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The current state of consumer information about hydrogen-powered vehicles: a quantitative analysis

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Abstract

A consumer survey was conducted from April to August 2012 to gather information about consumer reaction to hydrogen-powered vehicles, based on a sample of 586 consumers. The survey covered issues such as eco-friendliness, safety aspects, costs, and convenience of hydrogen-powered vehicles. The data collected was analyzed descriptively in order to explore current consumer moods and trends with regard to hydrogen-powered vehicles. The results of the survey were correlated to establish connections within the dataset. The correlations were analyzed in terms of strength, direction, and significance. Subsequently, management implications were defined, and possible areas for further investigations were suggested.

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1. Introduction

The fact that fossil fuels, like oil or natural gas, are finite is undeniable. Therefore a scenario based on alternative fuels has to be devised which guarantees energy sustainability and provides the world with the possibility of being independent of these finite fossil fuel resources. One of the major industries in which alternative sources of energy play an important role is the automotive industry. Here, alternative sources of energy can reduce dependence on conventional sources of energy. Some of the more established alternative sources of energy, for example, are biomass or electricity (Busby 2005, pp. 3-4). Another energy carrier that has received a lot of attention is hydrogen. For the automotive industry, hydrogen provides several advantages compared to other alternative sources of energy. For example, combustion produces only water vapor while achieving a similar level of efficiency as conventional fuels (Busby 2005, pp. 17-20).

This raises the question of the current level of consumer information about hydrogen-powered vehicles. As potential buyers and drivers of such vehicles, their preferences and feelings have a considerable impact. This thesis tries to gather and analyze information about consumers' attitudes to hydrogen-powered vehicles, in line with the research question: "What is the current status of consumer information and feelings about hydrogen-powered vehicles?"

As part of the introduction, the advantages of hydrogen as a viable alternative to conventional fuels will be pointed out. Hydrogen and two major applications of this gas in the automotive industry are described in the first chapter of this thesis.

As consumers are still largely unfamiliar with alternative sources of energy, eliciting information about the topic from them is important for the development and market potential of vehicles powered by alternative sources of energy. The definition of consumer behavior and how levels of consumer information affect their choices are dealt with in the second chapter.

To be able to collect data about the current status of consumer information in a valid way, an instrument of data collection has to be designed and a survey has to be conducted.

Before the study can be conducted, the method of research has to be defined. Therefore, a short introduction into the topic of social research is given in the third chapter. Furthermore, the two major methods of data collection are explained and the choice of method appropriate to the study conducted for the purpose of this thesis is made. At the end of the third chapter, the social research method, qualitative or quantitative, is selected.

After the appropriate data collection method has been selected and the method of social research has been chosen, it is important to create a valid instrument for conducting the survey. To achieve this goal, a ten-step process for designing a valid research instrument is implemented.

Subsequent to collecting the data, an analysis is carried out. In the first step the collected data is analyzed in a descriptive way to generate information about every single item of the questionnaire. In the second step, correlations between items are established to provide better insight into the data collected. This happens by correlating topic-related variables with each other and afterwards by correlating topic-related variables with demographic variables. For reasons of relevance, only the strongest correlations among the items are selected for the analysis. To be included in the analysis, the correlation has to be stronger than 20% and the connection, of course, has to be significant.

The most important findings are set out in the management implications. These implications show how hydrogen-powered vehicles could be installed as the fuel of the future for the automotive industry. The last chapter summarizes the whole thesis and poses a number of interesting questions for further studies.

2. Definition of terms

In this chapter the terms hydrogen, consumer behavior and consumer information are defined. This definition aims to clarify these terms and to create the knowledge base required for further reading and understanding this study and analysis.

2.1. Hydrogen

As the object of this thesis is to gather information about consumer feelings with regard to hydrogen-powered vehicles, it is important to provide a short definition of the term hydrogen. The first sub-chapter provides some basic information about hydrogen, the second sub-chapter describes a scenario of an economy using hydrogen as an alternative to fossil fuels, and the third sub-chapter sets out how hydrogen can be used to power vehicles.

2.1.1. Basic information about hydrogen

The term hydrogen refers to a colourless and odourless gas. It is the lightest chemical element and its structure consists of an electron and a proton. Another property of hydrogen is that it has the second lowest boiling point after helium, at -252.9°C, and the second lowest freezing point, at -259.3°C. Again, helium has the lowest freezing point (Evers 2010, p. 90). Hydrogen is an energy carrier, which refers to the fact that it is a source of energy that can be stored and transported. However, it is not a primary source of energy and therefore not a natural source of energy. Hydrogen has to be produced from primary energy resources (Busby 2005, p. 3). In the process of hydrogen production, a part of the energy is lost as thermal energy. Therefore the production of hydrogen is faced with an efficiency problem. Possible technologies for producing hydrogen are:

- *Electrolysis:*

  The term electrolysis refers to a general method of producing hydrogen from different primary sources of energy by water splitting. This could be electricity, nuclear energy or energy from fossil sources. Additionally, alternative sources of energy, like wind or solar energy, can deliver the energy for the process of water splitting. When using wind energy, electricity is produced by wind turbines. Solar

cells are also able to produce the electricity necessary for electrolysis. The problem involved in electrolysis is the fact that huge amounts of electricity are required to produce hydrogen and therefore the hydrogen produced is only as clean as the source of primary energy (International Energy Agency 2006, pp. 9-12).

- *Steam reformation*

  Steam reformation is a relatively efficient method of hydrogen production, where hydrogen is separated from the carbon part of fuel by using thermal energy. The primary energy of steam reformation is natural gas. The problem of this hydrogen production method is the generation of carbon dioxide. This happens in two ways. The first is that carbon dioxide is a by-product of the steam reformation process. The second is that carbon dioxide is generated in the production of fuel cells (International Energy Agency 2006, pp. 7-9).

- *Coal gasification*

  The method of coal gasification has the potential to produce considerable amounts of hydrogen because of the large amounts of coal available. Furthermore, the production process is of relatively low cost. Coal gasification is a good method for economically producing large quantities of hydrogen, but the main problem of this method is that, like with steam reformation, the amount of carbon dioxide emitted is rather high (Turner et al. 2004, p. 972).

- *Photo-electrochemical process*

  The photo-electrochemical production process produces hydrogen directly by splitting water through the illumination of a water-immersed semiconductor. This process is powered by solar energy. There are two possible photo-electrochemical processes, either imitating photosynthesis or converting solar energy into chemical energy (International Energy Agency 2006, pp. 12-13).

- *Biomass processing methods*

  Biomass can be converted into liquid fuels like ethanol, methanol and biodiesel, which can be used to produce hydrogen. Although biomass is sustainable, it is not able to produce hydrogen in amounts needed. As food is not always available in

infinite amounts, there is a critical trade-off between using biomass for fuel production or food production (Turner et al. 2004, p. 972).

As has been shown, hydrogen can be produced by a number of different processes and from a variety of primary energy sources. The critical arguments for not switching to a hydrogen economy are problems with efficiency in the production as well as cost effectiveness and the clean production of hydrogen. The most important things to keep in mind in the production of hydrogen are (International Energy Agency 2006, pp. 6-18):

- Hydrogen has to be extracted from primary resources like coal, water or natural gas. Energy is needed to extract hydrogen from these primary energy resources.

- Hydrogen is only as clean as the primary energy source from which it is produced and the technology used to extract hydrogen. Both coal gasification and steam reformation produce carbon dioxide.

Busby (2005) mentions the problem that people think that the use of hydrogen is unsafe. However, compared to gasoline or propane, the use of hydrogen does not pose any danger. Due to the ultra-light character of the gas it would just disperse in the event of a leak. Furthermore, there is no problem with hydrogen spilling on the ground and thus contaminating ground water (Busby 2005, p. 9). Hydrogen can be stored in either gaseous form or liquid form. To store hydrogen, high pressure is necessary. For transporting hydrogen, large investments have to be made in medium- to large-range pipelines. As the technology is similar to transporting natural gas via pipelines, only small alterations need to be made to contain the smaller hydrogen molecules with acceptable leakage rates. Other transportation methods of hydrogen are in containers by either ship or truck (Sörensen 2012, p. 93).

To provide an example of a possible scenario of the world using hydrogen for powering vehicles, here is a brief introduction to the hydrogen economy scenario.

2.1.2. Hydrogen economy

Increasing industrialization in developing countries, like China and India, means that the demand for energy will continue to rise in the future. The finiteness of fossil fuels, such

as oil and natural gas, raises the question of whether or not the current energy projections, which rely on the assumption of the continuation of the world's economic growth, take the available remaining supply into consideration in an adequate manner. While, in the short and medium term, improved internal combustion engines, hybridisation and dieselisation can improve the fuel economy of vehicles, long-term strategies have to focus on the development of alternative energies. Among other alternative energies, like biomass or electricity, hydrogen seems especially promising as it burns similarly to petrol or gas-fired engines to produce pure mechanical energy (Ball/Wietschel 2009, p. 38).

The hydrogen production from renewable and locally available energy resources is seen as an ambitious, near-zero-emission scenario of energy provision. This scenario offers the possibility of reducing dependence on fossil fuels and slowing the depletion of finite resources at the same time, which would secure the supplies of energy in the future. Using fossil fuels for the production of hydrogen is an interim option for bridging the gap between the carbon economy of today and an economy that is based on hydrogen produced from renewable resources, the hydrogen economy. This economy is one of the long-term priorities of the planned energy politics of the European Commission. Apart from Europe, the transition from a carbon economy to a hydrogen economy is also pursued by the USA and Japan (Ball/Wietschel 2009, p. 39)

2.1.3. Hydrogen in vehicles

There are two types of technologies for using hydrogen in vehicles. The first is the internal combustion engine, in which hydrogen is used similarly to conventional fuels. The second is fuel cell technology. This technology uses hydrogen to produce electricity, which then powers the vehicle.

Hydrogen internal combustion engines

The ability of hydrogen internal combustion engines to burn hydrogen without emitting CO_2 and to operate efficiently is the result of the unique combustion characteristics of the gas. These characteristics allow ultra-lean combustion with low nitrous gas production and low engine-load[1] operation. High engine-loads entail technical challenges due to the

[1] Engine-load is the measurement of how hard an engine works. It is measured in percent. Engine load is usually measured by reading of the inlet airflow. (Erjavek 2010, pp. 990-992)

increased propensity of the hydrogen-air mixture to pre-ignite and increased production of nitrous gases (White et al. 2006, p. 1293).

The future of the hydrogen internal combustion engine in the short-term is conceivable and economically viable because it could serve as an option of a portable power plant in a hydrogen economy. The long-term future of the hydrogen internal combustion engine is hard to predict, as is the future of the whole hydrogen economy itself. This uncertainty is due to the multiple options for technologies for the internal combustion engine and the development of these different technologies. The commercial viability of these technologies requires continued advancements in fundamental hydrogen internal-combustion engine research, the reduction of nitrous gases emission, research into, and development of, advanced engine components and highly advanced control and optimization strategies (White et al. 2006, p. 1303).

Hydrogen fuel cells

Fuel cells play an important role in the hydrogen economy as they produce energy on demand, which could mean the end of hydrogen transportation problems, for example via pipelines. Fuel cells are similar to batteries which produce energy. In contrast to ordinary batteries, which produce energy from stored chemicals, chemical energy in the form of fuel is inserted into the cell, which then uses this fuel to produce energy. The fuel cell is able to produce energy as long as fuel and oxygen are available. For fuel cells, the energy carrier hydrogen is an efficient fuel. Electricity is generated in fuel cells by mixing hydrogen and oxygen from the air in an electrochemical process that is clean and flameless. Furthermore, no emissions are created except pure, distilled water (Busby 2005, pp. 11-12).

Nowadays the efficiency of fuel cells is two and a half times that of a car engine running on gasoline. Fuel cells can capture between 40% and 65% of the hydrogen's energy and convert this energy into electric power (Busby 2005, pp. 11-12). The overall efficiency from wells-to-wheels is not more than 30% if production of hydrogen from hydrocarbon resources is taken into account, too. In comparison, the efficiency of the traditional internal combustion engine powered by gasoline is not more than 15% (Davis et al. 2003, p. 22).

Now that the term hydrogen and the major technologies for using it in the automotive industry have been described, it is important to explore how consumers behave in a situation in which they do not have complete information. Since hydrogen as a fuel for vehicles is not a topic covered by the mass media every day, most consumers have only very little information about this alternative fuel. The next chapter will be dealing with consumer behavior and how the level of information impacts on consumer decisions. The chapter also sets out why "knowledge-behavior" gaps are important for the study, as well as irrelevant information.

2.2. Consumer behavior and knowledge

Like any other innovation, hydrogen-powered cars have to be available for the masses to provide an alternative to vehicles powered by fossil fuels. Therefore, it is necessary to gather information about consumer behavior in the context of hydrogen-powered vehicles. Generally, consumers do things for specific reasons. Therefore, every consumer acts in a different manner, influenced by his or her knowledge.

2.2.1. Consumer behavior

As the purpose of the survey is to find out about levels of information among consumers with regard to hydrogen-powered vehicles, it is important to collect information about the behavior of consumers whose information is incomplete. First of all, the term consumer behavior can be defined as all activities associated with the purchase, use and disposal of goods and services. This also includes a consumer's emotional, mental and behavioral responses which precede, determine or follow these activities. Since hydrogen-powered vehicles are not available for the mass market yet, the emotional, mental and behavioural reasons impacting on consumer purchasing decisions are the object of research (Kardes et al. 2008, p. 8).

The term consumer can refer to either individual consumers or organizational consumers. Individual consumers purchase goods or services to satisfy their own needs or the needs of their families, while organizational consumers buy goods or services for the purpose of producing other goods or services to resell to other organizations or individuals or to help them to manage and run their organization (Kardes et al. 2008, pp. 8-9). The survey of

this thesis mainly aims at individual consumers who are interested in the topic of hydrogen-powered vehicles for themselves or for their families.

Consumer research focuses on consumer reactions. There are several theories with regard to the research of consumer information, for example the psychological and economic view or the biological and historical view. The latter describes the consumer not as a conscious, rational decision-maker as defined in the first view, but as an emotional, unfocused, learning human. The micro-levels focus on individual judgements of product attributes must give way to the theory of how people set goals, make important decisions and are influenced by other people in making their choices (Case 2012, p. 333-334).

One object of researching consumer information is to define knowledge-behavior gaps. These gaps occur if consumers do not get first-hand information and they can influence the behavior of humans. In this study, the current level of information among consumers is researched and therefore only little information about the topic is given to the respondents. So, one of the goals of the study is to work with consumer knowledge-behavior gaps by not influencing the respondents with any primary information and gathering their preferences (Case 2012, p. 334).

2.2.2. Consumer knowledge

Prior familiarity with a product may determine whether consumers leave it sitting on the shelf or buy the product and take it home. This familiarity with a product reflects the consumer's knowledge of the product. Consumer knowledge can therefore be defined as the subset of the total amount of information about a certain topic stored in memory that is relevant to product purchase and consumption. What consumers know and what they do not know influences their decision-making. Beyond affecting how a decision is made, consumer knowledge may also determine the final decision. Knowledgeable consumers are more capable of evaluating a product's true attributes, which gives them a greater chance of making the right decisions. Because of the fundamental role which consumer knowledge plays during the decision-making process and the many business and public implications resulting from the status of knowledge of consumers, establishing and enhancing this knowledge is essential. In this thesis, two types of knowledge are important: the knowledge of the product's existence and the knowledge of the product's attributes and associations (Blackwell et al. 2001, pp. 259-260).

Knowledge of the product's existence

One of the most fundamental aspects of consumer knowledge involves whether consumers are aware of a product's existence. Before a product can enter the consideration set, it must gain entrance into the awareness set. This awareness set comprises products known to the consumer. Gaining awareness among consumers is essential, especially for new products. There are two basic approaches to assessing consumer awareness. The first approach focuses on what consumers are able to recall from memory. This approach is also called top-of-the-mind-awareness. The second approach that wants to measure awareness focuses on name recognition. This means that consumers are given a list of names and asked to identify names familiar to them rather than asking consumers to recall names (Blackwell et al. 2001, pp. 260-261).

A major issue in consumer behavior is the acceptance of new products. The framework for exploring consumer acceptance of new products is drawn from the area of research known as the diffusion of innovations. In the field of consumer research, two processes, which are closely related to each other, are the most interesting: the diffusion and the adoption of innovations. Diffusion is a macro process concerned with the spread of a new product from its source to the consuming public. In contrast, adoption of a new product is a micro process which focuses on the stages which an individual consumer passes through when deciding whether to accept or reject a product innovation. The ability of marketers to identify and reach consumers plays a major role in the success or failure of new-product introductions (Schiffman/Kanuk 2010, p. 450).

