WP6: D6.1
Social acceptance of hydrogen demonstration projects

Report Status: Final

Report Date: 17.08.2010

Author(s): Bas van Bree, Ingo Bunzeck/ECN

Revision:

Acknowledgement

This project is co-financed by funds from the
European Commission under
FCH-JU-2008-1 Grant Agreement Number 245133.

The project partners would like to thank the EC for establishing the New Energy World JTI framework and for supporting this activity.

Disclaimer

This document is the result of a collaborative work between NextHyLights 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 NextHyLights Industry Partners.

The ideas presented in this document were reviewed by certain NextHyLights 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 NextHyLights 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.

Executive summary

Social acceptance of hydrogen projects

Social acceptance is a necessary condition for a successful introduction of hydrogen as a fuel. In this report, social acceptance is defined as (i) a lack of (explicit) public opposition to the introduction of hydrogen as fuel in the transport sector and (ii) the willingness to use hydrogen when the opportunity arises.

The current status of social acceptance of hydrogen has been assessed using existing studies. The assessment has been carried out using a framework that distinguishes three types of acceptance (Figure S.1).

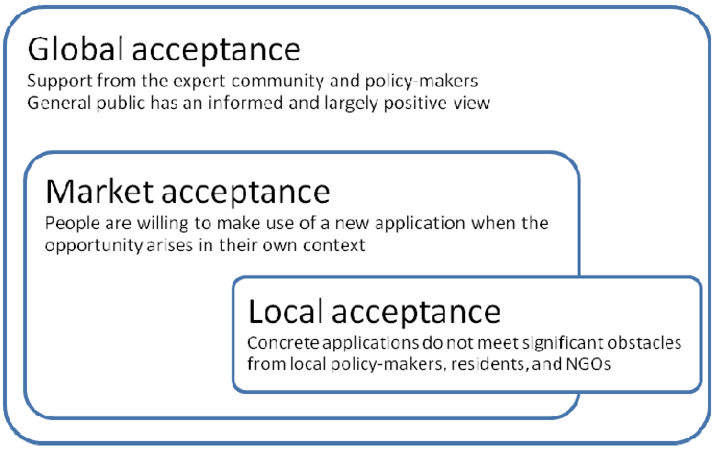

Figure S.1 *Three types of social acceptance*

A review of the existing surveys of social acceptance in hydrogen projects indicates that current social acceptance is good. Respondents typically have a positive attitude towards hydrogen and show high levels of support. Associations with hydrogen are neutral in majority, while positive and negative associations claim about equal proportions.

Yet, the current, favourable situation might change when hydrogen applications will be implemented on a larger scale. This study has reviewed the existing material, compared them with the development of social acceptance for other technologies, and provides recommendations to stimulate social acceptance for in the large-scale demonstration phase and beyond.

Global acceptance: Current status and outlook

Apart from the positive indicators of current social acceptance, many studies report a low level of knowledge on hydrogen, implying that the public does not yet have an informed view. Outreach activities have generally only informed the public in the vicinity of demonstration projects, leaving the larger public uninformed.

The lack of knowledge in the general public implies that its opinion may easily change. Hydrogen is currently an uncontroversial technology, which implies that the general public has so far not had the need to seek information on hydrogen.

As experiences with other new energy technologies show, a technology may turn controversial when experts disagree on aspects (e.g. appropriateness, risk) of the technology. Comments from the critical parts of the expert community may be picked up by the media and fuel an increased need for information on the part of the public as the technology enters the commercialisation phase (and becomes more visible).

This may turn hydrogen into a controversial technology, with plummeting acceptance ratings as a consequence. Although hydrogen has properties that fit political objectives (e.g. energy independence) and enjoys the backing of the marketing skills of the car industry, its uncontroversial image is not a given.

It is therefore recommended that measures are taken to monitor and mediate these developments in the large-scale demonstration and commercialisation phases of hydrogen technology. A survey among experts can help to identify potentially controversial aspects. Joint study groups may then be formed to create a forum for the various opinions and perform research on these aspects that produce factual information. Finally, a survey that identifies longstanding values and beliefs in the general public may increase understanding on how issues that experts consider controversial may be perceived by the general public.

Local acceptance: Current status and outlook

Concrete applications of hydrogen have met with good local acceptance. So far, only one project has reported local resistance.

Local acceptance results from the interaction of a project with its context, moderated by project management. Hydrogen projects are vulnerable to opposition in siting of infrastructure, a mismatch between (local) expectations and the scale of implementation, and a (bad) reputation of the operator/initiator. Although hydrogen projects have so far been perceived as safe, safety is still a topic of major concern.

It is not foreseen that hydrogen will encounter additional issues with local acceptance in the commercialization phase. Yet, a larger scale of implementation may lead to an increase in the number of cases that encounter local opposition.

The first step in achieving local acceptance is to select a favourable site. An assessment framework for site selection has been developed in the project HyLights. It is recommended that the social acceptance section in this tool is expanded in NextHyLights.

In addition to site selection, good project management can help to improve the fit between a project and its context. Key to good project management is early involvement of stakeholders. Engaging stakeholders helps to understand the local context, and engaging stakeholders early in the process keeps the possibility open to adapt the project plan to stakeholders' concerns. As lack of communication and engagement has shown to build distrust, engagement of stakeholders helps to build trust among local stakeholders. Trust – in turn – is important to communicate the risks that are associated with hydrogen projects in an effective way.

ESTEEM is a tool to engage stakeholders in new energy projects, including hydrogen. It is recommended that ESTEEM (or a comparable tool) is used for the practical organisation of the stakeholder engagement process.

Market acceptance: Current status and outlook

Market acceptance is different for different types of vehicles, due to different market structures. Yet, costs are a major barrier in every segment. As hydrogen moves into the commercialisation phase, this barrier is expected to diminish due to technological progress and economies of scale.

Recommendations for stimulating social acceptance

The following actions are recommended to improve social acceptance of hydrogen technology.

Stimulate *global acceptance*, by:

- Implementing a periodic survey to monitor expert and policy-maker opinions on the application of hydrogen. The purpose of this survey is to spot and respond to controversial issues.
- Implementing a monitor of public attitude towards hydrogen and its applications. The monitor should include a section on public values towards possible controversial aspects of the use of hydrogen as a fuel.
- Based on the results of the monitor, create a communication plan to inform and educate the general public on hydrogen as a fuel. Communication efforts should complement planned demonstration projects and develop as the scale of implementation develops. It is likely that the public need for information increases with the scale of implementation, possibly with a focus on controversial topics.

Stimulate *local acceptance*, by:

- Selecting sites with favourable conditions for local acceptance. To this end, it is recommended to extend the social acceptance section in the regions eligibility assessment tool. Moreover, the eligibility score of potential sites in the tool should be included in the selection procedure for the proposals for future hydrogen demonstration projects.
- Requiring hydrogen demonstration project plans to include a section on stimulating local acceptance. This section should detail how local stakeholders will be engaged. The design of the engagement process should be such that the objectives outlined in section 4.2 can be met.

Investigate *market acceptance*, by:

- Conducting a study to establish a business case for various applications of hydrogen.

Contents

1 Introduction

This report (D6.1) is part of the NextHyLights project that aims to support the next phase of large-scale demonstration projects in hydrogen transport. The project has 12 partners from industry and academia and is financed from within the Fuel Cell and Hydrogen Joint Undertaking (FCH JU), equally shared between the European Commission and industry partners from Europe.

The introduction of fuel cell vehicles (FCVs) and the associated hydrogen infrastructure is confronted by challenges of various natures. Some of those challenges relate to technology (e.g. storage of hydrogen, durability of fuel cells), others relate to techno-economic aspects (e.g. costs of hydrogen vehicles, costs of hydrogen production and storage). Yet, there is a good perspective that these challenges can be overcome, as exemplified by the ongoing efforts of large automotive companies (e.g. Daimler, Toyota) and the emergence of industry initiatives such as 'H2 Mobility'[1].

However, even if FCVs are widely available at reasonable cost, they will only be successful if they meet with a good social acceptance. The list of technologies that have underestimated and experienced severe problems regarding social acceptance is long e.g. nuclear and more recently, carbon capture and sequestration (CCS). Inhabitants of the municipality of Barendrecht (near Rotterdam, the Netherlands) purposefully demonstrated against a planned CCS demonstration project beneath their houses, prompting the national government to overturn local decision-making procedures and causing severe delays in the project (Feenstra & Mikunda, 2010).

The definition of social acceptance is problematic (Heiskanen et al, 2007; Ricci et al, 2008). First of all, many terms are used to describe acceptance: social acceptance, societal acceptance, public acceptance, customer acceptance. These terms seem to be at least partly overlapping, and oftentimes no explicit definition of acceptance is provided (see e.g. O'Garra, 2005). Moreover, acceptance is used in connection with other terms (e.g. attitude, perception) without specifying the relationship to acceptance.

In this report, we will use the term social acceptance. We will use a slightly expanded version of the definition that Ricci et al. (2008) derive in their literature analysis[2]: acceptance is (i) a lack of (explicit) public opposition to the introduction of hydrogen as fuel in the transport sector and (ii) the willingness to use hydrogen when the opportunity arises. The objective of this report is to set up a framework to practically analyse social acceptance for hydrogen demonstration projects, to evaluate the current status of social acceptance, and to come up with a set of practical recommendations for stimulating social acceptance. The findings of this report intend

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[1] H2 Mobility was established in September 2009 and brings together EnBW, Linde, OMV, Shell, Total, Vattenfall, and the NOW GmbH.

[2] Ricci et al. argue that their definition is too narrow and list additional factors that influence acceptance. As the definition captures the essence of acceptance, it is nonetheless used in this report. The additional factors are either incorporated in the analysis framework of this study, or are beyond the scope of this report as defined in this introduction.

to contribute to the preparation of the upcoming next calls for projects within the FCH JU until 2013.

Designed as a sub-task within the NextHyLights project, the social acceptance report involves no new field work, and draws its input from existing research on social acceptance of hydrogen and expert opinions. This input is placed in the context of a more general framework on social acceptance. Eventually it provides a status quo of hydrogen acceptance, and enables the formulation of recommendations on how to stimulate future social acceptance[3].

