HYLIGHTS

Hydrogen for Transport in Europe

Policy support for large scale demonstration projects for hydrogen use in transport

Summary report Hylights phase I, Deliverable D 5.1 (PART A)

Report Status:	**Version Final**
Report Date:	**July 2007**

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.

The European Commission is supporting the Coordination Action “HyLights” and the Integrated Project “Roads2HyCom” in the field of Hydrogen and Fuel Cells. The two projects support the Commission in the monitoring and coordination of ongoing activities of the HFP, and provide input to the HFP for the planning and preparation of future research and demonstration activities within an integrated EU strategy.

The two projects are complementary and are working in close coordination. HyLights focuses on the preparation of the large scale demonstration for transport applications, while Roads2Hycom focuses on identifying opportunities for research activities relative to the needs of industrial stakeholders and Hydrogen Communities that could contribute to the early adoption of hydrogen as a universal energy vector.

Further information on the projects and their partners is available on the project web-sites www.roads2hy.com and www.hylights.eu.

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.

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Summary

This report summarises the main findings of the analysis of policy support schemes carried out in the first phase of the HyLights project. HyLights is a coordination action funded by the EC which aims to accelerate the commercialisation of hydrogen and fuel cells in the field of transport in Europe. More information on the HyLights project can be found on www.HyLights.eu.

The following conclusions are drawn:

In the early phases of market introduction hydrogen needs a technology specific support scheme. This technology specific support schemes can be accompanied by general support schemes such as emission trading, CO_2 taxation or internalisation of external costs. Without the protection of a technology specific support scheme, incremental innovations will have an advantage over disruptive technologies such as hydrogen. These lock out effects may seriously hamper the development of hydrogen as a transport fuel. In time, when the competitiveness improves, the emphasis needs to shift towards competition based instruments (including competition with incremental innovations).

Barriers have to be overcome in all parts of the hydrogen energy chain and the policy framework should take this into account. The barriers to be addressed are technology specific and depend on time. Support schemes for e.g. renewable electricity production can not straightforward be translated to the case of hydrogen. In the case of renewable electricity an *existing* energy carrier (electricity) is produced (though by means of renewable resources). In the case of hydrogen, a *new* energy carrier is introduced into the energy system. Production, distribution and end-use have to be facilitated. In comparison to renewable energies such as wind power or biofuels (blending) which can be introduced on an incremental bases into the current energy mix, hydrogen needs a more complex policy support scheme since its introduction into the energy system require changes in all parts of the energy chain.

The technology support schemes within the framework programmes of the EC apply to hydrogen as well as other technologies. The generic subsidy rate on investments does not provide specific incentives for the various barriers in each part of the hydrogen energy chain. This means for example hydrogen production technologies are subsidised by the same percentage as end-use applications. Due to the generic character of the support scheme, it is unable to adapt to changing market conditions. For these reasons, the current support schemes are likely not to be the most

effective support scheme for the support of the deployment of hydrogen in transport now and in the future.

For incremental innovations, it is possible to calculate the difference in costs with the reference technology rather straightforward. That is not the case for hydrogen in transport, where total impact on costs is determined by both the fuel cost (which is determined by infrastructure cost and hydrogen production cost, which depends on the chosen production pathway) as well as the cost of the vehicle (investment costs, depreciation, operation costs). A possible solution, to be further explored in the next phase of the project, is to see whether target levels for costs of hydrogen as a fuel as well as a calculation method for the additional costs of a vehicle can simplify the design of a policy framework for hydrogen in transport.

The policy support scheme for hydrogen in transport in the US provides stronger incentives to the deployment of hydrogen fuel cell vehicles in comparison to the policy framework at the EU-level. Minimum market shares for zero emission vehicles are set in California. In addition, the subsidy percentage (50%) for demonstration projects exceeds the subsidy level in EU-framework programmes (35%). This leads to a disturbed level playing field between the US and the EU. Specifically in the case where the technology development is less prosperous as expected, all available cars may have to be deployed in the US (as a result of the obligation and higher subsidy level) and deployment in the EU may lag behind considerably. This can endanger the ambition to be a leading region in the development and production of hydrogen vehicles.

As stated before, the current findings are based on the work conducted in the first year of the HyLights project. Within the next phase of the project, there will be a specific focus on the required support for each of the different parts of the hydrogen energy chain.

1 Introduction

1.1 Activities within the HyLights project

This report serves as the executive summary of the study on policy support mechanisms for large scale demonstrations projects for hydrogen in transport. The study is carried within the HyLights project, a coordination action funded by the EC which aims to accelerate the commercialisation of hydrogen and fuel cells in the field of transport in Europe, see www.HyLights.eu. The HyLights project started January 2006 and will continue until December 2008. This executive summary report as well as a accompanying background report, see (ECN-E--06-054), reflect the results obtained in the first year of the project within the task ‘Assessment of program financing issues’, see Figure 1.1, and provides a starting point for more in depth analysis for the upcoming two years.