As new technologies for hydrogen-powered vehicles are still in the phase of introduction to the major public and as they have not reached the level of technology which makes them ready for mass production they can be seen as innovative products. Consumers can develop resistance to some innovations. To overcome this resistance or to prevent it altogether, the consumer knowledge of the product's attributes has to be increased.

Knowledge of the product's attributes and associations

Each product within the awareness set is likely to have associations between the product and some other information stored in a person's memory. The entire array of associations defines the product image, and these associations may involve physical properties and attributes as well as the benefits and feelings derived from product use or consumption.

Image analysis is all about examining what consumers know about the attributes and associations of a product. The initial step of an image analysis is the identification of the particular attributes and associations that determine a product's image. Not all associations are equally distributed across a product since some associations will be more salient and stronger than others. The second step in image analysis is to assess the strength of a product's associations. One approach to measuring this strength is simply to count how many consumers report a particular association when responding to questions about what comes to mind when they are thinking about different attributes of the product. The stronger the association, the more often a certain specific answer should be given by the consumers in the survey (Blackwell et al. 2001, pp. 261-263).

One of the purposes of the survey is to indicate what image of hydrogen-powered vehicles is created by consumers. If consumers do have a certain mental image of hydrogen-powered vehicles, the answers elicited by the survey should all tend in the same direction. If the image of the attributes of hydrogen-powered vehicles does not agree with reality, consumers have to be informed about the real attributes. This procedure is anything but easy because hydrogen-powered vehicles have, of course, not only advantages.

Giving primary information to survey respondents is always a subjective measure taken by the researcher. Therefore, the respondents may not find all the information given in the introduction useful, they may also view the information as irrelevant. Providing irrelevant information to people may weaken their belief in a product's ability to deliver the desired benefit (Meyvis/Janiszewski 2002, p. 618). Four mechanisms of irrelevant information can influence survey respondents (Meyvis/Janiszewski 2002, p. 618):

1. Adding irrelevant information reduces the weight that consumers assign to the information provided and thus weakens their belief in the product's ability.

2. Consumers may view irrelevant information as relevant because they are relying on conversational norms, which assume that all information given is relevant to assessing the product's ability to deliver the benefit.

3. Consumers may rely on a representativeness heuristic using similarities between the target product and other typical products that provide the benefit. This procedure enables the consumers to estimate the probability of the target product also delivering the benefit.

4. Consumers may treat the idea that the product delivers a benefit as a focal hypothesis. This could cause them to test the hypothesis in a biased fashion. However, most of the studies concerned with biased hypothesis testing have demonstrated that adding non-diagnostic information, which means irrelevant information, increases belief strength. On the other hand, there are also researchers who suggest that irrelevant information weakens the strength of the consumer's beliefs.

Although the first three mechanisms have received widespread attention, the fourth perspective of biased hypothesis testing has been largely ignored. Irrelevant information can also create dilution effects which lead to a less extreme judgement on the part of the respondents. The dilution effect has been using both, the non-social stimuli with probability judgements and the social stimuli with natural judgements (Meyvis/Janiszewski 2002, pp. 618-619)

In the design of this survey, information is given in the introductory text, but the amount of information is kept to a minimum. Only basic information about hydrogen and its characteristics is provided to survey respondents to introduce them to the topic if they have no prior information about hydrogen-powered cars. Since no special group of respondents is targeted, their levels of prior information diverge. For this reason, the introduction offers only a minimum of information designed to introduce the topic to respondents without any knowledge about hydrogen-powered cars and, simultaneously, not to discourage potential respondents with prior information from participating in the survey.

2.2.3. Consumer behavior as a field of study

With the emergence of the marketing concept, research into consumer behavior has become important for identifying and satisfying the needs of potential customers. A very focal point in the survey about hydrogen-powered cars is the consumer perceived value.

The value perceived by the consumer refers to the overall assessment of the utility of a product based on the perception of cost and benefit. In other words, the consumer perceived value is the net gain which consumers derive from expending time, money and effort to purchase, use and dispose a product or a service. This concept is important because the ultimate goal of the survey is to establish the perceived value of hydrogen-powered cars from a consumer point of view (Kardes et al. 2008, p. 13).

To gather information about possible consumer behaviour, three approaches have evolved over time: motivation research, behavioral science perspective and interpretivism. Motivation research fell out of fashion in the 1960s but it bequeathed two major findings to the field of consumer research: the focus on consumer motivations and the technique of in-depth interviews. The behavioral science perspective applies a scientific method relying on systematic, rigorous procedures to explain and predict consumer behavior. In the behavioral science perspective the consumers are seen as largely rational (Kardes et al. 2008, pp. 14-16).

The main object of the behavioral science perspective is to find the causes of specific behavior. Research is therefore conducted into strategic decision-making, and quantitative methods are primarily used for research (Kardes et al. 2008, pp. 14-16). In interpretivism, the social reality of a country is regarded as the product of the everyday activities of a country's inhabitants (Blaikie 2010, p. 99).

The behavioral science perspective can best be applied when looking at the status of consumer information with regard to hydrogen-powered vehicles because it allows the use of quantitative research methods to find out the causes of consumer behavior driven by a certain status of information, which basically means consumer perceived value. As consumers do not have complete information about hydrogen-powered vehicles, they state their opinions about certain aspects of the topic. These opinions will lead to conclusions after the survey is conducted and the data is collected and analyzed. The method of data collection is described in detail in the following chapter.

To achieve the goal of the survey, a decision has to be made as to whether the research should be conducted as basic research or applied research. The category of basic research looks at the relationship between variables without any concern for a specific situation.

The key benefits of the concept of basic research are that it provides information which can be generally used in a variety of situations, and researchers are able to use these generalizations to guide strategic planning. Applied research also examines variables, but in contrast to basic research, the variables are examined in a certain situation (Kardes et al. 2008, pp. 19-20).

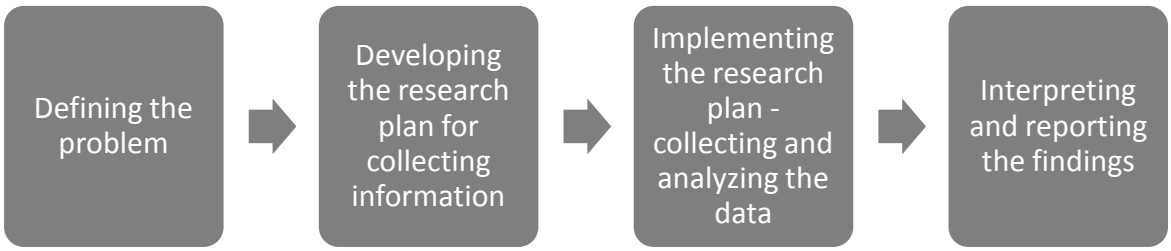
Applied research is more common than basic research because researchers want to gain information out of variables for specific situations of interest to them (Kardes et al. 2008, pp. 19-20). In the survey conducted, the concept of applied research was used because the aim of the survey was to search for information about consumer opinion about hydrogen-powered vehicles only.

3. The structuring of the research process

This chapter deals with the research process and with gathering the information required for the data analysis. Defining a structure for the process of research is fundamental to obtaining the valid data needed for a successful analysis.

Research has to be structured in accordance with a systematic process to be able to provide valid answers. This systematic process comprises the design of an instrument for data collection, analysis and reporting of relevant data. The research process has four steps (Kotler/Armstrong 2008, p. 100):

Figure 1: The research process



Source: Kotler/Armstrong 2008, p. 101

3.1. Defining the research problem

Defining the research problem can be the hardest step in the research process as there is often a feeling that a certain circumstance needs to be researched, but the specific problem is not known. For this thesis, the research problem has been defined in the introduction. After the definition of the problem, descriptive research has to be done to better describe problems, situations such as the consumer attitudes. The research problem guides the entire research process (Kotler/Armstrong 2008, p. 101)

3.2. Developing the research plan

Once the research problem has been defined, the specific information to be attained has to be defined, a plan for gathering this information has to be developed and the information gathered has to be analyzed. The research plan outlines the sources of already existing data and spells out specific research approaches, contact methods, sampling plans and instruments used to gather new data. Therefore, the research objective has to be translated into specific information needs (Kotler/Armstrong 2008, p. 101).

Once the research problem has been defined the task of data collection begins. First, it is important to define the source of data for collection to know where data can be found and what the advantages and disadvantages of the different sources of data are. When this task is finished, the next step is to select a research method. Not every research method fits every research problem. Therefore, selecting of the right method of research is indispensable for collecting the right data and answering the research question (Kothari 2004, p. 95).

3.2.1. Primary vs. Secondary data

There are two major sources of data: primary data and secondary data. The researcher has to decide which source of data is to be used for a certain study. The methods for collecting primary data differ from the methods for collecting secondary data because primary data has to be collected from original sources, while the process of collecting secondary is restricted to compilation (Kothari 2004, p. 95).

The different sources of data now described next, including their advantages and disadvantages.

3.2.2. Secondary data collection

Data which already exists is called secondary data. This kind of data has been collected for another purpose, not connected with the current study, but it can provide information that can be relevant and therefore used for the current study. As secondary data provides several advantages, research should start with exploring secondary data before collecting primary data. The most significant advantage of secondary data is that it saves costs and time. If data relevant to a certain study is available, the researcher only needs to locate it.

Primary data should therefore only be collected if the secondary data collected is insufficient for the purpose (Churchill/Iacobucci 2010, pp. 143-144). Although secondary data is probably not able to answer all questions of a certain study, it still is able to

- help to define the problem of investigation,
- suggest improved methods for investigating the data needed,
- provide a comparative benchmark against which the primary data can be more insightfully interpreted (Churchill/Iacobucci 2010, pp. 143-144).

The major disadvantages of secondary data are that it typically does not completely fit the issue to be investigated and that there may be problems with the accuracy of the secondary data with regard to answering a certain question. Furthermore, a problem could arise on the account of the age of the secondary data (Churchill/Iacobucci 2010 p. 144).

The problem of fit is caused by the fact that the secondary data was collected in the past for another purpose than the current study. To evaluate the accuracy of secondary data, the source of the data needs to be checked. To guarantee a high level of accuracy, the original source of the data has to be accessed. Data accuracy can be established by evaluating the research methodology employed. This evaluation needs to examine the sampling plan, how the survey was constructed and tested, what field collection procedure was used, and how the data analysis was carried out. As regards the age of secondary data, old data does not necessarily have to be irrelevant, but in today's fast-moving world up-to-date information is very important to obtain results which comply with the current situation (Churchill/Iacobucci 2010, p. 144).

Sources of secondary data can be either internal or external. Internal sources of secondary data can be close at hand, for example if they are within the organization that initiated the research process. This data is readily available to be consolidated, compared and analyzed to answer the new research question being posed. External secondary data has its origin outside of the confines of the organization. Useful external secondary data can be found, for example, in libraries or through web searches (Wrenn et al. 2007, pp. 74-75).

For this study, secondary data collection was carried out in order to find comparable studies for providing benchmarks against which the collected primary data could be interpreted more insightfully. This happened in the phase of pre-testing the survey. Two secondary data sources were found, which provided at least some data to evaluate the results of the conducted pre-test. However, to find the results needed for answering the research question, primary data collection was needed as no secondary data provided enough information.

3.2.3. Primary data collection

Primary data is the second source of data which is especially useful for the research purpose at hand. It needs to be relevant, accurate, current and unbiased, in order to enable the researcher to complete the study in a valid way. The advantage of primary data is that this data is obtained for a specific project. Furthermore, the data directly collected is current, and the process of data collection can be controlled by the researcher. The disadvantages of primary data are that the collection of data is expensive and data collection, organization and analysis are very time-consuming. In the following figure, research approaches, contact methods, sampling plans and research instruments for primary data collection are outlined (Kotler/Armstrong 2008, p. 103).

Table 1: Primary data collection methods

Research Approaches	**Contact Methods**	**Sampling Plan**	**Research Instruments**
Observation	Mail	Sampling unit	Questionnaire
Experiment	Telephone	Sampling size	Mechanical instruments
Survey	Personal	Sampling procedure	
	Online		

Source: Kotler/Armstrong 2010, p. 133

Observational research involves gathering primary data by observing people, actions and situations which are relevant for the study. Experimental research is the best approach for gathering causal information. Experiments involve selecting matched groups of relevant subjects and giving each group different treatment, controlling the unrelated factors and checking for different responses of the groups. The requested information can be received by mail, telephone, personal contact or via the Internet. The advantages and disadvantages of the different contact methods are described in detail in the survey design process in the chapter "Designing a valid survey instrument." To design the sample plan, three major points need to be taken into account. First, the unit of the research, in other words the respondents, must be defined. The exact definition of the sampling unit is conducted in the chapter "Designing a valid survey instrument." Second, it is important to define the number of units needed to safeguard that the study is conducted in a valid way. Third, it is important to define what kind of sample should be chosen (Kotler/Armstrong 2008, pp. 104-105).

The different kinds of samples comprise probability samples and non-probability samples. When probability samples are used, each member of the whole population has equal chances to be selected for the study. If probability sampling costs too much or takes too much time, non-probability sampling is used. Non-probability sampling can cause a measurement error, because only certain groups of the population respond to the study. These different ways of sampling provide varying degrees of accuracy and statistical properties. Which method fits best depends on the needs of the individual research project. Research instruments could be, for example, mechanical instruments or questionnaires. Mechanical instruments used for research could be people meters to measure the television programs which people watch most, or eye cameras which show where people look most when driving a vehicle. The research instrument of questionnaires is by far the most common one. As questionnaires are very flexible by in that they enable the researcher to use different kinds of questions, a great deal of information can be gathered The design of a questionnaire needs to be valid to ensure that relevant information is gathered (Kotler/Armstrong 2008, pp. 109-110). For this survey, the research instrument 'questionnaire' was used because of its flexibility to gather the information needed to answer the research question. The questionnaire design is described in detail in the chapter "Designing a valid survey instrument."

As a probability sample would have been too costly and would have taken too much time, the sample used in the survey for this thesis is a non-probability one, even if a measure error might occur. As the survey was conducted as an online survey, which is described in the chapter "Designing a valid survey instrument," only respondents with access to the Internet were able to provide information. The possible measure error resulting from the instrument of an online survey caused by a selection bias probably does not constitute a stronger bias than the interviewer bias in a personally conducted survey or a telephone survey. Taking into account the costs incurred, the time required and information gathered an online survey provides a maximum of benefits.

After defining the data collection source, it is now important to decide on a research method for collecting the data. In the next part of this chapter, two different research methods are presented, and the best fit is selected for gathering the data necessary for answering the research question.

3.3. Implementing the research plan

Implementing the research plan involves collecting and processing as well as analyzing the information. For collecting data, several research methods can be used. The collected data must also be processed and analyzed to elicit important information and findings. Furthermore, the data has to be checked for accuracy and completeness as well as the coding for analysis. After this step, the data has to be tabulated and statistical measures have to be computed.

3.3.1. Research Methods

Research methods can be divided into two main types: quantitative and qualitative research methods. Both quantitative and qualitative research methods are concerned with reliability and study design. The validity and reliability of a research question are proven if the item or subject of a study elicits the intended information. Research methods can be regarded as valid if they are successful in eliciting true responses, relevant to the desired information. It is essential that the respondent fully understands the questions and responds to them as intended by the researcher (Taylor 2005, p. 5). To secure valid responses of the consumers, a systematic approach should be adopted for the questionnaire.

This systematic survey design process is set out in the chapter "Designing a valid survey instrument." To provide a short introduction to the methods of empirical research, both terms, qualitative and quantitative research are defined.

3.3.2. Qualitative research

By qualitative research any type of research is understood which produces findings not arrived at by statistical methods. Methods of data collection can be more or less structured personal interviews or observations. The qualitative analysis of data is described as the nonmathematical process of interpretation. This process of interpretation is carried out for the purpose of discovering concepts or relationships in raw data and afterwards integrating these relationships and concepts into a theoretical explanatory scheme. A reason for doing qualitative research could be that the researcher has preferences for this method because research in some areas traditionally makes more use of qualitative methods. Another reason for choosing qualitative research can be found in the nature of the research problem (Strauss/Corbin 1998, p. 10).