The scope of this report is limited in two ways. First, in accordance with the scope of the NextHyLights project, it will focus on large-scale hydrogen demonstration projects in the transport sector. Second, the acceptance of hydrogen by consumers is not the primary project focus This is (partly) dealt with by other work packages in NextHyLights as well as more in-depth by the FCH JU-funded project PreparH_2[4], and its relevance is only really apparent from the early commercialisation phase onwards. However, if hydrogen meets good acceptance in large-scale demonstration projects, the chances of good acceptance in the (early) commercialization phase are also more favourable.

Social acceptance will be treated as one subject for all vehicles that are considered in the NextHyLights project (passenger cars, buses, special-purpose vehicles). Whenever any significant differences for the various types of vehicles exist, this will be mentioned.

Social acceptance of hydrogen has been the subject of a number of previous studies, many in connection with demonstration projects. Chapter 2 comprises a literature review, putting these studies and their results in chronological order. Additionally, this chapter presents a framework in which three types of acceptance are identified. Chapters 3 (global), 4 (local), and 5 (market) elaborate on the current situation of hydrogen of each of these types. Chapter 6 concludes the report and provides recommendations to stimulate hydrogen acceptance.

[3] This report is thus complementary to field work that is carried out in connection with demonstration projects such as HyChain and Zero Regio, as well as to projects that constitute a more detailed study of the workings of social acceptance, such as PreparH_2.

[4] The PreparH2 project, see project coordinator IcelandicNewEnergy http://www.newenergy.is/en/ines_projects/research_based_on_demonstration/prepar-h2_2010_-_11/

2 Literature review and analysis framework

In this chapter, we review the existing literature on social acceptance of hydrogen. We then introduce a framework for analysing acceptance, which we will use to interpret the results of the literature review.

2.1 Literature review

Research on hydrogen acceptance has been conducted for over a decade, triggered by an early wave of hydrogen demonstrations and studies that started in the end of the 1990s. Table 2.1 presents an overview of empirical studies undertaken so far. The studies typically concern surveys among users (e.g. bus drivers, bus passengers) of hydrogen technology. The remainder of the studies are surveys in the public at large.

Virtually all studies that relate to demonstration projects concern buses[5]. Interestingly, there is only one study that directly investigates attitudes towards hydrogen infrastructure (O'Garra et al, 2008), although it is not unreasonable to expect acceptance issues with infrastructure.

The *level of knowledge and awareness* about hydrogen and its applications is consistently found to be low (Altmann & Gräsel, 1998; Haraldsson et al, 2006; Heinz & Erdmann, 2008; Maack et al, 2008; Ricci et al, 2008). In the general public, one study found that in three out of four of the CUTE cities, more than three-fifths of respondents had never heard of hydrogen vehicles prior to the hydrogen bus trials[6] (O'Garra, 2005). An extensive U.S. survey on hydrogen knowledge and opinions found that about half of the respondents answered 'don't know' to a series of technical questions on hydrogen, whereas only a quarter of respondents provided the correct answer (Schmoyer et al, 2006). German high school students did not do much better, with 40% unable to answer more than one out of four questions correctly (Altmann & Gräsel, 1998).

Respondents that have participated in demonstration projects of hydrogen applications do not express significantly higher knowledge levels. However, not surprisingly, they do express a desire to receive more information(Haraldsson et al, 2006).

A few studies have measured the *associations* that connected to hydrogen. The majority of associations is neutral, whereas the rest is about equally divided over positive and negative associations (Dinse, 1999; O'Garra, 2005). Contrary to popular belief among hydrogen experts, the association with the Hindenburg disaster is virtually absent (Ricci et al, 2008).

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[5] An exception is Saviko Consultants (2006), which is connected to the Zero Regio demonstration project that includes cars. However, the study cited here was not yet based on user experiences – the final report on social acceptance was not available at the time of publication of this report.

[6] The three cities are London, Luxembourg and Perth. Knowledge was higher in Berlin, with 72% of respondents reporting knowledge about hydrogen vehicles. In all four cities, knowledge increased as a result of the trials with 5%-point (London) to 18%-point (Luxembourg).

Author(s)	Pub. date	Project(s)	Location	Start	End	Description
Altmann and Gräsel	1998	Bus Demo	Erlangen, München	1996	1998	Survey of bus passengers and secondary school students
Schmoyer et al.	2004	-				Large-scale US survey on hydrogen knowledge and opinions
O'Garra	2005	CUTE	4 cities	2002	2006	Survey of bus passengers and general public
Saviko Consultants	2006	Zero Regio	Frankfurt-Höchst, Mantova	2004	2009	Analysis prior to vehicle demonstration
Haraldsson et al.	2006	CUTE	Stockholm	2002	2006	Bus passenger and driver survey
Saxe et al.	2007					Bus passenger and driver survey
Hickson et al.	2007	Bus Demo	Winnipeg			Bus passenger survey
Maack et al.	2008	ECTOS	Reykjavik	2000	2006	Surveys and focus groups among bus drivers, bus passengers, hydrogen experts, and the Icelandic population
		CUTE	Reykjavik	2002	2006	
		HyFLEET:CUTE	Reykjavik	2006	2009	
Heinz and Erdmann	2008	HyFLEET:CUTE	8 cities	2006	2009	Survey of bus passengers and general public
O'Garra et al.	2008	CUTE	London	2002	2006	Survey on attitudes towards hydrogen refuelling facilities
Pietzner and Yetano	2010	HyChain	4 regions in 4 countries	2006	2011	Bus driver satisfaction survey
Zimmer	2010	HyTrust	-			Survey among hydrogen experts and the German population
Achterberg et al.	2010	-				Survey in the Dutch population at large

Table 2.1 *Overview of empirical studies of hydrogen acceptance*

The *attitude* towards hydrogen is generally positive and hydrogen generates high levels of *support* (Altmann & Gräsel, 1998; Dinse, 1999; Haraldsson et al, 2006; Hickson et al, 2007; Maack et al, 2008). This holds both for the public at large and participants in hydrogen demonstration projects. Yet, the basis for this support is not very stable. Respondents often indicate that they require more information to make an informed answer, which is in line with earlier findings that uninformed opinions are unstable and easily changed by any new piece of information (De Best-Waldhober et al, 2009). One study notes that the positive results may change drastically if the currently undecided respondents were to take an unsupportive stand, although there would still be a majority of supporters (Heinz & Erdmann, 2008).

Additional information has found to influence hydrogen support. Although results are not very conclusive, there is evidence that additional information (in the form of direct contact and education) increases support (Altmann & Gräsel, 1998), most likely due to increased understanding (Ricci et al, 2008).

The positive attitude is reflected in the low concern for *safety* that is expressed in most studies. Generally, most participants in demonstration projects feel safe with the hydrogen applications (Saxe et al, 2007). The general idea seems to be that hydrogen will be engineered to be safe, although there is also evidence that perception of safety changes with the sort of information that is provided (Ricci et al, 2008).

2.2 Analysis framework

Acceptance depends on context (Heiskanen et al, 2007). Acceptance is likely if contextual factors align with technological properties. For instance, hydrogen projects are more likely to be accepted in an environment (i.e. context) that values air quality highly, and puts less emphasis on costs for transport.

Previous research has taken place in three different contexts. Most studies have taken place in a *local context,* interviewing participants in demonstration projects. Research in the *global context* has targeted the general public (although some studies connected to demonstration projects have also included the general public). Finally, a number of studies have investigated the willingness to pay for hydrogen applications in an attempt to establish future performance in a *market context*.

These three contexts form the framework for the remainder of the report (Wüstenhagen et al, 2007). The global context encompasses the overall environment into which hydrogen will be introduced, without reference to individual projects. The local context encompasses the environment into which specific projects (e.g. a refuelling station) are introduced. The market context encompasses the interactions between potential consumers and producers of hydrogen and hydrogen vehicles.

As acceptance in each of the contexts may differ, three forms of acceptance can be distinguished (Figure 2.1). Global acceptance exists when there is support from the expert community and policy-makers, and the general public has an informed and largely positive view. Local acceptance exists when concrete hydrogen applications do not meet significant obstacles from local policy-makers, residents, and NGOs.

Market acceptance exists when people are willing to make use of hydrogen applications when the opportunity arises in their own context.

All three forms of acceptance are required for a successful introduction of hydrogen. Without global acceptance, support for a large-scale rollout is likely to be lacking. A lack of local acceptance will lead to problems in local hydrogen projects (e.g. construction of infrastructure). A lack of market acceptance will imperil the business case of hydrogen as automotive fuel and the willingness of industry to invest.

The analytical borders between these forms of acceptance are best explained by clarifying how they are interlinked. Global acceptance refers to the existence of a general, positive view on (in this case) hydrogen, to the extent that no opposition to its introduction arises. This view is not directly connected to the concrete application of hydrogen in specific locations.

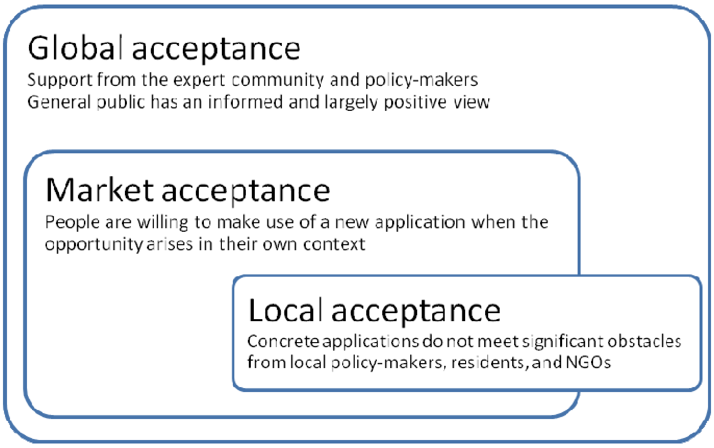

Figure 2.1 *Three types of acceptance and the conditions necessary for their existence. Based on Heiskanen et al. (2007) and Wüstenhagen et al. (2007)*

The existence of global acceptance does not imply that there will be no opposition to the introduction of hydrogen at all. On a local level, opposition may still arise. This may be due to local context, e.g. due to misalignment with local policies, specific safety concerns with respect to a (planned) site for a hydrogen filling station, etc.