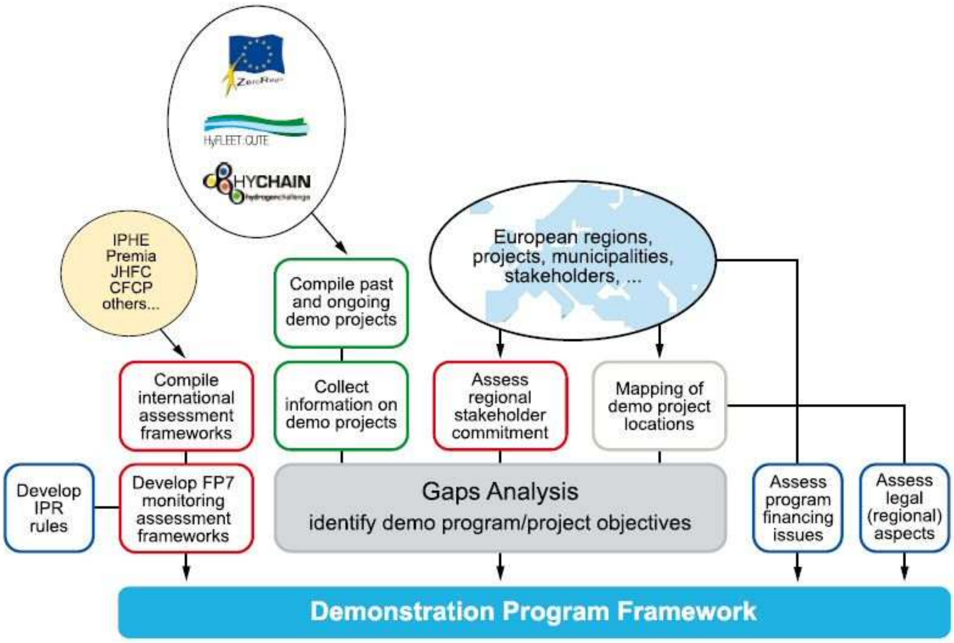

Figure 1.1 Schematic representation of the various tasks within HyLights and the relationship to other projects and programmes

Being a disruptive technology that is still in the early phase of market penetration, hydrogen in transport can yet not compete with the conventional technology. Within HyLights, the potential gap between the market requirements and the performance level of the hydrogen vehicle will be explored. Herewith, specific attention is paid to early markets, including demonstration projects. The policy framework, which comprises financing mechanisms as well as regulatory instruments, is an important instrument to bridge the gap between the market requirements and the actual performance level of the hydrogen technology.

1.2 Approach

Policy support mechanisms can include various types of instruments, such as regulation and financing. This report specifically focuses on financing mechanisms, though where applicable the interaction with regulatory measures is taken into account. Support schemes can be implemented on local/regional, members state or EU-level. This study analyses the impact of the various support schemes with a specific focus on implications for demonstration projects and deployment of innovative (disruptive) technologies such as hydrogen.

In order to identify and make recommendations for suitable support schemes for innovations, a distinction needs to be made with respect to (1) the innovation stage of the technology and (2) the specific characteristics of the technology. This is specifically of relevance in the case of hydrogen in transport, due to its disruptive nature. Therefore, it can be expected that technology specific barriers will play an important role and the (evolution of) the support scheme should be designed to this.

First, a summary is given on the main conclusions drawn from the analysis of effectiveness of policy support schemes for different phases of the innovation trajectory (Chapter 2). Policy schemes that are likely to be most effective in supporting large scale demonstration projects are identified. In addition, some general recommendations are given with respect to the (potential) design of the policy framework in the phases after the large scale demonstration projects. As a next step (in Chapter 3), the potential options to translate existing policy schemes for deployment of renewable technology towards a support scheme for hydrogen is analysed. For this, a comparison of the hydrogen chain and the renewable electricity chain is made. Finally, a comparison between the hydrogen support schemes of the EU and the US is made (Chapter 4).

2 Effectiveness of policy support mechanisms in the various stages of the innovation cycle

2.1 The need for a policy support framework

New technologies face a number of barriers after their technical feasibility has been demonstrated. This holds for incremental innovations, which usually fit well in the existing energy system but still have a disadvantage with respect to investment costs, as well as disruptive technologies such as hydrogen which require changes in the whole energy system. Potential barriers comprise not only technological and economic aspects such as high(er) investment and operational costs, infrastructure needs, slow capital stock turnover, but also other aspects such as market organisation, regulations, codes and standards, end-user behaviour and (lack of) information. By means of (temporary) support by a policy framework, these barriers can be overcome. With increasing market share, costs will go down due to learning by doing (the deployment component in technology learning) and learning by searching (the R&D component in technology learning).

In general, it can be stated that innovative technologies are only able to conquer the reference technology with the absence of a support framework in case they offer additional functionality that has a higher value to the end-user then the price difference between the innovation and the reference technology[1]. If the added functionality is limited or even absent, a supporting policy framework is needed in order to overcome the initial (cost) barriers. Although the introduction of hydrogen in transport may introduce improved functionality, specifically in the case of electric propulsion with a fuel cell vehicle, the added value is insufficient[2] to overcome the initial barriers. Therefore, a policy framework is needed to support hydrogen in transport (at least) in the early stage of its introduction.

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[1] In other words, people are willing to accept a higher price in case of new or improved functionality. Mobile phones did offer a new functionality that did not exist before they were introduced. CD and DVD players basically offered improved functionality in comparison to vinyl record players or VCR-recorders. Green electricity however basically offers the same functionality as the average grid electricity. History has shown that consumers hardly accept any price differences between green and average grid electricity (assuming that they can choose freely between the products).

