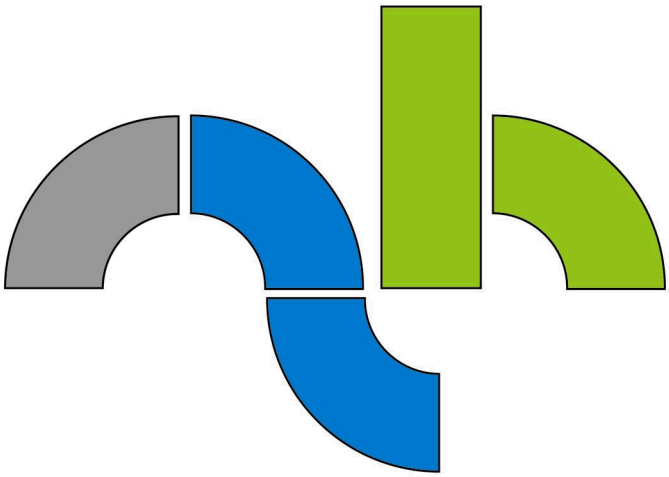

Roads2HyCom

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Work Package 1, Task 1.6, Deliverable 1.6

EXISTING ACCEPTANCE ANALYSIS IN THE FIELD OF HYDROGEN TECHNOLOGIES

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Document Number: R2H1007PU

Date: 11 April 2007

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EXISTING ACCEPTANCE ANALYSIS IN THE FIELD OF HYDROGEN TECHNOLOGIES

1. Introduction

Roads2HyCom is a project to assess and monitor Hydrogen and Fuel Cell technology for stationary and mobile energy applications by considering what the technology is capable of, relative to current and future Hydrogen infrastructure and energy resources, and the needs of communities that may be early adopters of the technology.

This study is part of a package of work aimed at characterising the “state of the art” in European technology development in the field of Hydrogen and Fuel Cells. Complementing a review of the “Technical State of the Art” in the elements of Hydrogen and Fuel Cell technology, it aims to provide insight into the “public acceptance” of Hydrogen and Fuel Cells.

Hydrogen may become one of the main energy carriers of the future, because it produces less local air pollution than fossil fuel based energy, and can be manufactured from a wide variety of sustainable and carbon-free sources. High investments are made for developing hydrogen technology and applications. Rising public expenditures give rise to the concern whether the public will accept the change in its energy system. Are associations with hydrogen still related to Hindenburg´s accident with a zeppelin or with a hydrogen bomb? There is still little attention to public acceptance in hydrogen related research.

In the eyes of the public, it is often difficult to separate the use of Hydrogen as a fuel, from the fuel cell as a device to turn Hydrogen into useful power. Generic issues of performance, cost and reliability must be addressed as for any new product, but for some less visible applications, attitude might be, “if it does the job, people will accept it”. An exception might be vehicles, especially passenger cars, where there is heavy interaction between the driver (purchaser) and the car’s engine (accelerator inputs, engine noise). The fuel cell offers a “different” driving experience. This review focuses on Hydrogen as a fuel, but also considers the devices, such as Fuel Cells, that use it.

The purpose of this paper is to look at the state of art in acceptance analysis on hydrogen. It summarizes what has been written so far, analyses some of the critical points and draws conclusions on what stakeholders could undertake in order to raise acceptance and to engage European regions in the uptake of Hydrogen as an energy vector.

Acceptance Analyses are of great importance for introducing a new technology into the market. Even if the technical bottlenecks have been solved, the public still needs to be convinced of the advantages of an upcoming new product. It is indispensable to look at the motivations, attitudes, fears and hopes of the final users. New technologies that may bear risks and ought to be used by the public (be it in form of a product like electricity or be it in a direct form like a fuel) depend on acceptance by the public. Nuclear energy or genetically modified organisms can be seen as examples of how the public acceptance has shaped the market development of those technologies.

Looking at the different life cycle of Hydrogen (production, distribution and use of hydrogen it becomes evident that:

a) all parts of a hydrogen economy are affected by public acceptance and

b) technical maturity is but one factor that may make an introduction into the market successful.