Finally, even if hydrogen is viewed positively on a global level and no major hurdles exist on a local level, people still need to be willing to make use of it. This form of acceptance is referred to as market acceptance. Market acceptance is to a large extent determined by techno-economic aspects, e.g. the price of hydrogen and the availability of different models of hydrogen vehicles.

The following chapters will analyse the current status of the three types of acceptance for hydrogen applications, building upon the results of the literature review.

3 Global acceptance

Global acceptance refers to acceptance unrelated to a particular application of hydrogen technology. Global acceptance exists when there is no opposition from the expert community and policy makers, and the general public has an informed and largely positive view. Basically, this implies that there is no controversy surrounding hydrogen.

Although the majority of energy technologies is uncontroversial (and accepted), some technologies have been surrounded by controversy and met with resistance. Nuclear energy is a notorious example. CO_2 capture and storage presents a more recent case.

There is a possibility that a controversy will develop around hydrogen. Hence, it is useful to draw lessons from the process by which other technologies have turned controversial.

Jasper (1988) has studied the process that turned nuclear energy into a controversy in the United States, France, and Sweden. He distinguishes three periods, with two transitional periods in between (Figure 3.1).

In the first of these periods, the *pre-political period*, there is no controversy yet. Experts and policy makers agree that the new technology is promising and R&D proceeds to get the technology to the deployment phase. The public is unconcerned and positive, and – since the new technology is not seen as problematic – generally has no opinion on the technology.

The development of a controversy starts with disagreements among experts. The media pick up on this and publish about the disagreements. The technology is *politicised* and turns into an 'issue'. The public feels a need to form an opinion. The information from the media is used as a basis to form this opinion.

Although the media plays an important role in creating the controversy and – in this case – antinuclear sentiments, the media do not completely dictate public opinion. Information from the media is processed in accordance with longstanding values and beliefs about technology, science, environment, politics, large corporations, etc. The public is divided into proponents and opponents accordingly.

The *political period* is thus characterised by value conflict. There is a fierce societal and political debate on whether or not to implement the new technology. The role of the media is different in this period. In the politicization period, the media could create opposing sentiments by tapping into the appropriate values of a part of the population. The opposing and supporting camps can now no longer be enlarged, since the media is unable to change longstanding beliefs and values (at least in the short term). The role of the media has been reduced to setting the agenda of the debate.

Fierce debate is always short-lived. Either one of two camps wins the debate, or the two sides of the debate end up in some kind of stand-off. Sooner or later – usually sooner – other issues capture the public debate. This is the start of *depoliticization*.

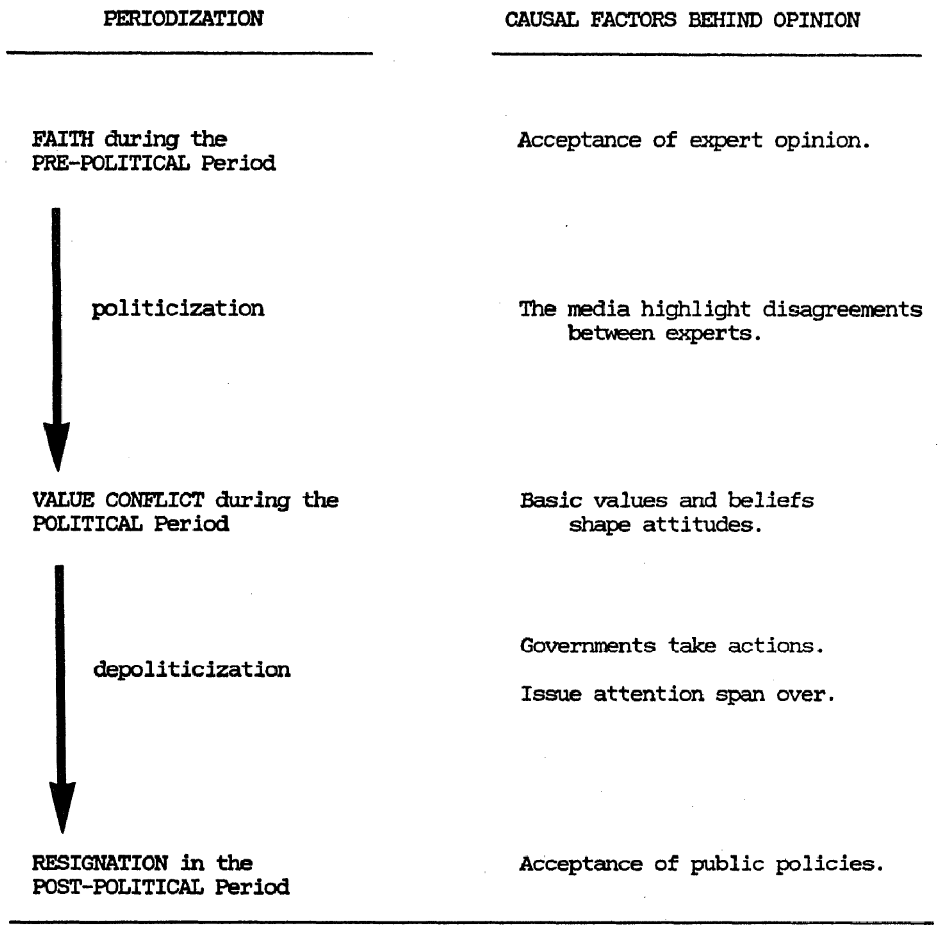

Figure 3.1 *Periods in the process of technology turning controversial (Jasper, 1988).*

The *post-political period* is characterised by resignation. The public accepts the policies that have been implemented. Interestingly, public opinion develops in accordance with the policies adopted. Note that depoliticization does not imply that the controversy is solved, although it may be in many cases. If public opinion remains divided, the issue could come to the fore of the debate once more, for instance through media intervention.

Jasper (1988) derived this model studying the controversy surrounding nuclear energy. Although the model has not been applied beyond nuclear energy, there is strong evidence that other technologies (e.g. CO_2 capture and storage, biofuels) are going through the same cycle. Therefore, the model is used in the remainder of this chapter to frame the current situation of hydrogen technology and to derive recommendations on preventing and dealing with politicization of hydrogen.

3.1 Current status and possible future developments

The results of the literature review (section 2.1) suggest that hydrogen is currently in the pre-political period (Saviko Consultants, 2006). Although support for hydrogen applications is high, a large part of the population is undecided (Heinz & Erdmann, 2008) and knowledge levels and media attention for hydrogen are very low (Ricci et al, 2008). Although participants in demonstration projects show a desire to have more information, there is no such need nor desire for the general public. In short, hydrogen is not yet an 'issue'.

However, the examples cited above illustrate that the current high levels of support for hydrogen need not be sustained when current applications are scaled up. Disagreements between experts can provide a trigger for politicization of hydrogen and the decline of support.

Among experts, the use of hydrogen as automotive fuel is not without dispute. The results of a small survey among experts (Zimmer, 2010) show that about a quarter associates hydrogen vehicles with negative connotations (e.g. 'unnecessary' or 'problematic in principle').

Examples of topics that may divide opinions among experts are the greenhouse gas reduction potential of hydrogen and the development of fuel cell costs. To start with the former: the impact of the introduction of hydrogen vehicles on greenhouse gas emissions is not straightforward. Although hydrogen vehicles produce no tailpipe emissions, varying amounts of emissions may be produced in the well-to-tank process. The amount of greenhouse gases produced depends on the hydrogen source and may range from close to nil – hydrogen produced by electrolysis using electricity from renewable sources – to well over 200gCO_2/km – e.g. hydrogen produced from coal (JRC et al, 2007). In the latter case, well-to-wheel emissions exceed those of vehicles on conventional fuel. Critical experts may point out that the advantages of hydrogen vehicles in terms of greenhouse gas emissions are not all that clear-cut (Romm, 2006).

The development of costs of hydrogen applications is also not without debate. Studies estimate that fuel cells (Schoots et al, 2010) and the use of hydrogen in automotive applications (JRC et al, 2007) will be more expensive than conventional powertrains after learning effects and economies of scale are taken into account. This is a potential source of resistance to material and immaterial public support for hydrogen, especially if other alternative fuels (e.g. electric vehicles, biofuels) prove to be less expensive Hydrogen, however, has advantages that can lend it political support, such as the promise of larger energy independence. Also, the energy and car industries are unlikely to move hydrogen applications into the commercialization phase unless they foresee cost reductions that will make FCVs competitive with conventional vehicles, and will employ powerful marketing communication tools to convey that message.

Nonetheless, topics like the ones pointed out above hold the seeds for the politicization of hydrogen. As the commercialization of hydrogen moves into the large-scale demonstration phase, (public) resources committed to these projects increase along with the attention that the projects solicit. Media become more interested and zoom in on any disagreements between experts in their account of the new developments. In this phase, hydrogen will become more visible and the need for information on the part of the general public will grow. Media accounts will represent an important source of information, and reports on differences between experts may possibly lead to a division of opinions (in proponents and opponents) among the general public.

3.2 Recommended actions

The large-scale demonstration phase of hydrogen commercialisation should include measures to influence this chain of events and prevent it to the extent possible. This section will elaborate on (i) monitoring expert opinions, (ii) measuring beliefs and values in connection with hydrogen, and (iii) interactions with the general public.

3.2.1 Monitoring expert opinions

As politicization is likely to originate from disagreements among experts, spotting and monitoring disagreements can provide clues on the likeliness of hydrogen turning controversial. Controversial aspects may reach beyond the examples provided in section 3.1 – safety could for instance also be a topic that is to be debated among experts. In practice, monitoring can take the form of an *annual, standardized survey among experts*, complemented by a selection of professional dissemination activities (e.g. journal publications and conference presentations). Such a survey can present the state of the field of hydrogen in the eye of experts.

Just spotting controversial issues does not contribute towards preventing politicization. Attempts should be made to build consensus among experts on these issues. For some issues, this is already being done: effects of hydrogen on emissions of greenhouse gases are analysed and updated in a broadly supported study jointly undertaken by JRC, Concawe and EUCAR (JRC et al, 2007), and safety standards are worked on in the International Association for Hydrogen Safety HySafe.

The proposed study could be organized by the FCH JU and/or in cooperation with the International Partnership on Hydrogen and Fuel cells in the Economy (IPHE)[7] to link with important international stakeholders and active regions such as the US and Japan.