[2] For a disruptive technology, (cost) barriers but also the learning potential are higher than for incremental innovations

2.2 Effectiveness of a policy support framework

The effectiveness of a policy instrument to support (the introduction of) a certain technology depends on the market stage of the technology. The supporting policy framework needs to be able to adapt to the changing competitiveness of the technology. Over-stimulation leads to a poor cost-effectiveness where insufficient stimulation leads to an undesirable slow introduction. Hydrogen in transport is entering (or at the brink of) the next market phase. The step to large scale demonstration projects has to be made, being an essential step within the trajectory towards mass market deployment. After the series of large scale demonstration projects, the next steps towards the mass market can be made by entering a series of early markets with increasing economic and technological demands.[3] The supporting policy framework has to adapt to various market phases that hydrogen in transport has to go through in order to reach the mass market.

In Figure 2.1, the various steps that a technology has to take in order to reach the mass market are shown.

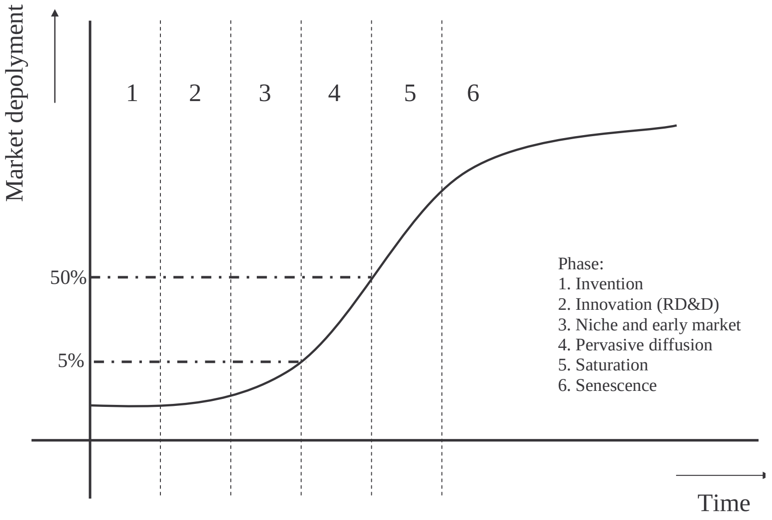

Figure 2.1 Schematic representation of the different phases of market introduction

Direct and indirect support schemes

When the competitiveness of the innovation improves the innovation is able to enter the next phase. The competitiveness is determined by both the costs of the option as

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[3] In principle, also the large scale demonstration projects are likely to be part of the early market trajectory.

well as the technical performance (and also end-user preferences). A policy support framework can contribute to this in a direct as well as indirect way.

A direct impact on the competitiveness is obtained through changing by the price level of the reference technology (e.g. by taxation) or decreasing the price level of the innovation (i.e. by subsidising). These type of instruments aim to decrease costs by increasing the deployment of the technology ('learning by doing'). Regulation (i.e. minimum shares or exclusion) is another way to improve the competitiveness of the innovation in a direct way. The cost competitiveness can also be improved by means of indirect instruments such as R&D schemes ('learning by searching'). R&D expenditures will lead to an increase in performance and a decrease in costs.[4] A reduction in costs through R&D will lower the total cumulative investments needed to reach the break even point. In comparison to the direct support mechanisms, the (desired) effect of the indirect instruments can not be guaranteed; technology improvement on the level of individual technologies is not a linear process and technological break troughs can neither be predicted nor guaranteed.

The policy support framework is most effective in case both direct (deployment related - learning by doing) and indirect (R&D related - learning by searching) support mechanisms are combined. The balance between learning by doing and learning by searching depends on both the type of technology as well as the market stage. How to find the optimal balance between direct and indirect support schemes is a priority field in academic research. With given knowledge, no straightforward general statements can be made with respect to the optimal balance between R&D and deployment for hydrogen in transport. However, both mechanisms play an important role and need to be included in the policy support framework.

General versus technology specific support schemes

A further characterisation of support schemes can be made by making a distinction between technology specific and general support schemes. The aim of general support schemes is for example to support sustainability. All options that offer an advantage in comparison to the non-sustainable reference technology are supported. This type of instrument focuses on cost-optimisation and relies on the optimal (or at least correct) functioning of market forces. The incentive is based on the current contribution to policy goals. The long term potential, or more important: the lack of a

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[4] In an early stage of technology development, public R&D schemes can initiate/facilitate the development of an innovation. When market prospects improve, private R&D is aligned and a multiplier effect is obtained, increasing the effectiveness of the public R&D.

long term potential, is not taken into account. Short term optimisation, as induced by the general support schemes, may lead to serious and undesirable lock in effects. Examples of general support schemes are CO_2 trading schemes, CO_2 taxation and internalisation of external costs. A support scheme can also be technology specific, supporting only specific renewable energy production methods such as wind energy, solar and biomass each with a tailor made incentive. This offers the opportunity to support options with a higher long term potential with stronger incentives. On the short term, a less cost-effective solution is obtained. Lock in effects can be avoided, ensuring that also future long term policy goals can be achieved at acceptable costs.