Qualitative research can be used to explore substantive research fields if only little knowledge is available or if there is a superabundance of information. Basically, there are three major components in the field of qualitative research: The first component comprises the data which can come from various sources like interviews, observations or documents. The second comprises the procedures that researchers can use to interpret and organize the data. The procedures most often used are the ones of conceptualizing and reducing data, followed by establishing categories in terms of their properties and dimensions and relationship through a series of prepositional statements. Written and verbal reports constitute the third component. These reports may be presented in books or theses (Strauss/Corbin 1998, pp. 11-12).

3.3.3. Quantitative research

The second method of doing research is quantitative research. Quantitative attempts to explain phenomena by collecting numerical data which is analysed using mathematics-based methods, in particular, statistics. There are only few phenomena which appear in the form of naturally quantitative data. Therefore research instruments like the Likert scale are designed to convert data that does not exist in a naturally quantitative form into a form which can be analysed statistically. While it is important to use the right data

analysis tools, it is even more important to use the right research design and data collection method. In most cases, statistical tools are used for the analysis of the collected data. This statistical interpretation is one of the reasons why quantitative methods are often seen as more complicated than qualitative methods, but this view is incorrect because computer-based instruments help to make the interpretation of the collected data relatively easy and quick to conduct (Mujis 2004, pp 1-3).

The essential difference between quantitative and qualitative research is that qualitative research collects non-numerical data and quantitative research collects numerical data. The touchstones of quantitative research are the variables derived from the units. The respondents in quantitative research are seen as the units, and the data collected from these units are known as the variables. Variables are therefore any characteristics from the units in which the researcher is interested, for example age or a certain opinion. Variables may differ from unit to unit. Quantitative researchers design studies that allow them to test hypotheses. A hypothesis is a tentative explanation which accounts for a set of facts and can be tested by further investigation. This test is conducted by statistical techniques to decide whether the hypothesis can be rejected or not. Therefore not every situation is well suited to quantitative research. Four situations where quantitative methods do not produce satisfactory solutions are (Mujis 2004, pp. 3-9):

- When problems need to be solved in depth, quantitative methods are not effective. Quantitative methods are useful to provide information on a broad basis from a large number of units. For exploring problems in depth, quantitative methods are too shallow; in this case, qualitative methods are more efficient.

- Quantitative methods are not able to create hypotheses and theories. But they are a good method for testing hypotheses and theories.

- Quantitative research has a limit of variables that can be observed because the researcher defines the items for the instrument chosen. In the case of qualitative research, unexpected variables can emerge.

- Another point is that, while quantitative methods are well suited to looking for cause and effect, qualitative research methods are better suited to looking at the meaning of certain events, opinions and circumstances.

The problem of exploring consumer opinions about hydrogen-powered vehicles is well suited for a method that can explore a given number of variables in a broader rather than deeper sense. Furthermore, a large number of units are needed to receive a sample to test the hypotheses and work on the research question. As the variables, hypotheses and theories are defined in the chapter "Designing a Valid Research Instrument" no further hypotheses need to be created. All variables that need to be investigated are given, and no new variables need to be created. Furthermore, the purpose of the study is to look for causes and effects and not for the meaning of the opinions of the units. Therefore, the use of quantitative methods for collecting data and testing hypotheses is superior to the use of qualitative methods because data can be collected more easily and in a more efficient way, and a larger size of sample can be achieved.

When the research method has been defined, a valid survey design has to be created to ensure that the required information can be gathered. Furthermore, it is important to define the groups of people who are involved in the study. So, the stakeholders in the survey are defined in the following chapter, and a ten-step design process is described.

4. Designing a valid survey instrument

This chapter is about the creation of a valid instrument for a survey. As stated before previously, the research method was a quantitative one and the instrument was a questionnaire. The reasons and the process of designing a valid questionnaire are set out in this chapter. Before the questionnaire design process is described, the stakeholders of the questionnaire are defined to establish who is involved in the study.

4.1. The stakeholders in a questionnaire

There are a number of different stakeholders in a questionnaire, and on each of them it will have a different impact. Up to five different stakeholders of a questionnaire can be distinguished. Each group of stakeholders has certain demands on a questionnaire (Brace 2008, p. 9):

- Clients, or people commissioning the survey, require the survey to deliver data which provides information required for certain decisions.

- When conducting interviews via telephone or personally, interviewers are needed who want a questionnaire which is straight-forward and easy to administer and which provides questions easily understood by respondents.

- The respondents want questions they can answer without too much effort. Furthermore, the questions have to be such as to maintain their interest without taking up too much of their time.

- The data processors want a questionnaire layout that allows them uncomplicated data entry. Furthermore, the layout has to provide for easy production of data tables and other analyses that may be required.

- The researcher or questionnaire designer has to meet all the needs of the different people while working within a certain budget.

As so often when different groups of people interact, it is not always possible to meet all the needs of all the people at the same time. One of the most important tasks of the researcher is to juggle the demands of the various stakeholders. Respondents are generally volunteers who give their time, and therefore do not wish to be bored by the questionnaire. The researcher's job can be summarized as creating a questionnaire that collects the required data to answer the research question of the study as objectively as possible while not irritating and annoying the respondents. Furthermore, he or she has to minimize the likelihood of errors occurring at any stage in the process of data collecting and analyzing (Brace 2008, p. 9).

This survey has four stakeholders, with one and the same person carrying out two functions. The client initiating the survey is the Department of Innovation- and Technology Management. The evaluation process of the questionnaire is conducted in cooperation with the client. Furthermore, there are the respondents who answered the online questionnaire. Finally, the researcher and data processor is one and the same person, which means that the questionnaire is designed, conducted and analyzed by the author of the thesis.

After the definition of stakeholders in the survey, the research instrument has to be created. For this, a ten-step design process is used.

4.2. Questionnaire design process

In contrast to this thesis, the questionnaire is in German, as it was published only in the German speaking area. The translation of each item is part of the chapter Data Analysis. The design of a valid questionnaire requires a systematic approach. Many hours have been wasted because researchers developed questionnaires which answered types of questions which the decision maker did not want to be answered. In theory, there are many possible approaches, and the selection of a valid questionnaire design model is elementary for creating a formal framework for generating questions and scales (McDaniel/Gates 2008, p. 292).

In this thesis, a ten-step process was used to design a valid questionnaire (McDaniel/Gates 2008, p. 292). This process consists of the following steps (McDaniel/Gates 2008, p. 292):

- Step 1: Determine survey objectives, resources and constraints
- Step 2: Determine the data-collection method
- Step 3: Determine the question response format
- Step 4: Decide on the question wording
- Step 5: Establish questionnaire flow and layout
- Step 6: Evaluate the questionnaire
- Step 7: Obtain approval of all relevant parties
- Step 8: Pre-test and revise
- Step 9: Prepare final questionnaire copy
- Step 10: Implement the survey

To provide a more thorough understanding of the design process, the ten steps are now set out in detail.

4.2.1. Step one: Determine survey objectives, resources and constraints

To determine the survey objectives for primary data analysis, there must be a need for decision-making information. First, all secondary data sources have to be evaluated to make sure that the required data is not already available. Survey objectives should be spelled out in a clear and precise way. If this step is completed in a thorough way, the rest of the process of designing the questionnaire will be smooth and efficient (Mc Daniel/Gates 2008, p. 293).

The purpose of the survey is to find out the level of consumer information with regard to vehicles powered by alternative sources of energy, especially hydrogen. The overall field of research, as well as the research question, was agreed in cooperation with the supervisor of this thesis. There are four fields of interest which the respondents of the survey should comment on by filling out the questionnaire: the environmental effects of alternative sources of energy, the costs of alternative sources of energy and the safety of alternative sources of energy in combination with convenience of use of hydrogen-powered vehicles. The objective was to sound out the overall opinion of the participants

with regard to these items and to filter the data by demographics. Resources used for this survey are an online survey via a free web page and the SPSS software for statistical interpretation of the results. This survey was conducted under the constraints of incompleteness, time, and budget. The findings of the survey are based on a sample and therefore have no claim to completeness. Furthermore, the questionnaire only was available to potential participants for a three-month period, and the budget for conducting the survey was very low.

4.2.2. Step two: Determine the data-collection method

Data can be gathered in a variety of ways. For example, it is possible to gather data via the Internet, the telephone, E-Mail or mail and via personal interviews. The research method will have an impact on the design of the questionnaire. An in-person interview will have different constraints from an Internet questionnaire, for example (Mc Daniel/Gates 2008, p. 293).

For this survey, the data-collection method of online questionnaires via the Internet was used. This method provides several advantages for gathering the required data: An important advantage of conducting online surveys is that they are less expensive per respondent than other methods of surveys. The survey is self-administered and no coding is necessary because the survey platform provides the collected data already in coded format. As a result, the data collected by the online survey is almost immediately ready for statistical analysis (Hair et al. 2010, p. 113).

Also, the data can be gathered more quickly than for example by means of telephone surveys. Furthermore, online surveys are more flexible and versatile than other survey methods. The wording of the questionnaire can be supplemented with visual elements. What is also important for this survey is the anonymity and impersonal nature of online questionnaires. There is no interviewer the respondents could be biased against. Race or gender of the interviewer, or the chemistry between interviewer and respondent do not play any role in an anonymous online survey (Monette et al. 2011, pp. 190-191). Another advantage of online surveys is that they are able to collect data from hard-to-reach samples like specific interest groups (Hair et al. 2010, p. 113).

However, online surveys also have certain disadvantages which need to be overcome. The problem of representativeness and sampling in online surveys is caused by the limited access of people to the Internet (Monette et al. 2011, pp. 191). The goal of a survey is to get the same representative results by asking a sample as if every member of a whole population were to be asked. The key to this goal is the fundamental principle called equal probability of selection. This principle states that if every single member of a population is equally likely to be included in the sample, then that sample will be representative (Scheaffer et al. 2012, p. 15).

This survey does not meet the strict requirements of representativeness in accordance with the equal probability of selection principle, but for the purpose of eliciting consumers' opinions about vehicles powered by alternative sources of energy, the method of a survey via the Internet is the most adequate one. This fact can be elucidated by comparing the method of an online survey with other methods of data collection, namely mail surveys, personal surveys and telephone surveys.

Mail surveys

The findings of research studies comparing online surveys with mail surveys are all consistent, with response rates the only exception (Evans/Mathur, 2005, pp. 203-207):

- In a review of eight studies, Sheehan and McMillan showed in 1999 that the response rates were sometimes higher with online surveys and sometimes lower. This was caused in most cases by the chosen sample and the topic of the survey. In all the studies the response times were shorter in the online surveys.

- In 2003, Griffits et al. surveyed managers belonging to the Council of Logistics Management. Their results showed that the online survey had a higher response rate, faster responses and lower costs. Furthermore, the quality of the data gathered by online surveys and mail surveys was similar.

- In 1995, Metha and Sivadas surveyed message posters of popular news groups. They found out that online surveys were cheaper and more time efficient. Furthermore, the response rate was higher than with mail surveys. The authors found that the quality of the answers in online and mail surveys was similar.

Personal surveys

The advantage of personal surveys is that there is personal interaction between the interviewer and the respondent. Furthermore, the interviewer has the chance to give clear instructions to the respondent before the interview starts, and the survey environment can be controlled by the interviewer. Major disadvantages are geographic limitations, limited sample sizes, interviewer bias and costs per respondent (Evans/Mathur 2005, pp. 206-207). The findings of two studies comparing personal surveys with online surveys are:

- Scholl et al. (2002) conducted a survey in three countries – the UK, Sweden and Singapore – using personal surveys with face-to-face interviews and online surveys. The results were that online surveys achieved faster and less costly results. However, the personal interviews gathered more information and allowed greater probing of the respondents. In fact, the overall results of the two survey methods were similar.

- Curasi (2001) found out that semi-structured online surveys have advantages as an additional data collection method. Online surveys can be a good alternative to personal surveys if time and cost restraints play a role or if geographic boundaries limit a study.

Telephone surveys

The strengths of surveys conducted by telephone are that the possibility of random sampling is given and that good geographic coverage can be achieved. Furthermore, cost savings can be achieved by using centralized phone banks or discount phone providers. There is also some kind of personal interaction in telephone surveys. Major potential weaknesses include interviewer bias, the low degree of motivation of respondents to give interviews over the telephone, the need to be brief when interviewing people and the low level of trust of respondents caused by not knowing the interviewer (Evans/Mathur 2005, p. 207). The findings of two studies comparing online surveys with telephone surveys are:

- Rubin found, in 2000, that the overall response rates of telephone surveys fell from 40% in 1990 to 14% in 2000, which could be caused by the use of telephone

answering machines. Opt-in online surveys received response rates of 60% in 2000.

- Roster et al. (2004) conducted online surveys as well as telephone surveys. Their results showed, among other things, that telephone respondents were older.

Taking into account the time and budgetary constraints of this survey, the best method was seen in conducting online surveys, to reach as many respondents as possible without any geographic limitations and with a low cost per respondent.

4.2.3. Step three: Determine the question response format

There are three major formats of questions used in the field of marketing research: open-ended questions, closed-ended questions and scale-response questions (McDaniel/Gates 2008, p. 293).

Open-ended questions

This is the type of question which requires respondents to reply to the question in their own words. This means that the interviewer does not limit the way in which the respondent can answer the question. Open-ended questions provide the advantage to the researcher that they enable the respondents to give their general reactions to questions. The disadvantages of open-ended questions are that coding and editing can consume great amounts of time if done manually. The potential problem of open-ended questions triggered by interviewer bias is eliminated by the research method of online surveys (McDaniel/Gates 2008, pp. 293-297).

In the questionnaire of this thesis there are two open-ended questions, and two closed-ended questions have an open-ended answer choice called “sonstige” which stands for “others.” The small number of open-ended questions is due to time constraints.

Closed-ended questions

The closed-ended questions require the respondent to select from a list of possible choices. The major advantage of closed-ended questions is to overcome the disadvantages of open-ended questions. When the respondent sees the possible alternatives he or she may be reminded of these possible choices and therefore the

response could be a more realistic one. Furthermore, interviewer bias is eliminated because the respondents are just clicking a box. Another advantage of closed-ended questions is that coding can be done automatically with questionnaire software programs. There are differences in pre-coded open-ended questions and multiple-choice questions. Pre-coded open-ended questions allow the respondent to answer in a freewheeling way. The interviewer just checks if the answer of the respondent is already coded. If the answer is not pre-coded, the interviewer writes the answer in the "other" column. Closed-ended questions can be divided into two types: the dichotomous closed-ended questions and the multiple-choice closed-ended questions (McDaniel/Gates 2008, pp. 297-299).

Most of the questions about demographic data are closed-ended single choice and dichotomous questions. This is important for categorizing the answers to the questions by age, for example, or net income per month, which allows a closer look into the preferences of certain groups of respondents. In addition, multiple choice questions are used in the questionnaire section dealing with environmental factors of hydrogen as fuel.

Scaled-response questions

The last response format, scaled-response questions, is defined as closed-ended questions with choices for the respondents to express the intensity of their feelings. The primary advantage of scaled-response questions is that the scaling permits measuring the intensity of the respondents' convictions. Furthermore, scaled-response questions can be used directly as codes, like the school grade code from 1, being the best, to 5, being the worst. The most significant problem with scaled-response questions is that the respondent could misunderstand the scaling. To overcome this problem, the answers must explain the response category options (McDaniel/Gates 2008, pp. 299-300).

The scaled-response questions in the questionnaire of this thesis are all seven-step Likert scales. With a Likert scale, the respondent has the choice of answering single items from the positive extreme to the negative extreme. Each step in the scale is connected to a certain number of points. In the seven-step Likert scale of the questionnaire, the most positive answer, for example, corresponds to the value of one, and the most negative answer corresponds to the value of seven for most of the questions (McDaniel/Gates 2008, p. 265). The scale for each question can be seen in the Appendix.

The Likert scale provides several advantages (Kumar 2008, p. 108):

- it is simple to construct,
- it can be used in most cases,
- and the larger range of responses may make the respondents of the questionnaire more comfortable when indicating their position than the simple agree vs. disagree choice which is forced on them, for example, by Thurston items. The graded response options tend to give more reliable information about the respondent's opinion.

4.2.4. Step four: Decide about the question wording

There are four general guidelines for the wording of question: (1) the wording must be clear, (2) the wording must not bias the respondent, (3) the respondent has to be able to answer the questions and (4) the respondent must be willing to answer the questions (McDaniel/Gates 2008, p. 300).