The outcomes of the hydrogen expert survey should be checked with the efforts of these existing studies and associations to make sure that all potentially controversial topics are covered and that all relevant (critical) experts are included – at least to the extent practically possible. If necessary, a new study on a particular topic should be commissioned or the formation of a new association stimulated.

There is no guarantee that this approach will be able to solve all controversial issues. Some issues might prove impossible to reach consensus for. However, including as many parties as possible in the process at least provides insight in possible politicization issues and offers a better perspective to keep the dialogue with hydrogen critics open.

[7] IPHE, see http://www.iphe.net

3.2.2 Measuring beliefs & values

In the politicization phase, the division of opinions will take place according to longstanding beliefs and values.A *survey among the general public* can shed light on these beliefs and values in connection with hydrogen. The survey can provide information on how beliefs and values influence opinions and relative importance of a number of topics, including (but not exclusively) the following[8]:

- energy independency;
- energy security;
- concern for climate change / greenhouse gas reductions;
- concern for local air quality;
- trust in technology;
- attitude towards public support of novel technologies;
- traffic noise;
- risk tolerance and perception;
- safety

Note that the focus of this survey would be slightly different from the surveys on hydrogen that have been undertaken so far. These surveys have tended to ask to what extent respondents are supportive of hydrogen. However, because hydrogen is in the pre-political period, knowledge on hydrogen is low. Consequently, many respondents are inclined to fill in ‘don’t know’, ‘need more information’ or ‘support’ (but without a solid basis for their answer).

When hydrogen moves into the large-scale demonstration phase, more information on hydrogen will become available, possibly partly in the form of media accounts of expert disagreements. The processing of this information is likely to be based on cultural predispositions (Achterberg et al, 2010). Measuring beliefs and values provides clues as to how people may respond to information about hydrogen. Furthermore, it forms a basis for the design of a communication strategy to the general public (see next section).

Direct questions in relation to support for, knowledge about, and associations related to hydrogen may be included, bearing in mind the limitations with regard to the interpretation of these items in the period leading up to the large-scale demonstration phase. If these items are included, it makes sense to conduct the survey on a periodical basis, so that the development of these indicators over time may be tracked. This also enables evaluation of hydrogen dissemination and outreach activities (connected to demonstration projects and in general).

Measuring beliefs and values does not provide any direct information on the willingness to use hydrogen applications. Even if beliefs and values align with the

[8] The survey design would require a small pre-study to determine the most appropriate topics, e.g. based on a literature review.

properties of hydrogen applications, the resulting positive attitude may not lead to adoption, due to the notorious attitude-action gap (Lane & Potter, 2007). A respondent may decide not to purchase a hydrogen vehicle himself, but at the same time not oppose the purchase of such vehicles by others and tolerate the build-up of associated infrastructure. Conversely, the adoption of hydrogen technologies by some consumers does not imply global acceptance either.

Insight in beliefs and values can provide information on the position of hydrogen vis-à-vis alternative technologies such as battery-electric vehicles and biofuels. For example, if the survey shows that sustainability issues are considered relatively salient, this may put biofuels at a relative disadvantage.

In the US, a survey among the general public has already been administered in 2004, with the purpose of assessing the baseline of hydrogen knowledge (Schmoyer et al, 2006). This survey addresses knowledge and other aspects of hydrogen acceptance directly, but most of all contains useful insights such as a ranking of public values (Figure 3.2). Clearly, it makes sense to align an EU survey with the US survey as closely as possible.

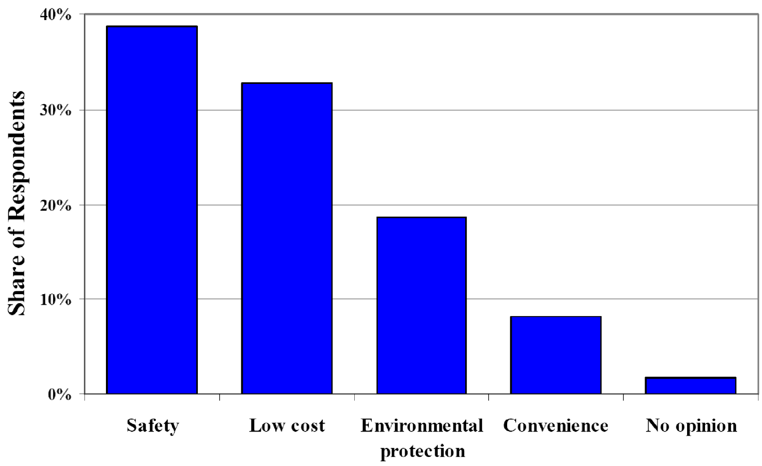

Figure 3.2 *Value rankings by the general US public (Schmoyer et al, 2006)*

3.2.3 Interactions with the general public

To stimulate global acceptance, the large-scale demonstration phase of hydrogen introduction should be accompanied by a communication campaign to the general public, thus reaching out beyond participants in hydrogen demonstration projects. This contributes to global acceptance, a requisite for which is an informed and largely positive view by the general public.

The outcomes of the survey described in the previous section provide a starting point for the campaign design. Information is processed according to the beliefs and values that the public holds (Achterberg et al, 2010). This explains why merely providing knowledge does not guarantee the increase of support for hydrogen, as shown by the mixed results on the relationship of knowledge and acceptance (Altmann et al, 2003).

Therefore, the campaign should align with the beliefs and values that result from the survey. For example, the US survey shows that safety is considered the most important aspect (Figure 3.2). If the EU survey would generate the same result, safety should be one of the important themes of the communication campaign. Conversely, environmental protection scored considerably less important in the US survey. Again, if the EU survey would produce the same result, the environmental benefits of hydrogen should be given less attention.

As explained in section 3.1, it is possible that hydrogen turns into a controversial technology. In that case, the media will highlight topics on which experts disagree. It is important to communicate about these issues to as a counterweight to critical views on these topics. Importantly, claims on the performance of hydrogen applications on these controversial topics should always be substantiated and based on factual information (Saviko Consultants, 2006).

4 Local acceptance

The acceptance of hydrogen on a global level does not equal nor guarantee local acceptance. Local acceptance requires residents, local policy-makers, NGOs and other local stakeholders to support the local application of the technology.

The EU-funded project CreateAcceptance (Heiskanen et al, 2007) represents an extensive study into the acceptance of specific instance of energy technology. An important finding of the CreateAcceptance project is that acceptance results from the interaction between a project and its context. Projects change the context that they are operating on, e.g. a hydrogen project might result in increased traffic and lower value of surrounding property. Depending on the nature of the changes and the characteristics of the context, this may lead to local acceptance or resistance.

Table 4.1 lists a number of contextual factors that influence project success, divided over four categories. *Political factors* relate to local policies and politicians. Examples of local policies that are relevant for hydrogen projects are urban planning policies and the involvement of local/regional governments in (co)financing a project. On a local level, individual politicians may exert quite a lot of power related to decisions on these issues.

Socio-economic factors are in part related to the availability of local resources and knowledge, and – contingent on that – the expectation of stakeholders about project feasibility. Local acceptance is enhanced by bringing benefits such as economic development, local employment and local energy independence. On the other hand, projects implemented by large institutions such as big corporations may induce suspicion and even resistance.

Cultural factors include trust in local partners, which project partners may leverage to create a trustworthy image for the project. The best way to mobilise these local partners is again context-dependent – in some contexts this is best done bottom-up, whereas in other contexts top-down processes may be dominant, perhaps via an influential local politician. Positive historical experiences with a location or technology may be beneficial for acceptance.

Finally, *geographic factors* are relevant. A location with suitable climatic conditions may make a project fit better with the environment, thus providing a better base for acceptance.

Contextual factors are not the sole determinant of project success, however. They provide a baseline – project success is more likely if the contextual factors are favourable. Sound project management can ease the process of changing the environment the project operates in. Table 4.2 lists project management factors that CreateAcceptance found influenced project success.

FACTORS PERTAINING TO THE LOCAL CONTEXT	EXAMPLES OF RELEVANCE FOR NEW ENERGY PROJECTS
Political factors	
Power of local government	Influence of decisions of local government on the project
Policies for urban planning and financial involvement in new energy	Influence of local policies concerning urban planning and financial involvement in new energy on the project.
Impacts on the local environment	Impact of the project on local environment influencing the societal acceptance.
Influence of individual local public figures	Personal influence of public figures on the (acceptance) of the project.
Socio-economic factors	
Availability and perception of natural resources	Stakeholder confidence in feasibility of project due to (perception of) availability of sufficient resources on the location.
Attitude to ‘foreign’ (non-local) investors	Stakeholder confidence in external (non-local) project partners influences their acceptance of the whole project.
Importance of local energy independence	Number and types of arguments supporting project visions based on willingness to become locally energy independent and to insure local security of supply
Interest in employment opportunities	Social and economic support available for projects from stakeholders that support development of employability locally
Availability of local competence and infrastructures	Existence of local competence and infrastructures influences the support of stakeholders for the project
Cultural factors	
Trust in local institutions	Stakeholders’ trust in local project partners and institutions
Tradition of top-down vs. bottom-up movements	Project partners’ ability to mobilize resources locally from the top down or from the bottom up.
Historical experiences	Local experiences with the location / technology / initiator or other aspects of the project
Geographic factors	
Climate	Natural endowments and demands for energy due to temperature, wind, etc.
Availability of suitable locations	Possibilities and problems encountered in the location of the project

Table 4.1 *Local contextual factors that influence the success of new energy projects (Heiskanen et al, 2007)*

Factors that contribute to local conflicts	Factors that contribute to project success
Development involuntarily imposed from outside / Overlooking local stakeholders' concerns	Local embeddedness
Unfamiliar technology	Continuity of existing (physical, social and cognitive) structures
Development for corporate profit rather than local benefit	Local benefits
Decide-announce-defend communication strategy	Good communication and participation

Table 4.2 Factors related to project management influencing project success (Heiskanen et al, 2007)

The common denominator of these factors is the involvement of local stakeholders in the project. Taking stakeholder concerns into account and trying to design the project in such a way that benefits accrue to both project partners and project stakeholders enhance project success. Early involvement of stakeholders ensures that there is still sufficient scope for inclusion of stakeholders' suggestions. The decide-announce-defend strategy is obviously the opposite of early stakeholder involvement.