By means of implementation of a general support framework, the competitiveness of hydrogen in comparison to the reference (non-sustainable) technology will improve. However, since this instrument basically focuses on short term cost effective optimisation, disruptive technologies, such as hydrogen will be at a (relative) disadvantage in comparison to competing incremental innovations. In other words: the gap between hydrogen and less disruptive innovations will increase, even though the gap with the reference technology decreases. This imposes a serious threat. The reference technology may be replaced by an improved technology. Only after the failure of the incremental innovation to reach future policy goals at acceptable costs, market prospects of the disruptive technology improve, implying that its introduction is delayed. This does not mean that the incremental innovations should not be supported. They do offer valuable benefits at the short and medium term, but their potential to meet long term more ambitious policy goals is lacking. The temporary solution offered by these incremental innovations should be used to further develop the disruptive technology.

Both disruptive as well as incremental innovations will benefit from general support schemes. In addition to this, disruptive technologies such as hydrogen need a technology specific support scheme that enables them to compete with incremental innovations. In the first market phases, the disruptive technologies need protection to be able to increase its competitiveness. In time however, the support scheme needs to shift from protection to competition. At the end, the market forces will determine the market shares of the various technologies. Without being able to make the first steps in a protected environment (so technology specific support schemes), disruptive technologies will only reach the stage where they can compete with incremental innovations with severe delay.

Flexibility of the support schemes

The type and strength of the barriers that have to be overcome by means of a policy support framework depend on the market phase of a technology. This holds specifically for disruptive technologies such as hydrogen, since barriers with varying characteristics exist in all parts of the energy chain (production, distribution, end-use). Incremental innovations usually only face the barrier of high investment costs. In order to remain effective, the policy support framework has to be able to adapt to these changing conditions in time.

More complex policy support schemes with high technological detail need often more time to adapt to change. The past has shown that specifically detailed regulatory measures such as minimum performance standards are in practice quite inflexible. The computation of the required performance level is data intensive and time consuming. Moreover, future standards have to be set on extrapolation of past and current performances. If the standards are set too ambitious, they can only be met at excessive costs (assuming they can be met at all). If the standards lack ambitions, there will be no response at all within the market. Given the rapid change of market conditions, it is very complicated to set the standards at the right level and they may be outdated within months.[5] Given the complexity of the process to determine the right ambition level of the standards, an update is not likely to follow soon.

Subsidy schemes can for example be changed fast or be designed in a robust way. When market conditions change rapidly and deployment increases fast, subsidy budgets may explode. With appropriate monitoring, subsidy levels can be brought down almost instantly[6]. Several options do exist to ensure that the subsidy scheme remains within budget. One (of the various) option is to limit the total number of applicants for the subsidy. A second option is to make the applicants tender for the subsidy[7]. Also, subsidy schemes may suffer from the need to include high technological detail in order to maximise cost-effectiveness. Required support levels may e.g. vary between city cars and long distance cars and between cars, medium and large vehicles.

Taxation schemes have the advantage that unforeseen circumstances lead to higher income. Tax exemptions, just as subsidies, may lead to unforeseen debits in case of

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[5] The implementation of minimum performance standards evoke more resistance than e.g. the implementation of a budget neutral financial scheme (taxation combined with exemptions or subsidies). This may cause a (severe) delay in the implementation process.

[6] History has shown that subsidy schemes can be terminated from one day to the other.

[7] In this case the subsidy can be assigned on specific quality criteria, increasing the effectiveness of the subsidy, but the effort to apply for the subsidy also increases.

inappropriate monitoring. Taxation and tax exemption schemes can be coupled to a budget neutral support scheme, although also in this case proper monitoring is required. All options have different side effects and no ‘one size fits all’ solution exists.

In conclusion

The required need for flexibility of the policy support scheme as well as the need to specifically support the reduction of various barriers in each part of the hydrogen energy chain imposes a major challenge in the design of an effective support scheme for hydrogen in transport[8]. Policy schemes which are low in detail with respect to technological detail are more flexible. They are however not able to handle the time and energy chain specific barriers appropriately.

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[8] Electricity production by means of renewables can for example be stimulated by means of a tax exemption for renewable energy. This is a simply and rather straightforward scheme (although appropriate monitoring is required). It’s up to the market to decide upon the production method and the most cost effective option on the short term will dominate. As an alternative, each of the individual production methods can get a tailor made subsidy level. The subsidy scheme becomes rather complex and unexpected disruptions are likely to occur.)

3 The policy framework for renewable energy - lessons learned for hydrogen

This chapter provides a summary of the analysis of policy support schemes for renewable energy. A number of renewable energy options, such as for example wind energy and photo voltaic solar panels (pv) have already passed the innovation phase that now is being entered by hydrogen in transport[9]. The question arises if and how the support schemes for renewable energy can be translated to the case of hydrogen in transport.

3.1 Support schemes for renewable energy

The energy chain for renewable energy is given in Figure 3.1. The use of (an increasing) share of renewable electricity basically requires changes in the production part of the electricity chain. The properties of renewable electricity do not differ from conventional electricity produced from fossil fuels or nuclear energy and the existing distribution grid can be used.[10] Also, no changes are required for the end-use applications (dish washers, washing machines, lighting etc.).

