EVS24
Stavanger, Norway, May 13-16, 2009

Facilitating the introduction of hydrogen vehicles: possible options to close the cost gap through policy measures

Ingo Bunzeck[1], Harm Jeeninga[2], Menno Ros[3]
[1](corresponding author) [2, 3] Energy research Centre of the Netherlands (ECN), Policy Studies, P.O. Box 1, 1755 ZG Petten, The Netherlands, bunzeck@ecn.nl

Abstract

From an innovation perspective, hydrogen applications in passenger vehicles remain on a small scale, i.e. the total number of vehicles deployed worldwide remains low. The current produced vehicles have to be understood as prototypes that might strongly resemble a mass-manufactured vehicle, but with very high cost per unit due to low production volumes (e.g. the Honda FCX Clarity cost about US$ 1m per unit). On the technological development trajectory for hydrogen cars, large-scale demonstration projects represent the next important step before early markets are entered. Eventually production volumes will further grow towards mass production. Within the HyWays project, it has been calculated that hydrogen vehicle cost will only start to come down once about 100,000 units of cumulative productions have been reached. At this point, the additional cost per vehicle becomes within reach of policy measures. As a preparation for the early market phase of hydrogen vehicles the impact of different policy measures has been analyzed within the HyLights project. In the policy support tool, vehicle and fuel cost for conventional and hydrogen vehicles are calculated over lifetime and mileage on a €ct/km basis. The exercise has been carried out taking into account the taxation and road transport related subsidy schemes of five selected EU countries. Based on cost forecasts for 100,000 hydrogen vehicles produced, a cost gap of about 10€ct/km has been calculated. Taxation differs from country to country and this influences the cost gap between conventional and hydrogen vehicles, but it also predetermines the choice of instruments. Generally, already existing instruments can provide sufficient means of overcoming the initial cost barriers. In this paper, a number of policy measure examples are analyzed towards their potential to lower the cost gap between conventional and hydrogen vehicles in the EU and provide an outlook how these measures should be implemented from the perspective of a policy maker.

Keywords: hydrogen, fuel cell, taxation, market, demonstration

1 Introduction

New technologies need to be constantly developed and improved to achieve the aim that they are ready to enter the mass market at one day and provide revenues that counterbalance the R&D and deployment costs that occurred earlier in the various development stages.

For new and innovative technologies it is difficult to enter the market and compete with the existing reference technology. High initial cost, start up problems and lock-in effects are just some barriers which have to be overcome for the new technology to succeed. This specifically holds for disruptive technologies such as hydrogen.[1]

Hydrogen will be only able to conquer the reference technology in case it offers additional functionality or has a higher intrinsic value for the end-consumer than only the price difference between the two technologies. In case of hydrogen, the additional functionality is insufficient to overcome the initial cost barrier. One of the options to stimulate deployment are policy support schemes. However, generic support schemes for e.g. on sustainable road transport would not be sufficient since they also favour other, incremental solutions (e.g. biofuels). There is a need for specific support for hydrogen in transport to facilitate the introduction and deployment in the commercial market.[2]

1.1 The need for policy support

Hydrogen technologies are now entering the next phase of development leaving the pure R&D phase behind. After a series of large-scale demonstrations jointly financed by industry and government (e.g. through JTI[1]), hydrogen technology will move towards early commercialisation. However, also deployment support for vehicles from the JTI will fade out at one point in time but the vehicle production needs a quick ramp-up in order to make the step to a higher production level, see Fig. 1.

[1] Joint Technology Initiative on Fuel Cells and Hydrogen to facilitate further technology RD&D, founded by European Commission and Industry in 2008.