4.1 Current status and possible future developments

The CreateAcceptance project has performed a number of case studies[9] that were specifically devoted to hydrogen. In these case studies, issues and success factors specific to hydrogen were identified. The findings are summarised in Table 4.3.

Key problems and uncertainties	Factors likely to promote success
Siting of distribution infrastructure	Roots in fresh, clean technology
Reputation of the operator or initiator	Shared investment
Relations between expectations and current implementation scale	Sense of shared benefits
Management of risks	Risk tolerance in context

Table 4.3 *Critical issues and success factors specific for hydrogen projects (Heiskanen et al, 2007)*

[9] The case studies concern the construction of a hydrogen fuelling station as part of the London CUTE project, the bus trials as part of the H2Accept project in Berlin, and the ECTOS hydrogen project in Iceland.

Hydrogen apparently enjoys an inherent advantage, as it roots in fresh, clean technology. This is certainly true for the part of the application that is generally visible to the public in a demonstration project. The vehicles that are showcased do not produce tailpipe emissions and are thus clean. It must be borne in mind that knowledge about hydrogen applications is not widespread yet, and hydrogen source and emissions in hydrogen production may become an issue upon larger-scale implementation and growing knowledge in the public. The connotations of clean and fresh technology derive from hydrogen projects in Iceland, which has an abundant potential to produce hydrogen from renewable sources. Connotations in other hydrogen projects are more vague.

Additionally, hydrogen projects offer the opportunity to share investments among public and private partners – indeed, the current demonstration projects mostly take the form of a public-private partnership. The involvement of local investors (both public and private) may increase the support for local projects.

This relates to the sense of shared benefits that contribute to project success, since benefits accrue to local partners. Shared benefits may go beyond benefits for project partners. Hydrogen projects offer the opportunity to improve local air quality. Also, there is evidence that the creation of local employment opportunities in regions with low economic prospects contribute towards the local acceptance of hydrogen projects (Ricci et al, 2008).

Consequently, hydrogen projects have met with (very) good acceptance, permitting the conclusion that hydrogen projects were generally well aligned with the project context (Altmann & Gräsel, 1998; Haraldsson et al, 2006; Heinz & Erdmann, 2008; Hickson et al, 2007; Maack et al, 2008; O'Garra, 2005). Further evidence of the hitherto low obtrusiveness of many projects is that media attention was generated by the projects themselves – it is unlikely that a large media interest would have been triggered without this active outreach (Altmann et al, 2003).

However, there is one example of local resistance to a hydrogen project due to misalignment with the local context, and involving three of the four key problems that are mentioned in Table 4.3. As part of the CUTE project, a refuelling station was planned in Hornchurch, a town in the East London Borough of Havering (see the boxed text for more details). Local residents opposed the construction of the refuelling station. The objections that they cited mainly related to specific aspects at the site. A good example is the effects on nature, as the site was located in the so-called Green Belt.

Yet, the problems were exacerbated by the reputation of the operator and the expectations of the local residents. The lack of communication on the side of BP provided space for opposition to form. BP was ‘foreign’ to the local context and was also perceived as such.

The lack of communication also allowed for a difference in expectations for the project to persist. BP expected to ‘drop in’ their technology and test how it would work, both in terms of technical performance as well as social acceptance. The residents suspected that BP might have other plans with the site as well, such as maintaining it as a regular refuelling station after the end of the CUTE project.

Three key lessons emerge from the experience with the London refuelling station (Hodson, 2006):

- *The first instance of implementing a new technology is of emblematic importance*
  By definition, the first application of a new technology implies that the particular technology is unfamiliar. The lack of knowledge of affected parties requires that it is important to address *why* the technology is implemented in this instance.
- *Understand the local context*
  There may be opposition in the local community against the plan as originally formulated, possibly based on factors unrelated to technology. Understanding such concerns in an early stage is crucial, since it allows the possibility to align the visions of the project partners and the local stakeholders.
- *Project managers should actively engage the community in an early project phase*
  Upstream engagement is crucial. Through engagement, negative ideas can be confronted and often refuted. Public meetings are very effective for this if done correctly Successful engagement can create trust and enlist the specific support of local individuals and groups (e.g. the Residents Association). Moreover, non-action or no contact communicates a lack of concern and/or secrecy.

So far, the Hornchurch station is the only documented case that met problems with local acceptance. The case study gives rise to the thought that the problems with the Hornchurch station could for a large part have been avoided if the project would have (been) adapted to the local context. A more elaborate study indicates that there is moderate opposition for the development of hydrogen storage at existing refuelling stations among households potentially affected by such storage (O'Garra et al, 2008). In the survey, almost three-fifths expressed the need for more information before they could provide an opinion, highlighting the need to engage with local stakeholders.

The London CUTE hydrogen fuelling station

The aim of the CUTE project was the demonstration of hydrogen-powered buses in nine European cities (including London) and was partly funded by the European Commission. The London demonstration commenced in 2003 and involved a network comprising technology suppliers, a bus operator, and governments at various levels.

The technology providers' typical aim was to test new technologies in a real-life environment. This was also the expectation of BP, that was involved BP's assumption was that technology could be 'dropped-in' to the local context, gaining experience from the exercise.

BP's responsibilities included the construction of a hydrogen refuelling station with a publicly accessible forecourt. For this, the town of Hornchurch was selected as the most appropriate site.

BP started site development after the announcement that London would participate in the CUTE project in March 2001. BP contracted various consultants for the application process. Upon submission of the application (September 2002) other actors became involved, such as councillors in the Planning Committee, the Health and Safety Executive, and the London Fire Brigade. Up to this point, no local stakeholders had been consulted.

Local residents were informed of the planning application by the Planning Committee in December 2002. The notification triggered objections from local residents, local councillors, and the local media. Their grounds for objection included safety concerns, concerns for detrimental effects on nature (the site was located in the so-called 'Green Belt'), and concerns about nuisance from increased traffic and lights.

In June 2003, a meeting was organised by the Planning Committee to discuss the development. This was the first instance where BP and the local objectors met – although not on BP's initiative. The objections raised during the meeting led to the refusal of BP's application in July 2003.

BP's response was to launch a legal campaign and submitted a revised planning application, which was again refused by the Planning Committee following objections from local residents. BP appealed again, upon which a Public Inquiry was held. the Inquiry lasted three days. Finally, permission was granted in July 2004 upon intervention of the First Secretary of State, citing 'very special circumstances'.

There had still been no contact between BP and the local residents on the initiative of BP. However, after obtaining the permission, BP organised three public meetings and an open day. During these meetings, BP was able to 'put people's minds at rest on a number of issues'. Note that the first of these meetings took place 42 months after BP started site development.

Interestingly, the meetings were a great success. BP was able to convince the residents that some of the ideas they had – such as that the site would remain in operation as a regular refuelling station after the CUTE project – were not true. In fact, a representation of the local Resident Association was present at the third meeting. BP was so successful in eliminating local opposition that an extension of the planning application was granted without a single objection.

Source: Hodson (2006)

The objections of the Hornchurch local residents included safety concerns, and other studies have also identified safety as a key concern (Haraldsson et al, 2006; Schmoyer et al, 2006). Yet, a typical outcome of surveys administered to participants in demonstration projects is that they feel safe using hydrogen technology[10] (Hickson et al, 2007; Saxe et al, 2007). This lends credibility to the thought that hydrogen will be 'engineered to be safe' (Ricci et al, 2008). Apparently, there is a large risk tolerance with respect to hydrogen, as was also identified in the CreateAcceptance project.

Nonetheless, risk perception is an important part of the local context that needs to be understood for a project to be successful. Risk perception has been studied extensively, and some of the results provide clues for dealing with risk perception of hydrogen applications (Midden & Montijn-Dorgelo, 2004).

First of all, risk perception is context dependent. Knowledge on hydrogen is low, hence local stakeholders will take information about risk from the context in which the hydrogen is presented. It is not unlikely that hydrogen will be associated ('assimilated') with natural gas as an automotive fuel with similar properties. Natural gas as an automotive fuel has not encountered major risk perception problems, so that is a positive development for hydrogen.

On the other hand, the risks associated with natural gas are easily imaginable and the perceived catastrophality of natural gas incidents is high. These are two factors that have been found to increase the perception of risk in general (Slovic et al, 1980). These factors are also applicable to hydrogen, along with the newness that is inherent to hydrogen which is also a factor influencing risk perception.

Technically, there are differences between the risks associated with natural gas and hydrogen, but it may be difficult to communicate this. The differences can be quantified, but calculated risk differs from risk perception. Rather, risk is processed using an affect heuristic, i.e. based on feelings.

Interestingly, in case of uncertainty, trust plays an important role. If local stakeholders do not have the knowledge to judge the risks of a hydrogen project, they will rely on what they consider trustworthy sources of information for judgment (Midden & Montijn-Dorgelo, 2004). Therefore, building and maintaining a trustworthy image is important in the risk communication for hydrogen projects.

Apart from considering the risk itself, risk perception often also takes the benefits of an application into account. Unfortunately, the benefits associated with hydrogen application are – apart from improvement of local air quality – societal rather than individual, especially if e.g. residents living near a hydrogen refuelling station not use a vehicle (passenger car, bus) that fuels at the station. In specific cases, project partners may consider offering individual benefits to local stakeholders to compensate for the additional risk. Such benefits need not be monetary, but may also include rewarding business to local companies or creating local employment.

[10] Saxe et al. (2007) report the finding that safety is no concern among hydrogen bus passengers, yet a close look at their survey data reveals that the passengers feel safe – which does not imply that safety is not a concern.

Great care must be taken that monetary compensation is not rejected as immoral propositions.

The examples and studies cited above have already illustrated that good project management can improve the alignment of hydrogen projects and their project context. As exemplified by the Hornchurch case, local engagement in an early stage and adaptation to the local context is paramount.

The ECTOS project in Iceland, which met with extremely good acceptance, is another testament of the success of good project management (Maack et al, 2008). This project organised various activities to disseminate information about the project and gather opinions from various stakeholder categories. It also succeeded in generating a lot of positive media attention.

Furthermore, despite strict risk management, an incident happened in which a pipe blew up (Maack & Schucan, 2006). Fortunately, there were no personal accidents. The incident was tackled in an open fashion and valuable lessons were learned. Support for the project maintained very high levels.