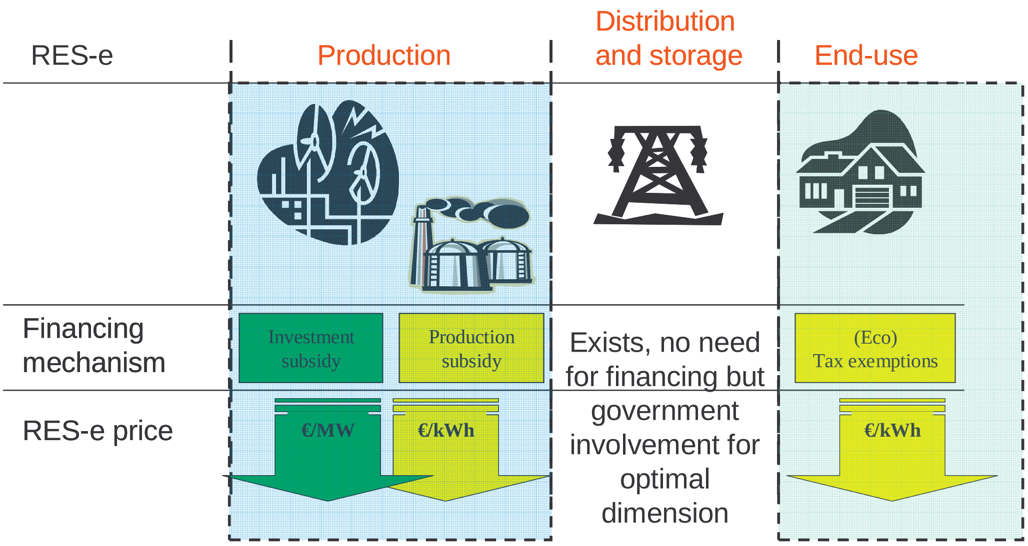

Figure 3.1 Overview of the different options to support renewable electricity

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[9] Even though wind and pv have passed the market phase that yet is being entered by hydrogen successfully, this does not imply that these technologies can survive without a supporting policy scheme.

[10] At very high shares of intermittent resources, changes in the power sector are required (including e.g. storage options, an increase share of back up power and reinforcement of the high voltage electricity grid).

The production of renewable electricity can be supported both at the level of the end user or at the production level.

Support at the end-user level

At the level of the end-user, renewable energy can be supported by means of tax exemptions (in €ct/kWh). Thus, the price can be brought down to a level comparable to the price level of conventional electricity. This type of support scheme supports renewable electricity in general without making a distinction between the various production sources. It’s up to the market to choose the most economic way to provide the renewable electricity demanded at the end-user level. Since the renewable electricity offers no additional functionality in comparison to the conventional electricity, the end-user is not willing to pay a lot more for the green electricity. Price differences between renewable and conventional electricity have to be small to negligible in order to obtain a significant market share.

Support at the production level

Renewable electricity can also be supported at the production level. This can be done by providing incentives on the investment for the production facility (e.g. the wind mill, the pv panel, e.g. in €/MW) or by means of an incentive on the renewable energy production (e.g in €/MWh). Examples are an investment subsidy for wind mills or purchase subsidies for pv panels. Also, production subsidies are commonly used. An example of such a production subsidy for renewable electricity is feed-in tariffs. Feed-in tariffs guarantee a minimum price for every unit of green electricity produced. In the case of providing incentives at the production level, it is possible to make the support tailor made to the needs of the specific technology. In Germany, the feed-in tariff for wind differs from the feed-in tariff for pv, due to the lower production costs of wind power plants. Also investment subsidies are in general technology specific.

To summarise

Renewable energy can be supported at the end-user and/or production level. When supported at the production level, technology specific support can be provided for. Instead of providing a subsidy on either investment or production, also regulation can be implemented. The most common way to do this is by setting a minimum share of renewable electricity (%, in MWe), although also obligations for a minimum amount of capacity (in MW) are used. It is not possible to state which of the options now is the most effective support mechanisms. All of the schemes outlined above are widely being used. The main distinction is the question whether one wants to support renewable electricity in general (in that case incentives at the end-user or a general obligation are most effective) or that specific (renewable) technologies have to be favoured (in that case, incentives at the production level are most effective).

3.2 Support schemes for hydrogen

The introduction of hydrogen into the energy system requires changes in the whole production chain. Figure 3.2 gives an overview of the hydrogen energy chain.

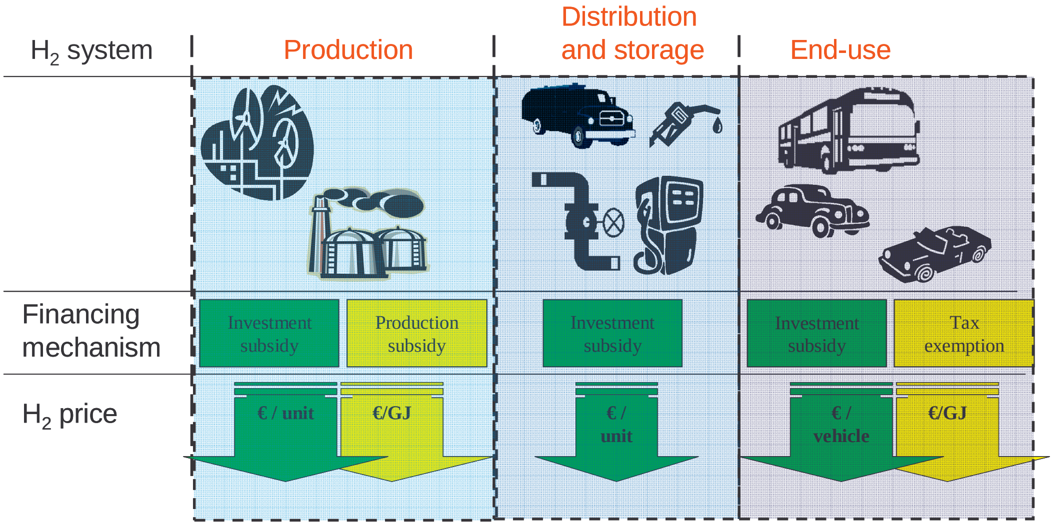

Figure 3.2 Overview of the different options to support hydrogen in transport

Again, incentives for hydrogen in transport can be provided at the end-user level and production level. On top of that, also incentives can be provided at the infrastructure level (distribution and storage).

