data about recycling that can be used for life cycle analysis.

- An analysis and identification of recycling and dismantling pathways for FCH technologies

- Liaison with international developments that can leverage impact on the use of FCH technologies and influence RCS and overarching developments at an early stage.

- The FCH 2 JU programme will be monitored and assessed against benchmark results with incumbent technologies (e.g. Internal Combustion Engine (ICE) vehicles) and parallel developments (e.g. Battery Electric Vehicles (BEV)).

- A system implemented which takes into account the cost of the coordination actions for the members of N.ERGHY and NEW IG in the context of programme development (MAWP and AWP), international liaison, and participation in RCS development.

[39] Ecodesign Directive (2009/125/EC)

4. Interactions and coordination activities of the FCH 2 JU

To act efficiently, the FCH 2 JU needs to interface with other organisations at the European scale or at a more local scale: for example regions, Member States and Associated Countries, but also the JRC, other EIIs under the SET-Plan and EGVI.

This part presents the coordination actions to be undertaken by the FCH 2 JU to define a common position within its Members, for example on RCS, or to coordinate its actions with those undertaken by other organisations.

4.1 RCS Strategy Coordination

The implementation of an RCS Strategy Coordination (RCS SC) is crucial for the market deployment of FCH systems. Today, the lack of harmonized RCS and PNR to fill RCS knowledge gaps at EU (and world) level is still recognised as a major barrier for the commercialization of FCH products. For instance, in the road transportation sector, key areas of technical standardization remain to be agreed to by the industry and regulators:

- Cooling level of hydrogen dispensed,
- Footprint / safety regulations in retail HRS,
- Purity of hydrogen.

The overall goal of RCS SC is to enable the development and actual use of harmonized performance-based standards for FCH appliances and systems, together with their safety in energy and transport applications so that these standards can be referred to in legislation. The RCS SC therefore aims to facilitate the deployment of the activities which will enable European industry interests to be met, e.g. establishing compliance/certification criteria within the EC and United Nations (UN) regulatory framework; developing European and international standards that provide the technical requirements to achieve safety and build confidence; as well as to guide authorities and other stakeholders in their application.

Currently, some organisations are already in place to define and express the European position on some FCH technologies, such as the European Industrial Gases Association (EIGA), or the European Automobile Manufacturer's Association; but there is no platform to define and express the needs and strategy of the whole European FCH sector.

The FCH 2 JU will tackle RCS issues through the Cross-cutting activities. An industry led RCS Group, composed of NEW-IG and N.ERGHY representatives will be created. With the support of the Programme Office (PO), the RCS Group will define a strategy in consultation with all European stakeholders and will take the necessary actions to implement it in line with the requirements of the European Standardization Regulation[40].

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:

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

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 refueling
    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 poposals.

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[41]) 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.).

These tasks require empowerment of the RCS Group and the FCH 2 JU PO to establish an effective and efficient structure and provide the tools required for their implementation.

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.

4.2 Environment and sustainability

Fuel cells and hydrogen have the potential for reducing emissions of greenhouse gases and air pollutants, facilitating the increased use of renewable energy sources, raising overall efficiencies of energy use and, in general, establishing a sustainable energy system and mitigating the human factor of global warming.

However, the complete fuel cell and hydrogen energy value chain needs to be evaluated in order to assess the social, economic and environmental impacts of these technologies so

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

that emissions reduction and resource conservation can be targeted at all stages of the life-cycle. The main factors that affect the magnitude of the impacts are the hydrogen production pathways (i.e. renewable, fossil or nuclear), the availability of scarce materials, manufacturing processes for the production of components and systems, the types of operational applications involved, and the recycling and disposal of all the components and materials at the end of their useful life.

A goal of the FCH 2 JU is to develop and apply Life Cycle Assessment (LCA) at the programme and project level on the technology system for fuel cells and hydrogen. This will allow assesment of the impacts in a way that is consistent and compatible with tools currently used by industry and policy makers. As a first step, specific practice guidance for these technologies will be prepared, building upon the International Reference Life Cycle Data System (ILCD) Handbook on LCA[42] along with LCA guidelines already prepared under HyGuide and taking into account LCA approaches that exist, for example, at the vehicle level (E-Mobility Life Cycle Assessment Recommendations (eLCAr), covering Electric Vehicles). Once this guidance becomes available it is expected that LCAs will be performed at both project and programme levels. The resulting Life Cycle Inventory (LCI) data sets will form a database, published as part of the ILCD Data Network, and maintained by the industry partners of the FCH 2 JU. The FCH 2 JU shall also establish an international exchange thus providing for a globally consistent framework.

The LCA related activities will be properly interfaced with the Technology Monitoring Assessments (TMA) and with TEMONAS. Together they will deliver the necessary quality data and scientific information required to assess, in a systematic and reliable way, the potential benefits and drawbacks of fuel cells and hydrogen technologies along the entire life-cycle, from raw material extraction and processing to recycling and final disposal. This will facilitate a more effective policy evaluation and decision making process and will help prevent the build-up of potential health and/or environmental problems before they can cause serious damage or heavy costs, as well as systematically review the availability of scarce materials such as noble metals.

4.3 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 1 JU was structured under a Framework Agreement that covered support activities that JRC provided in-kind to FCH 1 JU, as well as possible funded JRC participation to FCH 1 JU projects. Based on the lessons learned and considering new implementation aspects of the Horizon 2020 programme and of its activities, a follow-up agreement between FCH 2 JU and JRC for the period 2014-2020 is being prepared. As before, this follow-up agreement defines areas where JRC, as a neutral European Union research institute, provides an in-kind contribution to projects and areas where JRC may participate in FCH 2 JU funded projects with a view to enhancing their specific impact, next to aspects of more strategic importance to the FCH 2 JU programme. In particular, the JRC contribution could cover:

- Participation in monitoring scientific and the technical progress achieved by FCH 2 JU projects and evaluating the FCH 2 JU programme contribution to the Europe 2020 Strategy objectives for smart, sustainable and inclusive growth.

[42] http://lca.jrc.ec.europa.euEPLCA/)

- Support to individual projects, offering the services of a reference laboratory upon request by the projects or by the PO.
- Support, upon request of the Governing Board, the formulation and implementation of the FCH 2 JU strategy, as well as monitoring its progress (e.g. via the Programme Review Days).
- Conducting specific pre-normative research, helping to define the technical inputs necessary for safety and RCS activities, assisting the RCS Group and acting as a liaison function with European and international standardisation and regulatory bodies.
- Contributions to ensuring consistency/complementarity with relevant European Commission initiatives (SET-Plan EIIs, EIT[43], KET, FET[44], EGVI, ..).

4.4 Coordination with Member States, Associated Countries and Regions

It is a key objective of FCH 2 JU to strengthen alignment efforts and leverage additional innovation investments within Member States, Associated Countries and Regions. FCH 1 JU has established coordination and cooperation mechanisms which will be utilised and expanded to build on the accumulated expertise in fuel cells and hydrogen technologies and related innovation programmes. Targeted cooperation and coordination can considerably expand the scope and impact of FCH 2 JU activities, at programme level and, when possible, at project level through appropriate co-funding schemes or via Joint Calls.

Coordination and cooperation is essential to ensure a consistent and coherent FCH deployment strategy, moving from medium to large scale demonstration activities and on to market introduction, including infrastructure development, together with prototyping, pilot line projects for mass production preparation (KETs will play a role in this perspective), for both Energy and Transport Pillars covering, for example, H2 Mobility programmes as they develop and link with international corridors and networks. It is also essential for the development of appropriate RCS.

The FCH State Representative Group (SRG) will be a key enabling entity in these coordination and cooperation tasks.

At the regional level, various regions in Europe have already started local programmes on FCH technologies and significant budgets have been committed for future development. These regions have and will continue to play a crucial role in supporting local SMEs, maintaining and expanding hydrogen infrastructures and planning public procurement.