Acceptance, i.e. market demand driven by a broad public understanding forms the other side of the coin and might even be regarded as the most important factors for success in the end.

Therefore, it is vital to find out how the public currently perceives hydrogen as an energy carrier and what feedback could be given to producers and how the engagement of the broader public might be increased.

Additional questions that are useful to answer are for example:

- How does the public develop a trust approach and confidence towards a new technology? Some elements of acceptance are certainly reliability, low risk and problem solving capacity.

- Does acceptance generally increase automatically over time or is it driven by i.e. external factors, such as climate change, moving away from oil dependency, etc.

Nevertheless, acceptance analyses are often very limited and rather go into the analysis of single demonstration projects. It might therefore be worth looking into detail how the wider and narrower public can be involved in the process of setting up a hydrogen economy.

2. State of the Art in Literature

Only a few studies already exist (i.e. Altmann 1998, Hickson 2006, Maak, Skulason 2006) analyzing the acceptance of hydrogen in the general public. A lot of these studies were carried out in Germany, but there are also studies to be found in Iceland, UK, Canada and the Netherlands. What immediately catches ones eyes is that all of them are looking at acceptance in the transport sector and here mostly public transport, such as buses and taxis. There is no study yet taking into account neither the entire production line of hydrogen nor other possible field of applications such as stationary or portable applications. The first study looking at the acceptance of hydrogen in the public was conducted in 1998, before that date only studies covering the acceptance of alternative fuels in vehicles and electric vehicles could be found.

We will look shortly into the existing acceptance studies that are already made public, state if possible and known name of the project, methodology, who has been interviewed and what the results are. Some of the studies below have been taken out of the literature overview made by the project AcceptH2 in 2003. Some more projects were added. Later on the chapter will shortly wrap up the most important results of all studies and goes into some aspects written in past studies that were concerned with introducing new environmental friendly technologies but not hydrogen.

1. 2006

Authors: Hickson, A., Phillips, A. Morales, G.

Title: Public Perceptions related to a Hydrogen Hybrid Transit Demonstration and Hydrogen Fuel

Examines public perceptions of riders of a hydrogen hybrid internal combustion engine bus and hydrogen as a fuel source in Winnipeg, Canada. The bus was approximately operated for 20 cycles in across city service passing through several inner city areas. A total of 369 surveys were collected. The study lets participants compare the hydrogen bus with conventional buses regarding bus comfort, smoothness of acceleration and stopping, noise level and temperature comforts. Another part of the survey sought the respondent's perception of the use of hydrogen as a fuel.

Results:

The following results of the bus rider survey in Winnipeg were articulated:

- Riders appear to prefer hydrogen hybrid bus technologies when compared to conventional technologies.
- There is a strong overall support for hydrogen as a motive fuel.
- Support for hydrogen as a fuel appears to be greater amongst males than females.
- More frequent bus users are more positive toward the introduction of hydrogen technologies.

2. 2006

Project: ECTOS- Ecological City Transport System (Iceland)

Authors: Maack, M.H.; Skulason, J.B.

Title: Implementing the hydrogen Economy/ Assessment and evaluation of socio-economic factors

In the cadre of the ECTOS project a reference public survey was already conducted in December 2001 for reference purpose. The Institute for Applied Sociology of the University of Iceland performed a telephone interview with 1154 people regarding issues around hydrogen. The questions were rather general and short. Gender and education did not play a role in this interview.

The second survey was conducted in March 2004 in which actual passengers and other commuters in Reykjavik were asked to answer to a more detailed questionnaire. In April 2003 the first electrolytic hydrogen production, compression and filling station was inaugurated in Reykjavik The most important feature was the question whether individuals are willing to pay for fuels that are clean and made domestically, therefore would make Iceland independent of imports. The survey was taken in hydrogen buses as well as conventional buses. To be more precise, the questionnaire was put to 50 passengers on hydrogen buses, 50 passengers on diesel buses on the same route, 50 people on the street near to the bus stops and to 50 people that are living closely to the main bus routes where FC hydrogen buses were operating.

