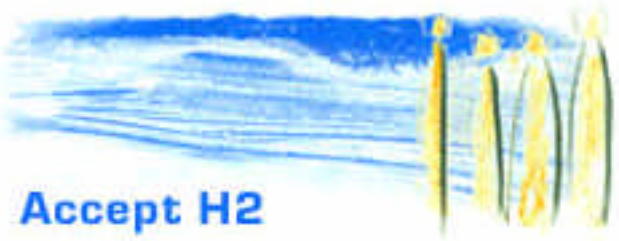

Work Package 3

ANALYSIS AND COMPARISONS OF EXISTING STUDIES

Final Report

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Public Acceptance of Hydrogen Transport Technologies

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3 WP3 ANALYSIS AND COMPARISONS OF EXISTING STUDIES

Only very few studies exist analysing the acceptance of hydrogen technologies in the general public and in more specific target groups.

Most of these studies have been carried out in Germany, so that very little information is available about other countries. In Germany, all studies indicate that in general the level of acceptance of hydrogen vehicles and hydrogen fuel is relatively high. At the same time, the general knowledge about the subject is rather low.

This is a rather unusual situation, as generally a low level of general knowledge on a subject results in a rather low level of acceptance or, put in other words, is a reason for uncertainty and fears.

In the following subchapter, the existing studies on the acceptance of hydrogen technologies are presented in some detail.

In the second subchapter, empirical literature on public preferences for clean vehicles and fuels in general is reviewed including the major studies on hydrogen acceptance.

3.1 Analysis of hydrogen acceptance studies

3.1.1 The Acceptance of Hydrogen Technologies – Die Akzeptanz von Wasserstofftechnologien

Executed by: Matthias Altmann (Ludwig-Bölkow-Systemtechnik GmbH [now L-B-Systemtechnik GmbH], Ottobrunn, Germany), Dr. Cornelia Gräsel (Ludwig-Maximilians-Universität München, Germany; Dr. Gräsel is now Professor at Saarland University, Saarbrücken, Germany). The study was funded by the European Commission.

Place and time: Study 1: School students were interviewed in three secondary schools, one in the city of Munich (Germany), one in the outskirts of Munich and one in Oldenburg (Germany).

Study 2: Passengers of the world-wide first hydrogen bus in public operation in Munich (bus line 56 from “Sendlinger Tor” to “Ostbahnhof”) were interviewed on the bus.

The interviews for both studies were carried out in autumn 1997. The study was published in 1998.

Target groups: Study 1: A total of 410 secondary school students were questioned about their acceptance of, their knowledge of, and need for information about hydrogen technologies.

Study 2: The use of the worldwide first hydrogen-powered regular bus in summer/ autumn of 1997 in Munich offered the chance to complement the data from the students with a passenger poll in the hydrogen bus.

Study 3: Answers of school students in the class room were compared to those of students of the same age in the bus.

Objectives: The spread of a new technology is not least dependent on being accepted by possible users. It has already been investigated for various technologies whether the general public considers them dangerous, rejects them, or greets them. There is, as of yet, little information of this kind on the subject of hydrogen-powered transportation. For example, there is the question of whether transportation of this kind arouses any fears – for example of a possible danger of explosion – or whether the positive aspects are more prominent in people‘s thoughts – e.g. the environmental friendliness.

With this background, the study pursued three overall questions:

- What level of acceptance is there for hydrogen technologies?
- What knowledge is there about hydrogen technologies or what is associated with the term "hydrogen"?
- Is there a demand for information about hydrogen technologies?

The study was carried out by Ludwig-Bölkow-Systemtechnik GmbH (LBST) in co-operation with the Ludwig-Maximilians University of Munich. The LBST has developed in HyWeb a comprehensive information system about hydrogen technologies which has been available in the Internet under www.HyWeb.de since April 1997. The goal of HyWeb is to increase both the knowledge and acceptance of hydrogen technologies. Thus, a goal of the study was to draw conclusions from the results of the study, which are of consequence to the design of HyWeb.

Methods applied:

Study 1

A total of 410 students at three secondary schools ('Gymnasium') were surveyed: One school in the city of Munich, one in the outskirts of Munich and one in Oldenburg. The questionnaire was distributed at the participating schools in 10th through 13th grades, and filled out in the classroom (Duration: ca. 30 min.).

The following variables were recorded through multiple-choice questions which were answered on a five-point scale:

- Acceptance of hydrogen: 8 items regarding the acceptance of hydrogen technologies were recorded
- Environmental awareness: For the measurement of environmental awareness, the following dimensions were observed: environmental attitude (7 items; example item: "If we go on like we have until now, we are steering toward an environmental catastrophe."), Threat of environmental problems (assessment of 12 environmental problems regarding the degree of their threat; example items: "Deterioration of the ozone layer", " species extinction", "Depletion of fossil fuels"), Perceived quality of the environment in own neighbourhood (9 items; example item: "I think that the air in my neighbourhood is harmful to one's health"), Individual effectiveness on the environment (6 items; example item: "My energy use does not make a difference").
- Environmental practices: Environmental practices were measured through 20 questions. To be precise, the actual practices of the students were not recorded, rather their statements about their own practices.
- Environmental knowledge: General environmental knowledge was measured through 6 multiple-choice and 2 open questions related to fuels and energy.
- Knowledge about hydrogen as a fuel (measured in three questions).
- Associations with "hydrogen": The students were asked to name everything they could think of on the subject "hydrogen". This free-association task was done before the other questions. The associations were categorised afterward by two evaluators.

Study 2

The bus passenger poll was conducted with 145 persons who were riding in the hydrogen bus in the Munich busline. Every tenth person who boarded the bus was asked to answer a few questions on the subject of "Hydrogen as a fuel". Of the passengers questioned, 80 were women, 65 were men; the average age of the subjects was 40 years. The evaluation only took persons into consideration who had a strong knowledge of German.

A short version of the questionnaire was constructed from the one given to the students (Study 1). The questions were read to the passengers and their answers were noted immediately. For ease in answering they received as an aid for the multiple-choice questions an answer scale on a piece of paper. The same scale was used for all multiple-choice questions.

- The acceptance of hydrogen-powered forms of transportation was collected with 6 items. The items were summed to a scale.
- The environmental awareness was recorded in three items on environmental attitudes which also was summed to a scale.
- At the start of the interview the passengers were asked to name all associations which occurred to them on the subject of hydrogen. The associations were written down by the observers and categorised by two evaluators afterwards. The same categories were used as in Study 1.

Study 3

For the comparative investigation the 24 students between 15 and 18 years of age attending a 'Gymnasium', which had been interviewed on the bus, were considered. This group was compared with 188 students from Munich of the same age, who were questioned in more detail in Study 1 on their acceptance of and knowledge about hydrogen.

The comparison was made possible because the questionnaire for the passengers represented a short version of the instrument distributed to students in the classroom. The questions for this study can be found above under “Study 2”.

Results: Several general conclusions can be drawn from the results of the present hydrogen acceptance study.

First of all and most importantly, hydrogen technologies enjoy a high level of acceptance among hydrogen bus passengers and among secondary level school students in Germany. People are in favour of further development of

hydrogen technologies, they support their deployment and they see their environmental benefits. Even though people see a certain danger of explosions in hydrogen technologies, the study does not reveal potentially severe acceptance problems. It is noteworthy that hydrogen is very rarely associated to danger spontaneously; only when people are asked to assess the risk of explosions they tend to see a certain risk.

It can be stated clearly that in contrast to most hydrogen experts' opinion people do not associate hydrogen with past accidents or catastrophes such as the Hindenburg disaster. At least in Germany, hydrogen is almost free of this negative burden.

The study shows a general tendency towards higher acceptance of hydrogen technologies when people are in direct contact with them. School students interviewed in the bus made significantly more positive evaluations than students in the classroom.

Other items do not have such a clear influence on the level of acceptance of hydrogen technologies: A high priority given to environmental issues and a high level of knowledge on hydrogen only have a weak positive influence on the acceptance.

The test of hydrogen knowledge of school students showed that the general level of knowledge is rather poor. This result is confirmed by the bus passengers, half of which had not had information about hydrogen before. At the same time, people are interested in knowing more on the subject.

Conclusions and recommendations

Both the direct contact to hydrogen technologies such as taking a hydrogen bus, and learning about hydrogen technologies at school have a significant positive effect on people's acceptance of hydrogen technologies.

At the same time, knowledge about hydrogen technologies and its environmental advantages is not very wide-spread. And hydrogen is neither spontaneously associated with danger nor with past accidents.

From the acquired results the following recommendations for the introduction of hydrogen technologies can be distilled:

- Hydrogen technologies enjoy an "advance" trust and are better accepted when a direct contact with the technology is made. Public field tests, demonstration and pilot projects, should thus be increasingly

implemented and be accompanied in particular by comprehensive measures to introduce information.