Coordination and collaboration with Regions, in particular where such regions act relatively independently of national activites, is therefore important in order to pool resources, in particular for large demonstration projects, facilitate the deployment of the fuel cells and hydrogen technology and contribute to ensuring a coherent and influential action at the regional level.

The FCH 2 JU will therefore collaborate with Regions involved in or planning significantfuel cells and hydrogen activities in order to align strategy and coordinate research and demonstration activities at the project level (for example, exploring opportunities for joint public outreach actions). The Hydrogen and/or Fuel cells national

[43] European Institue for Innovation and Technology
[44] Future Emerging Technologies

associations may also provide a relevant basis for dialogue and cooperation due to their alignment with Regions and local authorities. Furthermore, the Smart Specialisation Platform[45] can provide guidance to the countries and regions in designing and financing their research and innovation strategies to achieve maximum synergies regarding FCH activities. A path to be explored further is how synergies with Structural Funds can be achieved; these funds can be allocated at national or regional level to also cover research and innovationactivities, thereby offering interesting opportunities.

4.5 The role of small and medium size enterprises

One of the specified tasks of the FCH 2 JU is the promotion of the involvement of SMEs in its activities. To ensure this, at least one member of the IG Board represents SMEs on the FCH 2 JU Governing Board.

SMEs are a key stakeholder group for the success of the FCH 2 JU. They are an important source of innovation and represent a large share of companies engaged in early markets and are involved in many industrial supply chains. Their role is crucial for future commercialisation.

Two of the largest obstacles that SMEs must overcome are the need to raise financing, especially in the early stages of growth, and to kick-start sales and thereby gain valuable field experience. In order to address the specific limitations and risks of SMEs, the FCH 2 JU will, inter alia, explore ways to open access to the necessary manufacturing and process capabilities through partnership schemes and education initiatives.

4.6 International cooperation strategy

The importance of international cooperation in science and technology is explicitly recognized in the European Union's Innovation Union flagship initiative and the Horizon 2020 programme. It is described in the communication entitled "Enhancing and focusing EU international cooperation in research and innovation: a strategic approach"[46]. Following this principle, in order to align with, facilitate and accelerate world-wide market introduction of fuel cell and hydrogen technologies the FCH 2 JU will identify priority areas, at the policy and technology level, for coordinated and collaborative international activities.

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

Among the relevant international activities those developed by the International Energy Agency (IEA) under the Hydrogen Implementing Agreement, Advanced Fuel Cell Implementing Agreement and the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), are where relevant objectives and targets have already been set. In particular, FCH 2 JU will collaborate closely with the EC representatives in the steering committees of these two international agreements in order to optimize and share the effort, participation and role of each IA and improve coordination with the EC. In the case of the

[45] See http://s3platform.jrc.ec.europa.eu/home

[46] COM(2012)497

IEA, FCH 2 JU could provide expertise to scientific, technical, and strategic tasks of the Hydrogen Implementing Agreement in alignment with Member State representatives and FCH 2 JU funded projects be involved in and contribute to its different Tasks. Fuel Cells and Hydrogen outreach will be a specific target for FCH 2 JU participation in any international agreement, such as IPHE (International Partnership for the Hydrogen Economy).

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Other organizations could also be followed if they become an important place for Fuel Cells and Hydrogen standards and policy developments. Examples are the International Renewable Energy Agency (IRENA), and the World Energy Forum.

Contacts will also be maintained and further expanded where appropriate with non-EU and Associated Country (AC) states that have significant and sustained involvement in the development and deployment of FCH technologies, namely Japan, Korea, and the USA. Of special interest in this context are regulatory and policy frameworks, socio-economic and environmental assessments, LCA, RCS, safety, development of common methodologies for monitoring large-scale demonstrations and alternative technical solutions and/or options considered for hydrogen purity, hydrogen cooling and hydrogen dispensing measurement. Collaboration schemes such as those being implemented by the Working Group "Energy Technology RD&D" of the EU-US Energy Council should be used as a reference.

4.7 Communication and dissemination

Fuel cell and hydrogen technologies are as yet relatively unknown to the public. Their benefits and the innovation results obtained within the FCH 2 JU programme must therefore be carefully explained and widely disseminated. For this reason, efficient and pro-active communication and dissemination activities are of great importance for the success of the FCH 2 JU. The objectives are to:

- Ensure that the FCH 2 JU is perceived as the key European strategic initiative for focused, coordinated and competitive innovation activities in the field of fuel cells and hydrogen.
- Raise public awareness of the role of fuel cells and hydrogen in creating a sustainable, secure and affordable energy system, together with employment.
- Ensure internal communication and coordination with members and stakeholders managing their expectations and promoting continued interest in the FCH 2 JU activities speaking with one voice.
- Engage external stakeholders to encourage increased innovation investment in fuel cell and hydrogen technologies.

Communication materials and tools will be chosen according to the target group (e.g., media, influencers, educators, policy makers, general public, etc.). As a key communication tool serving all these groups, the FCH 2 JU will further develop its new website to include press material, brochures, fact-sheets, audio-visual material and standard presentations. Furthermore, the website will be instrumental in disseminating project results. All dissemination and communication activities will be in line with the European Commission’s general strategies for dissemination and communication of the projects results in Horizon 2020. Coordination will also be ensured with the SET Plan Information System (SETIS). The Stakeholders Forum will also be an important channel for communication and information exchange of FCH 2 JU activities. Finally, a ‘do tank’ (a working group with responsibility for implementation), can be introduced via the Cross-cutting activities to fulfil the four objectives quoted above.

Annual review days will be organised parallel to the Stakeholders Forum starting in 2014. These will be a major opportunity to raise visibility on FCH 2 JU activities and to assess projects and innovation pillars as well as ultimately, FCH programme development, especially in relation to international developments.

To further increase the presence and visibility of the FCH 2 JU and its activities, there will be participation at relevant events or exhibitions, at national, European or international level.

It will be valuable to coordinate all the information and communication activitiess (especially awareness, policy makers, media) with the national efforts and initiatives through SRG, Regions groups, national associations etc…

4.8 Interface with other EU policies

The EU 2020 Strategy[47] puts forward the priorities for smart, sustainable and inclusive growth and proposes a number of EU headline targets as well as a wide range of actions at national, EU and international levels necessary to underpin them. Tackling the challenges of resource efficiency, climate change and energy security are some of the core objectives of the EU 2020 Strategy, which will be mainly addressed by two major EU Flagship Initiatives, namely the "*Resource efficient Europe*"[48] and the "*Innovation Union*"[49].

The portfolio of energy technologies needed to achieve these objectives has already been identified and agreed in the SET Plan[50]. The SET Plan sets out a long-term energy research, demonstration and innovation agenda for Europe to make low carbon technology fully cost-competitive, more efficient and proven at the right scale for market roll-out. It will be implemented mainly through the European Industrial Initiatives (EIIs) and the Joint Programmes of the European Energy Research Alliance (EERA). The relevant role of the SET Plan is highlighted in the Communication on "*Energy 2020 - A strategy for competitive, sustainable and secure energy*"[51] and the importance of its implementation has been confirmed by the Heads of State and Government on 4 February 2011[52].

The Communication on Energy Technologies and Innovation of 2 May 2013 announced a strengthening of the SET Plan to address energy system and innovation chain integration, incorporate energy efficiency as a stand-alone priority and consolidate the individual SET Plan technology roadmaps. The process is managed by the Commission services and includes the development of a single SET Plan Integrated Roadmap, followed by an Action Plan. The Integrated Roadmap document is developed under the guidance of the SET Plan Steering Group of Member States, with the support of all SET Plan stakeholders, including the FCH 2 JU.

Research and innovation will remain a crucial dimension of the SET Plan Integrated Roadmap. Furthermore, the Roadmap actions will strive to reinforce European supply chains and build industrial capacity in Europe. According to its field of activity and capacity to act, the FCH 2 JU aims to support these developments.