Results:

For the first short survey before Hydrogen buses were operating in Iceland 93 % responded to have a positive stand towards using hydrogen as a main fuel for buses, ships and cars. A lot would like to have more information regarding hydrogen, especially the young and women. In general the outcome was more positive than expected.

The attitude question in the second questionnaire gave similar results amongst the passengers of hydrogen and conventional fuel buses. A vast majority connected hydrogen to water, clean fuel and clean environment even though they were given the option of bombs, burning Zeppelins and expensive technology. Regarding their willingness to pay, a majority of the participants claimed to be willing to pay 10-20% higher prices for hydrogen during an introduction phase. Regarding safety, most people considered hydrogen as a save fuel or indicated that they did not know. Regarding the awareness of the ECTOS project going on, half of the participants indicated that they saw hydrogen buses in the city, but more than 40% also indicate that the test had been little or very little presented to the public.

3. 2005

Project: AcceptH2

Authors: O'Garra, T.

Title: **Comparative Analysis of Impact of Hydrogen Bus Trials**

Represents findings from 4 studies carried out in London, Berlin, Luxembourg and Perth. Studies used survey based methods to investigate public knowledge, perception and attitudes towards hydrogen fuel cell buses. In each of the cities a similar study was conducted before the bus trials started. The studies used survey based methods to investigate public knowledge, perception and attitudes towards hydrogen fuel cell buses and estimate willingness to pay for the introduction of hydrogen buses in the associated cities. The comparative analysis of ex post and ex ante data aimed at assessing the actual influence the buses has on public perception.

Results:

Awareness of hydrogen vehicles before the actual bus trials were highest in Berlin, which could be explained by the fact that Berlin had already bus trials in earlier years. It can also be stated that ex post the inhabitants of Perth and Luxembourg are most aware of the H2 bus trials in their city. The reason might be the size of the city, where the bus trials took place (H2 buses are more visible in smaller cities, such as Perth), but can also be explained by the campaigns that were taking place along side the trials. In Perth there has been major campaigning associated for the project, involving brochures, school visits, TV Programs and radio commercials etc. Luxemburg also had radio commercials and more than 1000 people participated in a guided tour. In London only little attention was given to advertisements; the same holds for Berlin. Support for large scale introduction of hydrogen buses was significantly higher in each city after the bus trials. However support for large scale introduction of hydrogen buses is not matched with an increased willingness to pay for such an introduction. The willingness to pay for the ex post survey was about 0.35 Euros for all cities and did not change from the ex ante survey.

4. 2003

Authors: Mourato, S., Saynor, B., Hart, D.

Title: Greening London's Black Cabs: a study of driver preferences for fuel cell taxis.

A survey with cab drivers in London was conducted in April to May 2001. 99 responses to the survey were received which tried to understand the user benefits and factors of demand for a successful market penetration of hydrogen technologies in vehicles. A contingent valuation method was used and investigates the preferences of London's taxi drivers for driving emissions free taxis in short and long term.

Results:

The results show that there the willingness to pay in the short term is usually driven by the driver's expectations for individual gains. Regarding long term issues it seems that environmental considerations are found to affect taxi driver's long term vehicle demand decisions. Safety concerns were found not to be very prominent among taxi drivers in London.

5. 2003

Funded by: partly BMW; Study conducted by 5 students with different backgrounds (business administration, chemistry, mechanical engineering, politics, European economics)

Authors: Lossen, U., Armbruster, M., Horn,S., Kraus, P., Schich, K.

Title: Factors influencing the market success of vehicles powered by hydrogen.

The study comprises two parts. Part one contains a qualitative investigation with 37 high executives in the areas of science, industry and public sector. They were interviewed about their views on hydrogen as a fuel. The second study was an internet survey in which 417 people took part. The objective has been to determine the opinion of the German population regarding hydrogen technology and deriving from there conclusions and recommendations for economics and politics.

Acceptance of hydrogen has been looked at by analyzing 5 important factors, which were by at least two indirect items (Advantages, price, safety, performance and flexibility). Mostly, statements were used to which participants could indicate their consent, dissent on a four level scale.

