HYLIGHTS

Hydrogen for Transport in Europe

Entering the next phase towards commercialization of hydrogen vehicles - role and interests of various stakeholders

Report Status: **Intermediate**
Report Date: **August 2008**

A Coordination Action to Prepare European and Fuel Cell Demonstration Projects on Transport

Acknowledgement:
HyLights is financed by funds from the European Commission under FP6
Contract: TEN/05/FP6EN/S07.53917/019990.

Disclaimer

This document is the result of a collaborative work between HyLights Industry and Institute partners. The results of the research were subsequently elaborated and presented in a coherent manner, which involved extensive stakeholder consultation in locations around the world as well as feedback from the “HyLights” Industry Partners.

The ideas presented in this document were reviewed by certain "HyLights" project partners to ensure broad general agreement with its principal findings and perspectives. However, while a commendable level of consensus has been achieved, this does not mean that every consulted stakeholder or "HyLights" Industry Partner necessarily endorses or agrees with every finding in the document. The producer of this document is the sole responsible for its content and recommendations.

Abstract

The preparation of large-scale demonstration projects for hydrogen fuel cells is underway. This is a necessary first step along the technological development trajectory in order to further test the technology and infrastructure in real-life environment for its feasibility. Yet, several challenges remain concerning the design of the demonstration projects and their location. Currently, there is a mismatch between the hydrogen vehicle supply and demand. On top of that, financing the deployment stages beyond the first large-scale demonstration projects imposes major challenges. The Joint Technology Initiative for hydrogen and fuel cells (JTI), a public-private partnership between the European Commission and industry partners that is scheduled to start in October 2008, is expected to play a key role as support instrument for the first large-scale demonstration projects and is the first major step towards addressing the policy gap for the deployment of Fuel Cell and Hydrogen Technologies at pan-European level. Other hydrogen specific support instruments have to be implemented already in the phase alongside the JTI. The JTI alone, which basically focuses on the first large-scale demonstration projects will not be able to guide the technology through the next phases of the innovation trajectory, which runs from demonstration to the (early) commercialisation phase. Despite the existence of the FCH JTI though, it is not expected that the transition from the demonstration phase to commercialisation will happen very smoothly if dedicated policy support schemes are not implemented at both national and regional level. Deployment may seriously be hampered if the right support measures are not in place at the right time. Given the long lead-time needed to design and implement policy support schemes this trajectory has to be initiated way before market barriers actually do become visible. This may only happen if commitment is high and interests are aligned. In practice, diverging views from the stakeholders involved in the process of establishing the demonstration projects are likely to exist.

Table of Contents

1 Introduction

Currently, a limited number of hydrogen vehicles are deployed in a number of demonstration projects at different locations worldwide. Some of the most important projects are the Clean Energy Partnership (CEP), the California Fuel Cell Partnership (CaFCP) and the Japan Hydrogen and Fuel Cell Demonstration project (JHFC). They have all in common that their purpose is to test and validate the technology in a real-life environment, providing valuable information about technical and economic performance that can help to refine and improve the technology to enhance their potential for commercialisation. The current hydrogen demonstration projects remain on a small scale, i.e. the total number of vehicles deployed in the projects is rather low.[1] Large-scale demonstration projects represent the next important step in the technological development trajectory [2] (see Figure 1).