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[47] http://europa.eu/press_room/pdf/complet_en_barroso___007_-_europe_2020_-_en_version.pdf
[48] http://ec.europa.eu/resource-efficient-europe/pdf/resource_efficient_europe_en.pdf
[49] http://ec.europa.eu/commission_2010-2014/geoghegan-quinn/headlines/documents/com-2010-546-final_en.pdf
[50] http://ec.europa.eu/energy/technology/set_plan/doc/2009_comm_investing_development_low_carbon_technologies_en.pdf
[51] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0639:FIN:EN:PDF
[52] http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/119175.pdf

FCH are part of the portfolio of technologies identified in the SET Plan for which their contribution is expected in the medium and long-term. The FCH 2 JU is one of the EIIs and will interact and keep regular contacts with the rest of the SET Plan EIIs, as well as with other EU initiatives such as Clean Sky 2, EGVI, Shift2Rail, Smart Cities, and KETs[53] in order to explore potential synergies and complementarities and to optimise resources. Also it will be critical that the results and achievements delivered by the FCH 2 JU are assimilated and used to inform and support policy and vice versa. To this end, the FCH 2 JU, in coordination with the relevant Commission Services, should explore possible ways and allocate resources to develop the necessary "interface mechanisms" between the FCH 2 JU and the concrete EU initiatives and policies that will stem from the EU 2020 Strategy, particularly in key areas such as transport, environment and industrial competitiveness.

Given the market introduction, and the technological maturity, of electric and plug-in hybrid vehicles, a strong interface and cooperation, as well as a coordination of strategies are needed with the European Green Vehicles Initiative (EGVI), which is the main instrument to support European research, development and demonstration in this area.

Electric components and architectures are common between fully electric, plug-in hybrid, range extended and FCEVs and therefore all possible synergies should be exploited, and integration and reorientation of efforts between the two initiatives will be considered should conditions so warrant. These actions will take place through the establishment of a working group reviewing actions, roadmaps and work programs.

In particular, having regard to the potential future role of hydrogen as a substitute for oil in transport, appropriate links should be established with the forthcoming Strategic Transport Technology Plan, the Clean Power for Transport initiative[54], the Trans-European Networks for Transport initiative, and actions arising from the White Paper entitled “Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system”[55] - to assure a consistent refuelling infrastructure build-up as described in the EU Procedure File “Deployment of Refueling Infrastructure”[56] and address the White Paper goals for phasing out conventionally fuelled cars in cities by 2050 and essentially CO_2-free logistics in major urban centres by 2030.

On the other side of innovation, new ideas, especially breakthrough technologies, are necessary to keep European Industry at the forefront of innovation. Even though the FCH 2 JU will be focused on projects with TRL above 3, links with basic research will be established and information processes organized between long term and basic research and the FCH 2 JU. The research grouping organization, N.ERGHY, will play a role with the help of FCH 2 JU program office to establish bridges with the relevant research organisations on FCH technologies, especially with EERA (European Energy Research Alliance).

[53] http://eur-lex.europa.eu/legal-content/EN/ALL/;jsessionid=xg6vTG1f34nJVvqyjJq9rvX0J3LznjQbVnzJl0JvKgrp5VG4Gvws!-1079227193?uri=CELEX:52012DC0341

[54] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0017:FIN:EN:PDF

[55] Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system COM(2011)144 final, 28/3/2011

[56] Commission Proposal for the Directive on the deployment of alternative fuels infrastructure: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0018:FIN:EN:PDF
2013/0012(COD) Deployment of alternative fuels infrastructure: http://www.europarl.europa.eu/oeil/popups/ficheprocedure.do?reference=2013/0012(COD)&l=en#tab-0

5. Implementation of the FCH 2 JU

5.1. FCH 2 JU Budget

The FCH 2 JU shall be jointly funded by the European Union and the Members other than the EU or their constituent entities or their affiliated entities through financial contributions paid in partial instalments, and contributions consisting of the costs incurred by them in implementing indirect actions that are not reimbursed by the FCH 2 JU. The FCH 2 JU is established for the period 2014–2024.

The administrative costs of the FCH 2 JU shall not exceed 38 M€ and shall be covered in cash, on an annual basis, divided equally between the Union and the private Members. The Union shall contribute with 50%, the Industry Grouping with 43% and the Research Grouping with 7%. If part of the contribution for administrative costs is not used, it may be made available for the operational activities of the FCH 2 JU.

Administrative costs will cover administrative expenditures such as staff costs, rental of building, equipment, IT equipment and maintenance, evaluation costs, meetings, etc.

The operational costs of the FCH 2 JU will be covered through the financial contribution of the Union (646 M€ over the 2014-2020 period), and through a non-reimbursable contribution consisting of the costs incurred in implementing indirect actions which are not reimbursed by the Union financial contribution by Members other than the Union.

The private Members of the JU shall report each year by 31st January to the Governing Board of the FCH 2 JU on the estimated value of the in-kind contributions incurred during the previous financial year. The costs shall be based on the usual cost accounting practices of the entities concerned and determined according to the applicable accounting standards of the country where each entity is established.

The resources of the FCH 2 JU available for its budget shall be composed of:

- Members' financial contributions to the administrative costs;
- The Union's' financial contributions to the operational costs;
- any revenue generated by the FCH 2 JU;
- any other financial contributions, resources and revenues.

Any other contribution to the FCH 2 JU may also be accepted. The Governing Board shall decide on their acceptance and utilisation in accordance with the Financial rules of the FCH 2 JU.

All resources of the FCH 2 JU and its activities shall be devoted to the objectives provided for in Chapter 2.

The FCH 2 JU shall own all assets generated by it or transferred to it for the fulfilment of its objectives provided for in Chapter 2 unless otherwise specified.

5.2 Calls for proposals

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.

However, other instruments foreseen in the Financial regulation and the Horizon 2020 Rules for participation may also be used. In particular, it is expected that a fraction of the budget will be used for studies that will be contracted through a public procurement procedure.

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. [57]

An extract on Condition for participation, Eligibility for funding, Types of actions, Funding rates, Submission and Evaluation procedure, Appointment of Experts, Consortium agreement, Grant agreement and Budget flexibility is provided for information in the sub-chapters below. **In case of any updates or changes, the conditions of the above Regulation will always prevail.**

In accordance with that Regulation, the FCH 2 JU shall be considered as a funding body and shall provide financial support to indirect actions as set out in Article 1 of the Statutes of the FCH 2 JU.

Pursuant to Article 8(5) of the above Rules for participation and dissemination in Horizon 2020, Annual Work Plans may provide for justified additional conditions according to specific policy requirements or to the nature and objective of the action, inter alia, that strategic topics in specific calls may also be reserved to the constituent entities of the Members other than the Union. This can only be applied in duly justified cases, upon agreement by the Governing Board.

At least one Call for proposals will be published each year, based on the Annual Work Plan (AWP). Proposals may be called for using a single stage process i.e. a single application, assessment and evaluation and award of grant; however, for more strategic actions, a two stage process i.e. outline proposals might be chosen in first stage, with successful ones invited to submit a full proposal at a later stage.

5.2.1 Conditions for participation and eligibility for funding

Any legal entity, regardless of its place of establishment, or international organisation may participate in an action provided that the conditions laid down in the Horizon 2020 Rules for Participation have been met, together with any conditions laid down in the relevant work programme or work plan.

The JRC may participate in actions with the same rights and obligations as a legal entity established in a Member State[58].

The following minimum conditions shall apply:

a. at least three legal entities shall participate in an action;
b. three legal entities shall each be established in a different Member State or Associated Country; and

[57] OJ L 347/81 from 20 December 2013

[58] JRC involvement in FCH 2 JU activities shall be described in the bilateral ‘Framework Agreement’

c. the three legal entities referred to in point (b) shall be independent of each other within the meaning of Article 8[59] of the Horizon 2020 Rules for Participation.

For the purposes of paragraph 1, where one of the participants is the JRC, or an international European interest organisation or an entity created under Union law, it shall be deemed to be established in a Member State or Associated Country other than any Member State or Associated Country in which another participant in the same action is established.

By way of derogation from paragraph 1, in the case of coordination and support actions and training and mobility actions, the minimum condition shall be the participation of one legal entity.