Results:

It is cleat that the internet survey does not result in a representative data collection.

Main result was that the both the executive interviews and the internet survey revealed a positive attitude towards hydrogen as a fuel. This in fact correlates with technology proximity. Concerns about safety issues were noticeable but not major. Information need to be spread more widely for further increase of acceptance.

The internet survey had 5 blocks with the following content:

- General environmental consciousness
- Acceptance, expectation, prejudice
- General knowledge on hydrogen
- Technical knowledge on hydrogen
- Social statistics

The results show that the general environmental consciousness seems to be high. It also reveals like other surveys that knowledge regarding hydrogen is generally low, but also that a good technical knowledge on hydrogen does not necessarily increases the acceptance of hydrogen, though the general level of education has an influence. The internet survey comes up with four statements that have been approved or disapproved:

The introduction of hydrogen cars is accelerated by improved information policies for the general public could not be disproved.

The introduction of hydrogen cars is accelerated by comparably low hydrogen fuel prices could be confirmed.

The introduction of hydrogen cars is accelerated by performance levels of hydrogen cars comparable to conventional cars is partially disproved as the performance aspect has not bee seen as very important.

The introduction of hydrogen cars is accelerated by a good availability of hydrogen filling stations is confirmed.

6. 2001

Funded by: VAG Nürnberg

Survey of the passengers of the MAN hydrogen fuel cell bus

156 bus passengers were interviewed during a trial period of a hydrogen bus. The questionnaire did not have an scientific purpose.

Results:

Bus passengers noticed the low noise level and favored the support of the technology because of the low noise level and environmental friendliness. They also mentioned that they appreciated the activity of the VAG Nürnberg in this regard. A large majority supported the idea of more hydrogen operated buses and apparently would even accept a slight ticket price increase for that.

Interview with 156 bus passengers.

7. 2000

Author: Gundi Dinse – Institut für Mobilitätsforschung BMW

Title: Acceptance of hydrogen vehicles-A study on the use of a new and unusual fuel.

Thousand employees out of 16324 employees of the BMW group in Germany have been randomly selected for a survey; most of them in Munich. 593 have returned their filled in questionnaire. The objective of the initiative was to develop strategies

for increasing the acceptance of hydrogen fuel. It must be noted that BMW is involved in hydrogen vehicles since the 70s and therefore it can be assumed that most of the staff members had heard about the BMW hydrogen program before.

24 hypothesis were developed. Those were then compared to the result of the written questionnaire, which contained 56 mostly closed questions.

Results:

The study shows that hydrogen as a fuel is widely accepted among BMW employees. The acceptance rate is even higher among male and well educated staff. A high rate thinks that hydrogen has the potential of replacing conventional fuels in the longer term, even though a lot of risk is involved and prices need to decrease and an usable infrastructure needs to be established. The conservation of the environment was seen as the main benefit.

To increase further the acceptance of hydrogen as a fuel, more educational activities should be pursued. Especially schools and universities should be in the focus. Customers should actually be given the opportunity to experience the vehicle themselves.

8. 1999

Institut Für Mobilitätsforschung

Author: Gundi Dinse

Title: Hydrogen Vehicles and their ambiance- an Analysis of the technical, political and social dimensions.

150 randomly selected people at six different public locations in Berlin were carried out in fall 1998. All locations were relatively crowded areas with high numbers of tourist.

The interviews took only ca. 5 minutes and open questions were used:

- Association with hydrogen
- What can hydrogen be used for
- Where have you gathered your knowledge on hydrogen
- Have you already heard about hydrogen powered vehicles, what do you think about it, are you interested in it
- Would you like to know more about hydrogen vehicles and what do you want to know
- Do you know other alternatives to diesel and gasoline driven vehicles

- Social data

Results:

Associations were mostly neutral and to about one fifth negative or positive. The Hindenburg accident was hardly mentioned. Looking at age specific analysis shows that the interviewed below 20 see hydrogen very rarely as an energy of the future. Regarding the possible use of hydrogen 4à% mentioned energy related issues and 25 % said that they do not have an idea. Men related hydrogen in 52% to energy related issues whereas only 14% of the women did so. The most important information source seems to be the school. Surprisingly 61% new about hydrogen vehicles, which is higher than the percentage of interviewees mentioning energy related uses of hydrogen. Three quarter of the persons knowing about hydrogen vehicles are also interested about them.