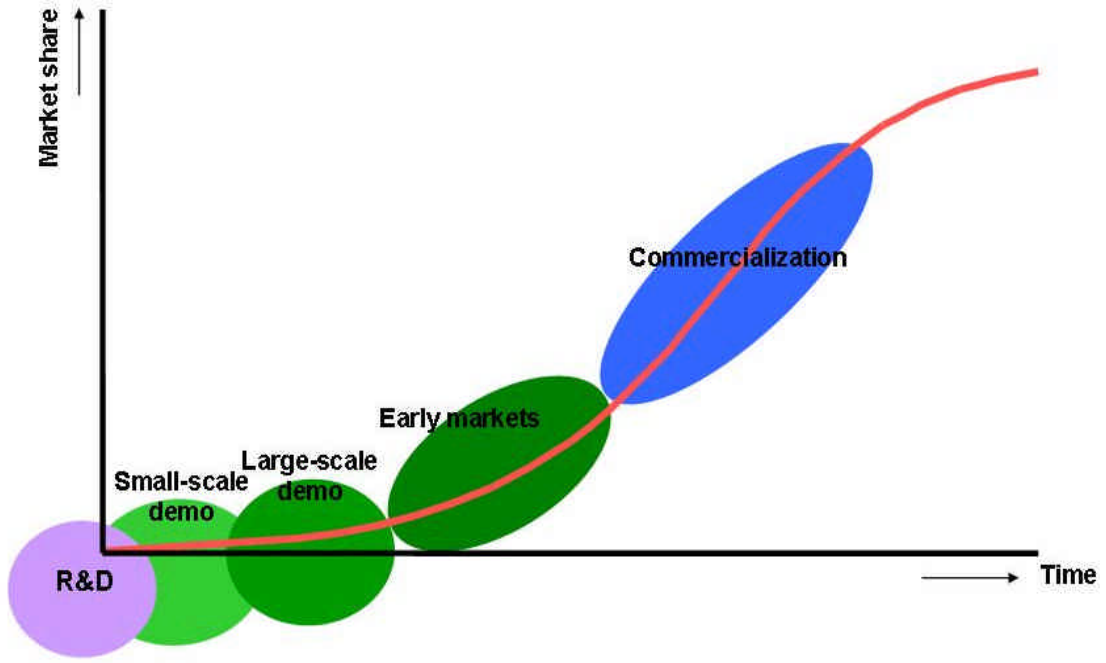

Figure 1: Phases of technology development from R&D to mass market

However, this shift towards large production volumes is not easily achieved through demonstration projects alone and is only the start of a longer trajectory towards mass production. The next big step is from a controlled environment to the early markets were the hydrogen technologies tested have to compete with existing technologies.

[1] For e.g. at the CEP project, 17 vehicles and two buses (15 buses in 2008) are in operation.[1]

The proposed Joint Technology Initiative for hydrogen and fuel cells (JTI)[2] is a public-private partnership initiated by the European Commission to accelerate hydrogen fuel cell market commercialization. It will fund a series of demonstration projects, of which is not yet clear where they will be located and how many there will be. However, it is not the objective of the JTI to define the future location of the demonstration projects. Funding for the JTI consists of a European Commission commitment of around € 450m that is equally contributed from industry. The focus of the JTI on deployment is on passenger cars.

The perspectives of the industry and the member states/regions may differ when it comes to the amount and size of demonstration activities. The JTI, even intended to last longer than the Seventh Research Framework Programme from 2007-2013 (FP7), will only be able to support the first series of large-scale demonstration projects. For the next phase of demonstration projects (beyond the initial planned scope of the JTI), national and/or regional budgets need to be substantial to support demonstration activities. In the early demonstration phase, the automotive industry (OEM) basically covers the cost of the production of the prototypes. Vehicles are not sold to the end-user, but the end-user sometimes has to pay a (modest) compensation for the use of the vehicles. When deployment goes up and production of small series starts, the OEM's cannot anymore afford selling the vehicles with a loss. This effect, together with the increasing size of the demonstration projects, leads to required support levels that are several orders of magnitude higher than during the early demonstration phase. Deployment support in this phase cannot be provided through the EC programs, since we are dealing with a series of identical vehicles and the focus of EC support is more on the R&D and demonstration phase. It is therefore questionable who is bearing the cost for the remaining large-scale demonstrations, though the options are very limited. The challenge therefore lies in the optimal deployment of the first vehicles to achieve maximum learning effects, while at the same time high commitment at member state level is generated for the preparation of future markets and secured finance.

[2] Joint Technology Initiatives are introduced by the European Commission as an instrument to facilitate European public-private research cooperation. Several JTI's are considered on different technologies. http://cordis.europa.eu/fp7/cooperation/home_en.html

2 The shift from R&D to deployment

2.1 Large-scale demonstrations

Large-scale demonstrations can be characterised by the fact that they have a much more integrated approach towards the technology testing, but also on market formation and the decrease of uncertainties, accompanied by a gradual ramp-up of vehicle production. The more mature the technology becomes, the larger the demonstration projects need to be (# of vehicles deployed) in order to obtain sufficient learning effects. With the advent of large-scale demonstration projects, hydrogen technology is being exposed to public space and accessible by a larger group of people. This phase will be fundamentally different from small-scale demonstrations, not only obviously by its size, but also by its objectives.