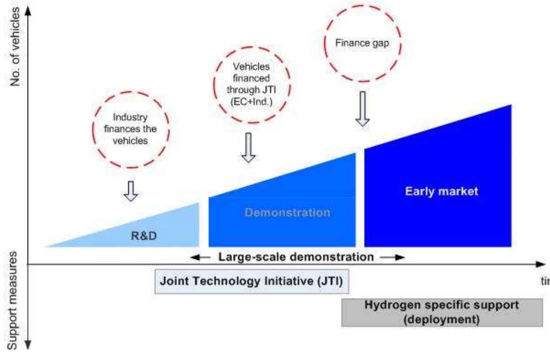

Figure 1: Hydrogen transition from R&D to early markets

This represents a critical transition since additional cost per hydrogen vehicle for the end-user will still be substantial. No funding from EU level will be available anymore to cover the extra cost because this part of the technology development trajectory is not included in their R&D strategy. 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. [3]

1.2 Support framework

A support framework should address both the high additional cost for hydrogen vehicles and hydrogen as a fuel. With respect to fuel, the support framework should specifically address high investment risks for hydrogen infrastructure providers (cash flow) as end-users rely on an operating refuelling network. Additionally, Europe has not a regulated vehicle supply as exists in California due to the deployment requirements of the Zero Emission Vehicle (ZEV) mandate.

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 (preferably overlapping), but also high commitment, since a substantial and increasing budget is needed for deployment support. It will take years to design and implement new incentives. Although member state (MS) specific conditions have to be taken into account and can even offer advantages, harmonisation between MS needs to be considered whenever possible as well as avoiding gaps between various incentives at different deployment phases. New policies are likely to gradually phase in (or out) in order not to disturb current market conditions.[4]

Given the fact that costs for hydrogen technology are expected to go down significantly over time when deployment goes up, a support scheme is necessary that is flexible enough to adapt to the technological and economical improvements of the technology. Static support schemes bear the risk of severe under or over stimulation of technology that would subsequently lead to an interruption or delay of the technological development.

2 Description of the tool

Within the HyLights project, ECN has developed a straightforward tool that calculates the cost gap between conventional and hydrogen vehicles[2]. The tool incorporates both vehicle and fuel cost and compares them assuming a certain amount of vehicle miles travelled over a given lifetime. It also takes into account the respective taxation and subsidy schemes as of 2008. For practical reasons, the tool is based upon a number of default values from well accepted sources such as the vehicle related taxation handbook from the European Automobile Manufacturers Association (ACEA) [5]. Additional input for e.g. on expected hydrogen prices were provided by the industry partners from the HyLights project. The tool should be seen as mean of exploration of the possibilities to influence cost of hydrogen vehicles once they will leave the demonstration phase. For a more detailed account of the tool please see Figure 2.

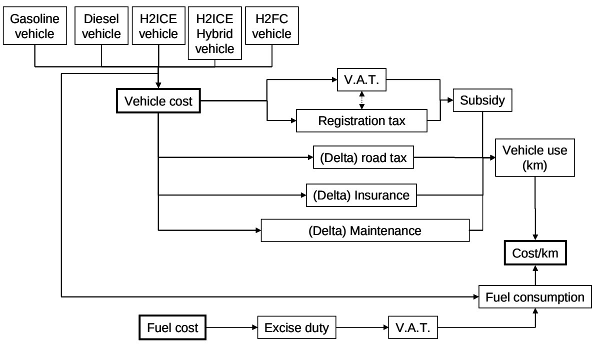

Figure 2: Schematic representation of the policy support tool

[2] The policy support tool is publicly available and can be downloaded under www.hylights.eu

2.1 Default values

The default values for the vehicle costs and fuel consumption are based on the EUCAR/CONCAWE/JRC Well-to-Wheels report [6]. The gasoline and diesel vehicle costs are reflections of 2010+ vehicle retail price projections based on a 2002 VW Golf. The default vehicle cost for the hydrogen vehicles are based on HyWays (www.hyways.de) projections and reflect the cost for the hydrogen fuelled vehicles when 100,000 units have been produced, see table 2.1.

Table 2.1 *Default values of vehicle costs based on the 2010+ vehicle configuration*

Vehicle	Cost (€)
Gasoline	19,850
Diesel	21,360
H2-ICE	24,310
H2-ICE hybrid	29,778
H2FC	31,193
H2FC hybrid	34,505

Source: EUCAR, Concawe, JRC

The annual driving distance is included in the tool to get from (yearly) vehicle cost to (yearly) cost per kilometre. The default value of the annual driving distance is 15,000 km. This is based on similar calculations done by ACEA and other national car associations for gasoline vehicles.