Make sure the wording is clear

Clarity in wording calls for the use of unambiguous terminology, which means that jargon should be avoided, and verbiage should be geared to the target audience. Words that provide precise meanings, universal usage and minimal connotative confusion have to be selected. This will minimize uncertainty among the respondents and minimize the risk of questions which are not clearly understood being left unanswered. Another requirement when formulating questions is to tailor the questions to the target respondent group (McDaniel/Gates 2008, p. 301).

As the target group for the questionnaire is made up of all potential users of cars powered by hydrogen, the wording of the questions has to be adequate for nearly every group, whether they are lawyers or construction workers. The clarity of the questionnaire can be improved by stating the purpose of the survey at the beginning, to put the questions in the right perspective. The respondent needs to get an idea of the nature of the study and what is expected of him/her. To avoid any lack of clarity in wording, the researcher should not ask two questions in one, each question should address only one aspect of the evaluation (McDaniel/Gates 2008, p. 301).

Avoid biasing the respondents

The possible risk of biasing of respondents by an interviewer asking questions in a way that is not clear was eliminated by conducting an online survey with no direct interaction between the interviewer and the respondents (McDaniel/Gates 2008, p. 301).

Consider the respondents' ability to answer the questions

In some cases, as it may be with the questions of the questionnaire of this thesis, the respondents may never have acquired the information needed to answer the questions in the survey. To minimize the risk that a potential respondent cannot answer the questionnaire because of a lack of knowledge, a short introduction to the topic of hydrogen as a fuel is given at the beginning of the questionnaire (McDaniel/Gates 2008, pp. 301-302).

Consider the respondents' willingness to answer the question

Respondents may not be willing to give truthful answers if a question is perceived as embarrassing, sensitive in nature, threatening or divergent from the respondent's self-image. To preserve the respondent's anonymity, the survey was constructed as an online survey. With no interviewer face-to-face with the respondent, the disinclination to give truthful answers to sensitive questions is lower than in personal interviews and telephone interviews (McDaniel/Gates 2008, p. 302).

4.2.5. Step five: Establish questionnaire flow and layout

A well-organized questionnaire elicits answers from the respondents that are more carefully thought through and in greater detail. General guidelines that have been generated by researchers concerning the questionnaire flow are: (1) screening questions to identify qualified respondents, (2) begin with questions that get the respondents' interest and are of a general nature, (3) ask the questions that require an effort in the middle, (4) position sensitive, threatening and demographic questions at the end of the questionnaire and (5) use a proper introduction and close for the questionnaire (McDaniel/Gates 2008, p. 303).

Use screening questions to identify qualified respondents

Screening questions are filled out by anyone who is interviewed. Demographics which are obtained provide a basis for comparing groups of people who qualify for the full study. The question whether the respondents have a driving license is not a real screener but people who have a driving license are more likely to be the future users of hydrogen-powered cars, and therefore their opinion about the hydrogen-powered cars provides the basis for the analysis (McDaniel/Gates 2008, pp. 303-304).

Begin with questions that get the respondents interested and are of a general nature

The initial questions should be easy to answer without any previous knowledge about the main topic of the survey. To get the respondents "warmed-up" for the questions which require some "effort" to answer, the initial questions should be general ones. The questionnaire for this thesis has two general questions at its beginning as a lead into the survey and to arouse some interest in the respondents in the topic (McDaniel/Gates 2008, p. 304).

Ask questions that require an effort in the middle

When the survey shifts to the scaled-response questions which require some "effort," the respondents will have been motivated by the initial questions and the general questions to be open to the response categories and options. The interest and commitment of the respondents must be sustained throughout the questionnaire (McDaniel/Gates 2008, pp. 304-305).

Position sensitive, threatening and demographic questions at the end

Some questions might make the respondents feel uneasy. These questions should be located near the end of the questionnaire to ensure that most of the questions are answered before the respondents can become defensive. The most sensitive questions of the topic are the open-ended questions about the opinion of the respondents regarding the price of one unit of hydrogen in comparison with the price of one unit of diesel, and the price of a hydrogen-powered car in comparison with a diesel powered car (McDaniel/Gates 2008, p. 305).

Furthermore, the question about net income per month is a sensitive one. These questions are all located near the end of the questionnaire to ensure that the respondents have already answered most of the questions and therefore are less likely to break off completing the questionnaire (McDaniel/Gates 2008, p. 305).

Use a proper introduction and close for the questionnaire

Every questionnaire must have an introduction and a closing section (McDaniel/Gates 2008, p. 305). The introduction of the questionnaire of this thesis provides some general information about the author and the thesis and a number of instructions concerning the questionnaire. Finally, the respondents are given some information about the topic of hydrogen. The closing stage consists of thanking the respondents for his or her time.

4.2.6. Step six: Evaluate the questionnaire

When a rough draft of the questionnaire has been designed, it is advisable to take a step back and critically evaluate the whole questionnaire. At this point of the questionnaire development, two issues need to be considered: (1) Is the question necessary? (2) Is the questionnaire too long? (McDaniel/Gates 2008, p. 306)

Is the question necessary?

Each question must serve a purpose, and it must directly and explicitly be related to the stated objectives of the survey. Any questions that fail these criteria have to be omitted from the questionnaire (McDaniel/Gates 2008, pp. 306). All questions in the survey of this thesis are targeted at assessing the respondent's opinion regarding environmental protection, costs of hydrogen-powered cars, safety issues of hydrogen-powered cars and the convenience of hydrogen-powered cars.

Is the questionnaire too long?

The researcher should role-play the questionnaire and invite volunteers to act as respondents. If the questionnaire is an Internet survey, it should not take longer than 15 minutes to complete (McDaniel/Gates 2008, p. 307). The questionnaire of this thesis was tested by ten volunteers and they all finished the questionnaire in ten to fifteen minutes.

4.2.7. Step seven: Obtain approval of all relevant parties

After completing the first draft of the questionnaire, the researcher has to distribute this draft to all relevant parties who have direct authority over the project. Following that, revisions of the questionnaire are often necessary. However, it is important to get final approval of the draft even if the parties with direct authority have participated in the development process of the survey (McDaniel/Gates 2008, pp. 308). For this particular questionnaire, the party with direct authority is the Department of Innovations- and Technologiemanagement of the BWZ of the University of Vienna. As a representative of the institute Mr. Martin Zsifkovits reviewed the questionnaire and released the first draft to be pre-tested.

4.2.8. Step eight: Pre-test and revise

Pre-tests constitute small-scale rehearsals of the data collection conducted before the main survey starts. The main purpose of pre-tests is to evaluate the questionnaire. Pre-tests using small samples have been standard practice in survey research for a long time. Pre-tests are usually used to collect quantitative information based on responses. The data collected during a pre-test is often entered and tabulated. The data enables questionnaire designers to look for items which have high rates of missing data, out-of-range values or inconsistencies with other questions. Furthermore, items with little variance could be dropped or could be rewritten (Groves et al. 2004, p. 247)

It is also possible for the questionnaire designer to look for misinterpretation by the respondents, lack of continuity and additional alternatives for closed-ended questionnaire items. The aim of the pre-test is to generate information about respondent reaction to the survey. The pre-test should be conducted in the same way as the final survey. In this case, the final questionnaire is an Internet survey, so the pre-test is also an Internet survey. On completion of the pre-test, any necessary changes should be made to fine-tune the questionnaire. If the pre-test results in major design and question alterations, a second pre-test is in order (McDaniel/Gates 2008, p. 309). The number of respondents is most often between 20 and 30 individuals (Hair et al. 2010, p. 191)

The questionnaire in this thesis was pre-tested by 25 individuals. The items were the same as in the final version of the survey, only an open question for general feedback was added to provide a direct opportunity for respondents to provide feedback. Major findings

of the pre-test showed the consistency of the questionnaire due to the fact that items which are connected show the same tendencies. For example, item 6 shows the same tendencies as items 7 and 8. Furthermore, the answers in item 12 show the same tendencies as the answers in item 13.

Another major finding of the pre-test is that the results show the same tendencies as the findings of similar studies. By way of a comparison, the surveys of the Clean Energy Project, which was conducted in June 2011, and the survey for Defense Distribution Depot Warner Robins, conducted in June 2009, were consulted. It became obvious that the respondents of the Clean Energy Project survey display the same tendencies when it comes to evaluating the potential of hydrogen to contribute to environmental protection. In terms of the safety of hydrogen in vehicles, findings in the Defense Distribution Depot Warner study are similar to the findings in item 4 of the pre-test.

Respondents' criticism mainly referred to the lack of information about hydrogen at the beginning of the questionnaire. Most of the participants in the pre-test were not familiar with the topic of hydrogen as an alternative source of fuel, and a brief introduction to hydrogen was demanded. The respondents of the pre-test stated that the introduction should contain more information about the possible technologies of using hydrogen for powering vehicles. Furthermore, the use of an odd number scale to answer the questions was criticized because of the possibility of being forced to state a preference in the items. Another source of criticism was the absence of items about alternative sources fuels in public transport.

In response to the feedback of the pre-test respondents, the order of the items was changed to locate the more general questions at the beginning, as mentioned in step five of the design process.

Furthermore, brief information about the topic of hydrogen was added to the introduction. The odd number of options of the scale was retained because it is the standard form of a Likert scale. The topic of alternative fuels in public transport was not covered in the survey of this thesis because it is seen as a separate field of research and should be dealt with in a separate survey.

4.2.9. Step nine: Prepare final questionnaire copy

In the final copy stage, precise instructions for numbering and pre-coding must be set out. For online surveys, the Internet provides platforms which let the designer choose the layout of the survey by providing several backgrounds, formats and other facilities (McDaniel/Gates 2008, p. 310).

The platform used for the survey of this thesis did not provide layout features due to the fact that the online survey was conducted for free. Numbering of the questions was done and the activity of selecting a pre-code for the questions was also done in this phase.

4.2.10. Step ten: Implement the survey

The completion of the questionnaire enables the researcher to obtain the desired information for his or her study. Thus, the implementation of the questionnaire involves following up to ensure that all previously made decisions are implemented in a proper way (McDaniel/Gates 2008, p. 311).

The implementation of the survey was conducted properly on June 1st 2012 and the questionnaire was online until July 31th 2012. After the questionnaire was uploaded onto the survey platform, the format and instructions were checked thoroughly. To obtain as many respondents as possible, media like an online community platform were used. Furthermore, E-mails with the link to the online questionnaire were sent out at the Wirtschaftsuniversität Wien and the Institute for Innovations- and Technologiemanagement at the BWZ.

5. Data analysis and findings

Converting information from a questionnaire for analysis is called data preparation. This process follows a four-step approach beginning with data validation, editing and coding, data entry, and the fourth step, data tabulation. The purpose of data preparation is to take data in its raw form, convert it and establish a meaning, and to create value for the researcher. The process of data preparation and the analysis of the data starts after the data has been collected (Hair et al. 2006, p. 478).

Data validation

The process of data validation is concerned with determining to the extent possible if surveys were conducted correctly and without bias. In many data collection approaches it is not always easy to closely monitor the data collection process. Therefore, in some surveys, to ensure accurate data collection, the name, the respondents' addresses and phone numbers may be recorded. The survey for this thesis is conducted in an anonymous way to ensure that no respondent feels monitored on account of the way he or she answers the questions, the step of data validation cannot be used for the survey about hydrogen-powered vehicles (Hair et al. 2006, p. 479).

Data editing and coding

In this step, the data is edited for mistakes. Editing is the process in which the raw data is checked for mistakes made by either the interviewer or the respondent. By scanning each completed interview, the researcher is able to check several areas of concern. These areas are: asking the proper questions, accurate recording of answers, the correct screening of respondents, and complete and accurate recording of open-ended questions (Hair et al. 2006, p. 480).

- Asking the proper questions:

  As a part of the editing process, the researcher has to make sure that all respondents were asked the proper questions. In cases where they were not, the respondents of the survey are contacted again to obtain a response to omitted questions (Hair et al. 2006, p. 480). In the survey conducted for this thesis, the questions of the questionnaire were evaluated during the questionnaire design

stage. Furthermore, it is not possible to contact the respondents again, as the survey was conducted anonymously.

- Accurate recording of answers:

  Even in completed questionnaires sometimes information is missing. The respondent may have accidentally skipped a question. Through a careful check of all questionnaires, these problems can be identified (Hair et al. 2006, p. 480). The survey of this thesis only contains questions which have to be answered to enable the respondent to continue to the end. Furthermore, the questionnaire can only be finished when all questions have been answered.

- Correct screening questions:

  During the editing phase the researcher has to make sure that only qualified respondents are included in the questionnaire. It is also of critical importance that the questions were asked and answered in the proper sequence (Hair et al. 2006, p. 480). As there are no real screening questions in the questionnaire because the questionnaire aims at all potential users of hydrogen-powered vehicles, no screening questions can be evaluated.

- Responses to open-ended questions:

  The responses to open-ended questions often provide very meaningful data. As open-ended questions do not force respondents to provide specific answers, they provide greater insight into the issues researched. The main task of editing the answers to open-ended questions is interpretation. The analysis of the open-ended questions is conducted by describing the maximum and minimum of the data and the most common answers (Hair et al. 2006, p. 480).

Data analysis

The sample used in the survey for this thesis comprises 586 respondents. Once the data has been collected and prepared for analysis, some basic statistical procedures are performed. The need for these statistics results from the fact that almost all data sets are disaggregated. Consequently, almost every data set needs some clustering developed that describes the numbers it contains. Basic statistics and descriptive analysis were

developed for this purpose. It is also important to display the results as a graphic to make it easier to understand (Hair et al. 2006, p. 506).

A statistical instrument used for analysing the data is the range which defines the spread of the data. It is the distance between the smallest and largest value of the variable. To illustrate this instrument, box plots are used. Furthermore, mean values and standard deviations are used for showing what the respondents of the survey think about the individual questions. To analyse relationships between the items of the dataset, hypotheses are used. After developing the null and alternative hypotheses, the level of significance for rejecting the null hypothesis and accepting the alternative hypothesis has to be selected. At this point, a statistical test can be conducted (Hair et al. 2006, pp. 512-520).

The open-ended Items 16 and 17 are designed to measure the customers' willingness to pay for fuel and the hydrogen-powered vehicle. When surveying consumers, there are several potential flaws (Breidert et al. 2006, p.14). Therefore the concept of willingness to pay is used in this thesis to gather information as to whether customers are willing to pay a higher or lower price for hydrogen as a fuel, and also for hydrogen-powered vehicles. The flaws are (Breidert et al. 2006, pp.14-15):

- By asking consumers for a price statement, there is a high focus on the price which can displace the importance of a product's other attributes.
- Customers do not necessarily have incentives to reveal their true willingness to pay. Consumers may attempt to quote artificially lower prices to keep the prices down (Nessim/Dodge 1995, p. 72)
- Even if consumers reveal their true valuations of goods or services, their valuations do not necessarily translate into real purchasing behavior (Nessim/Dodge 1995, p. 72)
- Asking for the willingness to pay for complex and unfamiliar goods or services is cognitive challenging for consumers. It remains unclear if this leads to over- or understating of true valuations, a bias is likely to occur.
- The perceived value of a good or service is not necessarily stable.

Relationships between variables can be described in many ways, including presence, direction, strength of association and type. The first and most obvious issue is whether two or more variables are related at all. If there is a systematic relationship between two or more variables, this is referred to as the presence of a relationship. To measure whether a relationship is present, the statistical concept of significance is used. If a relationship exists between two variables, the direction of this relationship is important. The direction of a relationship can be positive or negative. Furthermore, the strength of association also is an important issue. The strength of association can either be nonexistent, weak, medium or strong (Hair et al. 2006, p. 546).

A fourth concept that is important is the type of relationship. Two variables can have a linear relationship, which means that the strength and nature of the relationship between them remains the same over the range of the two variables and can be best described using a straight line. In contrast, two variables have a curvilinear relationship if the strength of relationship varies over the range of both variables. The Pearson correlation coefficient is a good instrument for measuring the linear relationship between variables. The null hypothesis for the Pearson correlation states that there is no association between two variables in the population and that the correlation coefficient is zero. In addition to the correlation coefficient, the level of significance must also be considered. The Pearson correlation coefficient makes several assumptions about the nature of the data. First it is assumed that two variables have been measured using interval scales. The second implicit assumption made by the Pearson correlation coefficient is that the nature of the relationship is linear. The use of the Pearson correlation coefficient also assumes that the variables used come from a bivariate normally distributed population. Although it is a common assumption, determining whether it holds for the data sample is sometimes difficult and often taken for granted (Hair et al. 2006, p. 546-555).