Support at the end-user level

At the end-user level, hydrogen can be supported by either incentives on the investment costs of the vehicle (€/vehicle) or by incentives to the fuel costs (€/GJ or €/kg). The combined effect of the investment costs and fuel costs determine the overall costs and can be compared to the cost of the reference option. The end-user will respond differently to each of the measures. High investments and low fuel prices may cause different market behaviour in comparison to low investment costs and high fuel prices, even if the net effect over the (economic) life time of the vehicle is the same.

In contradiction to the case of renewable electricity, barriers do exist at the end-user level. These have to be overcome by either incentives at the end-user level or by incentives at other parts of the energy chain that have an impact on these barriers. In practice, the most effective way to overcome the barrier of the higher investment costs of the hydrogen vehicle will be to subsidise or provide tax exemptions on the retail price of the hydrogen vehicle. A subsidy on production costs of hydrogen also positively influences the total costs for driving a hydrogen fuelled car, because the fuel price is lower(ed), but barriers are most effectively tackled at the level where they occur (which may be the car in stead of the fuel).

Support at the production level

At the production level, the case of hydrogen differs not that much from the case of renewable energy. Specific barriers at the production level have to be overcome, either by incentives on investments (€/unit) or by incentives for hydrogen production (€/GJ). Again, at this level incentives can be, and usually are, applied in a technology specific way.

Support at the infrastructure level

An important barrier in the introduction of hydrogen in transport is the absence of a hydrogen infrastructure (distribution, storage, fuelling stations). Infrastructure funding has no value of its own, since nobody buys a hydrogen vehicle just because of a station nearby, but without stations no one buys a hydrogen vehicle. Hence, the infrastructure support needs to be orientated at the production and end-use development and cannot be seen as autonomous parameter.

Different kinds of infrastructures can be distinguished for hydrogen. There can be an infrastructure which can be easily expended (liquid hydrogen trucks and storage tanks at the refuelling station) and an infrastructure that needs to be designed to meet long term specifications (e.g. pipelines). A key issue in this aspect is the design of the capacity of the infrastructure. Pipeline infrastructure has a very long life time and preferably should be designed based on the potential demand on long term and not on the expected demand in the next three to five years. The same holds, though to a lesser extent, for a hydrogen production unit. In case long term (expected) demand is taken into account in the design of hydrogen production capacity and/or pipe line infrastructure, severe underutilisation will occur for a significant period of time. This underutilisation likely leads to temporary negative cash flows, despite the fact that when considering the technical life time the capacity of the production unit is designed well. Both a temporary underutilisation as well as the uncertainty of development the future hydrogen demand imposes major barriers in the build up of the hydrogen production infrastructure.

In the past, the build up of infrastructure belonged to a large extent to the responsibilities of a public body. The market is insufficiently able to take into account the long term demands on pipeline infrastructure since their investments need to meet specific cost criteria. Total costs for society can however be lower in case these future aspects are taken into account. Due to factors such as market liberalisation and globalisation, it's unlikely that public bodies will become responsible again for building up a large scale pipeline infrastructure. However, it is still possible by means of the right incentives to steer the market into a direction where the long term requirements on infrastructure are (to some extent) taken into account. Such incentives need to be aimed at risk reduction for the investor. This might even be important in the early phase of introduction of hydrogen in the transport system, since the design of the first user centres may already predetermine (or influence) the design of the hydrogen infrastructure in the following decade.

3.3 Comparing support of renewable electricity and hydrogen

In the case of support of renewable electricity, incentives can be provided at the end-user level and production level. These incentives have the aim to overcome (cost) barriers at the production level. In the case of hydrogen, incentives can be provided on the end-user level and the production level as well as on the infrastructure level. The main difference, however, is that not only barriers have to be overcome at the production level, but also at the level of infrastructure build up and end-user application (the hydrogen vehicle). This makes the hydrogen policy scheme way more complex than the support scheme for renewable electricity.

A major question in the design of a hydrogen support scheme is whether it specifically should support hydrogen production from specific sources (e.g. renewable energy; differentiate the support depending on the pathway), or just hydrogen in general. In case of support of renewable hydrogen, this can both be done by a general support of renewable hydrogen (leaving it open to the market which renewable technology to use) as well as by technology specific support (e.g. ensuring that renewable technologies that are at the moment less cost competitive but which have a high future potential are already being developed).