3 Results

Based on the HyWays cost data, a gap of approximately 10€ct/km[3] - taking into account both vehicle and fuel cost – between a gasoline and hydrogen (FC hybrid) vehicle has to be bridged assuming around 100.000 vehicles being built. By using the policy support tool the sensitivity of the €/km gap to a number of factor such as oil price, vehicle price, hydrogen fuel price and several policy support schemes can be reviewed.

The €/km cost is firstly dominated by the vehicle cost (and taxes), followed by the fuel cost. Taxation applies to both vehicle and fuel costs. The current taxation schemes throughout Europe differ substantially. This not only influences the

[3] With a vehicle cost level cording to HyWays at 100.000 vehicles produced and a H_2 fuel price of 6 €/kg

gap (€/km) between gasoline and hydrogen, but also the potential to implement support schemes for hydrogen in transport. In all countries VAT, fuel excise duty and road taxes affect the cost of the vehicle and fuel, but differences in these taxes are minor and influence the cost per kilometre only little (around 0,2 - 0,5€ct/km). The biggest difference in the current taxation schemes is the registration tax on vehicles, see Figure 3 below.

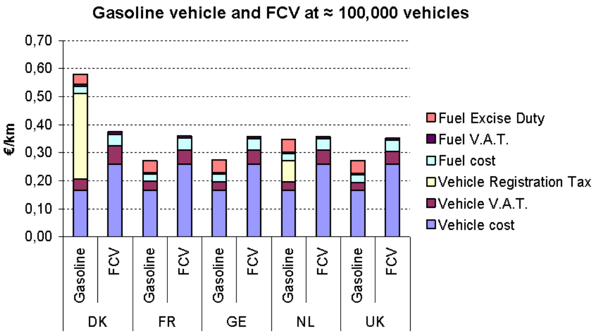

Figure 3: Example: Vehicle cost difference in selected EU countries (based on 2008 support schemes)

Denmark and the Netherlands (Energy labels) as non-car manufacturing countries have already high registration tax, on the other hand those countries with automotive industry do not have registration tax.[4] In Denmark and the Netherlands hydrogen vehicles are exempted from registration tax. This provides (already today) an incentive which covers the gap (almost) completely (30€ct/km in Denmark and 5€ct/km in the Netherlands), see Figure 4. On the other hand, countries without registration tax (like Germany) have to implement new specific policy support schemes and cannot build upon current taxation (by giving exemptions on current taxes) to support hydrogen in transport.

[4] One exception in this respect is France. Registration tax is applicable, but for historical reasons it has never been recognized as registration tax on EU level. The tax height is determined on the regional level.

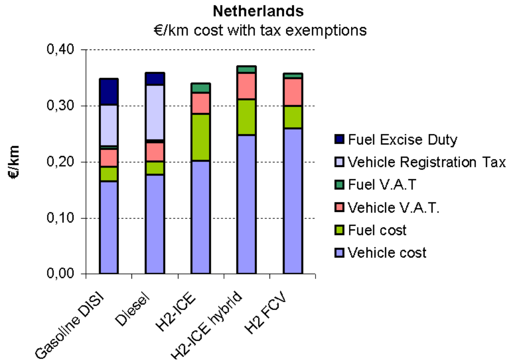

Figure 4: Example: €ct/km cost comparison with tax incentives in NL (based on 2008 support schemes)

However, one has to take into account that current (advantageous for hydrogen) tax regimes could change in the future. In the Netherlands, it has been already decided that registration tax will be phased out and replaced by road tax (by 2013).

Various other policy instruments are suitable to reduce the gap (€/km) between gasoline and hydrogen vehicles. Both registration tax and congestion charge have the highest impact on €/km and can potentially completely cover a cost gap of 10 €ct/km gap. Higher price levels for conventional fuel and lower prices for hydrogen have a much smaller impact (around 1-2 €ct/km). The inclusion of externalities and road transport in CO_2 pricing schemes has only marginal impact (1.4 €ct/km assuming a CO_2 price of 100€/ton) and has moreover the side effect that it only reduces the gap between hydrogen vehicles and conventional technologies but not or less between hydrogen vehicles and other environmental friendly transport options.

