H2FC EUROPEAN INFRASTRUCTURE; RESEARCH OPPORTUNITIES TO FOCUS ON SCIENTIFIC AND TECHNICAL BOTTLENECKS

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ABSTRACT

The European Strategy Forum on Research Infrastructures (ESFRI) recognizes in its roadmap for Research Infrastructures that "*in the near future hydrogen, as an energy carrier derived from various other fuels, and fuel cells as energy transformers, are expected to come into a major role for mobility but also for different other mobile and stationary applications*" |1|. This modern hydrogen driven society lags far behind the reality. Because of that, it is conform to question the current situation concerning the belief, that already most is comprehensively investigated and developed concerning hydrogen technology is correct and already done. From that it appears, the hydrogen technology is market ready only partial and not prepared in a sufficient way to get finally included and adopted in modern hydrogen driven society and especially the acceptance of the society is a critical. Beside this critical view through society several scientific and technical bottlenecks still discoverable. Nevertheless it is possible to foster furthermore science and development on hydrogen technology. The "Integrating European Infrastructure" was created to support science and development of hydrogen and fuel cell technologies towards European strategy for sustainable, competitive and secure energy, also while identifying scientific and technical bottlenecks to support solutions based on. Its acronym is **H_2FC** *European Infrastructure* and was formed to integrate the European R&D community around rare and/or unique infrastructural elements that will facilitate and significantly enhance the research and development of hydrogen and fuel cell technology.

1.0 INTRODUCTION

Hydrogen technologies including fuel cells currently do not achieve the required cost and performance targets for an immediate and broad market introduction. Also safety aspects are still an issue and public acceptance needs wider and more consistent information. A number of these issues are partially addressed by the European Fuel Cell and Hydrogen Joint Undertaking (FCH-JU) which mainly supports the demonstration and adoption of the currently available technologies. However, as the current state and demonstration clearly shows that there are still major open issues requiring further investigation. Thus much additional research work, both on the fundamental and applied levels, need to be done. Without this R&D, the prospect of commercial success is pushed further into the future |2|. H2FC European Infrastructure aims at fitting this gap and supporting the necessary research by providing the required world class research infrastructure for external users. In brief, H2FC European Infrastructure complements parallel to the European Joint Undertaking activities and facilitates tackling major R&D bottlenecks in the field by making available the necessary advanced infrastructures to the EU research community.

2.0 SUPPORT THROUGH RESEARCH INFRASTRUCTURES

H_2FC *European Infrastructure* is a European Infrastructure Project funded by the European Commission. The project combines Europe's leading R&D institutions together supporting research and development on i.e. hydrogen production technologies, pureness of hydrogen, storage materials and systems, storage and distribution possibilities, final use through fuel cells in a safe manner in stationary and mobile systems etc. The project consists of 19 European project partners,

collected from European's research centres, universities and industry. With a total cost of € 10.147.583,60, **H_2FC** *European Infrastructure* activities are subdivided into 25 work packages, fully interrelated, devoted to network activities, transnational access activities and joint research activities and oriented towards the resolution of identified scientific and technical bottlenecks.

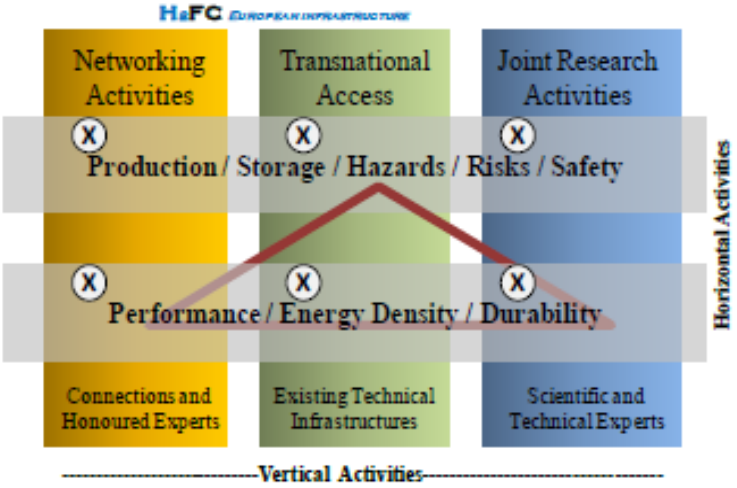

Figure 1. Thematic structure of H_2FC *European Infrastructure*

Main support to European's hydrogen and fuel cell community will be given through the transnational access activities of the project, while opening very different technical and experimental facilities to external users. A further strong international support will be given to scientists and also to students by a continuous researchers exchange program and four technical schools. The prospects, education and the access of external users of the research infrastructures, will be announced by continuous calls through the **H_2FC** *European Infrastructure* consortium.