- Questions of safety should be a priority in the development of technologies, not, however, in the public relations. It is probable that an intensified treatment of the existing safety risks induces assessments of danger, even when making the point that the danger is very slight. The focus should be much more on the environmental advantages of hydrogen, which increases the acceptance.
- There exists a large deficit of information. Therefore offerings of information like HyWeb should be built on and advertised. That the Internet represents an appropriate place of information of this kind follows from the results of the studies with the students: The Internet is considered as a potential source of information.
- An intensified education of teachers and other multiplicators in the field of hydrogen technologies is necessary for reducing the large knowledge deficit among students.

Availability/publications: The study is available in full text under www.HyWeb.de/accepth2 (Englisch version), www.HyWeb.de/akzepth2 (German version).

M. Altmann, R. Wurster, C. Gräsel, HyWeb – The Hydrogen and Fuel Cell Information System. Publication of a Hydrogen Acceptance Study as an Example of the Dissemination of Hydrogen Information via the Internet, Proceedings of the 12th World Hydrogen Energy Conference, Buenos Aires, Argentina, June 1998

Ifmo-Expertenworkshop: Akzeptanz von Wasserstoff und Wasserstofftechnologien, Institut für Mobilitätsforschung, Berlin, 2000

3.1.2 Wasserstoffahrzeuge und ihr Funktionsraum – Eine Analyse der technischen, politisch-rechtlichen und sozialen Dimensionen (Hydrogen vehicles and their ambiance – An analysis of the technical, political and social dimensions)

Executed by: Gundi Dinse (Technical University Berlin, now Institut für Mobilitätsforschung, Berlin, Germany)

Place and time: The interviews were carried out in Berlin, Germany, at six different public locations, three of which in the former western part and three

in the former eastern part of the city between October 13 and 17, 1998. The study was published in 1999.

Target group: Interviewed were 150 randomly selected people in the street. The social data gathered at the end of the interview result in the following structure of the sample:

- Sex: 67% male, 33% female
- Age: 8% below 15 years of age, 17% between 15 and 20 years, 23% between 20 and 30 years, 46% between 30 and 60 years, 6% above 60 years
- Formal education level: 65% “Fachhochschul-/ Hochschulreife” (i.e. allowed to enter university, equivalent to A-levels in the UK), 24% “Realschule” (roughly equivalent to GCSE in the UK), 11% “Hauptschule”.
- Residence: 59% Berlin residents, 41% non-Berlin residents.
- Public transport users: 47% owners of a season ticket, 53% not.

Objectives: As only very few material was available when this study was designed, a formulation of hypotheses with subsequent empirical verification was not possible. Therefore, empirical data with an explorative function were sought in a survey in order to generate hypotheses on the acceptance of hydrogen and hydrogen vehicles.

Method applied: 150 persons were interviewed personally in the street at six different public locations in Berlin, three of which in the former western part and three in the former eastern part of the city. All locations are crowded areas with relatively high numbers of tourists.

The interview took on average some 5 minutes to carry out. The questions were mainly open questions:

- Associations with “hydrogen” (open question).
- “What can hydrogen be used for?” (open question)
- “Where have you found/ gathered your knowledge on hydrogen?” (open question)
- “Have you already heard about hydrogen vehicles?” (yes/ no); if so, “where and how” (open), “what do you think about it” (open), “are you interested in it?” (yes/ no)

- “Would you like to know more about hydrogen vehicles?” (yes/ no); if so, “what do you want to know?” (open)
- “Do you know other alternatives to diesel or gasoline driven vehicles?” (open)
- Social data (sex, age, school education, residence, public transport).

The answers to the open questions were subsequently categorised in order to come to quantitative results.

For some of the analyses, the results of the question on associations with “hydrogen” were weighed in such a way that the results are representative for the German population matching its sex and age distribution (see “Results” below).

Results: The associations with “hydrogen” can be grouped into positive (e.g. alternative fuel), negative (e.g. hydrogen bomb) and neutral associations. 60% of the associations given were neutral, 21% positive, 19% negative. In less than 1% of the cases the Hindenburg accident was mentioned, thus confirming the result of the LBST-LMU study (see above). 17% of the associations mention hydrogen as energy carrier.

The sex specific analysis of the associations (weighed to match the sex distribution of the German population) shows that the emotional associations (both negative and positive) are predominantly given by women whereas men tend to give associations in relation to technologies. 30% of men and 14% of women relate to hydrogen as energy carrier in their associations.

The age specific analysis of the associations (weighed to match the age distribution of the German population) shows that Germans aged 20 and below very rarely associate hydrogen with “energy of the future” or “hydrogen technologies” at all.

When asked for possible uses of hydrogen, 40% of all persons interviewed name energy related uses, 25% have no idea, 23% name bleaching hair (referring to hydrogenperoxide), 21% bombs etc., 7% name specific technologies (e.g. welding). Asked explicitly to think about possible uses of hydrogen, it is noteworthy that the percentage of persons mentioning energy related uses is very much increased compared to the free associations. 52% of all male interviewees name at least one energy related use of hydrogen, while only 14% of the women do so. All interviewees above 15 years of age name energy related uses to between 31% and 43%; those younger than 15 mention such uses only in 17% of the cases.

Main sources of information on hydrogen are the school (46%), the press (13%) and television (12%). The school is much more important for women than for men, who find more information in the press and on TV.

61% of the interviewees new about hydrogen vehicles when asked about them. This again is a higher percentage than that of interviewees mentioning energy related uses of hydrogen (40%; see above). 71% of these give a positive assessment of hydrogen vehicles (ecological, innovative, alternative for the future). Main interest of this group is in the technology (60%), followed by costs (13%), outer appearance (10%) and performance (7%). Negative views expressed include lobbying aimed at hindering the development of hydrogen vehicles.

71% of persons knowing about hydrogen vehicles are interested in them, depending mainly on vehicle and fuel costs (36%), fuel consumption and environmental performance (16%), driving autonomy and engine power (10%). Only one person (2%) mentioned the infrastructure issue.

The results of this study confirm the results of the LBST-LMU study (see above). Both investigations show that the knowledge on hydrogen and hydrogen technologies is low, but that Germans are open and interested and that the acceptance levels are rather high.

Availability/publications: The study has been published by the Institut für Mobilitätsforschung, Charlottenstr.43, 10117 Berlin, Germany, Phone +49 30 2030040, Fax +49 30 20300429, ISBN 3-932169-07-7

Ifmo-Expertenworkshop: Akzeptanz von Wasserstoff und Wasserstofftechnologien, Institut für Mobilitätsforschung, Berlin, 2000

3.1.3 Akzeptanz von wasserstoffbetriebenen Fahrzeugen – Eine Studie über die Verwendung eines neuen und ungewohnten Kraftstoffs (Acceptance of hydrogen vehicles – A study on the use of a new and unusual fuel)

Executed by: Gundi Dinse (Institut für Mobilitätsforschung, Berlin, Germany)

Place and time: The persons who were surveyed (see target group) received the questionnaire at their workplace in Germany (around 85% in Munich). The survey was carried out in January 2000; the study was published in 2000.

Target group: Of the 16,324 employees of the BMW group in Germany 1,000 have been randomly selected for the survey. 593 have returned their

answers to the questionnaire. It has to be noted that BMW has been developing hydrogen vehicles since the late 1970ies.

Objectives: The objective of the study was to develop strategies that increase the acceptance of hydrogen fuel and vehicles based on results of a survey of a selected group of persons (target group).

Method(s) applied: In the first part, the study makes an analysis of the theoretical basics and results of acceptance research in general developing 24 hypotheses. In the second part, employees of the BMW group are surveyed on their acceptance of hydrogen fuel using a written questionnaire. The results of this survey are compared to the hypotheses developed in the theoretical part.

The standardized questionnaire contains 56 questions, most of which are closed questions with only a few (semi-) open questions. The survey aims at producing quantitative results and at verifying hypotheses.

Results: Hydrogen as a new fuel for vehicles has to be generally accepted by people in order to make the global launch of hydrogen vehicles into the market possible.

This acceptance of hydrogen as a fuel and of the vehicles is assessed hypothetically on the basis of eight theoretical variables of influence and the correlation of their effects upon each other. The variables are derived from technology acceptance research: the general attitude towards technology, the general interest in technology, the knowledge about the technology, the perception of risk, the perception of individual and societal benefits, word associations and mental links with the technology, the influence of media, and the trust into the technology. Socio-demographic factors can be of significant importance for some of the variables.

The empirical examination of the hypotheses shows that the acceptance of hydrogen and the corresponding vehicle technology is highly accepted among the employees of the BMW group. Higher qualified and especially male employees think positively and are open-minded about this innovation. The interviewees think that hydrogen should replace the conventional fuels in the future although the risk of the former is estimated to be significantly higher than that of the latter. Comparable prices and a sufficient refuelling infrastructure are preconditions for this positive attitude. The introduction as all-round or as high-tech vehicles can accelerate the process. The societal and individual benefit is mainly seen in the contribution to the conservation of

the environment. The results of the survey supports the theoretical results of acceptance research in most parts.