4 Implementation of policy measures

4.1 Introduction

Based on the HyWays cost figures for hydrogen vehicles over the development trajectory, conditions for vehicle deployment will differ substantially in two phases. First, after the large-scale demonstrations finish up to 100,000 vehicles produced. The second phase is early commercialization beyond 100,000 vehicles. This provides implications how and when to implement the necessary support schemes. Equalizing the vehicle cost in comparison with conventional vehicles is a key issue to stimulate a broad market roll-out that will further bring down cost due to higher production volumes.

4.2 Phase beyond 100,000 vehicles

Analysis of existing and foreseen instruments shows that for most EU countries a combination of instruments could bridge a gap of, for example, 10 €ct/km. However substantial higher investments are necessary to finance the first 100,000 vehicles that come after the JTI financed large-scale demonstrations that will only comprise of a few thousand vehicles at most. This represents a major hurdle since it is unclear how these vehicles will be financed. 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. Annually about 15 million cars are sold in Europe which means that the market share of 100,000 hydrogen vehicles would be less than one percent of the overall vehicle market. Here, favourable market conditions (early markets) combined with a set of policy instruments comparable to the phase beyond 100,000 vehicles (corresponding to a cost gap of approximately 10 €ct/km or less) need to bridge the gap. Vehicle deployment will take place at a limited number of locations (e.g. not complete EU27) that already possess favourable conditions, experiences or hardware from earlier deployment and therefore accumulate the majority of the vehicles. Once hydrogen vehicle cost have gone down in a way that they are competitive with conventional vehicles, the policy measures are no longer need to be in place.

4.3 Phase before 100,000 vehicles

The actual financial gap in the phase up to 100,000 vehicles is difficult to assess since none of the manufacturers has yet publicly announced production volumes together with an indication for sales prices. Research within HyLights has shown that fleet operators could be a starting point for vehicle deployment, but only on a case-by-case decisions basis. Yet, due to the lack of information on price levels, fleet operators are actually not in the position to make informed investment decisions and thus have not started to implement corporate policies supporting hydrogen vehicles In addition, it is unclear if and how a series of early markets could evolve into the mass market and what are the requirements for those vehicles (performance, tolerance to additional costs). [7]

A full transition is not likely to happen if additional governmental expenditures are not counterbalanced by increased revenues. It needs to be emphasised that the focus should not solely be on the existing schemes. Potential future changes, such as the foreseen shift from registration tax to road tax as proposed in the Netherlands, should be taken into account.

4.4 The perspective of the policy maker

The support schemes need to be stable for a long period of time and investors need to be able to rely on them. Implementation should be done in a way that it is not sensitive to budget cuts in case economy measures need to be taken. Preferably the instruments should be implemented in a budget neutral way, implying that the expenditures equal revenues, and should not be visible on the national account, clearly indicating the total cost of the scheme.[5] From a political point of view, exemptions from existing tax schemes are easier to implement (support politically), whilst increasing taxes or substantial subsidy schemes are politically less favoured. Such schemes are more likely to be terminated from year to year or once in case budgets increase, priorities shift or spending cuts. The schemes should be designed to enjoy support over more than one legislative period.

Also a distinction can be made between incentives playing a role when purchasing the vehicle and incentives during use (on operating cost) of the vehicle. Given the high discount rates of consumers, incentives playing a role when purchasing a vehicle are valued way higher and therefore more effective with respect to influencing purchase behaviour in comparison to future revenues. However, since the full gap has to be bridged at a single moment in time (the purchase), the magnitude of the incentives becomes too big (around 75 m€)[6] to be still

[5] Profits (for society) might be substantially higher, but these are not visible on the national account system.

[6] Example for the Netherlands: Assuming a hydrogen vehicle sales share of 1%, total passenger vehicle market size 500,000 in 2007, Source: Statistics Netherland, www.cbs.nl

favored by policy makers. From a political point of view, incentives on an annual basis but with less substantial payments are much easier to implement compared to an incentive at the amount of purchase, despite the fact that the total budget is equal and the effectiveness is higher at the amount of purchase.

Incentives that act upon operating cost of the vehicle are spread over time (the full life time of the vehicle) and do not have to be as substantial since operating cost only account for one-third of the additional vehicle cost. However, vehicle and fuel incentives need to be seen in conjunction since the sum determines the additional cost. From the perspective of the policy maker, an introduction of multiple instruments during both the moment of purchase as well as during operation is therefore most favourable.