It is the development of all key technologies of a hydrogen economy to market maturity that is in focus here. It might be sufficient to have a small number of vehicles operating to test their general technical performance, but to learn more about the daily operational characteristics a sizeable fleet and a cluster of filling stations is necessary. The Implementation Plan (IP) 2006 of the European Hydrogen and Fuel Cell Platform (HFP) puts a number of 200 vehicles forward for the first deployment phase until 2010, followed by an expansion of 3,000 vehicles starting from 2015 [3].

2.2 Cost reductions

None of the car manufacturers has yet reached a production volume where cost can go down massively through mass-manufacturing (automatisation) only. An initial production (first series) of vehicles is necessary to propel the first large demonstration projects. Those vehicles will still cost more than double compared to conventional vehicles. The initial population is only the first step to bring down cost through cumulative production and pave the way to a mass-market rollout.

The concept of experience (learning) curves has been applied to study the cost of vehicle production with hydrogen fuel cells and hydrogen internal combustion engines in the European Commission project HyWays [4].[3]

[3] The cost reduction of a technology as a function of cumulative experience of produced units is described in an experience curve. Basically, the costs of a unit decrease by 10-20% with every duplication of the cumulative production.

To do so, the drive train systems has been broken down to its single components (tank, motor, battery) for which different progress ratios have been applied based on figures from the automotive partners (Daimler, BMW and GM/Opel) involved in the project [2]. The calculation of the vehicle price is based on these assumptions and the projected price development for compact-class hydrogen powered vehicles over the cumulated total production volume is shown in Figure 2.

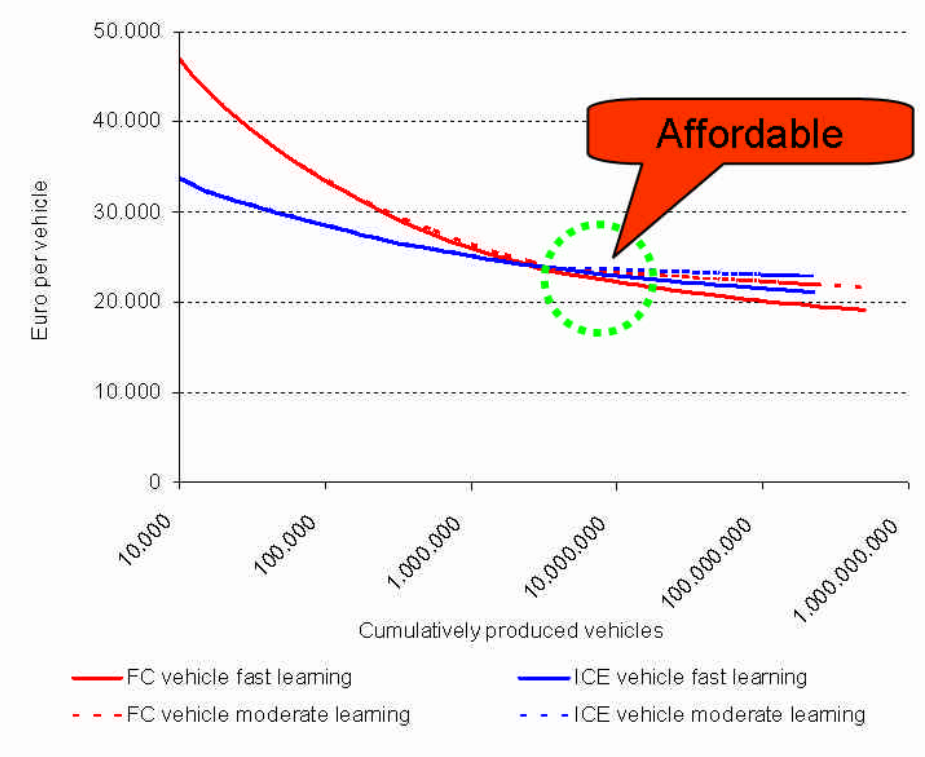

Figure 2: Cost reductions of hydrogen vehicles (compact-class) for 2010[4]

It is a common misconception that due to the learning effects, the total annual cost for vehicle deployment will go down immediately after finalisation of the first series of demonstration projects. Even though costs go down rapidly, the fast increase in deployment leads to a substantial increase in total annual budgets needed to bridge the cost gap between the reference and the hydrogen vehicle. Only after a number of years, the total annual budget reaches it peak to slowly decrease afterwards. This leads to the awkward situation that due to the success of the deployment scheme, a continuation of the support scheme is endangered since a yearly multiplication of the support budget is not foreseen upfront.