Hydrogen demonstration projects have so far been undertaken at a relatively small scale. Indeed, the small scale and closed character of many of the projects implied very little influence on the project context and, consequently, social acceptance was only a minor issue (Heiskanen et al, 2007).

Yet, scaling up demonstrations is unlikely to exacerbate the key problems and uncertainties that are associated with hydrogen demonstration projects. Arguably, a larger scale makes the engagement with local stakeholders more complex, but probably not unmanageable.

A larger scale may even bring benefits. Larger-scale demonstrations are likely to attract more media attention by themselves, i.e. less effort to generate media coverage is required by the project team. Furthermore, as the numbers of demonstration projects increase, hydrogen will gain visibility. Knowledge on hydrogen will increase, which may lead to less resistance to station siting at individual locations – provided local residents see the benefits of hydrogen.

4.2 Recommended actions

Local acceptance of hydrogen demonstration projects is not a given. However, the previous section gives rise to a number of recommendations for stimulating local acceptance. The following sections provide recommendations for the management of hydrogen demonstration projects. A project starts with the selection of a proper site (section 4.2.1). Additionally, involving stakeholders in the project as early as possible is paramount. Sections 4.2.2 to 4.2.5 outline the objectives that early engagement may help achieve, including areas of attention for each objective. Section 4.2.6 provides practical recommendations on how to organize the engagement process.

4.2.1 Site selection

The first conclusion that follows from the above is that choosing an appropriate local context contributes positively to project success. A tool that supports selection of most suitable sites has been developed in the FP6 HyLights project (HyLights, 2008a). Currently, the tool is being reviewed and improved by means of stakeholder consultation and will be published during the course of the project (NextHyLights, forthcoming).

4.2.2 Understanding the local context

Table 4.1 lists a number of factors in the local context that *may* be important for project success. However, these factors are not equally important in a particular context – in fact, some may not be important at all. Engagement helps in identifying local politicians and public figures that are important, and whether providing local benefits such as employment opportunities is appreciated in the local context.

Furthermore, engaging with local stakeholders helps to uncover critical issues, possibly connected to expectations. Local residents may expect a hydrogen filling station to cause nuisances such as a lot of traffic. Expectations could also be too positive, e.g. envisioning that the project will lead to a transition of the larger part of vehicles in the neighbourhood to hydrogen over the course of the project. Understanding such expectations and issues is the first step in managing them.

4.2.3 Adapting the project plan according to the local context

Project success results from the fit between the project and its context. This fit can be improved by adapting the context to the project, but also by adapting the project to the context. Managing expectations is an example of the former approach – appropriately communicating project plans is in many cases sufficient to change the expectations in the local project context.

Other issues require an adaptation of the project plan. It may be possible that (slight) changes to the design of construction plans or changes of operation hours may alleviate the impact that a project has on its environment.

Project managers should incorporate flexibility in their project design before engaging with stakeholders. It is useful to plan a periodic evaluation to assess whether new issues that require project plan adaptation have come up.

During the process of project design revision, the original objectives of the project must be borne in mind. Although acceptance of a project may increase when project plans are adapted, such adaptations should not harm the main project goals.

4.2.4 Building trust

Since local stakeholders do not have knowledge on the impacts that hydrogen demonstration projects might have, they rely on information from trustworthy sources. Trust is an affective judgment – it does not (fully) rely on rational argumentation.

It is not unlikely that project partners in hydrogen projects meet with distrust. Project partners often include large corporations and governments, institutions that are often distrusted (Ricci et al, 2008).

Engagement may help to build trust between project partners and stakeholders. Engagement includes outreach activities. Recommendations for building trust can be summarised in engaging early, engaging yourself, and engaging honestly.

Engaging early is important to signal commitment. In the Hornchurch case study, lack of communication allowed a negative image of BP to develop. Engagement should thus start as early as possible.

Engaging yourself is especially important for the major institutions that may be involved in the projects. Sending company or government representatives shows more commitment than sending a consultant that has only been hired for the project. A consultant can be useful for providing support in the engagement process (in which the representatives are involved).

Engaging fully and honestly acknowledges the fact that trust is an affective judgment. A major pitfall is that statements will prove to be made dishonestly or incompletely at some point in time. It is very likely that the trust in the project is irreparably damaged from that moment onwards, even when the statement in case only concerned a minor aspect of the project.

4.2.5 Managing and communicating risks

Although hydrogen applications are typically considered safe and hydrogen is expected to be engineered to be safe, safety remains an important concern for project stakeholders. Indeed, it is technically possible to reach safety levels that are comparable to the levels associated with conventional fuels. Naturally, all reasonable efforts should be made to achieve these safety levels.

Despite these efforts, risk will always be involved. The remaining risks need to be communicated in an appropriate manner.

Again, a general recommendation is to be *open and transparent* in communicating risks (Midden & Montijn-Dorgelo, 2004). Hydrogen applications are unfamiliar and stakeholders have little background knowledge against which they can test the information that they receive. Therefore, they will process information according to the trustworthiness of the person and/or institution that communicate the information. Communicating in an open and transparent way builds the requisite trust.

The unfamiliarity of the technology is likely to lead stakeholders place hydrogen in the context of a comparable but familiar fuel. In the case of hydrogen this is likely to be natural gas. If this is the case, project partners can incorporate this in their risk communication. Specifically, a *comparison* between the risks of use natural gas (and optionally, other fuels) versus the risks of hydrogen can be made. Both similarities and differences should be pointed out.

4.2.6 Organizing the engagement process

Lessons for the practical organisation of the engagement process can be taken from the HyFLEET:CUTE project. Table 4.4 summarizes these lessons in a number of do’s and don’t’s.

The ESTEEM tool provides a process in which these lessons can be incorporated and by which the objectives of the previous section can be met. ESTEEM specifies six steps that ensure all challenges are addressed (Figure 4.1).

DO	**DON'T**
Recognize that stakeholder perceptions are important and must be addressed	Engage if you are not going to listen
Spend at least as much time listening as talking	Try and develop all the answers before starting engagement
Engage in a way that allows all stakeholders to be heard	Base engagement on pre-existing personal contacts instead of a systematic process to identify issues and stakeholders
Develop mutually-agreed processes for engagement	Assume silence means consent
Give time for social, informal contact before and after consultation to enable trust to develop	Assume that one engagement approach works with all
Recognize the time stakeholders give up to participate in consultation	Assume stakeholders have your timelines
Follow-up with stakeholders after meetings rather than waiting for them to follow up with you	Rely on technology to substitute for face-to-face communication
Maintain records	Use external consultants to manage the process
Provide clear boundaries of what is and is not possible	Engage only with friendly stakeholders

Table 4.4 *Do's and don't's from the HyFLEET:CUTE project (Rouvroy et al, 2008).*

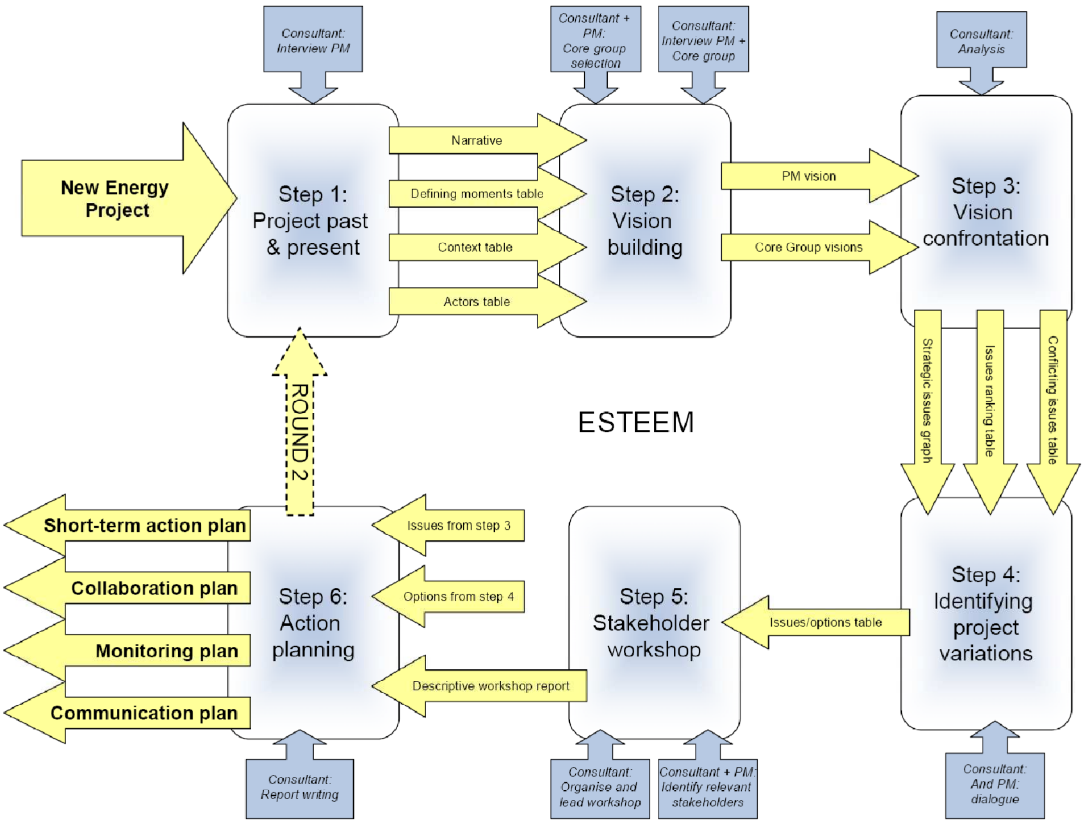

Figure 4.1 *Steps of the ESTEEM tool*

Following the ESTEEM process results in a better understanding of the local context (section 4.2.2). The process results in four plans that can be used to act on the better understanding:

- The *short-term action plan* lists actions that the project manager can take unilaterally, e.g. minor adaptations to the project plan (section 4.2.3).
- The *collaboration plan* lists actions that the project manager can only take in collaboration with others, e.g. additional studies for the project to be carried out jointly (section 4.2.3).
- The *monitoring plan* lists issues that cannot be solved immediately, and possibly not at all. It is still useful to keep these issues on the ‘radar screen’. The plan may also be used for periodic checks for new issues (section 4.2.3).
- The *communication plan* can be used to detail the means and content of communication, including risk communication (section 4.2.5).