The following participants are eligible for funding from the Union:

a. any legal entity established in a Member State or Associated Country, or created under Union law;
b. any international European interest organisation;
c. any legal entity established in a third country identified in the work programme.

In the case of a participating international organisation or in the case of a participating legal entity established in a third country not identified in the work programme, neither of which are eligible for funding according to paragraph 3, funding from the Union may be granted provided that at least one of the following conditions is fulfilled:

a. the participation is deemed essential for carrying out the action by the FCH 2 JU;
b. such funding is provided for under a bilateral scientific and technological agreement or any other arrangement between the Union and the international organisation or, for entities established in third countries, the country in which the legal entity is established.

The Governing Board may decide, in duly justified cases pursuant to Article 9(5) of the Regulation (EU) No 1290/2013, that to be eligible for participation a consortium must contain at least one constituent entity of the Industry or Research Grouping.

5.2.2. Types of action: specific provisions and funding rates

Research and innovation actions
Description: Action primarily consisting of activities aiming to establish new knowledge and/or to explore the feasibility of a new or improved technology, product, process, service or solution. For this purpose they may include basic and applied research[60], technology development and integration, testing and validation on a small-scale prototype in a laboratory or simulated environment.

Projects may contain closely connected, but limited demonstration or pilot activities aiming to show technical feasibility in a near to operational environment.

[59] Two legal entities shall be regarded as independent of each other where neither is under the direct or indirect control of the other or under the same direct or indirect control as the other.

[60] For the purpose of the FCH 2 JU actions, only projects addressing technologies with TRL 3 to 5 will be funded under Research and innovation actions. If a project starts below TRL 5 and finishes above, it can be funded as a research and innovation action only if most of the work is related to activities with TRL equal to 5 or below. In most cases, most of the work is related to the starting TRL.

Funding rate: up to100%

Innovation actions

Description: Action primarily consisting of activities directly aiming at producing plans and arrangements or designs for new, altered or improved products, processes or services. For this purpose they may include prototyping, testing, demonstrating, piloting, large-scale product validation and market replication[61].

A 'demonstration or pilot' aims to validate the technical and economic viability of a new or improved technology, product, process, service or solution in an operational (or near to operational) environment, whether industrial or otherwise, involving where appropriate a larger scale prototype or demonstrator.

A 'market replication' aims to support the first application/deployment in the market of an innovation that has already been demonstrated, but not yet applied/deployed in the market due to market failures/barriers to uptake. 'Market replication' does not cover multiple applications in the market of an innovation[62] that has already been applied successfully once in the market. 'First' means new at least to Europe or new at least to the application sector in question. Often such projects involve a validation of technical and economic performance at system level in real life operating conditions provided by the market.

Projects may include limited research and development activities.

Funding rate: up to 70% (except for non-profit legal entities, where a rate of 100% applies)[63]

Coordination and support actions

Description: Actions consisting primarily of accompanying measures such as standardisation, dissemination, awareness-raising and communication, networking, coordination or support services, policy dialogues and mutual learning exercises and studies, including design studies for new infrastructure and may also include complementary activities of strategic planning, networking and coordination between programmes in different countries.

Funding rate: up to 100%

Technology readiness levels (TRL)

Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

TRL 1 – basic principles observed
TRL 2 – technology concept formulated
TRL 3 – experimental proof of concept
TRL 4 – technology validated in lab
TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7 – system prototype demonstration in operational environment
TRL 8 – system complete and qualified

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[61] For the purpose of the FCH 2 JU actions, only projects addressing technologies with TRL 6 to 8 will be funded under Innovation actions.
[62] A new or improved technology, product, design, process, service or solution
[63] Participants may ask for a lower rate

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

5.2.3 Submission and evaluation procedure

Applications to the FCH 2 JU for financial support for innovation activities will mainly be made following competitive Calls for proposals. The evaluation, selection and award procedures are described in the document *"Horizon 2020 – General Annexes to the main Work-Programme" and "Horizon 2020 - Grants Manual - Section on: proposal submission and evaluation (sections III.5, III.6, IV.1, IV.2, IV.3, IV.5)".*

The evaluation shall be carried out by independent experts. Proposals will not be evaluated anonymously.

Standard admissibility conditions for grant proposals, and related requirements

1. To be considered admissible, a proposal must be:

   a. Submitted in the electronic submission system before the deadline given in the Call conditions;
   b. Readable, accessible and printable.

2. Incomplete proposals may be considered inadmissible. This includes the requested administrative data, the proposal description, and any supporting documents specified in the Call. The following supporting documents will be required to determine the operational capacity, unless otherwise specified:

- A curriculum vitae or description of the profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities;
- A list of up to five relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the Call content;
- A list of up to five relevant previous projects or activities, connected to the subject of this proposal;
- A description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;
- A description of any third parties that are not represented as project partners, but who will nonetheless be contributing towards the work (e.g. providing facilities, computing resources)

3. Proposals shall include a draft plan for the exploitation and dissemination of the results, unless otherwise specified in the Call conditions. The draft plan is not required for proposals at the first stage of two-stage procedures.

4. Page limits will apply to proposals. The limits will be clearly set out in the electronic submission system. If a submitted proposal exceeds the limits, the applicant will receive an automatic warning, and will be advised to re-submit a version that conforms. After the relevant call deadline, excess pages in any over-long proposals will be automatically overprinted with a "watermark". Expert evaluators will be instructed to disregard these excess pages.

Standard eligibility criteria

All proposals must conform to the conditions set out in the Horizon 2020 Rules for Participation. Furthermore, the following conditions apply unless they are supplemented or modified in the call conditions. A proposal will only be considered eligible if:

a. its content corresponds, wholly or in part, to the topic description against which it is submitted, in the relevant work programme part;
b. it complies with the eligibility conditions set out below, depending on the type of action.

Research & innovation action	Three legal entities. Each of the three shall be established in a different Member State or Associated Country. All three legal entities shall be independent of each other.
Innovation action	Three legal entities. Each of the three shall be established in a different Member State or Associated Country. All three legal entities shall be independent of each other
Coordination & support action	One legal entity established in a Member State or Associated Country.

<u>Selection Criteria</u>

- Financial capacity: In line with the Financial Regulation and the Rules for Participation. At the proposal stage, coordinators will be invited to complete a self-assessment using an on-line tool.
- Operational capacity: As a distinct operation, carried out during the evaluation of the award criterion 'Quality and efficiency of the implementation', experts will indicate whether the participants meet the selection criterion related to operational capacity, to carry out the proposed work, based on the competence and experience of the individual participant(s).

<u>Award criteria</u>
The proposals submitted shall be evaluated on the basis of the following award criteria:

a. excellence;
b. impact;
c. quality and efficiency of the implementation.

Type of action	**Excellence** The following aspects will be taken into account, to the extent that the proposed work corresponds to the topic description in the work programme.	**Impact** The extent to which the outputs of the project should contribute at the European and/or International level to:	**Quality and efficiency of the implementation** The following aspects will be taken into account:
All types of action	Clarity and pertinence of the objectives; Credibility of the proposed approach.	The expected impacts listed in the work programme under the relevant topic The in-kind contribution of the members of the consortium (including additional activities)	Coherence and effectiveness of the work plan, including appropriateness of the allocation of tasks and resources; Complementarity of the participants within the consortium (when relevant); Appropriateness of the

			management structures and procedures, including risk and innovation management.
Research and innovation; **Innovation**	Soundness of the concept, including trans-disciplinary considerations, where relevant; Extent that proposed work is ambitious, has innovation potential, and is beyond the state-of-the-art (e.g. ground-breaking objectives, novel concepts and approaches)	Enhancing innovation capacity and integration of new knowledge; Strengthening the competitiveness and growth of companies by developing innovations meeting the needs of European and global markets; and, where relevant, by delivering such innovations to the markets; Any other environmental and socially important impacts (not already covered above); Effectiveness of the proposed measures to exploit and disseminate the project results (including management of IPR), to communicate the project, and to manage research data where relevant.	
Coordination & support actions	Soundness of the concept; Quality of the proposed coordination and/or support measures.	Effectiveness of the proposed measures to exploit and disseminate the project results (including management of IPR), to communicate the project, and to manage research data where relevant.	