5 Conclusions

This paper has provided new insights into the expected cost gap between conventional and hydrogen vehicles once 100,000 units have been produced. Subsequently, the impact of various policy instruments to close or narrow the cost gap has been analyzed for their suitability. Furthermore, timing and responsibilities for the implementation of policy support along the different phases of technology development are determined.

Hydrogen specific policy support is indispensable to facilitate the market commercialization of hydrogen vehicles. Beyond about 100,000 produced vehicles, price levels will come down to a level where they can be compensated through a set of existing policy incentives. End-users might still have to pay a premium in comparison to conventional vehicles unless those extra costs are completely allocated by means of policies. Both hydrogen vehicles and hydrogen as a fuel need to be addressed by a policy framework. However, the expected cost gap of 10 €ct/km can be tackled by means of various existing policy instruments. Countries that already feature high taxation on conventional vehicles are in a better position to introduce or extend tax exemptions for hydrogen vehicles.

Attention on the member state level needs to be raised urgently to start with the design and implementation of support frameworks to be in place when the JTI financed demonstrations phase out and deployment could face an abrupt halt. Gaps between policy incentives covering different deployment phases need to be avoided. Stable support frameworks are necessary from an industry perspective to demonstrate long-term commitment for the technology, implying that preferably incentives should be budget neutral and designed in a way that they are little vulnerable to economy measures.

The challenge is to bridge the financial gap between the large-scale demonstrations and early market phase (up to 100,000 vehicles) where the cost gap is too large to be covered by means of policy support. In order to deploy the first 100,000 vehicles, hydrogen committed regions need to emerge as early market for vehicles with the accumulated demand within a constraint area that can be supplied by limited infrastructure. Therefore regions or municipalities in liaison with relevant industry stakeholders have to position themselves and come up with a viable plan on how to introduce numbers of vehicles, which segments and how to cover finance over a period in time.

Infrastructure is a serious problem since Europe has not regulated its vehicle supply. In the absence of national infrastructure support, regions should account for necessary infrastructure in their business plans. Finally, the regional activities should raise attention at national governments to implement complex support schemes for vehicles, fuel and infrastructure.

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] Grübler, A. et al. (1999): *Dynamics of energy technologies and global change*. Energy Policy, Vol. 27, Issue 5, pp. 247-280

[2] European Commission (2007), Summary report HyLights Phase I, Deliverable 5.1A, http://www.hylights.eu, accessed on 2009-04-07

[3] European Commission (2008), HyLights: *Entering the next phase towards commercialization of hydrogen vehicles – role and expectations of various stakeholders*, http://www.hylights.eu, accessed on 2009-04-07

[4] European Commission (2007), HyWays – European Hydrogen Energy Roadmap, *Action Plan*

[5] Association of European Automotive Manufacturers, ACEA Tax Guide 2008

[6] EUCAR, CONCAWE, JRC (2007) Well-to-wheels analysis of future automotive fuels and powertrains in the European Context - Well-to-Wheels report, Version 2c, March 2007

[7] European Commission (2008), HyLights: *Gaps analysis – minimal user requirements for hydrogen vehicles*, Deliverable 4.3

Authors

Ingo Bunzeck works as scientific researcher in the group Energy Innovation and Society at the unit Policy Studies at ECN. His research focuses on the socio-economic and behavioural aspects of sustainable transport technologies, electric transport and in particular hydrogen fuel cell technology. He has worked in EU projects such as HyWays and HyLights and is currently involved in a national project that studies the implications of hydrogen vehicle deployment and the development of a hydrogen refuelling infrastructure in the Netherlands.

Harm Jeeninga is head of the Energy Innovation and Society group at ECN policy studies. He is involved in many hydrogen projects like HyWays, Roads2HyCom and HyLights.

Menno Ros holds a masters degree in Science and Innovation Management which he studied at the University of Utrecht (the Netherlands). After working for the Ministry of Economic Affairs (in the Netherlands) he joined ECN in 2006. Now working for the Policy Studies Unit he is mainly involved in the field of hydrogen and fuel cells.