To further increase the acceptance of hydrogen as a fuel for vehicles and the potential for their global introduction into the market the knowledge about the technology and the trust in it has to be increased. This can be done in schools and universities, but also via mass media and specialized literature. Creating opportunities to experience hydrogen vehicles would be the most effective action to decrease the perception of risk.

Availability/publications: Institut für Mobilitätsforschung, Charlottenstr.43, 10117 Berlin, Germany, Phone +49 30 2030040, Fax +49 30 20300429, ISBN 3-932169-20-4

Ifmo-Expertenworkshop: Akzeptanz von Wasserstoff und Wasserstoff-technologien, Institut für Mobilitätsforschung, Berlin, 2000

3.1.4 Survey of the passengers of the MAN hydrogen fuel cell bus

Executed by: VAG Nürnberg (local bus operator)

Place and time: Nürnberg, Germany; April 4-6, 2001

Target group: Bus passengers

Objectives: To find out about the general acceptance of the hydrogen fuel cell bus by the bus passengers, and about the public perception of the environmental and innovative activities of the bus operator.

Method applied: 156 bus passengers were interviewed; no further details on the methodology are available.

Results: The general reactions were very positive.

- Bus passengers well noticed the low noise levels, both at the bus stop and on the bus.
- Nine of ten passengers had no clear idea about how a hydrogen fuel cell bus works, They would like to have more information.
- The bus passengers strongly favoured the further support of the technology because of the low emissions and the low noise level.
- The interviewees praised the activities of the bus operator in this project for being highly innovative and environmentally protective/ friendly.

- The large majority of the interviewees supported the idea of employing more hydrogen fuel cell busses and would even accept moderate increases in ticket prices.

Availability/publications: Press release by VAG of May 21, 2001

Comments: The survey was performed during the six month field trial of the first fuel cell bus in commercial operation in Germany between autumn 2000 and spring 2001. The survey was performed without scientific objectives, approach and support. Therefore, the results are only qualitative and cannot be compared scientifically with the other studies analysed here.

3.1.5 Survey of the passengers of the Ballard hydrogen fuel cell bus in Chicago

Executed by: Chicago Transit Authority

Place and time: Chicago (Illinois, USA), demonstration period of hydrogen fuel cell buses from 1998 until March 2000

Target group: Bus passengers

Objectives: To find out about the general acceptance of the hydrogen fuel cell buses by the bus passengers

Method applied: Bus passengers were interviewed; no further details on the methodology are available.

Results: In addition to technical objectives, “objectives for all participants included assessing public reaction to fuel cell powered buses and buses fuelled with hydrogen, determining the needs of transit authorities and users of the buses, and gathering data on their performance and maintenance from the drivers and mechanics.

Driver and passenger reaction to the program and the buses was positive. Drivers reported a smooth, quiet ride, absence of fumes and good acceleration. They also said passengers included visitors to Chicago who had made a point of riding a fuel cell powered bus during their stay.”

Availability/publications: Joint Ballard Power Systems, XCELLSIS, Chicago Transit Authority press release of March 23, 2000

XCELLSIS/ Ballard, Cleaning up: Zero-emission buses in real-world use. A report on the XCELLSIS/ Ballard Phase 3 Fuel Cell Bus Program

Comments: The survey was performed during the two year field trial of the first three fuel cell buses in commercial operation in Chicago, Illinois, USA, between 1998 and March 2000. Neither information about the scientific objectives, approach and support nor detailed results are available.

3.1.6 Einflussfaktoren auf den Markterfolg von wasserstoffbetriebenen Fahrzeugen (Factors influencing the market success of vehicles powered by hydrogen)

Executed by: Ulrich Lossen, Markus Armbruster, Sonja Horn, Peter Kraus, Kathrin Schich (Bayerische Eliteakademie, Munich, Germany). The study represents the final thesis of four students of the Bayerische Eliteakademie.

Place and time: Germany/ Internet (German language): The interviews with high level executives were carried out personally by visiting the interviewees. The Internet survey was carried out in German language with advertising banners leading the interviewees to the survey website from well-known media websites (in principle, German speaking persons from all over the world were able to participate in the survey; see “Comments” N° 1 below). The management interviews and the Internet survey were carried out in October/ November 2001. The study was published in January 2003.

Target groups: Part one: High level executives (all forming part of top and middle management) from the areas of science, industry and the public sector (public administration and politics, churches, media etc.) were interviewed.

Part two: German speaking Internet users were surveyed (see “Comments” N° 1 below). The persons surveyed revealed to be predominantly “young, male academics preparing for masters or PhD degrees”. In detail, the social analysis of the surveyed persons revealed the following characteristics: 71% are male, 79% are younger than 36 years, 41% had finished secondary schools allowing them to enter a university (“Hochschulreife” or “Fachhochschulreife”) with an additional 46% already having a university degree, 43% have a monthly salary of less than 3000 DM (around 1500 Euro). 67% own a car, 36% own a season ticket for public transport.

Objectives: The study is an explorative analysis of the factors that influence the market success of vehicles powered by hydrogen. The study aims at determining the predominant opinion of the German population concerning hydrogen technology and, from this, deriving recommendations for economy and politics.

The goal of the Internet survey was to verify four statements:

1. The introduction of hydrogen cars is accelerated by improved information policies for the general public.
2. The introduction of hydrogen cars is accelerated by comparably low hydrogen fuel prices.
3. The introduction of hydrogen cars is accelerated by performance levels of hydrogen cars comparable to conventional cars.
4. The introduction of hydrogen cars is accelerated by a good availability of hydrogen filling stations.

Methods applied: The study contains two parts: In a qualitative investigation, 37 high level executives (all forming part of top and middle management) from the areas of science, industry and the public sector (public administration and politics, churches, media etc.) were interviewed about their opinions and assessments of the subject. In study two, an Internet survey was carried out with 417 people taking part analysing the general attitudes towards and acceptance of hydrogen.

Acceptance of hydrogen has been subdivided into the five variables “Price”, “Advantages”, “Safety”, “Performance” and “Flexibility”. These variables have not been measured directly, but have been measured by at least two indirect items. The combination of the indirect items for each of the variables gives the result for the respective variable. Most of the items have been put in the form of statements with the surveyed persons indication their level of consent/ dissent on a four step scale from “I do not agree at all” to “I agree completely”. Some of the items were constructed as direct questions.

Results: One of the main results of the study is that both the interviewed high level executives and the participants of the Internet survey have a positive attitude towards hydrogen technologies in automobiles. This correlates with a strong confidence in the technology. Reservations concerning safety are noticeable, but limited. It will be decisive for the future market success of hydrogen vehicles for automotive industry to further increase this level of acceptance by means of information policy towards the future clients. Additionally, politics will have to support the market introduction phase of hydrogen vehicles, regardless of predominant technical designs.

The Internet survey was grouped in five question blocks. Block 1 (general environmental consciousness) contained six questions, block 2 (acceptance/ expectations/ prejudice) contained 13 questions, block 3 (general knowledge

on hydrogen) contained three questions, block 4 (technical knowledge on hydrogen) contained five questions plus questions on the sources of information, block 5 (social statistics) contained five questions.

In the following, the main results are presented qualitatively:

Question block 1: General environmental consciousness

- Perception of environmental problems: high
- Assessment of own environmentally sound action: high

Question block 2: Acceptance/ expectations/ prejudice

- Price sensitivity (3 questions): high
- Assessment of personal and societal advantages (4 questions): low/ medium (see “Comments” N° 3 below)
- Safety concerns (2 questions): low/ medium
- Performance of hydrogen car (2 questions): medium/ high
- Personal flexibility (2 questions): medium/ high

Question block 3: General knowledge on hydrogen

- “I feel well-informed by car industry”: low
- “I have informed myself well about hydrogen”: medium/ low

Question block 4: Technical knowledge on hydrogen (see “Comments” N° 2 below)

- Technical knowledge: medium/ low

Question block 5: Social statistics (see “Target groups” above)

As a general result, the acceptance levels are rather medium, with an average value of 15 out of 30 possible points with a rather large variation of results.

Factors influencing the acceptance of hydrogen technologies:

- A high general environmental consciousness has a *positive influence* on the acceptance of hydrogen.
- A good technical knowledge on hydrogen has *no influence* on the level of acceptance.

- Persons having informed themselves about hydrogen show a *slightly higher level* of acceptance than the average.
- Car owners display a *high level* of acceptance.
- The sex has a *low influence* on the level of acceptance.
- Age has a *low influence* on the level of acceptance, with the highest level in the age group between 36 and 45 years.
- The level of education has a *high influence* on the level of acceptance: Formally highly educated persons display the lowest level of acceptance.