5.1. Descriptive statistics

As a next step, the descriptive statistics for each item are analyzed. Thus the minimum and maximum values for defining the range are analyzed as well as the mean value for every single item. The last key figure is the standard deviation to show how the data is distributed around the mean value.

Item 1

The first item of the questionnaire was all about how environmentally friendly the respondents see themselves. The range of the item is six, which means that every step in the scale was picked once by the respondents. The mean value of the first item is located at 2.72. Thus the respondents see themselves as not as absolutely environmentally friendly, but the mean value is above the average of the scale of 3.5. The standard deviation of item 1 has the value of 1.062. This means that the data is scattered 1.062 points around the mean value of 2.72.

Table 2: Descriptive statistics of item 1

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
item1	586	1	7	2.72	1.062
Valid N (listwise)	586				

The absolute frequency table of item 1 shows that 83.1% of the respondents picked the options one, two or three of the scale, which means that most of the respondents are environmentally friendly. Only 16.9% of the respondents see themselves below the average of the scale and therefore picked options four, five, six or seven.

Table 3: Absolute frequency table of item 1

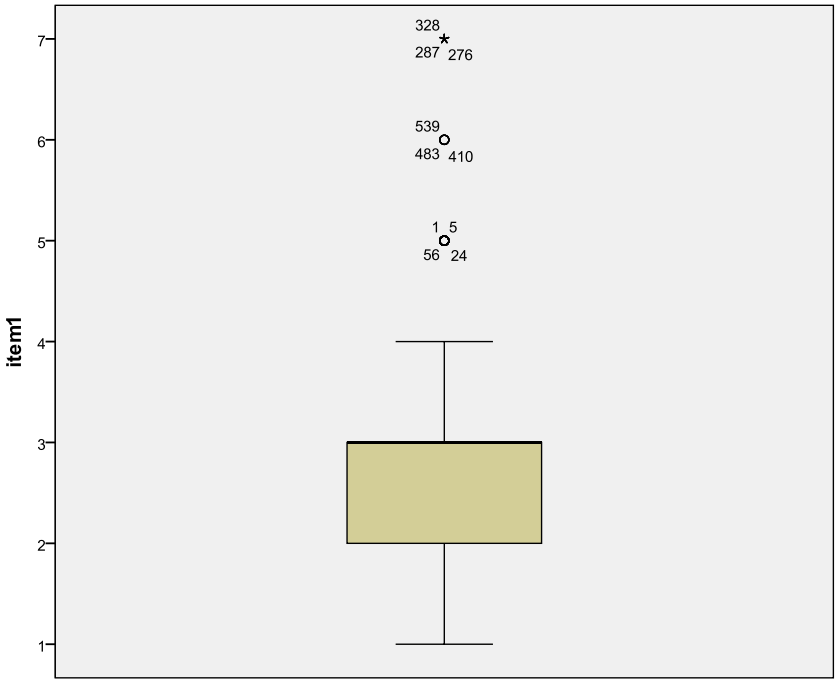
item1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	52	8.9	8.9	8.9
	2	209	35.7	35.7	44.5
	3	226	38.6	38.6	83.1
	4	64	10.9	10.9	94.0
	5	25	4.3	4.3	98.3
	6	5	.9	.9	99.1
	7	5	.9	.9	100.0
	Total	586	100.0	100.0	

The box plot of item 1 shows that the 0.5 percentile is equal to the 0.75 percentile, which results from the fact that both 50% and 75% of the collected data are larger than 3 on the

scale and smaller than 4 in the scale. Outliers are located at options 5, 6 and 7 of the scale. Consequently, nearly all data of item 1 is located between options 1 and 4. As the 0.5 percentile of 3 is larger than the mean value of 2.72, the data of item 1 is distributed with skewness to the left.

Figure 2: Box plot of item 1



Item 2

The second item was about the question of how committed the respondents are to protecting the environment. The range of the item is 6, so again all possible steps of the scale were chosen at least by one respondent. Furthermore, the mean value of item 2 is 3.72. Thus the respondents are not greatly committed to saving the environment as the mean value is below the middle of the scale of 3.5. The standard deviation of 1.455 explains that the data is spread 1.455 around the mean value of 3.72.

Table 4: Descriptive statistics of item 2

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
item2	586	1	7	3.72	1.455
Valid N (listwise)	586				

When comparing the absolute frequency tables of items 2 and 1, it becomes obvious that more respondents see themselves as environmental friendly than they are actively committed to saving the environment. This fact is interesting since using hydrogen-powered vehicles with fuel based on renewable resources is an active step in saving the environment. Only 51.2% of the respondents are above the average of the scale in comparison to the 83.1% in the frequency table of item 1.

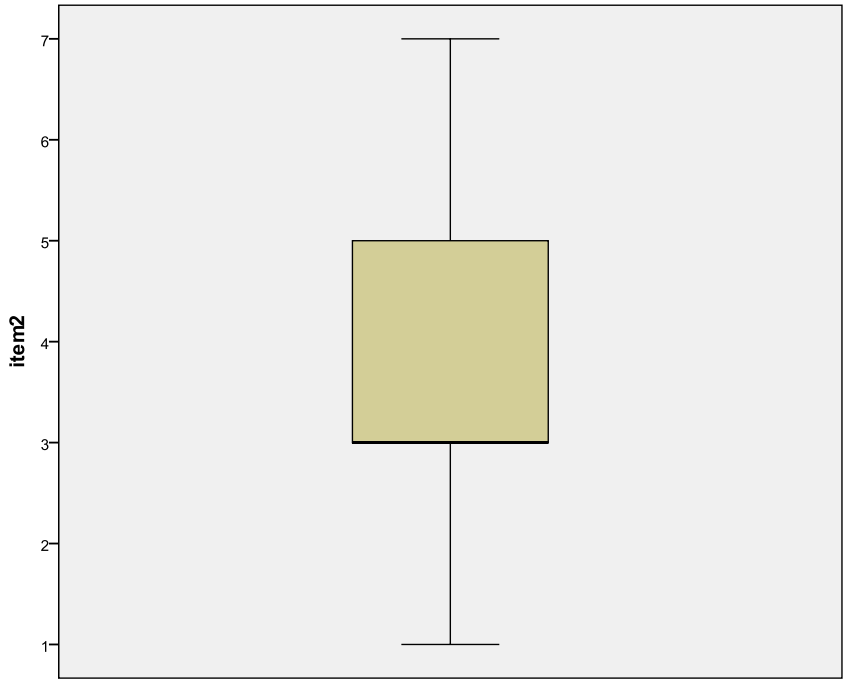
Table 5: Absolute frequency table of item 2

item2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	23	3.9	3.9	3.9
	2	80	13.7	13.7	17.6
	3	197	33.6	33.6	51.2
	4	136	23.2	23.2	74.4
	5	70	11.9	11.9	86.3
	6	46	7.8	7.8	94.2
	7	34	5.8	5.8	100.0
	Total	586	100.0	100.0	

The box plot of item 2 shows that there are no outliners given in the data. Furthermore, both the 0.25 percentile and the 0.5 percentile are located at 3 as 25% and 50% of all respondents picked an answer above 3 in the 7-step scale. As the 0.5 percentile is located at 3 and the mean value of item 2 is 3.72 the distribution of the data shows scenes to the left.

Figure 3: Box plot of item 2



Item 3

For item 3, the respondents had to pick the primary energy source for producing hydrogen. The question is a multiple-choice question with seven options to pick and an open-ended "other" column. The options for primary energy sources for producing hydrogen are: wind, water, solar, atomic, coal, oil, natural gas. To analyze the open-ended "other" column the most frequently mentioned answers are explained and the advantages and disadvantages of these answers for the production of hydrogen are listed.

The absolute frequency table shows that a high percentage of the respondents see renewable energy sources as the most popular primary sources for the production of hydrogen. The option of producing hydrogen using solar energy was chosen by nearly 90% of the respondents. The primary energy source of wind is also very popular, with 86.2% of all respondents choosing it. It is obvious that fossil energy sources like coal or oil are not popular and therefore only 2% or 1.2% of all respondents selected these options. An interesting fact is that nuclear energy is selected more often than coal and oil, since nuclear energy was also not seen as a clean energy source.

Table 6: Primary energy sources for the production of hydrogen

Energy Source	Frequency	Percent
Wind	505	86.2
Water	454	77.5
Solar	527	89.9
Atomic	47	8.0
Coal	12	2.0
Oil	7	1.2
Natural gas	46	7.8
Overall	**586**	**100.0**

The most frequently mentioned primary energy sources of the "other" column of item 3 were geothermal power and energy produced by a tidal power plant. A brief introduction to these two energy sources is provided and the advantages and disadvantages of geothermal power and tidal power are included.

- *Geothermal energy:*

  This form of power is produced by the heat of the earth. Geothermal power is a renewable source of power as it can be used again and again. The most common forms of producing geothermal power are using hot water and natural steam (Morris 2007, pp. 4-5). The advantages of geothermal power are that the production of electricity is very CO_2 emission friendly. Furthermore, geothermal power plants use much less land than other kinds of power plants. Another important advantage of geothermal power plants is that the reinjection of waste brines avoids contamination of the surface and groundwater aquifers (DiPippo, 2012, pp. 485-486). The disadvantages of geothermal power are that most energy can be won in areas which are subject to geological uncertainties and that high initial investments are necessary for building the power plants (UNESCO 2003, p. 263).

- *Tidal power:*

  Tidal power is the energy in water currents caused by the rise and fall of the tide. Currently, tidal power plants are placed across estuaries to trap rising and falling water and they allow the water to flow through turbines. A new idea being developed is the one of tidal lagoons, which are used like circular barrages (Oxlade 2008, p. 20).

  The advantages of tidal power are that no greenhouse gases emitted and that tidal power plants do not use up much space because they are built on the bays. The biggest disadvantage of tidal power is the variability in output caused by the variations in tidal range. The high costs of building tidal power plants constitute a major disadvantage of this technology in comparison to other sources of power (Abbasi/Abbasi 2006, pp. 72-74).

Item 4

The fourth item deals with alternative fuels that can be used instead of hydrogen. The question is also a multiple-choice question with an open-ended "other" column. As with item 3, the absolute frequency table is analyzed and the most frequently mentioned answers in the "other" column are briefly explained. The options in the multiple-choice question were the alternative fuels: biogas, biomass, bio fuel and battery/electricity.

The absolute frequency table shows that the option battery/electricity is selected by 59.7% of all respondents; therefore it is the most popular alternative source of energy to hydrogen. The second most selected option is biogas, followed by biomass. The option of bio fuel is only selected by 20.3% of the respondents. Overall, the alternatives to hydrogen are not very popular at all. Five respondents did not select any alternative to hydrogen and used the "other" column to state that there is no alternative. Others did not select any option and used the "other" column for writing down their alternative fuel for hydrogen.

Table 7: Alternative fuels for vehicles

Alternative	Frequency	Percent
Biogas	220	37.5
Biomass	201	34.4
Bio fuel	119	20.3
Battery/Electricity	350	59.7
Overall	**586**	**100.0**

The two most frequently mentioned alternative fuels in the other column were biomass to liquid and electricity from photovoltaic systems. Electricity from photovoltaic systems could be provided by solar powered electric car charging stations. By using this technology, electricity can be used to charge electric cars without producing any pollution (Chen 2011, p. 271). The second alternative fuel, biomass to liquid, is produced from gas out of biomass which afterwards is transformed into a liquid state again. With this procedure, all energy from the biomass is converted into a liquid form. However, this technology is still at an experimental stage and far from commercial use (Geitmann 2004, p. 107).

Item 5

Question number five asks whether or not the respondents think that hydrogen is more or less environmentally friendly than fossil fuels. The range of the item is 6 again. The mean value of item 5 is located at 2.19 and affirms that the respondents see hydrogen as more environmental friendly than fossil fuels. The standard deviation has the value of 1.107. Therefore the data is located 1.107 points around the mean value of 2.17.

Table 8: Descriptive statistics of item 5

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item5	586	6	1	7	2.19	1.107
Valid N (listwise)	586					

The absolute frequency table of item 5 shows that 89.8% of all respondents picked the options 1, 2 and 3 in the scale and therefore were above the average of the scale. Only 20 respondents picked points 5, 6 and 7.

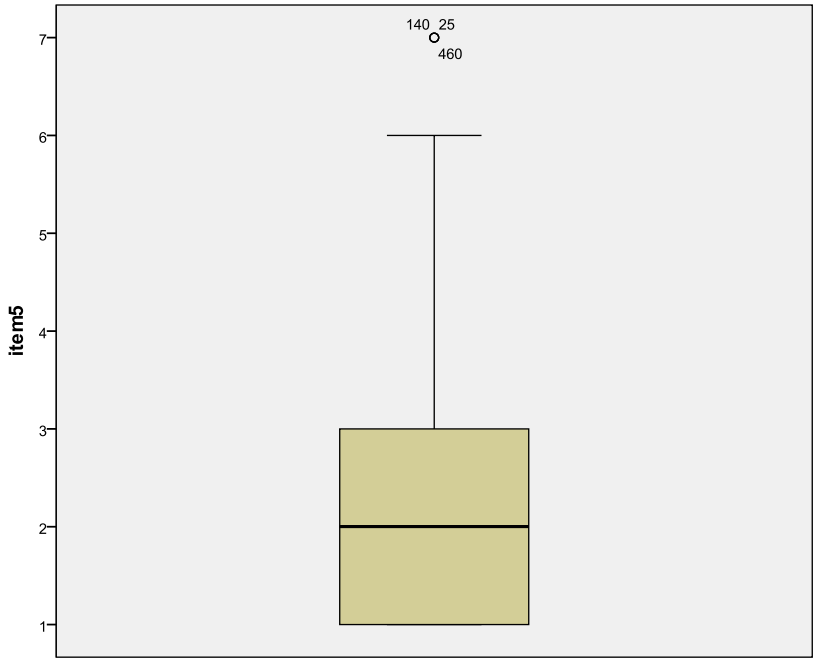
Table 9: Absolute frequency table for item 5

item5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	181	30.9	30.9	30.9
	2	204	34.8	34.8	65.7
	3	141	24.1	24.1	89.8
	4	40	6.8	6.8	96.6
	5	13	2.2	2.2	98.8
	6	4	.7	.7	99.5
	7	3	.5	.5	100.0
	Total	586	100.0	100.0	

The 0.5 percentile of item 5 is located at 2. As the mean value of item 5 is 2.17 the collected data has skewness to the right. The outliers of item 5 are the three respondents who selected option 7 in the scale stating that they find hydrogen much less environmental friendly than fossil fuels.

Figure 4: Box plot of item 5



Item 6

Item 6 is about the positive impact of hydrogen-powered vehicles on the environment. The range of the item is 6 and the mean value is located at 2.70. This shows that the respondents see a positive contribution of hydrogen-powered cars when it comes to protecting the environment. The standard deviation of item 6 is 1.457. This value means that the data is distributed 1.457 points around the mean value.

Table 10: Descriptive statistics of item 6

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item6	586	6	1	7	2.70	1.457
Valid N (listwise)	586					

The absolute frequency table of item 6 shows that points 1, 2 and 3 are nearly equally often selected by the respondents. These points constitute an aggregate of 73.5% of all respondents. Options 5, 6 and 7 are selected by 9.6% of all respondents.