We refer to the ESTEEM manual for details of the application of the tool (Jolivet et al, 2008).

5 Market acceptance

Market acceptance exists when people are willing to make use of hydrogen applications when the opportunity arises in their own context. In principle, market acceptance will only become relevant in the commercialisation phase - once vehicles are available in the showroom, i.e. beyond the large-scale demonstration phase that is the focus of NextHyLights. On the other hand, it is useful even in that phase to have information on whether market acceptance is to be expected and if so, under which conditions.

Since markets differ for the various types of vehicles, each vehicle type will be outlined in a separate section. Each section discusses expected market structure, to what extent market acceptance is to be expected, and how market acceptance can be stimulated.

5.1 Passenger cars

5.1.1 Market structure

It is expected that there will be two types of consumers in the market for passenger vehicles: private and business. Private consumers purchase vehicles for their own use and typically own only a few vehicles. Business consumers purchase vehicles for business use and may own a fleet of vehicles. Both types of consumers are served by car manufacturers and fuel providers (Figure 5.1).

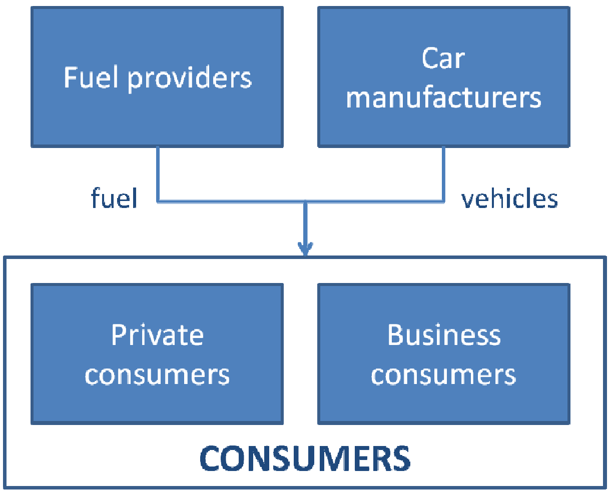

Figure 5.1 *Passenger car market structure*

5.1.2 Expected market acceptance

A literature review reveals that *private consumers* go through a two-step process when purchasing a vehicle (van Bree et al, 2010). In the first step, consumers select a vehicle class that fits their budget and needs. Within this class, they typically base their choice on safety, reliability and comfort.

FCVs are currently already able to match conventional vehicles in terms of safety, reliability and comfort. Therefore, market acceptance is conditional on the development of the following attributes:

- *Price*
  The majority of consumers is unlikely to accept a price that is (significantly) higher than that of a comparable conventional vehicle.
- *Fuel availability*
  The lack of availability of fuel is likely to lead to a perception that an FCV cannot fulfil all consumer needs, and may rule out FCVs in the first stage of the consumer purchase process.
- *Model availability*
  Consumers typically first choose a vehicle class and then opt for a vehicle within this vehicle class. Limited availability of models thus leads to a limited market acceptance.

Considerations are slightly different for *business consumers*. In their decision making process, there is a large emphasis on total cost of ownership (HyLights, 2008b). The major challenge in this segment is therefore to reduce costs to a level comparable to that of conventional vehicles. Note that total cost of ownership also includes cost items relating to reliability, lost time due to limited availability of refuelling stations, etc.

5.1.3 Stimulating market acceptance

Market acceptance can be stimulated by addressing the concerns highlighted in the previous section:

- The *cost* of vehicles can be brought down by technical improvements and economies of scale in mass production. Recent announcements of the automotive industry state that FCVs will be available at costs comparable to conventional vehicles when production volumes are scaled up (Anon., 2009). Government policy can help closing any remaining cost gap, by establishing a level playing field through either raising the cost of conventional vehicles or measures to reduce the cost of FCVs.
- *Model availability* and *fuel availability* are concerns to be jointly tackled by car manufacturers and energy providers. They need to ensure that model availability and refuelling station density develop in tandem and are geographically matched.

5.2 Buses

5.2.1 Market structure

Bus manufacturers and fuel providers supply bus operators. Bus operators use buses and fuel to deliver a service (transportation) to their consumers (Figure 5.2).

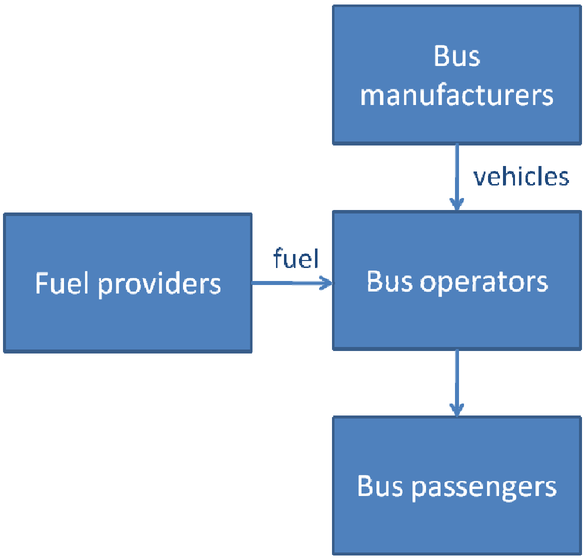

Figure 5.2 *Bus market structure*

5.2.2 Expected market acceptance

For *bus operators*, the following are requirements for market acceptance.

- *Reliability*, which has been proven to be in the same range as conventional buses. However, reliability of the next generation of fuel cell buses still needs improvement.
- *Refuelling processes* comparable to that of conventional buses. It is estimated that the provision of hydrogen at dedicated refuelling depots can be at cost comparable to conventional buses, but filling times are currently considerably longer.
- *Acceptance by bus drivers*. In the CUTE project, bus drivers rated the performance of fuel cell buses better or comparable to conventional buses, with the exception of brake and acceleration (Saxe et al, 2007). In the HyChain project, bus drivers were somewhat less satisfied with bus performance (Pietzner & Yetano, 2010).
- *Total cost of ownership (TCO)* comparable to conventional buses. Substantial cost reductions are required to achieve this level of TCO.

In the CUTE project, the requirements of *bus passengers* have been documented. Passengers considered safety, comfort, punctuality, frequency, and environment key factors of public transport (Haraldsson et al, 2006). Fuel cell buses score well on these criteria, with passengers reporting that

- they feel safe (Saxe et al, 2007), and
- comfort is better than on conventional buses (O'Garra, 2005; Saxe et al, 2007).

Additionally, passengers reported that fuel cell buses outperform conventional buses on

- appearance (O'Garra, 2005)

- noise levels (O'Garra, 2005; Saxe et al, 2007)
- vibrations (O'Garra, 2005), and
- fumes (O'Garra, 2005)

In theory, higher TCO for bus operators could be covered by raising bus ticket price. Several studies have therefore addressed the question whether bus passengers are willing to pay a higher price. Results have been mixed, ranging from a majority unwilling to pay more (Haraldsson et al, 2006), about equal shares willing and unwilling (Maack et al, 2004), and a general willingness to pay slightly more (O'Garra, 2005).

5.2.3 Stimulating market acceptance

The major barrier to market acceptance is the higher TCO of fuel cell buses. As with passenger vehicles, technological advancements are expected to bring costs down. Policy measures should be employed to close the remaining cost gap, if any.

5.3 Other vehicles

There is a wide variety of vehicles that can be equipped with fuel cells. Market structures depend on the exact type of vehicle, but are typically direct delivery to consumer (as with passenger vehicles, Figure 5.1) or delivery to a customer that employs the vehicle to deliver a (transport) service (as with buses, Figure 5.2).

The exact requirements for and status of market acceptance is dependent on the type of vehicle involved. A common barrier is that costs need to be brought down to a level that is acceptable. For business consumers, this typically implies that a feasible business case must be constructed. In some industries, the application of hydrogen might bring specific advantages over conventional technology that are favourable for the business case, implying that market acceptance in these niches might come early.

Measures to stimulate market acceptance vary per type of vehicle. Detailed discussion is beyond the scope of this report.

6 Conclusions and recommendations

A successful introduction of hydrogen as a fuel requires social acceptance. The objective of this report was to analyze the current level of social acceptance for hydrogen projects. This section summarizes the conclusions that the FCH JU can implement in future calls to stimulate acceptance of hydrogen projects.

6.1 Outlook for social acceptance of hydrogen projects

In this report, an analytical distinction between three types of social acceptance has been made: global, local, and market acceptance. For hydrogen demonstration projects, especially local acceptance is of importance – although a successful commercialisation of hydrogen requires all three types of acceptance. Each type has been analysed using existing studies, notably surveys and case studies in hydrogen demonstration projects.

From the literature review it appears that current acceptance levels are high. Related to *global acceptance*, experts, policy-makers and the general public are generally positive about the technology, although it must be noted that the view of the general public is rather uninformed. *Local acceptance* also appears to be high so far, with only a few projects meeting local opposition. The outlook for *market acceptance* is positive, provided that significant cost reductions can be realised once the vehicles enter the showroom.

The outlook for social acceptance of hydrogen projects is therefore positive, but is not a given. As other technologies that have previously enjoyed high acceptance levels, hydrogen technology may turn controversial, with plummeting acceptance levels as a consequence.

Relationships between global, local, and market acceptance provide insight in how such a scenario could develop. A drop in global acceptance can be initiated by disagreements among experts, e.g. on hydrogen’s greenhouse gas reduction potential. Such disagreements, when reported on by the media, may serve as a seed for a division of opinion in the general public. As a consequence, local and market acceptance may drop as well. Local residents now have a ground for resisting the construction of a hydrogen refuelling station in their neighbourhood – if experts disagree on greenhouse gas emission reductions, why build a station here? Consumers may turn sceptical as well – why invest in unfamiliar hydrogen technology when the greenhouse gas reductions are uncertain? Note that such opinions need not be based on objectively and independently established facts.

Conversely, project experiences (both good and bad) can spread from the local to the global context. In that sense, the large-scale demonstration phase will set the stage for social acceptance in the commercialisation phase. A bad reputation due to local controversies may also harm the market acceptance for hydrogen applications of a particular supplier.

6.2 Recommendations for the FCH JU

It is therefore paramount that measures be put in place to maintain the current high levels of hydrogen acceptance. As coordinating body for the next phases of the introduction of hydrogen, the FCH JU is in an excellent position to monitor and stimulate social acceptance.