Unless otherwise specified in the Call conditions:

- Evaluation scores will be awarded for the criteria, and not for the different aspects listed as sub-criteria. For full proposals, each criterion will be scored out of 5. The threshold for individual criteria will be 3. The overall threshold, applying to the sum of the three individual scores, will be 10.
- For Innovation actions, to determine the ranking, the score for the criterion ‘impact’ will be given a weight of 1.5.
- For the evaluation of first-stage proposals under a two-stage submission procedure, only the criteria ‘excellence’ and ‘impact’ will be evaluated. The threshold for both individual criteria will be 4.

In cases where the requested funding from the Union for the action is equal or superior to EUR 500,000 the FCH 2 JU shall, by means compatible with national law, verify in advance the financial capacity of only the coordinators.

Furthermore, whenever there are grounds to doubt the financial capacity of the coordinator or other participants on the basis of available information, the FCH 2 JU shall verify their financial capacity.

The financial capacity shall not be verified either in respect of legal entities whose viability is guaranteed by a Member State or an Associated Country or in respect of higher and secondary education establishments.

Proposals shall be ranked according to the evaluation results. The selection shall be made on the basis of that ranking. Unless the Call conditions indicate otherwise, ranked lists of proposals will be established for each Pillar and type of action; and the following method will be applied.

Priority order for proposals with the same score

As part of the evaluation by independent experts, a panel review will recommend one or more ranked lists for the proposals under evaluation, following the scoring systems indicated in the above rules. A ranked list will be drawn up for every indicative budget shown in the Call conditions.

If necessary, the panel will determine a priority order for proposals which have been awarded the same score within a ranked list. Whether or not such a prioritisation is carried out will depend on the available budget or other conditions set out in the call fiche. The following approach will be applied successively for every group of *ex aequo* proposals requiring prioritisation, starting with the highest scored group, and continuing in descending order:

i. Proposals that address topics not otherwise covered by more highly-ranked proposals, will be considered to have the highest priority.
ii. These proposals will themselves be prioritised according to the scores they have been awarded for the criterion excellence. When these scores are equal, priority will be based on scores for the criterion impact. In the case of Innovation actions, this prioritisation will be done first on the basis of the score for impact, and then on that for excellence.

If necessary, any further prioritisation will be based on the following factors, in order: willingness of the constituents of the consortium to declare additional activities, size of budget allocated to SMEs; gender balance among the personnel named in the proposal who will be primarily responsible for carrying out the research and/or innovation activities.

If a distinction still cannot be made, the panel may decide to further prioritise by considering how to enhance the quality of the project portfolio through synergies between projects, or other factors related to the objectives of the call or to Horizon 2020 and FCH field in general. These factors will be documented in the report of the Panel.

The method described in (ii) will then be applied to the remaining *ex aequos* in the group.

A reserve list will be constituted if there is a sufficient number of good quality proposals, which will be taken into consideration if budget becomes available.

Evaluation review procedure

The FCH 2 JU shall provide a transparent evaluation review procedure for applicants which consider that the evaluation of their proposal has not been carried out in accordance with the procedures set out in the Horizon 2020 Rules for Participation, the relevant work programme, work plan or the call for proposals.

A request for review shall relate to a specific proposal, and shall be submitted by the coordinator of the proposal within 30 days of the date on which the FCH 2 JU informs the coordinator of the evaluation results.

The FCH 2 JU shall be responsible for the examination of the request. The examination shall cover only the procedural aspects of the evaluation, and not the merits of the proposal.

An evaluation review committee composed of staff of the FCH 2 JU shall provide an opinion on the procedural aspects of the evaluation process. It shall be chaired by an official of the FCH 2 JU, from a department other than that responsible for the call for proposals. The committee may recommend one of the following:

a. re-evaluation of the proposal primarily by evaluators not involved in the previous evaluation;
b. confirmation of the initial evaluation.

On the basis of the recommendation, a decision shall be taken by the FCH 2 JU and notified to the coordinator of the proposal. The FCH 2 JU shall take such decision without undue delay.

The review procedure shall not delay the selection process of proposals which are not the subject of requests for review.

The review procedure shall not preclude any other actions the participant may take in accordance with EU law.

5.2.4 Appointment of independent experts

The FCH 2 JU may appoint independent experts to evaluate proposals or to advise on or assist with:

- the evaluation of proposals;
- the monitoring of the implementation of actions carried out under Regulation (EU) No ...+/2013 as well as of previous Research and/or Innovation Programmes;
- the implementation of Union research and innovation policy or programmes including Horizon 2020, as well as the achievement and functioning of the European Research Area;
- the evaluation of Research and Innovation Programmes;
- the design of the Union research and innovation policy, including the preparation of future programmes.

Independent experts shall be chosen on the basis of their skills, experience and knowledge appropriate to carry out the tasks assigned to them. In cases where independent experts have to deal with classified information, the appropriate security clearance shall be required before appointment.

Independent experts shall be identified and selected on the basis of Calls for applications from individuals and Calls addressed to relevant organisations such as research agencies, research institutions, universities, standardisation organisations, civil society organisations or enterprises with a view to establishing a database of candidates.

When appointing independent experts, the FCH 2 JU shall take appropriate measures to seek a balanced composition within the expert groups and evaluation panels in terms of various skills, experience, knowledge, geographical diversity and gender, and taking into account the situation in the field of the action. Where appropriate, private-public sector balance shall also be sought.

All exchanges with independent experts, including the conclusion of contracts for their appointment and any amendment thereto, may be done through electronic exchange systems set up by the Commission and FCH 2 JU as stipulated in Article 287(4) of Regulation (EU) No. 1268/2012.

5.2.5 Consortium Agreement

The members of any consortium wishing to participate in an action shall appoint one of them to act as coordinator, which shall be identified in the grant agreement. The coordinator shall be the principal point of contact between the members of the consortium in relations with the FCH 2 JU, unless specified otherwise in the grant agreement, or in the event of non-compliance with its obligations under the grant agreement.

The members of a consortium participating in an action shall conclude before the signature of the Grant Agreement an internal agreement ("the consortium agreement") establishing their rights and obligations with respect to the implementation of the action in compliance with the grant agreement. The Commission shall publish guidelines on the main issues that may be addressed by participants in the consortium agreement.

The consortium agreement may stipulate, inter alia, the following:

- the internal organisation of the consortium;
- the distribution of the Union funding;
- rules on dissemination, use and access rights, additional to those in Title III, Chapter I of the Horizon 2020 Rules for Participation, and to the provisions in the grant agreement;
- arrangements for settling internal disputes;
- liability, indemnification and confidentiality arrangements between the participants.

The members of the consortium may make any arrangements in the consortium they deem fit to the extent that those arrangements are not in conflict with the Grant Agreement or the Horizon 2020 Rules for Participation.

5.2.6 Grant Agreement

The FCH 2 JU shall enter into a Grant Agreement with the participants. The removal or substitution of an entity before signature of the grant agreement shall be duly justified.

The Grant Agreement shall establish the rights and obligations of the participants and of the FCH 2 JU in compliance with the Horizon 2020 Rules for Participation. It shall also establish the rights and obligations of legal entities which become participants during the implementation of the action, as well as the role and tasks of a consortium coordinator.

On the basis of a requirement in the work plan, the Grant Agreement may establish rights and obligations of the participants with regard to access rights, exploitation and dissemination, in addition to those laid down in the Horizon 2020 Rules for Participation.

Time to Grant

In accordance with Article 128(2) of Regulation (EU, Euratom) No 966/2012, Calls for proposals shall specify the planned date by which all applicants shall be informed of the outcome of the evaluation of their application and the indicative date for the signature of Grant Agreements or the notification of grant decisions. The dates shall be based on the following periods:

- for informing all applicants of the outcome of the scientific evaluation of their application, a maximum period of five months from the final date for the submission of complete proposals;
- for signing Grant Agreements with applicants or notifying grant decisions to them, a maximum period of three months from the date of informing applicants that they have been successful.