Further interesting correlations:

- Formally highly educated persons display the lowest price sensibility.
- Persons with a low monthly salary are more flexible, e.g. regarding the distance to the next hydrogen filling station, than person with a high salary.

Keeping in mind that the Internet survey has not been carried out reaching a representative sample of the population, the four statements (see "Objectives" above) have been confirmed or disapproved as follows:

1. Statement N° 1 "The introduction of hydrogen cars is accelerated by improved information policies for the general public" cannot be disproved. Nonetheless, the level of information has not displayed a high influence on the level of acceptance of hydrogen technologies.
2. Statement N° 2 "The introduction of hydrogen cars is accelerated by comparably low hydrogen fuel prices" is confirmed.
3. Statement N° 3 "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 been assessed as very critical by the surveyed persons.
4. Statement N° 4 "The introduction of hydrogen cars is accelerated by a good availability of hydrogen filling stations" is confirmed.

Availability/publications: expert verlag, 2003, ISBN 3-8169-2174-4, 28 Euro, www.goh2.de

Comments:

1. The authors of the study are well aware of the fact that the group of persons surveyed via Internet are not representative. What is not acknowledged is the fact that the persons surveyed are not necessarily Germans, but that they are German speaking (possibly even with German as a foreign language).
2. The questions relating to the technical knowledge on hydrogen rather seem to be posed in a way that any intelligent person who has ever heard remotely about hydrogen cars should be able to answer at least two questions correctly. Given the fact that 87% of the persons surveyed belong to academia, an average of two questions answered correctly could be regarded as a rather low value, while the authors of the study give the assessment: “the surveyed persons display a rough knowledge”.
3. The authors of the study come to the conclusion that the surveyed persons in general assess the personal and the societal advantages of hydrogen cars as medium to low. The breadth of the result curve is very high, i.e. the result is not very decisive. First of all it seems that the questions posed concerning this aspect were not very clear even being biased to a certain extent in their formulation. Secondly it seems advisable to separate the analysis into two aspects: personal advantages on the one hand and societal advantages on the other.

3.1.7 Greening London’s black cabs: A study of driver’s preferences for fuel cell taxis

Executed by: Susana Mourato, Bob Saynor, David Hart, Department of Environmental Science and Technology, Imperial College London

Place and time: The survey was conducted in five locations around London, in April-May 2001.

Target group(s): Drivers of Taxis in London; 99 useable responses were received (representing approximately 0.5% of taxi driver population).

Objectives: Understanding the user benefits of fuel cell vehicles and the determinants of demand is essential for their successful penetration. This contingent valuation study investigates the preferences of London taxi drivers for driving emissions-free hydrogen fuel cell taxis, both in the short term as part of a pilot project, and in the longer term if production line fuel cell taxis become available.

Method(s) applied: Key attributes influencing taxi drivers decision to participate in a fuel cell taxi project, were identified during focus groups. A survey was administered to London black cab drivers, containing attitudinal questions and a contingent valuation (CV) section, where willingness to pay (WTP) for fuel cell taxis was assessed. The CV section consisted of a payment ladder from £0 to £5000 in £500 increments, used to assess maximum WTP per year to participate in a fuel cell taxi project.

Results: The results show that willingness to pay to participate in a pilot project seems to be driven mostly by drivers' expectation of personal financial gains. In contrast, however, environmental considerations are found to affect taxi drivers' longer-term vehicle purchasing decisions. The results also reveal that driving hydrogen-fuelled vehicles does not seem to raise safety concerns amongst taxi drivers.

Availability/publications: S. Mourato, B. Saynor, D. Hart, Greening London's Black Cabs: A Study of Driver's Preferences for Fuel Cell Taxis, Energy Policy (in press, on-line since March 2003)

3.1.8 Innovationswerkstatt 2003: Saubere Energien der Zukunft. Delphi-Studie (Delphi-Study on Clean Energies of the Future)

Executed by: Volker Trommsdorff, Innovationswerkstatt 2003, Technische Universität Berlin, Chair Marketing I, Berlin/Germany

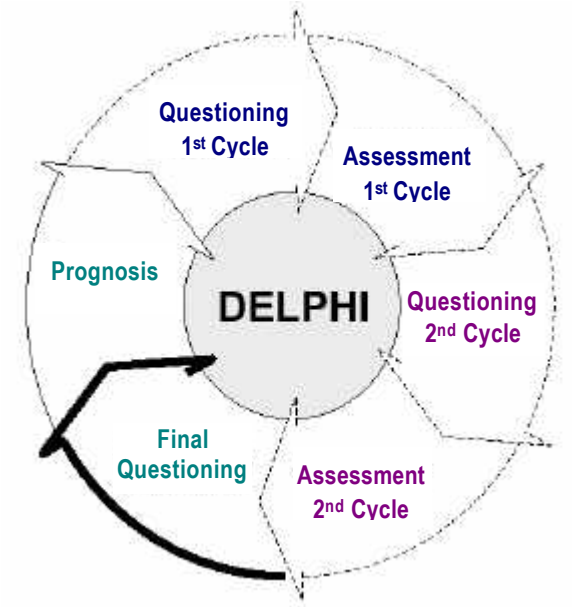
Place and time: 2003

Target group(s): Experts from various knowledge and interest domains.

Objectives: Description of probable scenarios regarding the future fuel mix.

Method(s) applied: Written interviews in the course of a Delphi-Study. Collection of experts' opinions on probable energy scenarios. Inter alia, several questions concerning hydrogen acceptance. Three cycles of questions / answers / assessment procedures were conducted as shown in the following phase diagram:

Fig. 3-1: Project phases of the Innovationswerkstatt Delphi study 2003



The participating experts don't know each other. Thus answers are given without reservation and the interview is not affected by external social effects. The survey is assessed by quantitative and qualitative measures. Results are stated at the end of each cycle and made available to the experts to further comment in case of significantly deviating positions.

Results: Concerning the acceptance questions, experts assume public acceptance towards hydrogen and hydrogen technologies to be low due to the perception that hydrogen vehicles tend to pose a safety risk. It has to be noted here that this expert assumption cannot be proven by any of the empirical studies summarized in the present analysis.

Experts think that the public mostly associates environmental issues with fuel cell technology, i.e. "clean", "quiet", "sustainable" and "innovative". They assume that there is hardly any knowledge about fuel cells which leaves room to shape the public opinion. Experts assume that public opinion is mostly formed by media. Thus, important media ought to be addressed.

The interviewees share the opinion that the public has to gain experience with hydrogen applications in order to turn reservation into appraisal. Yet, without economical viability, hydrogen technology may not ultimately gain acceptance.

Availability/publications: Volker Trommsdorff, Auswertung Delphi (Presentation), Uni Berlin, Chair Marketing I, Berlin/Germany, April 2004

Comments: Acceptance of hydrogen technology was only part of the Delphi study, though a relevant one. Acceptance was not measured directly, but experts' opinion of the general public's acceptance was collected.

3.2 Public preferences for clean vehicles and fuels: A review of empirical literature

3.2.1 Introduction

Most of the relevant literature on public preferences for new environmental transport technologies and fuels focuses on electric vehicles (EV's). Of the 24 reviewed articles, 13 of them deal with EV's, compared with 5 articles dealing with hydrogen-based transport. The remaining 6 articles deal either with generic alternative fuel vehicles (AFV's), which include electric, methanol, natural gas and gasoline vehicles, or address preferences for different attributes of vehicles in general, in order to identify the key factors influencing demand for low emission vehicles.

The studies reviewed in this paper can be divided into three types according to methodology used (Gould and Golob, 1998) – attitude studies, preference surveys and experimental analyses – although many of them involve a combination of methodologies.

Studies based solely on attitude questions (Lossen et al, 2003; Dinse, 2000; Dinse, 1999; Altmann and Graesel, 1998 – note that these are all studies of acceptance of hydrogen transport), tend to reveal very positive attitudes towards cleaner transport amongst respondents, in contrast with experimental and preference surveys which show lower acceptance levels overall for cleaner transport (Gould and Golob, 1998). The discrepancy between findings from these different methodologies may be due to the fact that attitude surveys reflect ideals rather than actual purchasing intentions (Kurani et al, 1996). As proposed in Fishbein's Theory of Reasoned Action (1977), intended behaviour (i.e. as measured by willingness to pay) is a better indicator of behaviour than attitudes. Attitudes merely guide intentions and, crucially, imply no trade-offs between one's limited budget and securing cleaner transport alternatives.

This discrepancy is highlighted in papers such as Gould and Golob (1998) where positive attitudes towards the environmental benefits of EV's are not complemented by purchasing intentions (78% respondents expressed belief that EV's were the solution to reduced air pollution; 47% expressed intention

to purchase an EV based on the environmental benefits). Similarly, Urban et al (1996) found that EV's were rated highly in terms of environmental attributes, but environment was rated as the least important attribute when purchasing a vehicle. These studies illustrate the fact that, in the absence of questions on purchase intention, results from attitudinal surveys may be misinterpreted and demand for cleaner transport overestimated.