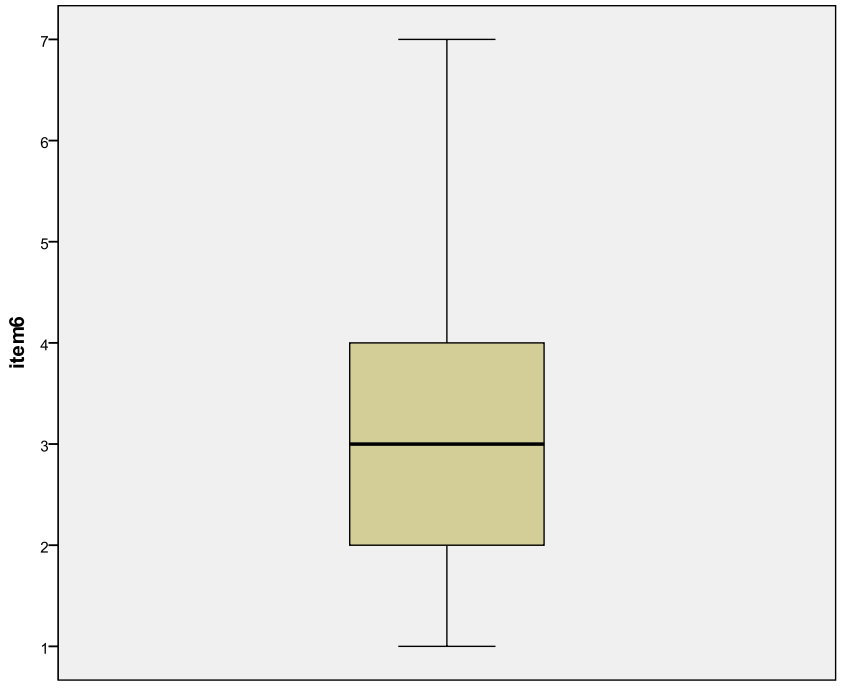
Table 11: Absolute frequency table of item 6

item6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	142	24.2	24.2	24.2
	2	149	25.4	25.4	49.7
	3	140	23.9	23.9	73.5
	4	99	16.9	16.9	90.4
	5	22	3.8	3.8	94.2
	6	22	3.8	3.8	98.0
	7	12	2.0	2.0	100.0
	Total	586	100.0	100.0	

First of all, the box plot of item 6 shows that there are no outliers in the data. The 0.5 percentile is located at 3, and with the mean value located at 2.70 the data has skewness to the left. An interesting fact is that the 0.75 percentile is located at 4 and the maximum is located at 7. Therefore 25% of all data is distributed over the last three points in the scale, whereas the other 75% of the data is distributed over the first four points.

Figure 5: Box plot of item 6



Item 7

Item 7 was about the question of how much power the respondents would be willing to forgo when driving a hydrogen-powered vehicle in comparison with a vehicle powered by fossil fuels for the sake of environmental protection. The range of item 7 is 9 and the mean value is located at 3.58. This shows that the respondents are willing to sacrifice only little power for the sake of environmental protection. With a standard deviation of 1.735 the data is distributed 1.735 points around the mean value.

Table 12: Descriptive statistics of item 7

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item7	586	9	1	10	3.58	1.735
Valid N (listwise)	586					

Points 3 and 4 are picked by the largest number of the respondents. Thus most of the respondents are willing to sacrifice 20% and 30% of power for the sake of environmental protection. This may not seem like much, but the numbers show that hydrogen-powered vehicles need not be equal in performance, at least at the beginning of mass production, unlike vehicles powered by fossil fuels, if they are more environmentally friendly. This points to the chance for hydrogen vehicle producers to launch vehicles even if they do not reach the same level of performance as fossil powered vehicles and may enable the producers to start mass production of hydrogen-powered vehicles earlier.

Table 13: Absolute frequency table of item 7

item7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	75	1.8	12.8	12.8
	2	70	1.9	11.9	24.7
	3	162	27.6	27.6	52.4
	4	142	24.2	24.2	76.6
	5	51	8.7	8.7	85.3
	6	52	8.9	8.9	94.2
	7	16	2.7	2.7	96.9
	8	13	2.2	2.2	99.1
	9	4	.7	.7	99.8
	10	1	.2	.2	100.0
	Total	586	100.0	100.0	

Item 8

The question is if the respondents think that hydrogen as a fuel is able to axe more CO_2 emissions than fossil fuels. The range of the item is 6. The mean value of item 8 is located at 2.39. This value displays that the respondents think that hydrogen as a fuel is able to save more CO_2 emissions than fossil fuels. The standard deviation shows that the data is located around 1.275 points around the mean value.

Table 14: Descriptive statistics of item 8

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item8	586	6	1	7	2.39	1.275
Valid N (listwise)	586					

The absolute frequency table shows that 87.9% of all respondents selected points 1, 2 and 3 in the scale, which is above the average of 3.5. This reveals that hydrogen is seen as less CO_2 producing than fossil fuels. Points 5, 6 and 7 were selected by 3.4% of the respondents. This result shows that only few respondents see hydrogen as more CO_2 emitting than fossil fuels.

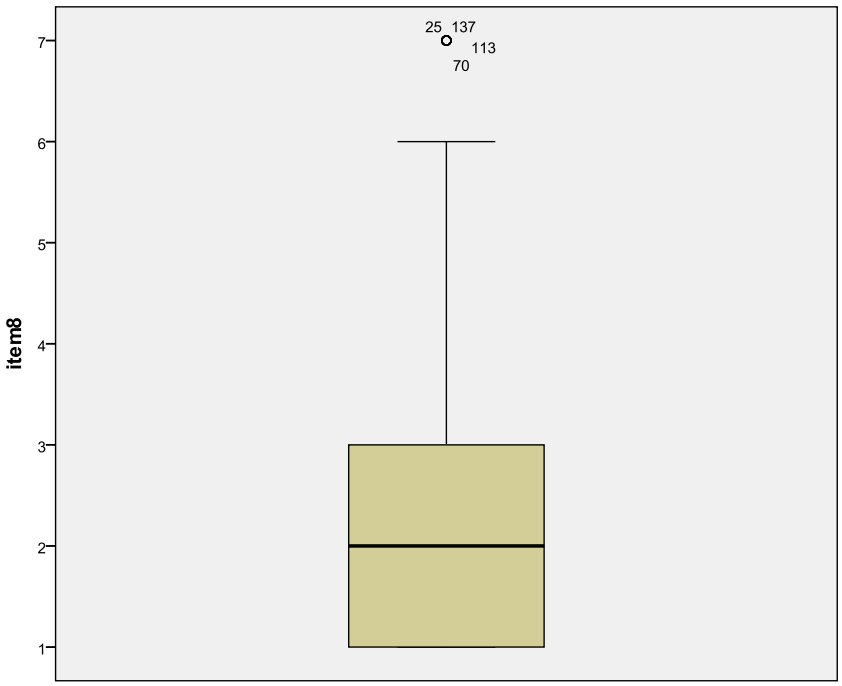
Table 15: Absolute frequency table of item 8

item8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	149	25.4	25.4	25.4
	2	200	34.1	34.1	59.6
	3	166	28.3	28.3	87.9
	4	34	5.8	5.8	93.7
	5	17	2.9	2.9	96.6
	6	7	1.2	1.2	97.8
	7	13	2.2	2.2	100.0
	Total	586	100.0	100.0	

The box plot of item 8 has its 0.5 percentile at point 2 of the scale. As the 0.5 percentile is smaller than the mean value, the data has skewness to the right. The outliers of the data are the respondents who picked option 7 on the scale.

Figure 6: Box plot of item 8



Item 9

The ninth item wanted the respondents to state their opinion with regard to hydrogen as the fuel of the future. The range of item 9 is again 6. The mean value is located at 2.98, which means that the respondents see hydrogen as the fuel for the future because the mean value is above the average of the scale of 3.5. Item 9 shows a standard deviation of 1.498.

Table 16: Descriptive statistics of item 9

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item9	586	6	1	7	2.98	1.498
Valid N (listwise)	586					

The absolute frequency table of item 9 shows that point 4 on the scale is chosen most frequently by the respondents. Thus 27.3% of the respondents are not sure if hydrogen is the fuel of the future. Overall, a positive trend for hydrogen being the fuel for the future is observable from the absolute numbers.

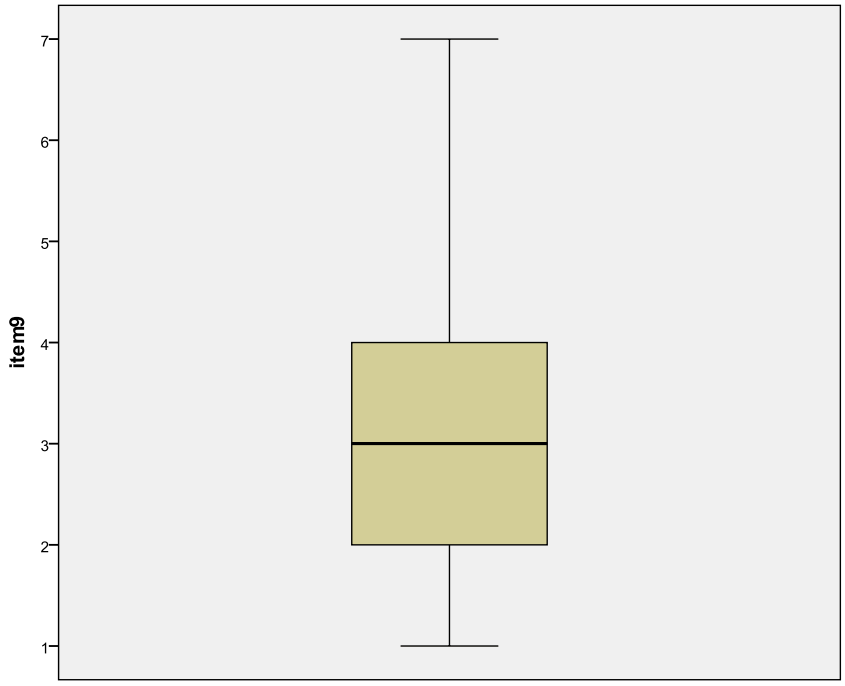
Table 17: Absolute frequency table for item 9

item9

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	117	20.0	20.0	20.0
	2	120	20.5	20.5	40.4
	3	125	21.3	21.3	61.8
	4	160	27.3	27.3	89.1
	5	26	4.4	4.4	93.5
	6	21	3.6	3.6	97.1
	7	17	2.9	2.9	100.0
	Total	586	100.0	100.0	

The box plot of item 9 shows that there are no outliers. The 0.5 percentile is located at 3. As the mean value is 2.98, the data has neither skewness to the right nor to the left.

Figure 7: Box plot of item 9



Item 10

The purpose of item 10 is to measure the degree of safety of hydrogen as a fuel in comparison with fossil fuels. Every option on the scale was selected at least by one respondent. The mean value of 3.88 reveals that the respondents do not think that hydrogen is safer than fossil fuels. The standard deviation is 1.449, which shows that the data is distributed 1.449 points around the mean value.

Table 18: Descriptive statistics of item 10

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item10	586	6	1	7	3.88	1.449
Valid N (listwise)	586					

The absolute frequency table of item 10 displays that 33.1% of the respondents think that hydrogen as a fuel is equally safe as fossil fuels. 21.8% of the respondents are of the opinion that hydrogen as a fuel is slightly less safe than fossil fuels. Item 10 reveals that consumers do not see hydrogen as a safer fuel in comparison to fossil fuels.

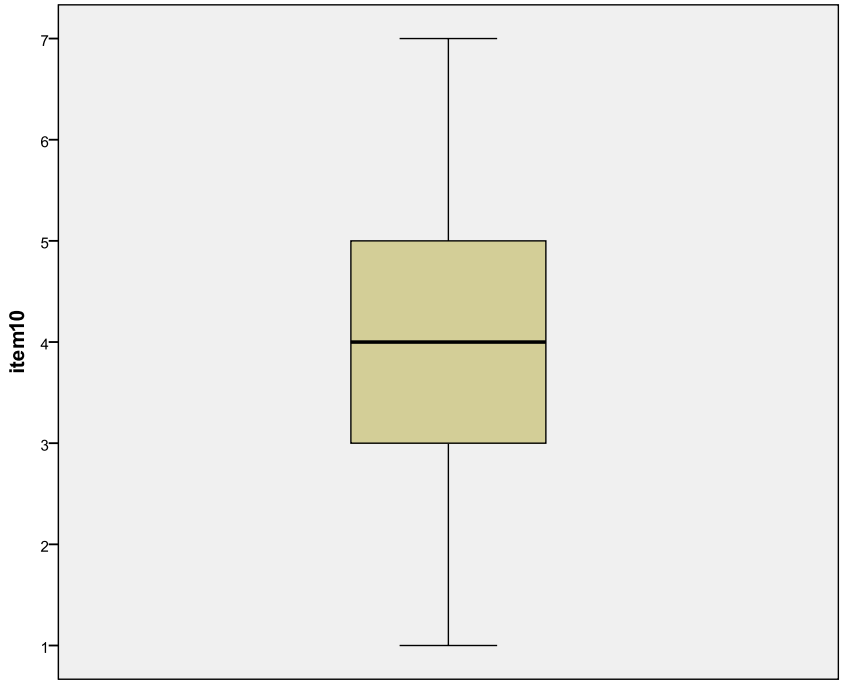
Table 19: Absolute frequency table of item 10

item10

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	41	7.0	7.0	7.0
	2	74	12.6	12.6	19.6
	3	81	13.8	13.8	33.4
	4	194	33.1	33.1	66.6
	5	128	21.8	21.8	88.4
	6	50	8.5	8.5	96.9
	7	18	3.1	3.1	100.0
	Total	586	100.0	100.0	

The box plot of item 10 shows no outliers in the data. The 0.5 percentile is located at 4. Thus with a mean value located at 3.88 the data has slight skewness to the left.

Figure 8: Box plot of item 10



Item 11

Item 11 was about finding out whether consumers want special safety precautions for storing the hydrogen in the vehicle. The range of item 11 is 6, and the mean value is located at 2.03, meaning that the respondents think that hydrogen-powered vehicles

should feature special precautions for storage. This feeling may result from the results of item 10, where hydrogen was seen slightly less safe than fossil fuels. Standard deviation is 1.236, which shows that most of the data is distributed around 1.236 points around the mean value.

Table 20: Descriptive statistics of item 11

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item11	586	6	1	7	2.03	.236
Valid N (listwise)	586					

46.8% of all respondents think that there should be special precautions for storing the hydrogen in the vehicle. As 46.8% of all respondents selected option 1 on the scale, the feeling that hydrogen could be dangerous without special precautions for storage is very strong. Only 2.4% of all respondents do not think that hydrogen-powered vehicles need special precautions for storage of the fuel.

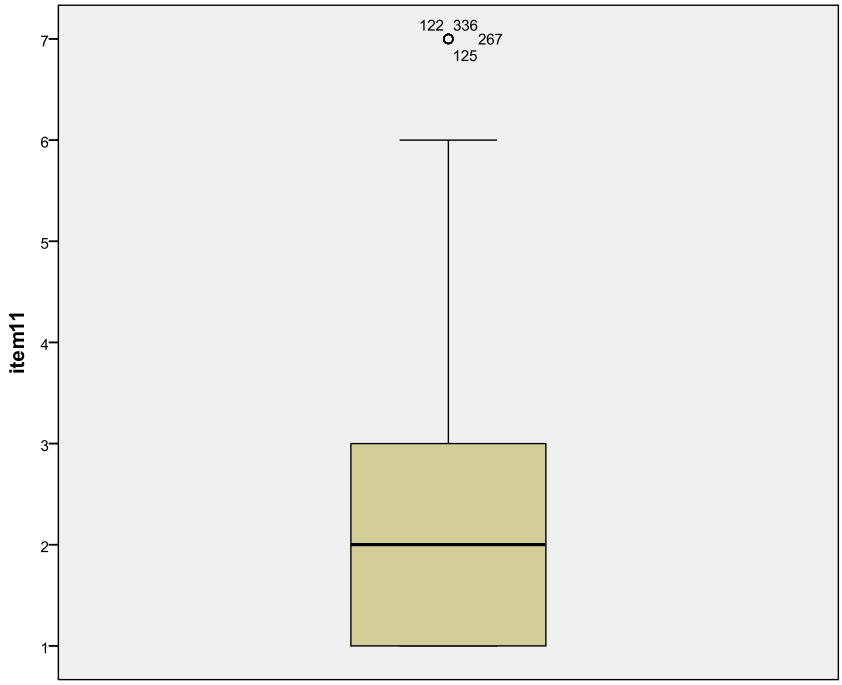
Table 21: Absolute frequency table of item 11

item11

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	274	46.8	46.8	46.8
	2	133	22.7	22.7	69.5
	3	94	16.0	16.0	85.5
	4	71	12.1	12.1	97.6
	5	5	.9	.9	98.5
	6	3	.5	.5	99.0
	7	6	1.0	1.0	100.0
	Total	586	100.0	100.0	

The box plot of item 11 reveals the fact that the outliers in the data are located at point 7 of the scale. As the 0.5 percentile is located at 2 and the mean value of the data is located at 2.03 there is no skewness of the data.