[4] The prices for a cumulative production of 100,000 units reflect the specifications from the CONCAWE/JRC/EUCAR study for the year 2010.

2.3 Bridging the gap

The future large-scale demonstration projects are assumed to host an initial population of a few thousand vehicles that are going to be deployed under the Joint Technology Initiative (JTI) and are expected to be finished around 2015-2017. It remains unclear what happens after the demonstration projects will be finished. The gap between the end of the large-scale demos and the early market phase is a critical phase in the technology development (see Figure 3).

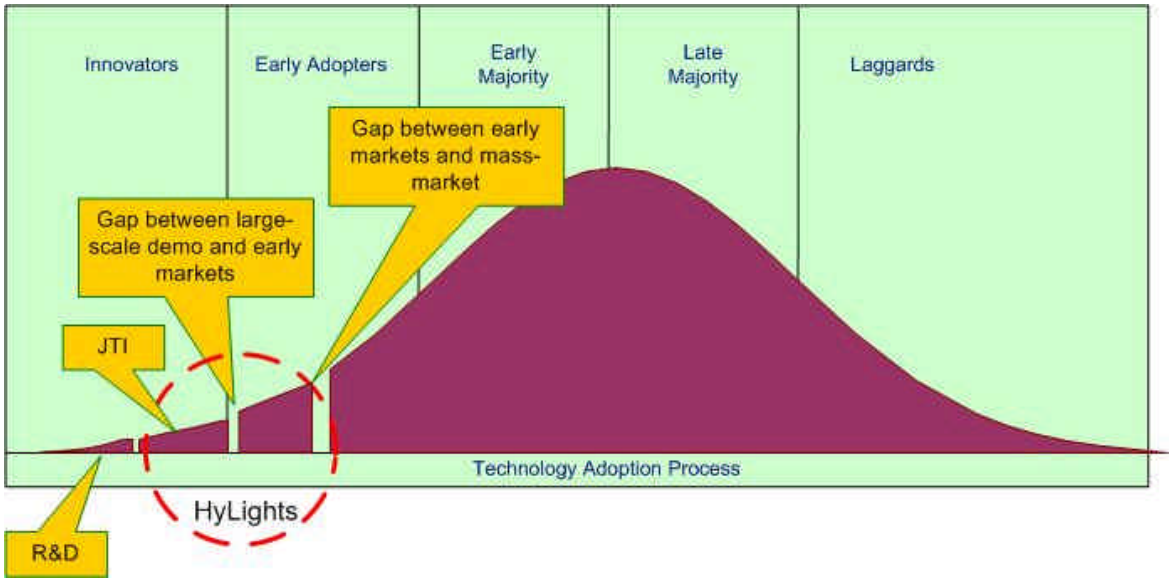

Figure 3: Technology adoption process

Deployment support from the JTI will fade out but the vehicle production needs a quick ramp-up in order to make the step to a higher production level. This could pose a threat, since the technology is still too expensive to be adopted in the early market and large production volumes cannot be realised due to insufficient demand. Although several thousands of vehicles may be produced, costs will still be high in comparison to the conventional vehicle (see also Figure 2). No funding from EU level is available to cover the extra cost. That means that in this phase, only the Member States and Regional governments can provide the required incentives to facilitate a quick ramp-up of the deployment of hydrogen applications. This not only requires a high sense of urgency at policy level, since a policy framework has to be designed and implemented way before the deployment barrier becomes visible (before the JTI phase ends), but also high commitment, since a substantial and increasing budget is needed for deployment support. It is also unclear how a series of early markets could

evolve into the (early) mass market. What are the requirements for the vehicle (performance, costs)?[5]

In order to create a sufficient market and business case for the industry, the demand needs to grow continuously. The hydrogen committed regions could emerge as early market users with centralised demand from regional stakeholders.