Furthermore main objective of the project will be to generate a coordinated and integrated alliance based on complementary, state-of-the-art, or even beyond state-of-the-art unique infrastructures to serve the needs of the scientific hydrogen and fuel cells community and facilitate world class research. The current key research topics identified are:

1. Reducing degradation and increasing performance of electrolyser, hydrogen storage systems and fuel cells

2. Assessing and reducing hazards and risks associated with the use of hydrogen or hydrogen blended fuels and thereby ensuring the appropriate safety level of systems

3. Improving current storage technologies, in particular through advanced materials research

Objectives of the project are to provide:

1. A single integrated virtual infrastructure accommodating H2FC communities' test and analysis facilities;

2. Transnational access for the H2FC R&D communities to member state infrastructures

3. Expert working groups to enhance work at the provided facilities and coordination in the aspects of safety, performance, durability

4. Central databases and libraries of safety, performance and durability data and modelling codes

5. Coordination of relevant education and training actions;

6. Integration, enhancement and improvement of the existing infrastructures

7. Coordination with national and international bodies as well as academic and industry demands.

3.0 IDENTIFICATION OF SCIENTIFIC AND TECHNICAL BOTTLENECKS

The **H_2FC** *European Infrastructure* consortium identified various scientific and technological bottlenecks indicated by the experts on various hydrogen and fuel cell technologies. Four main categories were defined to select different technologies and related challenges:

1. ***Hydrogen production (including purification)***
2. ***Hydrogen storage and distribution***
3. ***Hydrogen end-use / systems***
4. ***Cross-cutting issues***

Various technologies (sub-topics) were defined under each topic and challenges/bottlenecks identified related to key aspects:

- Main materials challenges
- Limiting cost factors
- Limitations in characterization/modelling tools
- Main system challenges
- Main safety issues
- Main market challenges
- Other challenges

Based on the 4 categories and challenges, a matrix of identified bottlenecks was prepared. Since the consortium of **H_2FC** *European Infrastructure* project does not possess competence and experience within the whole chain of hydrogen and fuel cell technologies, the input given should not be interpreted as a complete survey. It is an ongoing task to complete this matrix next year while collecting aspects from external experts all over Europe. In an attempt to condense the identified bottlenecks, the following sections list the main issues for the 4 defined topics.

Depending on the maturity of the considered technology, there is different room and requirement to focus on harmonizing testing protocols, developing common understanding and modelling or improving scientific areas before commercialization is possible. This can be illustrated by hydrogen storage for which the preferred technology is pretty much dependant on application. For automobile applications, high pressure composite tanks are typically used, while solid storage may be a preferred solution for smaller vehicles/systems and applications like materials handling. Regarding high pressure composite tanks, standard and safety tests are required. Feedback data on material performance and on field test behaviour are also required to assess the safety of the tank. Regarding solid materials, more fundamental understanding is required as this technology is less mature but also interdisciplinary.

Generally, for more mature technologies such as natural gas reforming to produce hydrogen, pressurized hydrogen storage and PEMFC as end-use, some challenges are more economical and institutional than basing on technical and/or scientifically bottlenecks. In addition to the lifetime/cost issue, the technical requirements that are commonly expressed are the need for harmonised tests and standards, the poor range of available BoP components and further need for improvement of process integration.

For less mature technologies such as electrolysis for hydrogen production, solid storage and SOFC

as end-use, challenges are still more scientific, as these technologies require more research and development before potentially being ready for market entry. The need for better understanding, for advanced characterisation methods including in situ characterisation and for concerted modelling is commonly mentioned. It is also worth noting that harmonised approaches stand as facilitating vector for increasing the technology readiness level of all technologies.

According to the input obtained within **H_2FC** *European Infrastructure* project, several material challenges still remain for hydrogen production, storage and end-use linked with their stability under operating conditions and their production cost. This indicates that significant attention is needed for improving catalyst, membranes, bipolar plates/interconnectors with respect to both durability and cost, which is in line with the long term vision of the EC materials Roadmap. Challenges related to high production cost of materials and components for the various technologies may alleviated with time as a cost reduction is naturally expected upon break-through of a technology and start-up of mass production.

Safety is also specially highlighted within the **H_2FC** *European Infrastructure* consortium, where modelling in general as well as safety related regulations, codes and standards for the various technologies and use of hydrogen in general are defined as bottlenecks. One of the most challenging safety issues is a low fire resistance of on-board hydrogen storage and consequences of accidental leaks from vehicles outdoors and indoors.

This analysis of the Scientific Bottlenecks for Commercialization of H2 & FC Technologies confirms that the **H_2FC** *European Infrastructure* project is positioned on these key issues:

- Test harmonisation and protocols
- Accelerated tests development
- Mechanisms understanding and modelling thanks to advanced characterisation means including in situ characterisation
- Safety

Based on the current status of the interim report on scientific and technical bottlenecks, some infrastructure development and/or adaptation should be considered for in situ analysis to further sustain basic understanding, and infrastructures for system integration may be foreseen. The latter is commonly mentioned as a technical bottleneck for mature technology close to commercialisation |3|.

4.0 SUMMARY

The structure proposed in **H_2FC** *European Infrastructure* will realize an alliance of the European scientific community for serving the necessities of the scientific community itself. The identification of actual scientific and technical bottlenecks is therefore essential. Over the next years, the H2FC consortium expects that external European experts will take up the opportunity to collaborate concerning identified scientific and technical bottlenecks, to strengthen hydrogen and fuel cell technologies, to support the adoption by industry and at least, to enlarge related knowledge.

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