These periods may be exceeded in exceptional, duly justified cases, in particular where actions are complex, where there is a large number of proposals or where requested by the applicants.

Participants shall be given reasonable time to submit the information and documentation required for the signature of the Grant Agreement. The Commission and FCH 2 JU shall make decisions and requests for information as promptly as possible. Where possible, resubmission of documents shall be avoided.

Time to Pay

Participants shall be paid in a timely manner in accordance with Regulation (EU, Euratom) No 966/2012.

Secure electronic system

All exchanges with participants, including the conclusion of Grant Agreements, the notification of grant decisions and any amendments thereto, may be made through an electronic exchange system set up by the Commission and FCH 2 JU, as stipulated in Article 179 of Regulation (EU) No 1268/2012.

Grants may take any of the forms provided for in Article 123 of Regulation (EU, Euratom) No 966/2012, taking into account the objectives of the action.

Conditions for eligibility of costs are defined in Article 126 of Regulation (EU, Euratom) No 966/2012. Costs incurred by third parties under the action may be eligible according to the provisions of this Regulation and of the grant agreement.

The funding of an action shall not exceed the total eligible costs minus the receipts of the action. The following shall be considered as receipts of the action:

a. resources made available by third parties to the participants by means of financial transfers or contributions in-kind free of charge, the value of which has been declared as eligible costs by the participant, provided that they have been contributed by the third party specifically to be used in the action;
b. income generated by the action, except income generated by the exploitation of the results of the action;
c. income generated from the sale of assets purchased under the grant agreement up to the value of the cost initially charged to the action by the participant.

A single reimbursement rate of the eligible costs shall be applied per action for all activities funded therein. The maximum rate shall be fixed in the work programme or work plan.

The Horizon 2020 grant may reach a maximum of 100 % of the total eligible costs, without prejudice to the co-financing principle.

The Horizon 2020 grant shall be limited to a maximum of 70 % of the total eligible costs for innovation actions and programme co-fund actions.

By way of derogation from paragraph 3, the Horizon 2020 grant may, for innovation actions, reach a maximum of 100 % of the total eligible costs for non-profit legal entities, without prejudice to the co-financing principle.

Indirect eligible costs shall be determined by applying a flat rate of 25 % of the total direct eligible costs, excluding direct eligible costs for subcontracting and the costs of resources made available by third parties which are not used on the premises of the beneficiary, as well as financial support to third parties.

Participant Guarantee Fund
A participant guarantee fund (the "Fund") is established and shall cover the risk associated with non-recovery of sums due to the EU under actions financed through grants by the Commission under Decision No 1982/2006/EC and by the Commission or Union funding bodies under Horizon 2020 according to the Horizon 2020 Rules for Participation. The Fund shall replace and succeed the Participant Guarantee Fund set up under Regulation (EC) No 1906/2006.

The Fund shall be considered a sufficient guarantee under Regulation (EU, Euratom) No 966/2012.

Participants in actions under Horizon 2020 whose risk is covered by the Fund shall make a contribution of 5% of the Union funding for the action. At the end of the action the amount contributed to the Fund shall be returned to the participants, via the coordinator.

Participants' contribution to the Fund may be offset from the initial pre-financing and be paid to the Fund on behalf of the participants.

5.2.7 Budget flexibility

Budgetary figures given in the work programme are indicative. Unless otherwise stated, final budgets may vary following the evaluation of proposals. The final figures may vary by up to 20% with respect to those indicated in the work programme for the following budgeted activities:

- Total expenditure for each Call for proposals;
- Any repartition of the Call budget within a Call, up to 20% of the total expenditure of the Call;
- Evaluation and, monitoring, up to 20% of the total expenditure for all these activities;
- All other individual actions not implemented through Calls for proposals.

6. FCH 2 JU Bodies

Under Horizon 2020 the FCH 2 JU will continue to be an industry led private-public partnership. The private sector will be represented by the NEW-IG for the European FCH industry and N.ERGHY for the European FCH research community. The European Union will be represented by the Commission. Each of the Members will appoint its representatives within the Governing Board of the FCH 2 JU.

The bodies of the FCH 2 JU shall be:

(a) the Governing Board;
(b) the Executive Director;
(c) the Scientific Committee;
(d) the States Representatives Group;
(e) the Stakeholder Forum.

6.1. Main actors: roles and representation

Together with the other stakeholders, the European Commission will ensure development and implementation of a research & innovation and innovation programme that contributes to the established objectives of the FCH 2 JU (e.g. provided by the SET Plan and other EU energy and transport policy frameworks, the Innovation Union and Industrial Policy).

The **Industry Grouping** for fuel cells and hydrogen technology (NEW-IG, also named IG) brings together a major proportion of the Europe's companies (small, medium and large) with activities in the field of FCH technology development and commercialization, and willing to take an active part in the FCH 2 JU. The NEW-IG represents the European Industry within the FCH 2 JU and is responsible for developing the strategy of the FCH 2 JU that is approved by the FCH 2 JU Governing Board.

The **Research Grouping** for fuel cells and hydrogen technology (N.ERGHY, also named RG) brings together the most important research institutions with activities in the field of FCH basic and applied research, and willing to take an active part in the FCH 2 JU. N.ERGHY represents the European Research community within the FCH 2 JU and together with the IG develops the FCH 2 JU Annual Work Programme.

Together NEW-IG and N.ERGHY cover the entire value chain in the FCH sector from basic and applied research to product commercialization. These two Groupings will continue to operate on the basis of transparency and are open to any European business or research institute with interest and activity in the FCH sector. The NEW-IG and N.ERGHY represent focused and dedicated partners and will provide the FCH 2 JU with a single point of contact for their respective membership, long term stability and resources. The application process for benefiting from FCH 2 JU programme funds will be accessible to the members of NEW-IG and N.ERGHY and also to non-members of these groupings.

The execution of the FCH 2 JU Programme will be managed by a **Programme Office**, under the responsibility of its **Executive Director**, who in turn will be under supervision of the **Governing Board**. A **Scientific Committee** and a **States Representatives Group**, both formal advisory bodies, will continue to provide relevant advice to FCH 2 JU stakeholders.

A **Stakeholders Forum** (SF) will be held each year to enable interaction with the larger European fuel cell and hydrogen community. It shall be informed of the activities of the FCH 2 JU and shall be invited to provide comments.

6.1.1 Governing Board

Composition and decision-making process:
The Governing Board shall have 10 members. It shall be composed of 3 representatives of the Commission (50% of votes), 6 representatives of the Industry Grouping (43% of votes) and of 1 representative of the Research Grouping (7% of votes). The decisions will be taken unanimously or, if an agreement cannot be reached, at least by 75% of all eligible votes. The chair for the Governing Board will be from the Industry Grouping.

To ensure their representation and foster their involvement, at least one of the representatives appointed by the Industry Grouping shall represent SMEs.

The chairperson of the States Representatives Group and Scientific Committee shall have the right to attend meetings of the Governing Board as observers, as will the Executive Director. These observers shall have no voting rights.

The Governing Board shall have overall responsibility for the strategic orientation and the operations of the FCH 2 JU and shall oversee the implementation of its activities.

Among other responsibilities, the Governing Board will adopt the Financial Rules of the FCH 2 JU, the annual budget, including the staff establishment plan, appoint, dismiss or replace, or extend the term of office, provide guidance to and monitor the performance of the Executive Director, approve the organisational structure of the Programme Office, based on a recommendation by the Executive Director, adopt the Annual Work Plan and the corresponding expenditure estimates, as proposed by the Executive Director, after having consulted with the Scientific Committee and the States Representatives Group, approve the annual accounts, approve the annual activity report, including the corresponding expenditure, approve the Calls for actions as well as the related rules for submission, evaluation, selection, award and evaluation review procedures, approve the list of actions selected for funding, establish the FCH 2 JU's communications policy based on a recommendation by the Executive Director and supervise the overall activities of the FCH 2 JU.