Calculation of additional costs

In the case of incremental innovations, such as renewable electricity, it is feasible (with some effort) to calculate the price difference between the innovation and the reference option. Barriers occur basically only in one part of the energy system and a rather straightforward comparison between the (incremental) innovation and reference technology can be made. By means of comparing the production costs of electricity of a wind mill with the production costs of the average power sector, the required subsidy for wind energy (either as investment or production subsidy) can be obtained. In the case of hydrogen, this straightforward comparison with the reference technology (the conventional vehicle) can't be made. As stated above, the total costs not only depend on the costs of the vehicle but also on the costs of the fuel. This makes it very difficult to assess the required force of the incentive for each of the barriers that hydrogen is facing.

A potential way that can be explored in order to be able to design a fair, flexible and effective policy framework for hydrogen is breaking down the total costs, being the basis for a comparison with the reference vehicle) in two (mutually related) components. This could for example be done by setting targets for the fuel costs as well as by developing a method to calculate the price difference on the vehicle level. The combination of fuel costs and vehicle costs have to lead to total costs (expressed e.g. in term of €ct/km) comparable to the conventional vehicle. By breaking down the total costs in two components, for each of these individual components a policy support scheme can be developed. This policy scheme is less complex and can respond more effectively to the changing market conditions.11 The main prerequisite is obtaining the right balance between the vehicle price and fuel price. Besides the design of an effective policy support scheme, also timely implementation is required. Given the potential complexity of the support scheme as well as the (current) relatively low attention at the policy level, timely introduction may also impose a major barrier.

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[11] Specifically since changes in market conditions for distribution and production are handled separately from changes in market conditions at the vehicle level.

4 The current policy framework for hydrogen

In this chapter, a brief overview of the current and foreseen support schemes for the support of hydrogen in transport is given as well as a brief comparison with the hydrogen support scheme in the US. The analysis is restricted to initiatives on the EU level. A more detailed analysis of the deployment related hydrogen programmes at local/regional and member state level is carried out as a separate activity in the HyLights project. The HyLights project focuses on the deployment support for hydrogen in transport. Within the Roads2HyCom project, an analysis of the R&D support has been carried out (ECN-E--06-046).

4.1 Deployment support for hydrogen within the EU

Hydrogen in transport is at the brink of making the step towards large scale demonstration projects. However, at the moment, the deployment of hydrogen vehicles is very low with only a limited number of vehicles in Europe running in demonstration projects[12]. No major deployment support schemes are in place at the member state level since due to the low deployment of hydrogen vehicles, no need was seen at the policy level to implement such schemes. In the absence of these schemes, also the deployment is hampered. A series of (successful) large scale lighthouse projects might be able to set hydrogen in transport high(er) on the agenda, enabling the design and implementation of deployment support schemes for hydrogen in transport at the local, regional and member state level.

At the EU-level, the most important support scheme is the technology subsidy scheme within the EC Framework Programme (FP6, FP7) in which a (maximum) subsidy of 35% of the total investments can be obtained within demonstration projects[13]. The FP support scheme is not technology specific. It applies for various technologies including hydrogen. The subsidy rate applies also uniformly for all parts of the energy chain. The aim of the FP support scheme is to support technology development. It is not meant to support large scale deployment.[14] In order to make

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[12] Prototypes not included.

[13] With additional funding for e.g. management fees etc. a total subsidy around 45% of the total project cost can be provided.

[14] The support scheme can not be adapted to the changing needs of an emerging technology, addressing technology specific barriers in various parts of the energy chain, see also Section 2.2. The subsidy rate is applied on total investments instead of additional investments. This already indicates that the scheme is not designed for a market ready technology but merely for new technologies where additional costs can hardly be

the step towards large scale deployment - this step can already include large scale demonstration projects - a tailor made and flexible support framework needs to be in place. However, at the moment, the FP is still one the most important support frameworks for hydrogen in transport.

Another incentive at the EU level that needs to be mentioned is the directive on the promotion of the use of biofuels or other alternative fuels for transport (EC, 2003/30/EC). With this directive, the European Commission obligates European countries to mix a certain amount of biofuel to diesel and gasoline. There is also a possibility to reach the targets by using renewable hydrogen. In practice, this directive most likely will force the alternatives to hydrogen to gain market share since they fit more easily into the current distribution system and have the advantage of ‘incremental’ introduction via blending into conventional fuels.

Hydrogen and fuel cells may become technologies to be covered by means of a Joint Technology Initiative (JTI). It is not clear yet what the conditions for the support of hydrogen and fuel cells will be in case such a JTI becomes operative. A number of stakeholders plead for increasing the investment subsidy for demonstration to 50% of the total costs. This support level is comparable to the support level in the US (see Section 4.2). Others argue that the investments subsidy should not exceed the maximum as given in the FP6 framework (35% investment subsidy for demonstration activities).

In the next phase of HyLights, specific attention will be paid to taxation of hydrogen as a fuel as well as taxation of clean vehicles.

4.2 Comparison between the EU and the US - a different philosophy?

In addition to the support scheme for hydrogen in transport in the EU, an overview of the support mechanisms in the US has been made.[15] In Figure 4.1, the incentives in place in the US and the EU are compared.

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calculated. Also for practical reasons, such as the high administrative load (writing a proposal, time needed to get approval), the FP7 frame is not suited to support large scale deployment of a technology.

[15] A comparison to Japan has not been made due to the lack of suitable documents. Further attempts will be made in the second phase of the project.