Preference valuation surveys are another approach used to identify potential demand for new technologies. There has been relatively little work to date on valuing the environmental attributes of transport, such as impacts on air quality, noise levels and visual amenity. Most valuation techniques have been used in the valuation of more traditional, non-environmental attributes of transport, such as travel-time savings, alternative route preferences, fare elasticities and public transport preferences (for case studies see Louviere et al, 2000, and Hensher, 2001). For a summary of the historical development of valuation methods in transportation research see Polak and Jones (1996).

Most preference surveys reviewed here address the potential demand for EV's and make used of stated preference techniques. Stated preferences are survey-based methods commonly used to measure, in monetary terms, the welfare impacts of changes in products, policies or projects: by means of a questionnaire, respondents are asked for their willingness to pay (WTP) to secure an improvement or, alternatively, to avoid an undesirable change (Bateman et al, 2002). The values elicited are contingent on the scenario and information provided in the survey. Specific stated preference techniques used in the transport studies reviewed include choice modelling methods (Bennett and Blamey, 2001; Louviere et al, 2000) and the contingent valuation method (CVM) (Mitchell and Carson, 1989; Bateman et al, 2002). Although specific results vary widely, there is general agreement across all studies that environmental concerns are not important for vehicle choice.

To date, the only study to estimate the economic value of hydrogen fuel cell vehicles is Mourato et al (2003), which uses CVM to evaluate the economic benefits of hydrogen fuel cell taxis to professional taxi drivers in London. Taxi driver willingness to pay for participation in a fuel cell taxi pilot project was found to be considerably less than the reductions in running costs associated with participation in the pilot project. Thus WTP was determined mainly by financial considerations (i.e. the expectation of financial gains), and not environmental factors. However, longer term WTP for purchasing a production line fuel cell taxi, in an optimistic future scenario of mass introduction, was found to be positively influenced by environmental concerns (as well as by financial and performance considerations).

There has been criticism of the use of stated preference techniques in evaluating potential demand for new technologies, as a new technology may have attributes that the consumer has little experience of, and hence no preferences for (Kurani et al, 1996). An example might be the home recharging attribute of EV's. One way of dealing with this issue involves providing respondents with direct experience of the technology, as in the experimental studies (Kurani et al, 1996; Urban et al, 1996; Kurani et al, 1995). These experiments combine different methodologies – attitudinal questions with choice modelling and CVM, as well as a variety of innovative techniques (e.g. videos, simulated information and vehicle trials) - in order to obtain values for potential demand for cleaner transport technologies. The general theme behind experimental approaches is experience of the technology, whether it is through direct experience or virtual simulation.

3.2.2 Main results from the studies

3.2.2.1 Environmental concerns less significant than price and performance

As noted above, in most studies, environmental concerns are not found to have a significant influence on acceptance of, or willingness to pay for cleaner transport (Mourato et al, 2003; Altmann and Graesel, 1998; Ewing and Sarigollu, 1998; Kurani et al, 1996; Urban et al, 1996; Kurani et al, 1995; Turrentine and Kurani, 1995; Calfee, 1985). Even self-reported environmentalists are not necessarily willing to pay for cleaner vehicles on the basis of environmental benefits alone (Turrentine et al, 1992). Price and performance are by far the most important factors in determining acceptance and acceptance for cleaner vehicles.

Of those studies that do report a correlation between environmental attitude and acceptance for cleaner transport, environmental concern is a weaker influence than price and performance (Chiu and Tzeng, 1999; Brownstone et al, 1996; Sperling et al, 1995; and also Mourato et al, 2003, in their long-term scenario). Only the study by Lossen et al (2003) finds that environmental attitudes significantly influence the acceptance of hydrogen transport. However, as noted by the author, the survey sample in this attitudinal study is highly unrepresentative, consisting of self-selected Internet users (71% male; 79% under 36 years; 87% in academia).

The only other hydrogen transport studies to address the influence of environmental concerns on acceptance include Mourato et al (2003) and Altmann and Graesel (1998). Mourato et al (2003) investigated WTP for hydrogen fuel cell taxis by London taxi drivers, and found that environmental

concerns did not play a role in taxi driver's WTP for a pilot hydrogen fuel cell taxi, in the short-term; however, concern with air pollution was found to affect to some extent taxi drivers' longer-term vehicle purchasing decisions. Altmann and Graesel (1998) reported a high level of acceptance for hydrogen buses by respondents onboard a hydrogen bus in Munich, but found the relationship between environmental attitudes and acceptance to be very weak.

In order to understand the factors likely to influence drivers to switch to low or zero emission vehicles Ewing and Sarigöllü (1998) carried out surveys with choice experiments, which required respondents to make trade-offs between cost, performance and emissions levels of private vehicles. It was found that there was a large potential demand for low emission vehicles, as long as they could compete with conventional cars in performance and vehicle price. Running costs and emissions were not found to have a significant influence on vehicle-purchasing decisions.

Similar results were found in an experimental study by Urban et al (1996), which presented respondents with a multi-media virtual buying environment simulating the information available to a consumer when making a new vehicle purchase. Designed to forecast consumer acceptance and purchase intentions for a 2-seater EV developed by General Motors, it was found that although the EV was rated highly in terms of environmental attributes, environment however, was rated as the least important attribute for a vehicle, whilst driving range was rated as the most important. Range was also found to be the most important variable in Calfee (1985), who used choice experiments to estimate potential demand for EV's among wealthier families with two or more vehicles, and in Brownstone et al (1994) who found vehicle range most sensitive to changes, followed by cost, emissions and fuel availability.

Experimental studies by Kurani et al (1996) and Kurani et al (1995), using focus groups, vehicle trials and mail surveys, assessed the potential for EV's in local household transportation. EV purchase was found to be most likely in hybrid households (Kurani et al, 1995): this refers to households that own various vehicles to satisfy different travel needs of various family members and in which at least one person has consistently shorter travel needs (e.g. taking the children to school). Home recharging was found to be the most highly valued attribute of EV´s and environmentalism the least valued. The implication is that EV´s should be marketed on the basis of their home recharging – and maybe other novel – attributes, and not on environmental attributes.

In another experimental study by Turrentine et al (1992), in which respondents' attitudes were elicited, before and after test-driving alternative fuel vehicles, it was found that members of environmental organisations did not show higher clean-vehicle purchasing intentions. However, in Turrentine and Kurani (1995) and Kurani (1996) the results suggest that respondents may have a latent negative perception of air pollution issues associated with transport, which, as the authors suggest, could influence future vehicle choices. This idea is supported by results in Mourato et al (2003) showing that concern with air pollution appeared to influence longer-term decisions to purchase a hydrogen fuel cell taxi (although it had no influence on short term decisions).

A few of the studies however, do report some willingness to pay based on environmental issues. Brownstone et al (1996) developed a transactions choice model for forecasting demand for alternative-fuel vehicles, and found that two-vehicle households with children under 21 years old, value emissions reduction more highly than other households. Chiu and Tzeng (1999) assessed preferences for electric motorcycles amongst users in Taiwan using choice experiments and found that females significantly favoured reduced emission levels. Sperling et al (1995) analysed the potential target market for methanol in the household vehicle market and found that 85% respondents were willing to pay 2 cents more per gallon, and 24% were willing to pay 45 cents more, for reduced air pollution, with male drivers 20% less likely to spend more on cleaner fuels than female drivers. And as mentioned, in Mourato et al (2003) the premium that drivers were prepared to pay for future production hydrogen fuel cell taxis was influenced by the degree of concern about air pollution.

However, even in these studies, environmental concern is a weaker influence on willingness to pay for cleaner transport than price and performance factors. Overall, from the empirical evidence to date it appears that environmental concerns are not strongly correlated with WTP for new transport technologies. In most cases, price and performance of the vehicle and/ or fuel are the key attributes for respondents, when choosing a vehicle. Dinse (2000) also finds 'infrastructure availability' to be a key precondition for acceptance of hydrogen transport (although in this study, the relative influence of environmental concerns is not considered). However, as suggested in Mourato et al (2003) and Turrentine and Kurani (1995), environmental factors may play an increasingly important role in future purchases of vehicles as they become an increasingly valued attribute.

3.2.2.2 Influence of knowledge on acceptance

Due to the novelty of hydrogen based transport, it is not surprising that most of the studies in this area address the relationship between knowledge of the technology and acceptance levels. However, there is no agreement as to the influence of knowledge on acceptance. In an exploratory study of public knowledge, perceptions and attitudes towards hydrogen in Berlin, Dinse (1999) found that despite low knowledge levels, acceptance levels were high. This finding is further supported by results reported in a study of acceptance amongst BMW employees (Dinse, 2000), and in Mourato et al (2003), where taxi drivers who were more familiar with the technology gave higher WTP estimates.