Figure 9: Box plot of item 11



Item 12

Item 12 deals with the question whether consumers would prefer refueling their vehicle with hydrogen in liquid form or hydrogen in gaseous form. The range of the item is 6 again, and the mean value is located at 2.89, thus the respondents of the questionnaire prefer refueling their vehicle with hydrogen in liquid form. The standard deviation shows that most of the data is distributed 1.49 points around the mean value.

Table 22: Descriptive statistics of item 12

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item12	586	6	1	7	2.89	1.490
Valid N (listwise)	586					

The table of the absolute frequencies shows that 40.8% of all respondents do not differentiate between refueling their vehicle with hydrogen in liquid or gaseous form. However, 163 respondents selected option 1, which means they prefer refueling their vehicle with liquid hydrogen, and only 15 respondents picked option 7, which means they prefer refueling their vehicle with gaseous hydrogen. Thus, a preference for hydrogen in liquid form is discernible.

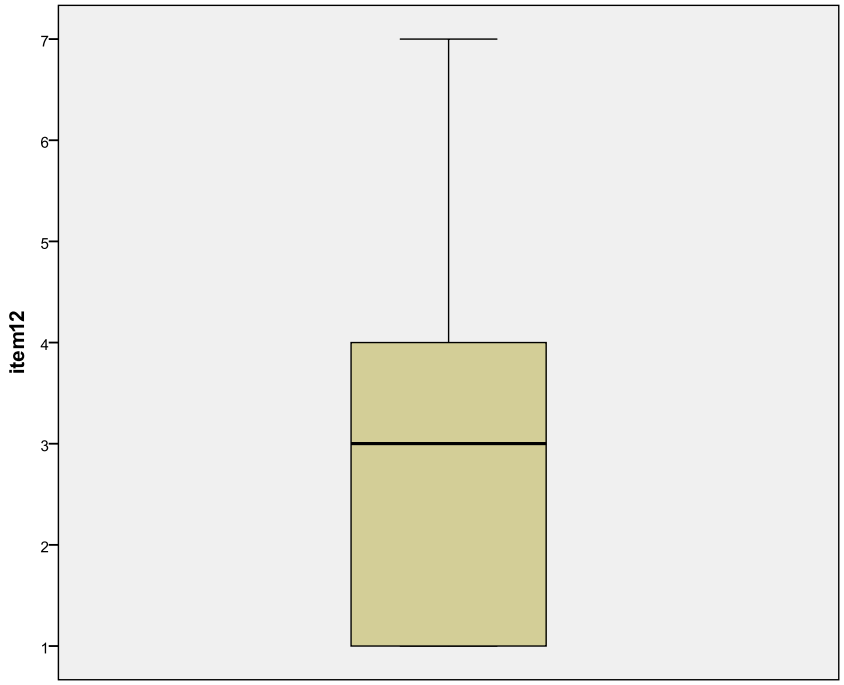
Table 23: Absolute frequency table of item 12

item12

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	163	27.8	27.8	27.8
	2	77	13.1	13.1	41.0
	3	75	12.8	12.8	53.8
	4	239	40.8	40.8	94.5
	5	11	1.9	1.9	96.4
	6	6	1.0	1.0	97.4
	7	15	2.6	2.6	100.0
	Total	586	100.0	100.0	

The box plot of item 12 reveals the fact that half of the data is below point 3 in the scale. This result also shows a preference among respondents to refuel their vehicle with liquid hydrogen. As the 0.5 percentile is located at 3 and the mean value is located at 2.89, the data has slight skewness to the left.

Figure 10: Box plot of item 12



Item 13

Items 13 and 14 go deeper into the topic of refueling a vehicle with hydrogen. Item 13 handles the question of how safe consumers feel when refueling their vehicle with hydrogen in liquid form. The range of item 13 shows that every option on the scale was selected at least once. The mean value is located at 3.46, which shows that the respondents display a slightly positive tendency towards the degree of safety of refueling their vehicle with liquid hydrogen.

Table 24: Descriptive statistics of item 13

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item13	586	6	1	7	3.46	1.470
Valid N (listwise)	586					

32.1% of the respondents do not feel safe or unsafe when thinking about refueling their vehicle with liquid hydrogen. This is the largest group in item 13, but there is a discernible tendency that a majority of respondents feel safe refueling their vehicle with liquid hydrogen.

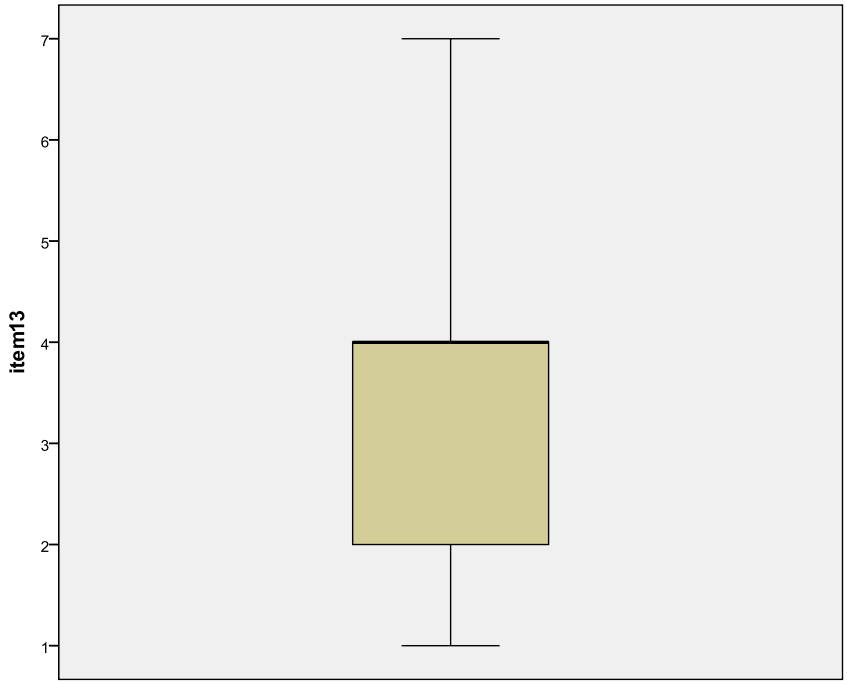
Table 25: Absolute frequency table of item 13

item13

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	56	9.6	9.6	9.6
	2	117	20.0	20.0	29.5
	3	105	17.9	17.9	47.4
	4	188	32.1	32.1	79.5
	5	70	11.9	11.9	91.5
	6	32	5.5	5.5	96.9
	7	18	3.1	3.1	100.0
	T1otal	586	100.0	100.0	

This tendency is also shown by the box plot of item 13. Both the 0.5 percentile and the 0.75 percentile are located at 4. The graphic shows that 75% of all respondents are at least indifferent about the safety of refueling their vehicles with liquid hydrogen. As the mean value is smaller than the 0.5 percentile, the data has skewness to the right.

Figure 11: Box plot of item 13



Item 14

This item tries to measure how safe consumers feel about refueling their vehicle with hydrogen in gaseous form. Every option on the scale has been selected at least once. The mean value of 4.28 shows that the respondents do not feel safe when they think about refueling their vehicles with hydrogen in gaseous form. Most of the data is distributed 1.475 points around the mean value.

Table 26: Descriptive statistics of item 14

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item14	586	6	1	7	4.28	1.475
Valid N (listwise)	586					

As the frequency table of item 14 shows, 32.1% of all respondents feel indifferent concerning refueling their vehicle with hydrogen in gaseous form. In contrast to item 13, where option 4 also was selected by the largest number of respondents, the negative side of the scale is larger than the positive side. Therefore, a negative tendency is visible with regard to refueling vehicles with hydrogen in gaseous form. This is also consistent with

item 12, where the respondents stated that they prefer refueling their vehicles with hydrogen in liquid form.

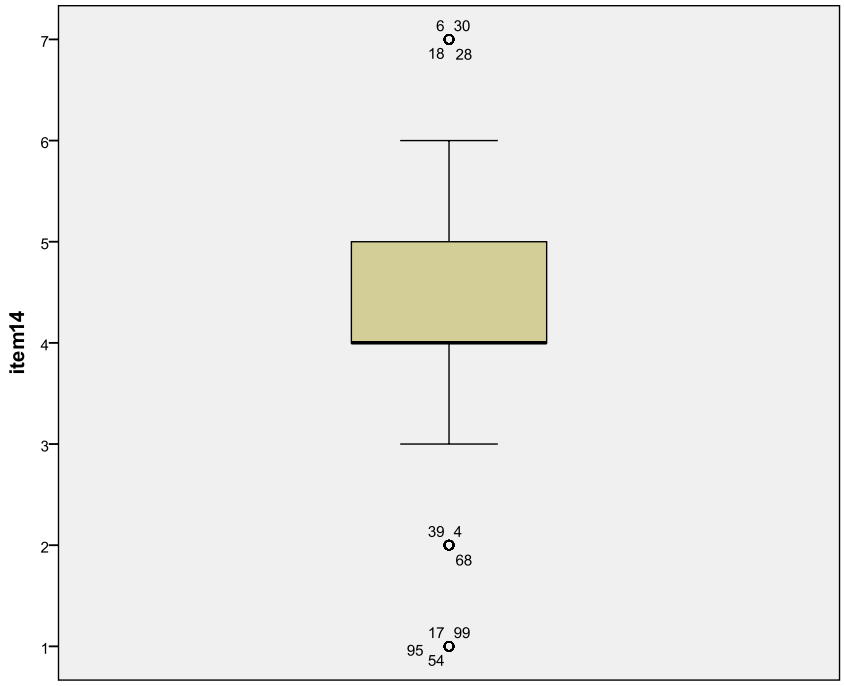
Table 27: Frequency table of item 14

item14

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	29	4.9	4.9	4.9
	2	43	7.3	7.3	12.3
	3	74	12.6	12.6	24.9
	4	188	32.1	32.1	57.0
	5	134	22.9	22.9	79.9
	6	77	13.1	13.1	93.0
	7	41	7.0	7.0	100.0
	Total	586	100.0	100.0	

The box plot of item 14 shows that there are a lot of outliers in the data. 19.2% of all data is located at options 1, 2 and 7 of the scale. The 0.5 percentile is located at 4, and with the mean value located at 4.28 the data has slight skewness to the left.

Figure 12: Box plot of item 14



Item 15

This item is about how consumers rate the situation when a hydrogen-powered vehicle is involved in an accident in comparison with a vehicle powered by fossil fuels. The range of item 15 is 6 again. As the mean value is located at 3.57 the respondents feel that an accident involving a vehicle powered by hydrogen is slightly more dangerous than an accident in a vehicle powered by fossil fuels.

Table 28: Descriptive statistics of item 15

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item15	586	6	1	7	3.57	1.316
Valid N (listwise)	586					

The largest group of respondents, 38.1%, regards accidents involving hydrogen-powered vehicles and vehicles powered by fossil fuel as equally dangerous. But when looking at the cumulative numbers, more respondents consider an accident involving a vehicle powered by hydrogen less dangerous than involving a vehicle powered by fossil fuels.

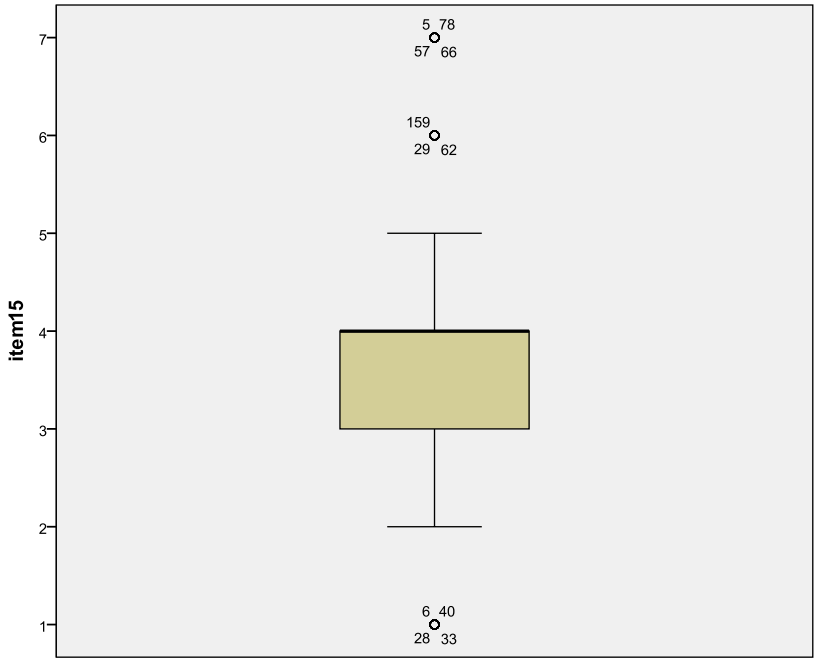
Table 29: Frequency table of item 15

item15

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	44	7.5	7.5	7.5
	2	64	10.9	10.9	18.4
	3	152	25.9	25.9	44.4
	4	223	38.1	38.1	82.4
	5	65	11.1	11.1	93.5
	6	18	3.1	3.1	96.6
	7	20	3.4	3.4	100.0
	Total	586	100.0	100.0	

The box plot of item 15 also shows a lot of outliers in the data. All items located at points 1, 6 and 7 of the scale are seen as outliers. As the 0.5 percentile is smaller than the mean value, the data has skewness to the right.

Figure 13: Box plot of item 15



Item 16

This item was designed as an open-ended question. With diesel priced at €1.5 per liter, consumers want to pay an acceptable price for the same amount of hydrogen. As it was not possible to determine a standard format for the answers, the creation of a frequency table is not useful without manipulating the dataset. Therefore, the most meaningful way of analyzing the data is to explain what guides the respondents when selecting the price of one liter of hydrogen. There is a tendency that one liter of hydrogen should at most cost the same as one liter of diesel to provide an alternative to fossil fuels. Moreover, one liter of hydrogen should cost 1€ or less to persuade consumers to switch from vehicles powered by fossil fuels to hydrogen powered vehicles. The minimum price for one liter of hydrogen in the dataset is €0.25and the maximum price for one liter of hydrogen is €40. This price is seen as a typo. The second highest price consumers are willing to pay for one liter of hydrogen is €4, which seems more realistic than €40 per liter.

Item 17

Like item 16, item 17 is also an open-ended question. Consumers had to to select a price they would be willing to pay for hydrogen-powered vehicles if the price for one liter of hydrogen is the same as for one liter of fossil fuel and the efficiency of a hydrogen-powered car is the same as the efficiency of a vehicle powered by fossil fuel. The reference price of a vehicle powered by fossil fuel is €20,000. As it was also not possible

to determine a standard format for answering item 17, a frequency table is not useful without manipulating the data. Thus the maximum and minimum prices are mentioned as well as the general tendency of the respondents in terms of selecting a price for a hydrogen-powered vehicle. The minimum price of a hydrogen-powered vehicle is €0, which signifies that hydrogen-powered vehicles are not wanted or they would be used only if they are for free. The maximum price that the respondents are willing to pay is €30,000. There is a tendency to a price of €25,000. Respondents also included costs for taxes, insurance and maintenance in their calculations and pointed out that if taxes, insurance and maintenance are cheaper, they would be willing to pay a higher price for hydrogen-powered vehicles.

Item 18

Item 18 is about state subsidies for hydrogen-powered vehicles. The options for answering are yes, yes if the hydrogen is produced from renewable primary energy sources, no, or indifferent. 67.2% of all respondents selected option two and thought that hydrogen cars should be subsidized if the hydrogen is produced from renewable primary energy resources. Together with the 16% of respondents who think that hydrogen-powered vehicles should generally be subsidized, 83.3% of the respondents are in favor of state subsidies. 10.8% do not think that subsidizing hydrogen-powered vehicles is a good idea, and 6% are indifferent to this topic.

Table 30: Frequency table of item 18

item18

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	94	16.0	16.0	16.0
	2	394	67.2	67.2	83.3
	3	63	10.8	10.8	94.0
	4	35	6.0	6.0	100.0
	Total	586	100.0	100.0	

Item 19

The purpose of item 19 is to find the desirable frequency of hydrogen gas stations for consumers. Given the total amount of gas stations in a certain area the respondents of the questionnaire had to decide whether every single, every second, every third, every fourth, every fifth, every tenth or every twentieth gas station should provide hydrogen for refueling a vehicle. The frequency table shows that 51.7% of all respondents think that every single or every second gas station has to provide hydrogen. 31.9% of the respondents feel that hydrogen provided by every third gas station is enough for them. Only 16.4% of the respondents would want every fourth, or even fewer, gas station to provide hydrogen.