In this respect, the FCH JU is recommended to take the following actions.

Stimulate *global acceptance*, by:

1. Implementing a periodic survey to monitor expert and policy-maker opinions on the application of hydrogen. The purpose of this survey is to spot and respond to controversial issues.(Extend with cooperation with other regions US/Japan or in cooperation with international bodies such as IPHE)
2. Implementing a monitor of public attitude towards hydrogen and its applications. The monitor should include a section on public values towards possible controversial aspects of the use of hydrogen as a fuel.
3. Based on survey results, create a communication plan to inform and educate the general public on hydrogen as a fuel. Communication efforts should complement planned demonstration projects and develop as the scale of implementation develops. It is likely that the public need for information increases with the scale of implementation, possibly with a focus on controversial topics.

Stimulate *local acceptance*, by:

4. Selecting sites with favourable conditions for local acceptance. To this end, it is recommended to extend the social acceptance section in the regions eligibility assessment tool. Moreover, the eligibility score of potential sites in the tool should be included in the selection procedure for the proposals for future hydrogen demonstration projects.
5. Requiring hydrogen demonstration project plans to include a section on stimulating local acceptance. This section should detail how local stakeholders will be engaged. The design of the engagement process should be such that the objectives outlined in section 4.2 can be met.

Investigate *market acceptance*, by:

6. Conducting a study to establish a business case for various applications of hydrogen.

The FCH JU can influence social acceptance at the programme level and at the project level. On the programme level, the multi-annual implementation plan 2008-2013 sets budget aside for cross-cutting activities, including socio-economic research and public education. The recommendations concerning global acceptance (1, 2, and 3) and market acceptance (6) can be implemented by designing calls for projects that carry out the activities that these recommendations specify within the budget set aside for cross-cutting activities.

The recommendations on local acceptance (4 and 5) need to be implemented at the project level, i.e. they need to be taken into account in future hydrogen demonstration projects. In the Calls for Proposals 2008-2010, vehicle demonstration projects are required to include activities that improve public awareness in their proposals. It is recommended that these requirements are expanded and that the calls and proposal selection procedures for future demonstration projects take into account the score of a site in the regions assessment tool (recommendation 4) and the project's proposal on engaging local stakeholders and stimulating local acceptance (recommendation 5).

References

Hydrogen Hopes: Hydrogen Speeds Up Preparation for Fuel-Cell Cars. Der Spiegel, March 26, 2009. http://www.spiegel.de/international/germany/0,1518,615673,00.html.

Achterberg, P., D. Houtman, S. van Bohemen, K. Manevska (2010): *Unknowing but supportive? Predispositions, knowledge, and support for hydrogen technology in the Netherlands.* International Journal of Hydrogen Energy, 2010, 35, p. 6075-6083.

Altmann, M. & C. Gräsel (1998): *The acceptance of hydrogen technologies*, 1998.

Altmann, M., P. Schmidt, S. Mourato, T. O'Garra (2003): *Analysis and comparisons of existing studies*. AcceptH2 Work Package 3 Final Report, 2003.

De Best-Waldhober, M., D. Daamen, A. Faaij (2009): *Informed and uninformed public opinions on CO2 capture and storage technologies in the Netherlands.* International Journal of Greenhouse Gas Control, 2009, 3(3), p. 322-332.

Dinse, G. (1999): *Hydrogen vehicles and their ambiance - An analysis of the technical, political and social dimensions*, Technical University Berlin, Berlin, 1999.

Feenstra, C.F.J. & T. Mikunda (2010): *What happened in Barendrecht?!* ECN-E--10-057, ECN, Amsterdam, 2010.

Haraldsson, K., A. Folkesson, M. Saxe, P. Alvfors (2006): *A first report on the attitude towards hydrogen fuel cell buses in Stockholm.* International Journal of Hydrogen Energy, 2006, 31, p. 317-325.

Heinz, B. & G. Erdmann (2008): *Dynamic effects on the acceptance of hydrogen technologies - an international comparison.* International Journal of Hydrogen Energy, 2008, 33, p. 3004-3008.

Heiskanen, E., M. Hodson, R.M. Mourik, R.P.J.M. Raven, C.F.J. Feenstra, A. Alcantud, B. Brohmann, A. Daniels, M. Di Fiore, B. Farkas, U. Fritsche, J. Fucsko, K. Hünecke, E. Jolivet, M. Maack, K. Matschoss, A. Oniszk Polawska, B. Poti, G. Prasad, B. Schaefer, R. Willemse (2007): *Factors influencing the societal acceptance of new energy technologies: Meta-analysis of recent European projects*. ECN-E--07-058, 2007.

Hickson, A., A. Phillips, G. Morales (2007): *Public perception related to a hydrogen hybrid internal combustion engine transit bus demonstration and hydrogen fuel.* Energy Policy, 2007, 35, p. 2249-2255.

Hodson, M. (2006): *London CUTE hydrogen fuelling station*. CreateAcceptance Case 20, 2006.

HyLights (2008a): *Regions Eligibility Self Assessment Tool for Hydrogen Projects in Transport*, 2008a.

HyLights (2008b): *The GAPS analysis - minimal user requirements for hydrogen vehicles*. HyLights D4.3, 2008b. www.hylights.eu.

Jasper, J.M. (1988): *The Political Life Cycle of Technological Controversies.* Social Forces, 1988, 67(2), p. 357-377.

Jolivet, E., R.M. Mourik, R.P.J.M. Raven, C.F.J. Feenstra, A. Alcantud, E. Heiskanen, M. Hodson, B. Brohmann, A. Oniszk Polawska, M. Di Fiore, U. Fritsche, J. Fucsko, K. Hünecke, B. Poti, G. Prasad, B. Schaefer, M. Maack (2008): *General Manual for the application of the ESTEEM tool*, 2008. http://www.esteem-tool.eu/fileadmin/esteem-tool/docs/ESTEEMmanual.pdf.

JRC, Concawe, EUCAR (2007): *Well-to-Wheels Analysis of Future Automotive Fuels and Powertrains in the European Context*, 2007.

Lane, B. & S. Potter (2007): *The adoption of cleaner vehicles in the UK: exploring the consumer attitude-action gap.* Journal of Cleaner Production, 2007, 15, p. 1085-1092.

Maack, M., G.J. Kristinsdóttir, H. Ögmundardóttir, L. Guðmundsdóttir, H.Þ. Ingason, B. Davíðsdóttir, K. Benediktsson, S. Þóeðardóttir, K. Georgsdóttir (2008): *Social aspects of introducing hydrogen as a fuel*. D5.4, HyFLEET:CUTE, Reykjavik, 2008.

Maack, M., K.D. Nielsen, H.T. Torfason, S.O. Sverrison, K. Benediktsson (2004): *Assessment of socio-economic factors with emphasis on: public acceptance of hydrogen as a fuel*. ECTOS Deliverable 12, 2004.

Maack, M. & T.H. Schucan (2006): *Ecological City Transport System*. IEAHA Case Study, 2006.

Midden, C. & F. Montijn-Dorgelo (2004): *Developing and introducing hydrogen technology, an analysis of social psychological factors*. Paper written for NWO programme CW/ACTS, 2004.

O'Garra, T. (2005): *Comparative Analysis of the Impact of the Hydrogen Bus Trials on Public Awareness, Attitudes and Preferences: A Comparative Study of Four Cities*. AcceptH2 D6.9, 2005.

O'Garra, T., S. Mourato, P. Pearson (2008): *Investigating attitudes to hydrogen refuelling facilities and social cost to local residents.* Energy Policy, 2008, 36, p. 2074-2085.

Pietzner, K. & M. Yetano (2010): *User perceptions and public attitudes towards hydrogen fuel cell vehicles in the EU.*, Presentation at the World Hydrogen Energy Conference 2010, Essen, (2010).

Ricci, M., P. Bellaby, R. Flynn (2008): *What do we know about public perceptions and acceptance of hydrogen? A critical review and new case study evidence.* International Journal of Hydrogen Energy, 2008, 33, p. 5868-5880.

Romm, J. (2006): *The car and fuel of the future.* Energy Policy, 2006, 34, p. 2609-2614.

Rouvroy, S., A. Rickard, N. Whitehouse, S. Whitehouse, V. Tsatsami, M. Kentzler (2008): *People, Transport and Hydrogen Fuel*, HyFLEET:CUTE, 2008.

Saviko Consultants (2006): *Problems of acceptance, analysed prior to vehicle demonstration*. Zero Regio D7.5, 2006.

Saxe, M., A. Folkesson, P. Alvfors (2007): *A follow-up and conclusive report on the attitude towards hydrogen fuel cell buses in the CUTE project - From passengers in Stockholm to bus operators in Europe.* International Journal of Hydrogen Energy, 2007, 32, p. 4295-4305.

Schmoyer, R.L., T. Truett, C. Cooper (2006): *Results of the 2004 knowledge and opinions surveys for the baseline knowledge assessment of the US Department of Energy Hydrogen Program*. ORNL/TM-2006/417, Oak Ridge National Laboratory, Oak Ridge (TN), 2006.

Schoots, K., G.J. Kramer, B.C.C. Van der Zwaan (2010): *Technology learning for fuel cells: An assessment of past and potential cost reductions.* Energy Policy, 2010, 38, p. 2887-2897.

Slovic, P., B. Fischhoff, S. Lichtenstein (1980): *Facts and Fears: Understanding Perceived Risk.* Societal Risk Assessment: How Safe Is Safe Enough?*,* eds. R. C. Schwing, W. A. Albers, Jr., Plenum, New York, pp. 181-214.

van Bree, B., G.P.J. Verbong, G.J. Kramer (2010): *A multi-level perspective on the introduction of hydrogen and battery-electric vehicles.* Technological Forecasting and Social Change, 2010, 77(4), p. 529-540.

Wüstenhagen, R., M. Wolsink, M.J. Bürer (2007): *Social acceptance of renewable energy innovation: An introduction to the concept.* Energy Policy, 2007, 35, p. 2683-2691.

Zimmer, R. (2010): *Acceptance of Hydrogen Technologies and the Role of Trust.*, Presentation at the World Hydrogen Energy Conference 2010, Essen, (2010).