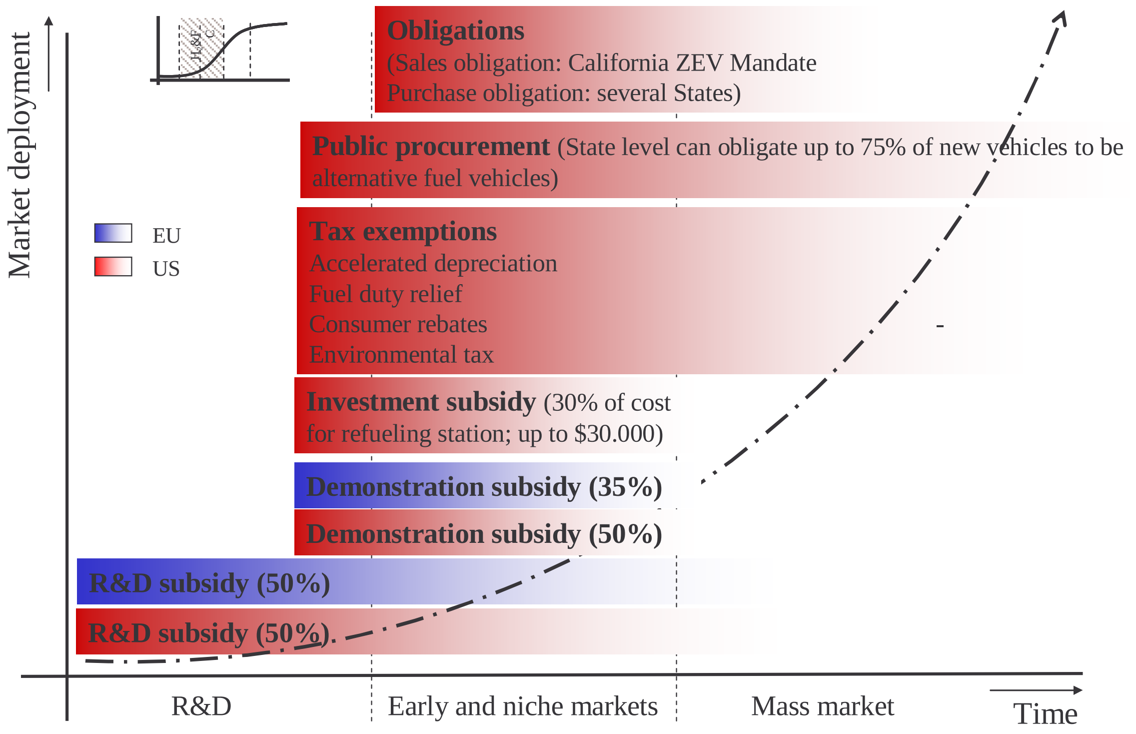

Figure 4.1 Comparison of the incentives for hydrogen in transport for the US and the EC-level

At the R&D stage, the incentives are comparable. However, at the demonstration level, conditions in the US seem to be more favourable due to the higher subsidy rate (50% in the US vs. 35% in the EU). Moreover, in the US a number of other financial incentives have been implemented. The most striking difference between the US and the EU however is obligation for deployment of hydrogen fuel cell vehicles through the Californian ZEV mandate. Large automotive manufacturers are obliged to deploy (and operate) an increasing number of ZEVs in time.

The philosophy with respect to how innovations have to be stimulated seems to differ between the EU and the US. In Europe, the innovation trajectory usually exists of a phase of technology protection with limited selection up front of which technology is the ‘best’, followed by a phase of competition, finally leading to obligations (e.g. by excluding old technology). In the US (in fact: California), already in the first phase of technology introduction, a clear choice has been made for hydrogen and fuel cell vehicles by setting obligations. This obviously imposes very strong incentives for technology development and deployment but also imposes major risks. Technology improvement is a non-linear process. Setting obligations too ambitious will lead to excessive costs, assuming that the target level actually can be met. This can have a very negative impact on the support and acceptance of a new technology, leading to a hampered deployment[16].

It is concluded that the current incentives for the deployment of hydrogen vehicles in the US are stronger than the incentives in Europe due to more favourable financial support schemes (e.g. higher subsidy rate) as well as the obligatory deployment through the ZEV mandate. This disturbance of the level playing field may lead to a delayed deployment in Europe. This does not mean, however, that the incentives that are currently in place in the US should be copied to Europe. Setting obligations on the deployment of a new (disruptive) technology that is in an early phase of introduction imposes high risk and may lead to severe negative side effects such as excessive costs or a loss of public acceptance. However, opportunities exist to increase the effectiveness of the (financial) support schemes, by designing it in a way that it tackles the technology specific barriers at the part of the energy chain where they occur.

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[16] This has happened in recent history with the case of electric vehicles. Targets for the deployment of electric vehicles turned out to be over ambitious and needed to be postponed several times.

References

EC, 2003/30/EC (2003): DIRECTIVE 2003/30/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. of 8 May 2003. on the promotion of the use of biofuels or other renewable fuels for transport. Brussels, 2003.

Lako, P. and M. Ros (2006): R&D expenditure for H2 and fuel cells as indicator for political will. Energy Research Centre of the Netherlands, ECN-E--06-046, Petten, the Netherlands.

Ros, M., H. Jeeninga. and P. Godfroij (2006): Policy support mechanisms for hydrogen use in transport. The role of financial and other incentives in the support of large scale demonstration projects in the transport sector. Energy Research Centre of the Netherlands, ECN-E--06-054, Petten.