In general the study confirms the HyWeb analysis that knowledge on hydrogen is low, but Germans are open and interested.

9. 1998

Project: HyWeb

Authors: Matthias Altmann and Dr Cornelia Gräsel

Title: The acceptance of hydrogen technologies

This three part study was conducted in Germany to ascertain the level of knowledge about hydrogen technologies and to establish whether there was a demand for additional information about hydrogen technologies. Two population groups were intervened, secondary school students and passengers on a hydrogen powered bus. Students that rode the bus were analyzed separately. The objectives were to analysis whether the general public considers new technologies in this case hydrogen as dangerous, rejects it or greets it. Three overall questions pursued the study:

1) What level of acceptance is there for hydrogen technologies?

2) What knowledge is there about hydrogen technologies or what is the association with the term hydrogen?

3) Is there a demand for information about hydrogen technologies?

The goal of the overall project HyWeb in which this study has been incorporated is to increase knowledge and acceptance of hydrogen technologies. (www.hyweb.de)

First Study: Three schools (Munich, Oldenburg and outskirts of Munich) and in total 410 secondary students from grade 11-13 participated. They were questioned about their acceptance, their knowledge and need for information about hydrogen. The issues questioned were recorded with a multiple choice system which could be answered on a 5 point scale.

In the first part the students were asked to name everything they could think of related to hydrogen. This exercise should show whether students relate hydrogen to positive or negative issues. More than half related hydrogen to chemistry and only 12% to something negative.

Second Study: The survey was conducted of 145 passengers using a hydrogen powered bus in Munich, Germany. Every 10th person entering the bus was questioned. The survey was very similar to the one used for the students but shorter. Aspects inquired were:

- Passengers were ask to name all associations they have towards hydrogen
- Environmental awareness
- Acceptance of hydrogen powered transportation

Third Study: For some comparative analysis, 24 students that have been interviewed in the bus and which had the same age group as the ones analyzed in the schools were considered.

Results:

In summary, both the students and the bus passengers has a high level of acceptance for hydrogen technologies. Even though there are people that see a certain explosion danger there does not seem to be any acceptance problem. Negative associations such as the Hindenburg disaster do not seem to play a role anymore. However the knowledge of hydrogen technologies is extremely low. This result was surprising since people tend to reject new technologies about they know very little.

But the study also shows, if only a slight increase in acceptance if people were in contact with the technology, such as the persons interviewed in the buses.

Another surprising result is that environmental issues have only limited influence on acceptance.

Concluding

Looking at all the studies that have been conducted it appears that the support for hydrogen is generally high, but that the knowledge about hydrogen and fuel cells is rather low. Males and people with higher formal education have a higher knowledge on hydrogen technologies than females and people with lower education. There is practically no opposition to the introduction of hydrogen as a fuel and hydrogen vehicles, though many people would like to get more information or do not feel well enough informed. Environmental concerns do not play a very big role in the short term. In the longer term Mourato et al finds some indication for environmental concerns being a factor influencing purchase decisions of cab drivers.

2.1 General Literature

As mentioned already before, the availability of specialized reports are rather limited. And we would like to look at more general publications for factors that influence consumer decision when switching towards a new technology.

For example Stobart (1999) regards customer satisfaction the overarching factor that influences people to switch from one technology to another. A positive public attitude can only be derived it services are offered to customers that are comparable or better than the current ones. It is important that the new technology is convenient and safe and a trust relation can be build upon (Midden and Monthijn-Dorgelo 2004). Midden's and Monthijn-Dorgelo's paper suggests to follow a strategy of openness in order to build trust and credibility from the start.