However, in the study by Lossen et al (2003), consisting of qualitative interviews with high-level executives, followed by an Internet survey involving attitudinal questions, technical knowledge of hydrogen had no influence on acceptance levels. Paradoxically, the paper also reports that respondents who had informed themselves about hydrogen had slightly higher acceptance levels. It is probably the case that the respondents who had informed themselves, had been interested in non-technical aspects of hydrogen.

3.2.2.3 Influence of information and experience on acceptance

Attitudes towards new objects or new concepts can be unstable and changed easily with new information (Converse, 1964). Information may come in different forms: in adverts and articles, television programmes, word-of-mouth, from sales representatives, etc.

Urban et al (1996) carried out an experimental study using information acceleration (IA). IA consists of a multi-media virtual buying environment that simulates the information available to a consumer when making a new vehicle purchase. Simulated information sources included virtual showrooms, adverts, articles and word-of-mouth interactive videos. After each exit from an information source, respondents were asked to indicate purchasing intentions for various vehicles presented in IA on a scale, and rate eight attributes of each vehicle (including environmental benefit). The idea behind the study was to gauge the effect of information on consumer demand. The authors concluded that information indeed did have an effect, and that purchase intention increased with the amount of information provided. However, the results are not clear, and no details are given as to how intentions changed with source of information (e.g. whether advert or word-of-mouth video).

Gould and Golob (1998) used data from a 2-wave panel survey of environmental opinions of Californian households to assess the impact of information on attitudes. Comparing data from 1993 and 1995, it was found that as people learned more about EV's from mass media or from conversation, they were less likely to view them as a key solution to environmental problems. However, those who had read business magazines, auto magazines and newspapers did view EV's as a key solution.

In the same study Gould and Golob (1998) looked at changes in environmental attitudes towards EVs before and after usage of an EV. The study involved 2-week long EV trials in California, and respondents had to complete an in-board travel logger (to record distance travelled), a travel diary, and pre-trial and post-trial attitudinal surveys. It was found that post-trial respondents had more positive attitudes about the environmental benefits than pre-trial; but users tended to cite reasons other than air pollution for selecting an EV.

Altmann and Graesel (1998) compared the acceptance for hydrogen technologies amongst samples of users and non-users of a hydrogen bus in Munich. Part 2 of the study investigated acceptance among secondary school students (and other passengers) on board a hydrogen bus. Results revealed that acceptance for hydrogen was high, and that perception of risk from hydrogen was low. Part 3 involved a comparison of attitudes between students on board a hydrogen bus and students in the classroom. Results revealed significant differences: acceptance levels were higher when students answered in the bus (mean values are 4.28 – bus; 3.93 – classroom); associations of hydrogen with danger were more frequently mentioned first time in the classroom than on the bus (8% compared to 1.6%, respectively), and associations with environmental benefits were much more frequent onboard the bus than in the classroom (29.4% compared to 2.6%, respectively).

The higher acceptance levels amongst users compared to non-users found in these studies may result from reduced uncertainty about the vehicles performance and risk. Uncertainty can lead individuals to perceive risks as being much higher than they actually are (Slovic, 2000), which in turn may lead to lower levels of acceptance. However, long-term changes in attitude may be seen as dissonance reduction. 'Cognitive dissonance' is a psychological phenomenon, which occurs when an individual is faced with contending cognitions (Festinger, 1957). The situation is psychologically uncomfortable and individuals will try to avoid it, as in the statement 'I love

my car; it's so horrible'. Hence, a user will justify his/her usage of the transport technology or fuel in order to avoid dissonance.

3.2.2.4 Hybrid households

Several papers have identified a significant market for EV's among a particular subset of households. Beggs and Cardell (1980) actually based their study of potential household demand for EV's on the assumption that niche market for EV's was with small-car buyers in multi-vehicle households. Segal (1995) found that multiple vehicle households in California showed greatest willingness to pay for electric vehicles, whilst Brownstone et al (1996) found that two-vehicle households with children under 21 years old valued emissions reduction more highly than other households. Kurani et al (1995) added further detail to the analysis, by concluding that neighbourhood EV purchase is most likely when a high proportion of household activities are concentrated nearby, and the household has flexibility concerning means of travel for different members.

These and other findings (Kurani et al, 1995) are developed in Kurani et al (1996), who propose that the initial market segment for EV's are hybrid households. This term is used to describe households that own various vehicles to satisfy different travel needs and which are defined by a lifestyle in which at least one person has consistently shorter travel needs (e.g. taking the children to school). These shorter travel needs can be suitably covered with an EV, as results from the study show.

3.2.2.5 Barriers to acceptance

Cheron and Zins (1997) address the question of barriers explicitly, by using a combination of unstructured discussion sessions, a group interview technique called Nominal Group Technique and a conjoint analysis survey to identify the key variables that might block the purchase of an EV and the trade-offs between these variables. They found that concern over battery charge duration i.e. reduced range, was the main variable that would prevent acceptance of the EV by the market. This finding is corroborated by most other papers on acceptance of EV's, where restricted range is identified as the key barrier to uptake of an EV (with the exception of hybrid households), followed by capital cost as the next important barrier.

3.2.2.6 Preferences for hydrogen-based transport

The only study that has estimated the economic value of hydrogen fuel cell vehicles specifically was carried out by Mourato et al (2003). Using CVM, the

economic benefits of hydrogen fuel cell taxis to taxi drivers were estimated for (i) driving a hydrogen fuel cell taxi for a pilot project, and (ii) purchasing one later on, in an optimistic scenario of mass introduction. It was found that despite support for cleaner fuels and vehicles, taxi drivers' WTP (which ranged between £2900 and £3500 for participation in the pilot project) was influenced mainly by personal financial concerns (i.e. reduced running costs associated with the project). However, driver's WTP of a premium for production hydrogen fuel cell taxis in the long term was influenced by concerns about air pollution, education levels and knowledge about the technology itself. The implication is that policy makers should aim to increase awareness about hydrogen fuel cell vehicles and air pollution issues in order to increase the WTP for hydrogen fuel cell taxis.

Another interesting finding was the lack of concern over the safety of hydrogen fuelled vehicles, an issue that has been often cited by experts as a potential barrier to hydrogen vehicle uptake. Although Altmann and Graesel (1998) also found hydrogen safety not to be an issue, more studies will need to be undertaken to clarify this issue.

3.2.3 Summary of results from the studies

It appears, from the above studies on public acceptance and preferences for new environmental technologies, that in the short run, environmental concern will not be the key influence on decisions to purchase cleaner vehicles. The key concerns will be price and performance. If alternative fuel vehicles are able to compete with internal combustion fuel vehicles in terms of price and performance, then environmental concern may indeed act as a predictor of consumer choice.

3.2.4 References

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3.3 Annex: Overview of relevant literature

	Title	Date	Author	Journal/ Source	Application	Method	Sample
1	Greening London's black cabs: a study of driver preferences for fuel cell taxis (to be published)	2003	Mourato, S., Saynor, B. and Hart, D.	Energy Policy (in press, on-line since March 2003)	**preferences for fuel cell vehicles** amongst black cab drivers in London	Key attributes influencing taxi drivers decision to participate in a fuel cell taxi project, were identified during focus groups. A survey was administered to London black cab drivers, containing **attitudinal questions** and a **contingent valuation** section, where WTP for fuel cell taxis was assessed. The CV section consisted of a payment ladder from £0 to £5000 in £500 increments, used to assess max WTP per year to participate in a fuel cell taxi project.	The survey was conducted in five locations around London, in April-May 2001. 99 useable responses were received (representing approx 0.5% of taxi driver population).
2	Einflussfaktoren auf den Markterfolg von wasserstoffbetrie-benen Fahrzeugen (Factors influencing the market success of vehicles powered by hydrogen)	2003	Lossen, U., Armbruster, M., Horn, S., Kraus, P. and Schich, K.	expert verlag, 2003, ISBN 3-8169-2174-4, 28 Euro; selected results are available at www.goh2.de	**Acceptance of hydrogen** has been subdivided into five variables "Price", "Advantages", "Safety", "Performance" and "Flexibility". These have been measured through indirect items.	The study contains two parts: In a qualitative investigation, 37 high level executives (all forming part of top and middle management) from the areas of science, industry and the public sector (public administration and politics, churches, media etc.) were interviewed about their opinions and assessments of the subject. In study two, an Internet survey was carried out with 417 people taking part analysing the general attitudes towards and acceptance of hydrogen.	Part 1: 37 high level executives Part 2: Internet survey with 417 German speaking people
3	Akzeptanz von wasserstoffbetriebene n Fahrzeugen – Eine Studie über die Verwendung eines neuen und ungewohnten Kraftstoffs (Acceptance of hydrogen vehicles – A study on the use of a new and unusual fuel)	2000	Dinse, G.	Institut für Mobilitätsforschung Charlottenstr.43, 10117 Berlin, Germany, Phone +49 30 2030040, Fax +49 30 20300429, ISBN 3-932169-20-4	**Acceptance of hydrogen** as a fuel and of the vehicles	In the first part, the study makes an analysis of the theoretical basics and results of acceptance research in general developing 24 hypotheses. In the second part, employees of the BMW group are surveyed on their acceptance of hydrogen fuel using a written questionnaire. The results of this survey are compared to the hypotheses developed in the theoretical part. The standardized questionnaire contains 56 questions, most of which are closed questions with only a few (semi-) open questions. The survey aims at producing quantitative results and at verifying hypotheses.	Of the 16,324 employees of the BMW group in Germany 1,000 have been randomly selected for the survey. 593 have returned their answers to the questionnaire. It has to be noted that BMW has been developing hydrogen vehicles since the late 1970ies.
4	Joint mixed logit models of stated and revealed preferences for alternative-fuel vehicles	2000	Brownstone, D., Bunch, D.S. and Train, K.	Transportation Research Part B, 34, 315-338	**developing mixed logit models using stated and revealed preference data** on household preferences for AFVs	(2 wave California vehicle market survey). Wave 1: June 1993, computer assisted telephone interview of households in urban areas of California. Data was used to send customised mail questionnaires, with SP questions and $5 incentive payment. Wave 2: 1995, households that completed 1993 telephone survey were approached by phone; those who had bought at least one vehicle since 1993 interview were asked about their **vehicle purchasing decisions (revealed preference data)**, and more **stated preference questions** provided. Revealed and stated preference results were combined using mixed logit models.	(2 wave California vehicle market survey). Wave 1: June 1993, computer assisted telephone interview completed for 7387 randomly chosen households in urban areas of California. 4747 households successfully completed mail survey (66% response). Wave 2: 1995, 7300 households that completed 1993 telephone survey were approached by phone; 874 of the 2857 who did the second survey had bought at least one vehicle since 1993 interview. These were followed up with a further revealed and stated preference survey.