6.1.2 Scientific Committee

As stated in the regulation, the Scientific Committee (SC) is an advisory body to the Governing Board. It shall conduct its activities in close liaison and with the support of the Programme Office.

The members shall reflect a balanced representation of world-wide recognized expertise from academia, industry and regulatory bodies. Collectively, the SC members shall have the necessary scientific competencies and expertise covering the complete technical domain needed to make strategic science-based recommendations to the FCH 2 JU. It shall consist of no more than 9 members.

The Governing Board shall appoint the members of the SC taking into consideration the potential candidates proposed by the States Representatives Group.

The main tasks of the Scientific Committee as described in the regulation are to:

- advise on the scientific priorities to be addressed in the annual work plans;
- and advise on the scientific achievements described in the annual activity report.

6.1.3 States Representatives Group

As stated in the regulation, the States Representatives Group (SRG) shall have an advisory role to the FCH 2 JU. It shall consist of one representative of each Member State and of each country associated with the Horizon 2020 Framework Programme. The main task of the States Representatives Group is to review information and provide opinions on the following topics:

- programme progress in the FCH 2 JU and achievement of its targets;
- updating of strategic orientation;
- links to the Horizon 2020 Framework Programme;
- Annual Work Plans;
- involvement of SMEs.

The SRG shall also provide information and interface to the FCH 2 JU on the status of relevant national research and innovation programmes and identification of potential areas of cooperation, including deployment as well as specific measures taken at national level with regard to dissemination events, dedicated technical workshops and communication activities.

The SRG may issue, on its own initiative, recommendations to the Governing Board on technical, managerial and financial matters, in particular when these affect national interests.

The Governing Board shall inform without undue delay the SRG of the follow-up it has given to such recommendations or proposals, including the reasoning if they are not followed up.

The SRG shall receive information on a regular basis, among others, on the participation in indirect actions funded by the FCH 2 JU, on the outcome of each Call and project implementation, on synergies with other relevant Union programmes, and on the execution of the FCH 2 JU budget.

6.1.4 Stakeholder's Forum

The Stakeholders' Forum (SF) has an advisory role to the FCH 2 JU. It is open to all public and private stakeholders, interest groups from Member States, Associated Countries as well as from third countries.

The SF shall be informed of the activities of the FCH 2 JU and shall be invited to provide comments.

The SF is an important communication channel to ensure transparency and openness of the FCH 2 JU activities with its stakeholders. It shall be convened once a year by the Executive Director.

6.2 Executive Director and Programme Office

6.2.1 Executive Director

The Executive Director shall be appointed by the Governing Board following a Call for expression of interest published in the Official Journal of the European Union and in other publicly accessible periodicals and internet sites. A balanced representation of the FCH 2 JU Members coming from the public and the private sector shall be ensured at all key stages of the selection procedure.

He/she is a member of staff and shall be engaged as a temporary agent of the FCH 2 JU with a term of office of three years. By the end of this period, the Commission shall, in association with other members of the FCH 2 JU, undertake an assessment which takes into account the evaluation of the performance of the Executive Director and the FCH 2 JU's future tasks and challenges. The Governing Board, acting on a proposal from the Commission, may extend once the term of office of the Executive Director for no more than four years. An Executive Director whose term of office has been extended may not participate in another selection procedure for the same post at the end of the overall period.

The Executive Director shall be the chief executive responsible for the day-to-day management of the FCH 2 JU in accordance with the decisions of the Governing Board. He/she shall be the legal representative of the FCH 2 JU. He/she shall perform his/her tasks with independence, and shall be accountable to the Governing Board.

The main duties and responsibilities of the Executive Director are to implement the budget of the FCH 2 JU, prepare and submit for approval to the Governing Board the draft annual budget, including the corresponding staff policy plans.

The Executive Director shall constitute, in accordance with Article 9(5) of the Council Regulation XXX, a Programme Office for the execution, under his responsibility, of all support tasks arising from this Regulation, by establishing and managing an appropriate accounting system, managing the launch of the Calls for proposals as foreseen in the Annual Work Plan, manage Calls for tenders for services and supplies, providing to the Members and to the other bodies of the FCH 2 JU all relevant information and support for them to perform their duties as well as to respond to their specific requests and ensuring the provision of the secretariat function of the bodies of the FCH 2 JU.

6.2.2 Programme Office

The Programme Office (PO) shall, under the responsibility of the Executive Director, execute all responsibilities of the FCH 2 JU. The PO will in particular:

- Monitor, regularly review and update the MAWP, based on programme achievements and information gained from benchmarks and global developments to ensure it has the proper scope and balance of activities and achievable targets from a European perspective. This revision should take place if any major breakthrough takes place, or at least once every three years.

- With the help of the SRG, create synergies and manage the interface with relevant national programmes, identify common interest, scope joint activities and implement them together with the national representatives, companies or research institutes and initiatives.

- Create synergies and manage the interface with relevant regional programmes, notably with Hydrogen Regions and Municipalities Partnership (HyER), identify common interests, scope joint activities and implement them together with the regional representatives, companies or research institutes and initiatives.

- Establish and maintain high profile communication and dissemination activities to ensure public awareness and acceptance of the technologies, share and disseminate information, expertise and experience and thus establish a platform to involve all relevant stakeholder groups.

- Identify, manage and coordinate the implementation of RCS and PNR actions needed to remove market barriers, in close collaboration with the JRC. Disseminate accurate RCS information.

- Identify, manage and coordinate activities to remove other non-technical market barriers, facilitate market drivers and reduce critical investment risks for the industry with specific focus on SMEs.

- Identify and manage the implementation of technology monitoring and bench mark activities including life cycle analysis and safety due diligence to assess relevance and impact of fuel cell and hydrogen technologies.

- Identify, participate in and explore international cooperation activities to address the global dimension of the technology development and to advance programme objectives.

- Establish and maintain proper risk management to identify and mitigate risks associated with programme activities and the financial administration of the JU.

- Support the Bodies of the FCH 2 JU, ensuring proper preparation and follow-up of their activities.

- Identify and manage interfaces with relevant technology platforms and activities and ensure proper coordination and collaboration.

6.2.3 Staff establishment plan

The staff of the Joint Undertaking is described in the “Staff establishment plan” of the FCH JU.

According to the Council Regulation setting up the FCH 2 JU, the Staff Regulations of officials of the European Union and the conditions of employment of other servants of the European Union will apply to the staff of the FCH 2 JU and its Executive Director.

The Executive Director shall submit a proposal to the FCH 2 JU Governing Board for approval of the organisational structure of the Programme Office and shall organise, direct and supervise the staff to meet the objectives of the FCH 2 JU.

The staff of the FCH 2 JU shall consist of temporary agents (TA) and contract agents (CA) recruited for a fixed period that may be renewed. If any of such renewals are the second renewal, it shall be for an indefinite duration.

The Programme Office will attract candidates with the required experience, qualifications and knowledge to ensure that its tasks are fulfilled to a high level of professional competence and quality.

Under the responsibility and supervision of the Executive Director, the staff shall, in particular:

- Organise and manage the competitive Calls for proposals as foreseen in the Annual Work Plans, including the evaluation, and selection of the project proposals with the assistance of independent experts, negotiate the selected proposals and the follow-up and administer the resulting Grant Agreements.

- Monitor and manage scientific, financial and administrative aspects of the operation of the FCH 2 JU.

- Organise and manage Calls for tenders for goods and services according to the financial rules of the FCH 2 JU.

- Provide the Governing Board and all other subsidiary bodies with relevant information, documentation and logistical support.

- Prepare and update as appropriate the Multi-Annual Work Program and the corresponding financial plans.

- Set up and implement management and control procedures, including financial auditing.

- Monitor scientific and industrial progress to assess the results of the JU actions towards its goals.

- Organise dissemination and communication activities of the FCH 2 JU.

- Coordination with Member States, Associated Countries and Regions programmes.