Customer satisfaction is a very subjective matter and depends on a lot of personal factors such as personality, educational background and interests (Buchan 2000). Whether a potential customer is interested in clean technology depends on for example his or her opinion towards environmental issues. This in turn means that an approach in which environmental benefits is used as the sole selling factor is not a very successful method for all individuals (Schulte et al. 2003).

An OECD (2002) study mentions the following factors as personal barriers for a new technology to penetrate the market:

1) Lack of awareness
2) Cognitive dissonance
3) Lack of concern for future generations
4) Fear of and thus resistance to change
5) Lack of adequate professional advice

The first and last point is very individual and depends on education in environmental issues. Point three can be seen as apathy, having a disinterest of being involved, which is often a consequence of the person not being directly affected by the problem. The fourth and second point relate to problem aversion and hostility showing that the advantages of the new technology, in our case hydrogen, needs to be communicated in such an extent as the environmental benefits. Only a broad range of arguments will lead to success since customers will be able to make a well thought through decision.

For a vehicle running on a next fuel the infrastructure and the fuel price is particularly important (Sperling et al. 1986). Though, he also mentions that the predictability of fuel station locality compensates partly for reduced fuel availability. This is an important point for the setting up of a hydrogen infrastructure and implies that a well planned network can reduce the number of stations needed.

Also Spitzley (2000) looked at factors that influence consumers to switch to alternative fuel vehicles. He is mentioning 6 major factors:

1) Performance
2) Fuel Consumption
3) Noise and Vibration
4) Cost to Consumer
5) Durability
6) Safety.

He points out to the essential that a new technology needs to be exceptional in at least one of the points. Even though Fuel Cell cars outperform conventional cars regarding Noise and Vibration, the costs are a matter that is of high importance for the acceptance of a new technology.

As mentioned before, education is very significant for an increasing acceptance of hydrogen as a new technology. Up to now most of knowledge has been distributed by specialized journals or web sites. The mass media still does not cover the subject Hydrogen as a new fuel. Starting coverage by the mass media might change the attention of the public given to hydrogen (Molin 2004).

The literature shows that the acceptance of a new product or technology depends on various factors. Schulte et al. (2004) tried the most important factors into a qualitative model that is visualized in the following figure.