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5	Wasserstoffahrzeuge und ihr Funktionsraum – Eine Analyse der technischen, politisch-rechtlichen und sozialen Dimensionen (Hydrogen vehicles and their ambiance – An analysis of the technical, political and social dimensions)	1999	Dinse, G.	Institut für Mobilitätsforschung Charlottenstr.43, 10117 Berlin, Germany, Phone +49 30 2030040, Fax +49 30 20300429, ISBN 3-932169-07-7	acceptance, existing knowledge and demand for information on **hydrogen technologies**	150 persons were interviewed personally in the street at six different public locations in Berlin, three of which in the former western part and three in the former eastern part of the city. All locations are crowded areas with relatively high numbers of tourists. The interview took on average some 5 minutes to carry out. The questions were mainly open questions.	Interviewed were 150 randomly selected people in the streets of Berlin, Germany.
6	The market acceptance of electric motorcycles in Taiwan experience through a stated preference analysis	1999	Chiu, Yi-Chang and Tzeng, Gwo-Hshiung	Transportation Research Part D, 4,127-146	**acceptance of electric motorcyles** among motorcycle drivers in Taiwan	**Contingent ranking experiments** , involving 3 choices (electric, low engine and high-engine volume motorcycles). 7 attributes with 4 levels. Based on initial results, questions for males and females have different attribute levels.	Two respondents over 18 (one male, one female) from 256 randomly selected households in Taipei, were interviewed in person. All male interviews were valid; 244 out of 256 female interviews were valid (95%).
7	The acceptance of hydrogen technologies – Die Akzeptanz von Wasserstofftechnologien	1998	Altmann, M. and Graesel, C.	A Report for HyWeb www.HyWeb.de/acceph2 (English) www.HyWeb.de/akzepth2 (German)	acceptance, existing knowledge and demand for information on **hydrogen technologies**, amongst users and non-users of a hydrogen bus in Munich	Three-part survey study carried out in Munich to secondary school students on board a hydrogen bus and in the classroom (Parts 1 and 2 respectively) and other passengers (Part 2). Survey involved **attitudinal and knowledge questions** relating to hydrogen technologies, as well as demand for more information. There was also an open question about respondent's associations with hydrogen. Part 3 involved comparing attitudes towards hydrogen technologies between respondents with direct contact and those without direct contact with hydrogen technologies. This part of the study is useful for comparing influence of use on acceptance of the technology or fuel.	Part 1 of study: 410 secondary school students in Munich and Oldenburg schools; Part 2: 145 passengers on board a hydrogen bus in Munich; Part 3: 24 students attending a 'Gymnasium' in Munich were surveyed on the bus (within part 2). These results were compared with those from 188 Munich students of the same age in Part 1 (also attending Gymnasium).
8	Clean Air Forever? A Longitudinal Analysis of Opinions about Air Pollution and Electric Vehicles	1998	Gould, J. and Golob, T.F.	Transportation Research Part D, 3(3), 157-169	**changes in environmental attitudes towards EVs** over time, and amongst highly-involved EV users	Two data sets used: 1) panel survey of environmental opinions of Californian households over two waves (1993 and 1995), and 2) **experimental survey** design, involving in-board **travel logger** (to record dist travelled); a **travel diary**; and pre-trial and post-trial **attitudinal and intention surveys** . (Note that data set 1 comes from a large 2 wave California vehicle market survey, developed used in other papers such as Brownstone et al, 1996; 2000; Brownstone and Train, 1998)	Two data sets: 1) panel survey of environmental opinions of Californian households (n=1718; 76% response rate) over two waves (1993 and 1995), 2) 69 households, who participated in 2-week long EV trials in California, had to complete an in-board travel logger (to record dist travelled); a travel diary; and pre-trial and post-trial attitudinal surveys. 53 completed surveys were usable (77%)

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9	Car fuel-type choice under travel demand management and economic incentives	1998	Ewing, G.O. and Sarigöllü, E.	Transportation Research Part D, 3(6), 429-444	**preferences of drivers for different attributes of private vehicles**, in order to identify the factors likely to influence the demand for lower emission or zero emission vehicles	6000 phone numbers from the postwar suburbs of the Montreal Census Metropolotan Area were called randomly and a pre-survey conducted to choose eligible respondents. To be eligible the respondent had to drive to work or school a minimum of 3 times a week. The questionnaire was posted to respondents, and it contained 9 **choice experiment** questions, in which 4 of the 8 attributes (vehicle price, maintenance cost, commuting time and cost) were customised to be proportional to the respondent´s situation. Each attribute had 3 levels.	881 of the 1500 individuals who agreed to complete the questionnaire did so (59% response rate).
10	Electric vehicle purchasing intentions: the concern over battery charge duration	1997	Cheron, E. and Zins, M.	Transportation Research Part A, 31, 235-243	identifying **key variables blocking the purchase of an EV**, and trade-offs between these variables	Four groups of car users from Montreal took part in discussion groups, which took place over three 2-hour phases in July 1994. Phase 1: **unstructured discussion session** about expectations, perceived risk and satisfactions with current vehicle. Phase 2: specific question about perceived problems of an EV. Question was designed using the **Nominal Group Technique** (see art for more info). Phase 3: 12 **conjoint analysis questions**, consisting of 4 attributes (range, max speed, recharging time and cost/delay in case of dead battery) with between 3-4 levels each. Also, a short questionnaire at the end.	Four groups of car users from Montreal were recruited for the discussion groups. Total number of participants was 37, with two groups having 10 participants, one group with 9 and the other with 8. 65% participants were male.
11	Commercial fleet demand for alternative-fuel vehicles in California	1997	Golob, T.F., Torous, J., Bradley, M., Brownstone, D., Crane, S.S. and Bunch, D.S.	Transportation Research Part A, 31(3), 219-233	**preferences for AFVs** amongst commercial fleet managers	**Two part survey** carried out Feb-June 1994: 1) computer assisted telephone interview, 2) based on results from part 1, customised mail questionnaires composed of 3 parts were sent to the person responsible for acquisition of the vehicles: i. basic info on vehicles and usage, ii. **variation on choice modeling question** (max 2 questions per respondent). The focus in these SP questions was on fuel types, and respondents were presented with 3 vehicle options (out of total 4) with 8 attributes and many different levels per attribute. iii. **attitudinal and intention questions**	Two part survey: 1) 2711 valid surveys (out of 3818 interviewed), representing 71% response rate, 2) 2131 valid mail surveys (out of 2732) representing 78% response rate. Surveys from respondents with less than 10 vehicles per fleet were excluded, leaving 2023 total usable surveys. Approx 136,000 vehicles in the sample, highly skewed towards larger organisations.