- Leveraging/coordinating public and private funding in FCH technologies.

The Executive Director of the FCH 2 JU should be able to freely define the most suitable the organisational structure, adapting it to changing needs, as long as it is within the administrative costs budget.

7. Programme reporting and control

7.1 Annual activity report

By 1st February of each year the Executive Director shall present to the Governing Board for approval a draft annual activity report on the progress made by the FCH 2 JU in the previous calendar year, in particular in relation to the Annual Work Plan for that year. The report shall include, inter alia, information on:

- the research, innovation and other actions performed and the corresponding expenditure;

- the indirect actions submitted, including a breakdown by participant type, including SMEs, and by country;

- the indirect actions selected for funding, including a breakdown by participant type, including SMEs, and by country and indicating the contribution of the FCH 2 JU to the individual participants and actions.

Once approved by the Governing Board, the annual activity report shall be made publicly available.

7.2 Management control and internal control procedures

The FCH 2 JU and its bodies shall avoid any conflict of interest in the implementation of their activities.

The FCH 2 JU will adopt its specific financial rules in accordance with Article 185 (1) of the Council Regulation 1605/2002, which departs from the framework Financial Regulation in cases where the specific operating needs of the FCH 2 JU so require and are subject to prior consent of the Commission.

The FCH 2 JU will establish its own internal audit capability according to the Council Regulation (EC) No. 521/2008 setting up the JU (art 6.2) and the financial rules of the JU (art 38.4). The Commission's Internal Audit Service have entrusted the functions indicated by Article 185(3) of Regulation (EC, EURATOM) No.1605/2002 under the responsibility of the Governing Board.

The FCH 2 JU shall protect the financial interests of the Members and implement anti-fraud measures. In particular, the FCH 2 JU shall ensure that the financial interests of its Members are adequately protected by carrying out or commissioning appropriate internal and external controls.

In the case of irregularities committed by the FCH 2 JU or its staff, the members shall reserve the right to recover any amount unduly spent, including by a reduction or suspension of subsequent contributions to the FCH 2 JU.

For the purposes of combating fraud, corruption and other illegal acts, Regulation (EC) No 1073/1999 shall apply.

The FCH 2 JU shall also carry out on-the-spot checks and financial audits among the recipients of the Joint Undertaking's public funding.

The Commission and/or the Court of Auditors may, as necessary, also carry out on-the-spot checks among the recipients of the FCH 2 JU's funding and the agents responsible for its allocation. To that end, the FCH 2 JU shall ensure that grant agreements and contracts provide for the right of the Commission and/or the Court of Auditors to carry out, on behalf of the FCH 2 JU, the appropriate controls and, in the event of the detection of irregularities, to impose dissuasive and proportionate penalties.

8. Definitions & Abbreviations

Term	Definition
AC	Associated Country (Countries)
AFC	Alkaline Fuel Cell
AIP	Annual Implementation Plan
APU	Auxiliary Power Unit
AWP	Annual Work Plan
BEV	Battery Electric Vehicle
BoP	Balance of Plant
BR **Long-term and break-through oriented research**	Activities addressing basic scientific fundamentals related to critical barriers and/or open up new pathways for technology, product and manufacturing improvements in the long run
BTH	Biomass-to-hydrogen (reforming processes)
CA	Contract Agent
CAPEX	Capital Expenditure
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CHP	Combined Heat & Power
CCHP	Combined Cooling, Heat and Power
CO_2	Carbon Dioxide
CPT	Clean Power for Transport
CTS	Clean Transportation Systems
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
DSO	Distribution System Operator (in relation to electricity grid)
EC	European Commission
EERA	European Energy Research Alliance
EGVI	European Green Vehicle Initiative
EGIA	European Industrial Gases Association
EII	European Industrial Initiative
EIT	European Institute of Innovation and Technology

eLCAr	e-Mobility Life Cycle Assessment Recommendations
EU	European Union, also referred to as the Union
FCEB	Fuel Cell Electric Buses
FCEV	Fuel Cell Electric Vehicle. This includes passenger cars, buses as well as commercial vehicless and two-wheelers
FC	Fuel Cells/Fuel Cell
FCH	Fuel Cells & Hydrogen
FCH JU, 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
FET	Future and Emerging Technologies
FP	Framework Programmes
GB	Governing Board
GHG	Green House Gas(es)
GW / GWh	GigaWatt / GigaWatt hours
H2	Hydrogen
H2 Mobility	Hydrogen Mobility
HFP	The European Hydrogen and Fuel Cell Technology Platform
HHV	Higher Heating Value
Horizon 2020	EU Research and Innovation programme over 7 years for the period 2014 to 2020
HRS	Hydrogen Refuelling Station
HTFC	High Temperature Fuel Cells
HyER	Hydrogen Regions and Municipalities partnership
IA	Implementing Agreement
ICE	Internal Combustion Engine
IEA	International Energy Agency
IEC	International Electrotechnical Committee
IG	European Industry Grouping for a Hydrogen and Fuel Cells JTI also referred to as "Industry Grouping" or NEW IG".
ILCD	International Reference Life Cycle Data System, set of technical guidance documents supporting good practice in Life Cycle Assessment
IP	Implementation Plan
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
IRENA	International Renewable Energy Agency
ISO	International Organization for Standardization
JRC	Joint Research Centre of the European 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
kg	kilogram
KPI	Key Performance Indicators
kW	Kilowatt
LCA	Life-Cycle Assessment
LCI	Life Cycle Inventory
LCOE	Levelised cost of electrcity
MAIP	Multi-Annual Implementation Plan
MAWP	Multi Annual Work Program
MCFC	Molten Carbonate Fuel Cell
mCHP	micro Combined Heat and Power
Members	The term "members" refers to the founding members of the FCH JU (EC & IG) and the Research Grouping, as the case may be.
MEA	Membrane Electrode Assembly
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 Horizon 2020 (named "Associated Countries" in the current document). It may also be referred to as "MS"
MW / MWh	MegaWatt / MegaWatt hours
NEW-IG	New Energy World Industry Grouping
N.ERGHY	New European Research Grouping for Hydrogen and Fuel Cells
NG	Natural Gas
NOx	Nitrous Oxides
O&M	Operation and Maintenance (costs)
OEM	Original Equipment Manufacturer(s)
OPEX	Operational Expenditure
PEM (FC)	Polymer Electrolyte Membrane (Fuel Cell)
PNR	Pre-normative Research, R&D work that addresses technical knowledge gaps in the development of RCS
PO	Programme Office
PSA	Pressure Swing Adsorption
R&I	Research & innovation
RCS	Regulations, Codes and Standards
RCS SC	Regulations, Codes and Standards Strategy Coordination
RG	European Research Grouping for a Hydrogen & Fuel Cells JTI, also referred to as " Research Grouping" or "N.ERGHY"
RTD Research and technological development	Activities that directly support the development, operation and commercialisation of products within the duration of the program

S/T Quality criteria	Scientific and technological quality criteria (to evaluate a proposal)
SAE	Society of Automotive Engineers
SC	Scientific Committee
SETIS	SET Plan Information System
SET Plan	Strategic Energy Technology Plan, see COM(2007) 723 Final
SF	Stakeholders Forum
SME	Small and Medium size Enterprise
SoA	State-of-the-art
SOFC	Solid Oxide Fuel Cell
SOx	Sulphur Oxides
SRG	States Representative Group, advisory body of the FCH 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 JU
STTP	Strategic Transport Technology Plan
TA	Temporary Agent
TCO	Total Cost of Ownership
TFEU	Treaty on the Functioning of the European Union
TMA	Technology Monitoring Assessment
TRL	Technology Readiness Level: TRL 1 – basic principles observed TRL 2 – technology concept formulated TRL 3 – experimental proof of concept TRL 4 – technology validated in lab TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) TRL 7 – system prototype demonstration in operational environment TRL 8 – system complete and qualified TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)
TSO	Transmission System Operator (in relation to the electricity grid)
UN	United Nations
UPS	Uninterruptabe power supply
US / USA	United States / United States of America