[5] Within the HyLights project, research is carried out to investigate the performance requirements of vehicle operators in the demonstration and early market phase.

3 The interests of various stakeholders

3.1 Two different perspectives

From the viewpoint of the industry, it is necessary/most beneficial to deploy the first vehicles in such a way that the highest learning effects are achieved, at lowest possible cost. This does not mean a widespread distribution, but rather the concentration on a few sites with favourable circumstances towards the vehicles (inherited from e.g. earlier demonstrations or past policy support measures).

The same motives hold for the infrastructure suppliers. Building one refuelling station for three vehicles is not in their interest, or even worst, 1,000 fueling stations for 10 vehicles that refill twice per week. The preferred case is to have concentrated hydrogen demand at one location, ideally close to an existing production facility with surplus capacities.

However, at a regional/Member State level the picture looks much different. Essentially the JTI is financed by taxpayers' money from the 27 EU Member States. That translates to a high desire at the regional/Member State level to host a high-technology demonstration project next door. If funding is provided from the JTI, then there should be also something visible and that at a certain timeframe. Accordingly, each Member State and/or Regional government wants to have its own demonstration project (showcase effect). Currently, a number of European regions compete for the location of the JTI demonstration project. Being not part of the first series of large-scale demonstration projects, the feeling of being excluded may have a negative effect on the commitment and sense of urgency to implement a hydrogen specific support scheme with high priority.

3.2 Scenarios and options

Those diverging perspectives could lead to two possible scenarios for the technology demonstration phase. In the first scenario, the automotive industry will optimise the innovation trajectory according to their understanding, in line with the theoretical optimal innovation pathway. This will lead to high technological progress. However, the trap is that countries not involved in the demonstration projects will fall behind in deployment because of missing support schemes. As a result, the deployment will slow down after the demonstration projects are finished.

A second scenario is that a large number of demonstration projects take place all over Europe, ensuring that everyone's interests are served. The technology learning will remain low since the applicability of the technology at large scale cannot be tested. Nevertheless, the technology as a whole will get increased attention and more efforts will be made towards specific support schemes that overcome the valley of death.

The theoretical optimal strategy will lead to substantial market barriers later on through a gap in the support schemes from EC to MS/regional support. On the other hand, if those market imperfections are taken into account it will lead to higher cost in the start-up phase and slower learning due to partial unnecessary duplication.

A potential trap when involving a broad portfolio of stakeholders in the early demonstration phase is that this may lead to disappointment with respect to the performance (usually cost effectiveness) of the large-scale demonstrations. In general, the effectiveness of policy schemes is determined, e.g. expressed in the costs to reduce on equivalent of CO_2 emissions. One should however realise that it makes no sense to judge the value added of a demonstration project by its cost effectiveness. Instead of that, the cost effectiveness over the whole innovation trajectory should be the leading motive. The technology itself should be benchmarked against the targets as formulated in a hydrogen roadmap, such as e.g. laid down in the HyWays project (www.HyWays.de). There is no definite solution or strategy for this dilemma. At the moment, each of the stakeholders follows their agenda without being aware of the other.

4 Conclusion

The diversity of expectations towards the progression of hydrogen technology and also the assumptions of its present stage represent a serious threat for development. The R&D stage has been barely left; nevertheless the increasing appearance of prototypes creates strong desires. The various stakeholder perspectives need to be exchanged and moderated to clarify that successful technological development can only happen if everyone is aware at which point of the innovation trajectory hydrogen technology is still located (see Figure 1). Both the regions and the member states should understand their future role in technology development. It should be clear to all member states that from an innovation point of view, not all of them should participate in large-scale demonstration projects in the first phase. A fast ramp-up is needed, but unnecessary duplication of technology demonstration should be minimised. It is important to create the understanding for the support shift from the EU to the member states. Due to the occurring finance gap after the end of the JTI financed demonstration projects, each of the member states needs to have a hydrogen support scheme in place (see Figure 4). Otherwise technology development will slow down due to a satellite effect of the demonstrations that will not spread to other countries without support schemes. Practically, there should be enough time to implement policy support schemes in the member states during the JTI demonstration phase. Yet, the required sense of urgency for the amount of time required for the process to establish a support scheme through the political instances is virtually absent. First of all, there is too much focus on reducing emissions within the next couple of years at lowest costs, implying a preference for incremental innovation. Secondly, up until now there have not yet been large-scale demonstrations projects to convince policy makers about the economic and technological prospects of the technology.