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12	Testing electric vehicle demand in `hybrid households' using a reflexive survey	1996	Kurani, K.S., Turrentine, T. and Sperling, D.	Transportation Research Part D, 1, 131-150	assessment of **potential for EV's** amongst *hybrid households*	**experimental study** involving a 4-part survey (with $50 incentive payment) sent to potential hybrid households in 6 metropolitan areas of California. The study included a video and other informational material, and required completion of a **3-day travel diary, a map of travel** locations and choice experiments.Part 4 of the survey involved **pairwise choice experiment** questions, in which a total of 6 different vehicle types were compared according to attribute levels. Choice questions had 5 attributes (relating to vehicle performance, price, novel features and environmentalism) with varied levels	740 potential hybrid households were identified (on the basis of number and type of cars owned) from market research databases in 6 metropolitan areas of California, and sent a 4-part survey with 50 dollars incentive payment. 454 households completed the study (61% response rate)
13	Premarket forecasting of really-new products	1996	Urban, G.L., Weinberg, B.D. and Hauser, J.R.	Journal of Marketing, 60, 47-60	forecasting **consumer acceptance and purchase intentions for a 2-seater EV** concept developed by GM, called *Impact*	quasi-experimental study, involving **information acceleration (IA) methodology** - this consists of a multi-media virtual buying environment that simulates the information available to a consumer when making a new vehicle purchase. Simulated information sources are: virtual showrooms, adverts, articles and word-of-mouth interactive videos. After each exit from an information source, respondents are asked to indicate **purchasing intentions** for various vehicles presented in IA on a scale, and **rate eight attributes** of each vehicle (including environmental benefit). Vehicles presented include the Impact, a popular ICE vehicle (Toyota Celica) and two future vehicles with environmental benfits. Purchase intentions with full-information was found when respondents exited from last information source.	participants were selected from a pool of consumers subject to various preconditions, such as acceptance of environmentally friendly vehicles and willingness to buy a premium vehicle. Of the 606 respondents who agreed to participate, 587 were interviewed. There was a $50 incentive for participation.
14	A transactions choice model for forecasting demand for alternative-fuel vehicles	1996	Brownstone, D., Bunch, D.S., Golob,T.F. and Ren, W	In: McMullen,S. (Ed) Research in Transportation Economics, (Vol 4, 87-129)	large-scale surveys of **preferences for AFV's** from both households and fleet operators, to help develop demand forecasting model for AFV's in California	see Golob et al (1997) for description of fleet-operator part of survey; see Brownstone et al (1994) for household part of survey	Surveys carried out across California. Fleet-operator survey sample: 1) 2711 valid surveys (out of 3818 interviewed), representing 71% response rate, 2) 2131 valid mail surveys (out of 2732) representing 78% response rate. Household survey sample: total of 4747 households completed all three parts of the survey, representing 66% response rate among households that completed the first CATI survey (7387 households)

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15	Household markets for neighbourhood electric vehicles in California (executive summary)	1995	Kurani, K.S., Sperling, D., Lipman, T., Stanger, D., Turrentine,T. and Stein, A.	Research Report UCD-ITS-RR-95-6, Inst of Transportation Studies, University of California, Davis Prepared for Calstart NEV Market Study	assessment of **potential for EV's in local transportation** (known as neighbourhood electric vehicles, or NEVs) for households	**experimental study** involving various sub-projects: **case-studies** of "golf-cart communities" in California; 'ride-and-drive' clinics, in which people tried out various NEVs; **vehicle trials** , in which households were given use of an NEV for 1 week; and a statewide mail **survey of EV purchasing intentions**. The survey was focused on the concept of hybrid households (see Kurani et al, 1995)	Focus groups were conducted with 35 households that own golf carts (as means of transport); 25 people took part in the 'ride-and-drive' clinics'; 15 households participated in the vehicle trials; the statewide survey was aimed at hybrid households (households owning two or more vehicles, of various sizes). Out of 658 surveys sent out, 454 completed ones were returned (69% response rate).
16	The Household Market for Electric Vehicles: Testing the Hybrid Household Hypothesis - a reflexively designed survey of new car-buying, multi-vehicle California Households	1995	Turrentine, T. and Kurani, K.	Research Report UCD-ITS-RR-95-5, Inst of Transportation Studies, University of California, Davis	assessment of **potential for EV's** amongst *hybrid households*	see Kurani et al (1996)	see Kurani et al (1996)
17	Forecasting the market for electric vehicles in California using conjoint analysis	1995	Segal, R.	Energy Journal, 16(3), 89-107	consumer **preferences for electric vehicles**	A sample of 2500 residential electricity customers in the Pacific Gas and Electric service teritory (California) were sent a questionnaire containing **contingent rating** questions. Each question had 7 attributes including refuelling attributes, range, fuel attributes and cost of vehicle. Between 2 and 3 levels.	662 questionnaires were completed out of 2500 that were sent (28% response rate)
18	The target market for methanol fuel	1995	Sperling, D., Setiawan, W. and Hungerford, D.	Transportation Research Part A, 29(1), 33-45	potential target **market for methanol** in the household vehicle market	**dichotomous choice CVM**, involving 8 different bid amounts for two main variables: WTP for cleaner fuel and WTP for extra power (note that methanol has higher engine power than premium gasoline).	5000 questionnaires were mailed to registered owners of a random sample of automobiles in New York and California, in February 1989. 1504 usable surveys were returned (response rate of 30%.
19	A Demand Forecasting System for Clean fuel Vehicles	1994	Brownstone, D. Bunch, D.S. and Golob, T.F.	UCTC No. 21, *Working Paper May 1994*, University of California Transportation Center	large-scale surveys of **preferences for AFV's** from both households and fleet operators, to help develop demand forecasting model for AFV's in California	Three part survey carried out Feb-June 1994: 1) computer assisted telephone interview (CATI), 2) based on results from part 1, customised mail questionnaires sent to households, composed of: i. basic info on vehicles and usage, ii. **choice modelling** question (max 2 questions per respondent). The focus in these stated preference questions was on fuel types, and respondents were presented with 3 vehicle options (out of total 4) with 8 attributes and many different levels per attribute, 3) final CATI interview with attitudinal questions and to collect stated preference results	Surveys carried out across California. Total of 4747 households completed all three parts of the survey, representing 66% response rate among households that completed the first CATI survey (7387 households)

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20	Predicting the market penetration of electric and alternative-fuel vehicles	1993	Golob, T.F., Kitamura, K., Bradley, M. and Bunch, D.S.	The Science of the Total Environment, 134, 371-381	consumer **preferences for electric vehicles** and clean-fuel vehicles	Three phase SP survey. Phase 1: recruitment letter, incentive prize announcement and household and vehicle ownership survey posted to random sample of respondents; Phase 2: basic socio-economic questions, and five **choice experiments** choice sets asking respondents to choose between three vehicle options. Attributes included: limited refuelling stations, range, vehicle prices, operating costs, emissions levels, multiple fuel capability and performance. Phase 3: 4 choice experiments based solely on fuel choice (as opposed to vehicle choice as in Phase 2); each option with 4 attributes.	Survey implemented in 1991 throughout South Coast Air Basin of California; response rate for phase 1: 34%; 67% of phase 1 respondents completed phase 2 (hence total response rate for 1 and 2 at 22%). Phase 3 not mentioned.
21	Demand for alternative-fuel vehicles in California: a discrete choice stated preference pilot project	1993	Bunch, D.S., Bradley, M., Golob, T.F., Kitamura, R. and Occhiuzzo, G.P.	Transportation Research Part A, 27, 237-253	pilot project (same as for Golob et al, 1993); assessing consumer preferences for AFVs	see Golob et al (1993)	see Golob et al (1993)
22	Estimating the demand for electric automobiles using fully disaggregated probabilistic choice analysis	1985	Calfee, J.E.	Transportation Research Part B, 19, 287-302	**potential demand for EV's** among wealthier families with two or more vehicles in US	survey consisting of 30 **choice experiments** ; each experiment presented 3 hypothetical vehicles with 5 attributes each (levels not specified). Environment not included as an attribute.	51 members of a church in Berkely, California were given a survey to take home; 10 were returned on time (20% response rate).
23	The potential market for electric vehicles: results from a national survey of commercial fleet operators	1985	Berg, M.	Transportation Research Record, 1049	potential market for Evs among commercial fleet operators in US	Randomly selected fleet managers throughout the US were surveyed by telephone. Although not specified, it appears that interviews were semi-structured, establishing exisitng commercial fleet characteristics, which the author then uses to examine potential market for EV's in fleets. No attitude or preference questions involved.	583 randomly selected fleet managers interviewd over 2 months during fall of 1983 (92% response rate)
24	Choice of smallest car by multi-car households and the demand for electric vehicles	1980	Beggs, S.D. and Cardell, N.S.	Transportation Research Part A, 14, 389-404	demand for EV's in mulit-vehicle households in US	based on assumption that niche market for EV's is with small-car buyers in multi-vehicle households, authors use panel data collected previously (in 1977) in Baltimore, USA, to estimate demand for EV's. **Contingent ranking** : using multinomial logit model with a number of attributes rating to vehicle size, cost and performance, they assess trade-offs between different attributes. These results are used to predict demand for EV's based on initial assumption	not specified