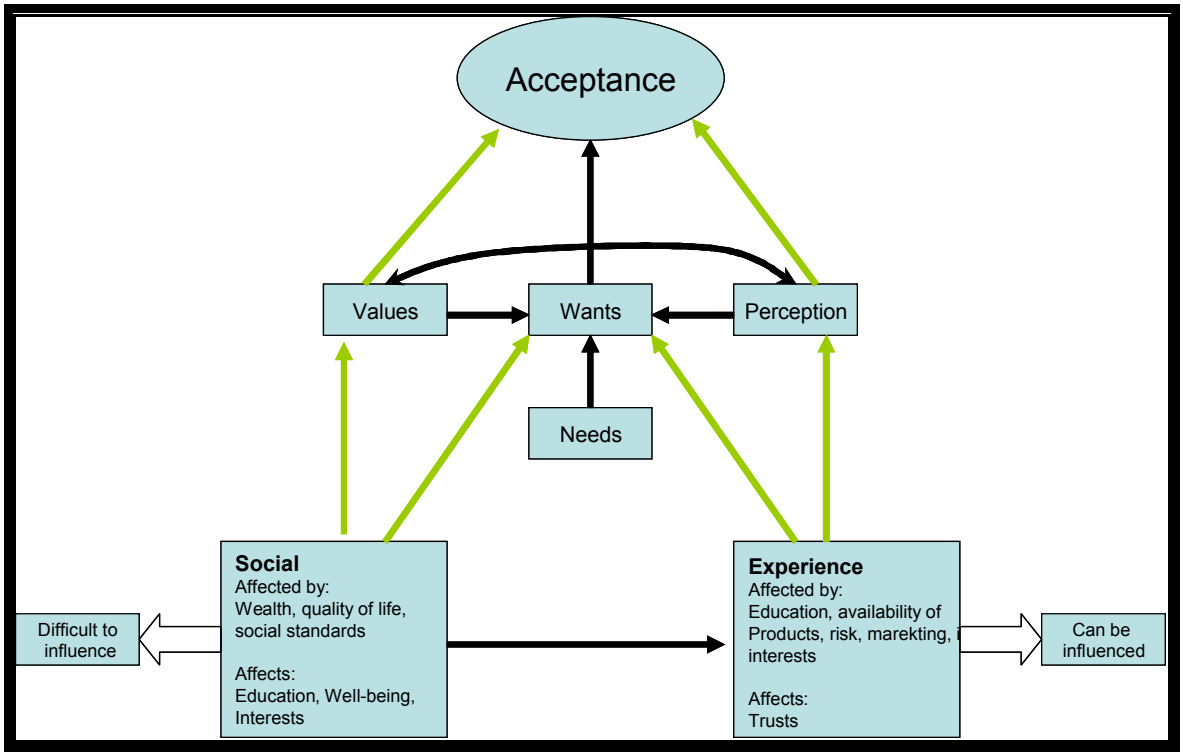

Figure 1: Acceptance is a combination of values, perception and wants. They are affected by the social background and experience of the person in question (based on Shulte et al., 2004)

3. Critical points of discussion and conclusion

Up to now the article looked into existing literature that deal with acceptance issues around hydrogen and other alternative technologies. The acceptance studies that have been conducted were usually incorporated in a single demonstration project and do not have further influence in the development of other projects and the development of hydrogen as a future energy carrier. Acceptance Studies on demonstration projects are usually very limited in scope. The only study that compares also over geographical zones is the one by O´Garra et al. (2005), looking at bus projects in 4 different cities in 4 different countries.

One needs to be very careful with the results as most of the studies were partly attitude analyses in which participants tend to answer more positive than in real life situations.

Missing so far within the scope of those studies are analysis of participation of users in designing demonstration projects; critical appraisal of costs; critical appraisal on the willingness of actors to become engaged either as investor or risk-taker as producer or user. Acceptance in regions on whole H2-Systems remains largely unaddressed. There should be an attempt to address means of cooperation and participation rather than (passive) acceptance.

The theory of constructive technology assessment CTA (Schulte 2001 and 1997), developed in the Netherlands and Denmark, is of particular interest here. CTA concentrates on dialogue among and early interaction with new actors. It proposes to bring all interested parties together as early in the design process as possible. A basic principle here is the inclusion of a variety of social actors in addition to technical experts. The actors to involve in CTA can roughly be grouped in 4 categories; First there are the technology actors that invest in and maintain technology developments. Secondly there are the societal actors that experience the impact of a new technology. Those are users, citizens, workers, etc. Thirdly, regulatory actors are those that develop rules and regulations for the new technology. The fourth group that is often mentioned in the context of CTA are the meta actors who are responsible for facilitating and moderating interactions among the other actors.

Firms are starting to anticipate the prospective social effects when developing sensitive technologies (Schulte 2001). The goal must be to embed anticipation as a regular frequent activity that begins early in the technology design process and to encourage reflexive and learning processes to come up. It is important to let customers experience the new technology from the start on.

There are a lot of participatory methods available for technology assessment that should be more frequently used in hydrogen applications. Single and simple attitude studies will in the end not result in any success. The connection between different demonstration projects and the development of acceptance analysis across projects could be an approach in order to end up in a system set up for regional hydrogen acceptance.

Notwithstanding these issues, evidence to date indicates reasonable acceptance of Hydrogen and Fuel Cell technologies compared to other emerging or advanced fields such as nuclear energy and genetic engineering. Of course it is important to recognise that acceptance of a limited and carefully managed demonstration is a different matter to acceptance of an individually purchased product. However, any "game-changing" technology can be expected to bring problems (for example, instances of fraud and trading indecent material on the Internet), and the acceptance issues associated with such problems should not be seen as an insurmountable barrier.

How the general public could be better included into the technology development process will be discussed in Work Package 7 of the Roads2HyCom Project. The Work Package will make some recommendations how communities could interact with the various stakeholders from the beginning onwards, which will be an important step in ensuring strong public acceptance.

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