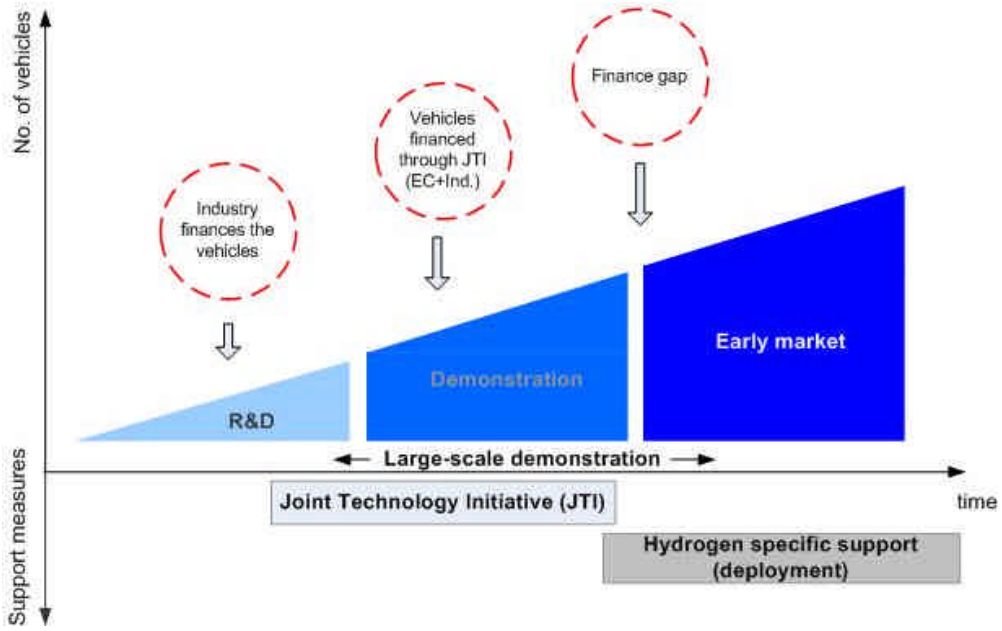

Figure 4: Transition from R&D to early markets and finance gap

On the micro (regional) level, series of early markets are necessary to provide sufficient demand and financial resources to represent a business case for the vehicle manufacturers, ramping up production volumes. The number of interested regions in hydrogen demonstration projects by far exceeds the number of demonstration projects. Those regions/cities that are not elected to host a large-scale demonstration project have an important function in the next step of market transformation. Also in this phase, commitment still needs to be high. Committed "frontrunner" regions should form interest groups and evaluate their vehicle needs. In the accumulated demand of a geographical bounded area lies the key for the early market deployment of a larger number of vehicles. Though, regions need to set-up a business plan that elaborates on interested fleet operators, total size of demand and how the supply is going to be financed. With the right incentives for hydrogen vehicles in place on the Member State level, the cost gap between hydrogen and conventional vehicles should have been brought down to an affordable level, nevertheless there will be a premium to pay. Regions that do not accumulate significant vehicle demand will be faced with high infrastructure costs in case they decide to deploy a small number of vehicles, this not even considering the reluctance of infrastructure suppliers to generally invest in isolated demonstration projects. The regions will later on also face problems to enlarge the projects to the early market stage due to restricted vehicle supply and remaining high cost per unit.

Acknowledgments

HyLights is a coordination action to prepare European Hydrogen and Fuel Cell Demonstration Projects on Hydrogen for Transport and is financed by the European Commission (EC) under the 6th Framework Programme [contract Nº TREN/05/ FP6EN /S07.53917/ 019990].

References

[1] Clean Energy Partnership (CEP), http://www.cep-berlin.de, accessed on 2007-11-12

[2] K.S. Gallagher, J.P.Holdren, A.D. Sagar, *Energy-Technology Innovation*, Annual Review of Environment and Resources, 31 (2006) 193-238

[3] European Hydrogen & Fuel Cell Technology Platform, *Implementation Plan - Status 2006*, 2007

[4] European Commission, *The European Hydrogen Energy Roadmap*, 2008