Table 31: Frequency table of item 19

item19

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	87	14.8	14.8	14.8
	2	216	36.9	36.9	51.7
	3	187	31.9	31.9	83.6
	4	65	11.1	11.1	94.7
	5	20	3.4	3.4	98.1
	6	9	1.5	1.5	99.7
	7	2	.3	.3	100.0
	Total	586	100.0	100.0	

Item 20

Item 19 clarified the attitude of the respondents concerning the required number of gas stations providing hydrogen. The object of item 20 is to measure the duration of the refueling process of a vehicle which consumers would consider acceptable, independent of the source of fuel. The options of how long the refueling process can take are: less than one minute, less than five minutes, less than ten minutes, less than 30 minutes, less than an hour, less than three hours and more than three hours. The frequency table of item 20 clearly shows that 94.5% of all respondents do not want the process of refueling their vehicle to take longer than 10 minutes. Only 5.2% of the respondents are willing to wait longer than 10 minutes to refuel.

Table 32: Frequency table of item 20

item20

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	13	2.2	2.2	2.2
	2	298	50.9	50.9	53.1
	3	243	41.5	41.5	94.5
	4	25	4.3	4.3	98.8
	5	2	.3	.3	99.1
	6	1	.2	.2	99.3
	7	4	.7	.7	100.0
	Total	586	100.0	100.0	

Item 21

This item deals with the question what range consumers would accept for a vehicle powered by an alternative fuel like hydrogen or battery. The options for selection were: less than 100 km, between 100 km and 200 km, between 200 km and 400 km, between 400 km and 600 km, between 600 km and 800 km, between 800 km and 1000 km and more than 1000 km. 34% of the respondents thinks that a vehicle powered by an alternative fuel should have a range of between 400 km and 600 km.

Table 33: Frequency table of item 21

item21

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	14	2.4	2.4	2.4
	2	51	8.7	8.7	11.1
	3	171	29.2	29.2	40.3
	4	199	34.0	34.0	74.2
	5	106	18.1	18.1	92.3
	6	35	6.0	6.0	98.3
	7	10	1.7	1.7	100.0
	Total	586	100.0	100.0	

Item 22

The question was how consumers feel about reduced engine noise in vehicles powered by alternative fuels like hydrogen or electricity. The range of 6 displays the fact that every option of the scale was selected by at least one respondent. As the mean value is located at 2.71 the respondents of the questionnaire feel comfortable without engine noise. Most of the data is distributed 1.793 points around the mean value.

Table 34: Descriptive statistics of item 22

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
item22	586	6	1	7	2.71	1.793
Valid N (listwise)	586					

More than 40% of the respondents appreciate the lack of engine noise. 19.5% of all respondents are indifferent to the fact that there is no engine noise, and only 3.9% feel absolutely uncomfortable if no noise is produced by the engine. This is a clear result in favor of a noiseless engine. But the noise of the engine of a vehicle should not only be viewed as annoying but also as a source of warning. No engine noise means no warning that a vehicle is in the vicinity, which could increase the danger at blind corners.

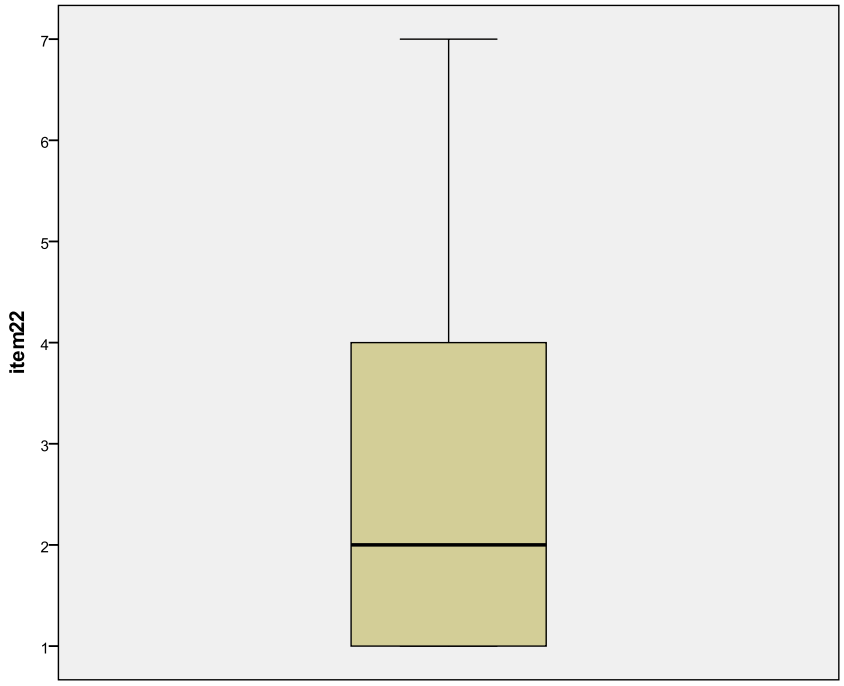
Table 35: Frequency table of item 22

item22

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	236	4.3	40.3	40.3
	2	83	14.2	14.2	54.4
	3	53	9.0	9.0	63.5
	4	114	19.5	19.5	82.9
	5	54	9.2	9.2	92.2
	6	23	3.9	3.9	96.1
	7	23	3.9	3.9	100.0
	Total	586	100.0	100.0	

The box plot of item 22 displays the fact that 75% of the data is above option 4 of the scale and therefore in favor of no engine noise or indifferent to the lack of engine noise. The 0.5 percentile is located at 2, and with a mean value of 2.71 the data has skewness to the left. There are no outliers in the data.

Figure 14: Box plot of Item 22



Demographic section

The first item of the demographic section is about the gender of the respondents. 55.5% of the respondents were men and 44.5% were women. So, the data is balanced.

Table 36: Frequency table of item 23

item23

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	325	5.5	55.5	55.5
	2	261	4.5	44.5	100.0
	Total	586	10.0	100.0	

The second question of the demographic section is about the age of the respondents. The categories are: 16-20 years, 21-30 years, 31-40 years, 41-50 years, 51-60 years, 61 to 70 years and above 71 years. 80.4% of all respondents are between 21 and 40 years. This results from the fact that the questionnaire was distributed over the BWZ of the University of Vienna and the WU of Vienna. So, most of the respondents were students. But as hydrogen-powered vehicles are still a future technology, the young people of today will be the target group when hydrogen-powered vehicles are ready for mass production. Therefore, the high percentage of young people does not weaken the meaningfulness of the data.

Table 37: Frequency table of item 24

item24

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	44	7.5	7.5	7.5
	2	371	63.3	63.3	70.8
	3	100	17.1	17.1	87.9
	4	41	7.0	7.0	94.9
	5	28	4.8	4.8	99.7
	6	2	.3	.3	100.0
	Total	586	100.0	100.0	

The next question of the demographic section deals with the consumer's places of residence. The two options of this item are whether the consumers live in a city or in the country. 74.6% of all respondents live in a city and 25.4% of the respondents live in the country. As consumers living in cities have more alternatives regarding transport, they may require differing attributes of vehicles.

Table 38: Frequency table of item 25

item25

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	437	74.6	74.6	74.6
	2	149	25.4	25.4	100.0
	Total	586	100.0	100.0	

Item 26 is concerned with the important question whether the consumer has an Austrian Class B driving license for a vehicle. The majority of the respondents do have a full driving license, and only 3.6% are not allowed to drive a class B vehicle. As only respondents who are allowed to drive a vehicle will be potential future users of hydrogen-powered vehicles Item 26 could be seen as a screening question.

Table 39: Frequency table of item 26

item26

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	565	96.4	96.4	96.4
	2	21	3.6	3.6	100.0
	Total	586	100.0	100.0	

As nearly all respondents have driving licenses for a class B vehicle, it is interesting how many of the respondents own a vehicle. 58.9% of the respondents do currently own a vehicle and 41.1% do not. This question is important because consumers who currently own a vehicle may have to be convinced to exchange their current vehicle for a hydrogen-powered one. Respondents who do not currently own a vehicle have to be persuaded to buy a hydrogen-powered vehicle rather than a car powered by another source of energy. It is interesting whether the two groups differ in their preferences about attributes of hydrogen-powered vehicles.

Table 40: Frequency table of item 27

item27

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	345	58.9	58.9	58.9
	2	241	41.1	41.1	100.0
	Total	586	100.0	100.0	

The last item of the demographic section and of the questionnaire is the one about the respondents' net income per month. The categories of this item are: less than €1,000, between €1,001 and €1,500, between €1,501 and €2,000, between €2,001 and €2,500, between €2,501 and €3,000, between €3,001 and €3,500 and above €3,501. As mentioned above, most of the respondents are students, so the net income of largest group is less than €1,000.

Table 41: Frequency table of item 28

item28

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	273	46.6	46.6	46.6
	2	112	19.1	19.1	65.7
	3	79	13.5	13.5	79.2
	4	61	10.4	10.4	89.6
	5	26	4.4	4.4	94.0
	6	15	2.6	2.6	96.6
	7	20	3.4	3.4	100.0
	Total	586	100.0	100.0	

5.2. Crosstabs and correlations

Now that all items have been described in detail and the preferences of the respondents with regard to each item are clear, it is now of interest to find out how single items of the questionnaire correlate with other items. First, correlations are drawn between topic-related items to show that there is consistency among items designed to measure, for

example, the degree of safety which consumers see in hydrogen as a fuel. The next step is to correlate topic-related items with demographic items. Items which show the highest degrees of correlation are pointed out and the reason for the correlation will be discussed. Correlations suggest connections between, for example, age and the degree of environmental commitment of the respondents. For other items, cross tabs are drawn and chi²-tests are conducted to see if there is a connection between these items. All correlations are based on the null hypothesis that the two items correlated are not connected, and the alternative hypothesis that the items are connected with each other. The level of significance used is 95% and therefore the asymptotic significance value has to be lower than 0.05.

5.2.1. Correlation among topic-related items

As there are many questions on different topics in the questionnaire, it is interesting to examine correlations among items dealing with different topics. For example, could there be a connection between an item designed to measure the degree of safety of hydrogen as a fuel and an item concerned with the degree of environmental benefit derived from hydrogen as a fuel. To show these connections and to show that there is consistency among questions, for example, the degree of safety associated with hydrogen as a fuel, correlations in combination with cross tabs and chi²-tests are conducted.

Correlation between items 5 and 6

As item 5 tries to measure whether consumers think that hydrogen as a fuel is more or less environmentally friendly than fossil fuels, and item 6 wants to measure the potential of hydrogen-powered vehicles to contribute to environmental protection, there could be a connection among these items. This correlation is shown both in the crosstab and the table of the Pearson correlation. The crosstab shows that the data is concentrated in the upper left corner, which suggests a positive correlation among these two items. This positive correlation suggests that respondents who think that hydrogen is more environmentally friendly than fossil fuels also think that hydrogen-powered vehicles are a beneficial to the environment. This may sound trivial, but consumers could also think that hydrogen as a fuel is more eco-friendly but see hydrogen-powered vehicles as still unsuitable for protecting the environment.

Table 42: Crosstab of items 5 and 6

item5 * item6 Crosstabulation

Count

		item6							
		1	2	3	4	5	6	7	Total
item5	1	99	46	16	13	2	3	2	181
	2	34	85	63	14	4	3	1	204
	3	6	18	57	44	9	7	0	141
	4	1	0	3	25	6	3	2	40
	5	2	0	1	3	1	3	3	13
	6	0	0	0	0	0	3	1	4
	7	0	0	0	0	0	0	3	3
Total		**142**	**149**	**140**	**99**	**22**	**22**	**12**	**586**

The chi²-test of items 5 and 6 shows that there is a connection between the two items that this connection is significant. This fact is displayed by the two-sided asymptotic significance column.

Table 43: Chi²-test of items 5 and 6

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	570.561[a]	36	.000
N of Valid Cases	586		

a. 27 cells (55.1%) have expected count less than 5. The minimum expected count is .06.

The Pearson correlation has a value of 61.3% which means that there is a medium to strong positive correlation between items 5 and 6. The more respondents are convinced that hydrogen as a fuel is more environmentally friendly than fossil fuels the greater their conviction that hydrogen-powered vehicles can help to protect the environment.

Table 44: Pearson correlation of items 5 and 6

Correlations

		item5	item6
item5	Pearson Correlation	1	.613**
	Sig. (2-tailed)		.000
	N	586	586
item6	Pearson Correlation	.613**	1
	Sig. (2-tailed)	.000	
	N	586	586

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between items 6 and 9

Two other items connected are items 9 and 6. Item 9 is concerned with measuring the consumers' opinions about hydrogen being the fuel of the future. Item 6 has already been described as the item concerned with measuring the consumer opinions about hydrogen-powered vehicles being able to help protect the environment. The crosstab of items 6 and 9 shows that most of the data also is concentrated in the upper left-hand corner. This means that respondents who think that hydrogen-powered vehicles help to protect the environment also think that hydrogen is suited to become the fuel of the future. This may sound trivial too, but people who on the one hand think that hydrogen can help to protect the environment could, on the other hand, think that there are better alternatives than hydrogen as the best fuel of the future.

Table 45: Crosstab of items 6 and 9

item6 * item9 Crosstabulation

Count

		item9							Total
		1	2	3	4	5	6	7	
item6	1	70	36	17	17	1	0	1	142
	2	33	52	35	26	1	1	1	149
	3	11	23	54	46	4	2	0	140
	4	3	7	14	56	11	5	3	99
	5	0	1	4	10	4	3	0	22
	6	0	0	1	5	4	9	3	22
	7	0	1	0	0	1	1	9	12
Total		**117**	**120**	**125**	**160**	**26**	**21**	**17**	**586**

The chi²-test shows that the two items are connected. Therefore the asymptotic significance column displays the significant correlation between items 6 and 9.

Table 46: Chi²-test of items 6 and 9

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	597.785[a]	36	.000
N of Valid Cases	586		

a. 25 cells (51.0%) have expected count less than 5. The minimum expected count is .35.

The correlation between items 6 and 9 has a value of 66.3%. This is a medium to strong positive correlation which describes the fact that respondents who think that hydrogen-powered vehicles are able to help to protect the environment also think that hydrogen is the best suited fuel for the future. As this is the highest correlation of all topic-related items, consumers want the fuel of the future to be eco-friendly.

Table 47: Pearson correlation between items 6 and 9

Correlations

		item6	item9
item6	Pearson Correlation	1	.663**
	Sig. (2-tailed)		.000
	N	586	586
item9	Pearson Correlation	.663**	1
	Sig. (2-tailed)	.000	
	N	586	586

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between items 10 and 13

Another correlation in the data is the one between items 10 and 13. Item 10 is about the consumers' feelings in terms of the safety of hydrogen as a fuel in comparison to fossil fuels. Item 13 is designed to measure the degree of safety or insecurity of refueling a vehicle with liquid hydrogen. The crosstab of items 10 and 13 shows that the data is concentrated in the middle and the upper left section of the table. An interesting fact is that the largest group of respondents is the one indifferent to items 10 and 13. This could lead to the assumption that item 10 correlates in a negative way with item 14, the item which tries to establish the customers' feelings about refueling a vehicle with hydrogen in gaseous form. Surprisingly, there is also a positive correlation between items 10 and 14, but not as strong as the correlation between items 10 and 13. In the crosstab of items 10 and 14, the largest group of respondents is also the one who are indifferent to both items.

Table 48: Crosstab of items 10 and 13

item10 * item13 Crosstabulation

Count

		item13							
		1	2	3	4	5	6	7	Total
item10	1	17	10	3	9	0	1	1	41
	2	12	27	8	21	5	1	0	74
	3	5	20	22	24	8	1	1	81
	4	21	38	40	79	12	1	3	194
	5	1	17	27	39	35	8	1	128
	6	0	3	5	11	10	15	6	50
	7	0	2	0	5	0	5	6	18
Total		**56**	**117**	**105**	**188**	**70**	**32**	**18**	**586**

The chi^2-test table shows a connection between those two items. This connection is significant because the asymptotic significance has a smaller value than 0.05.

Table 49: Chi²-test of items 10 and 13

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	209.597[a]	36	.000
N of Valid Cases	586		

a. 14 cells (28.6%) have expected count less than 5. The minimum expected count is .89

The table of the Pearson correlation shows that items 10 and 13 have a middle level of correlation of 45.8%. As above in the chi²-test, the correlation is of a significant level. Thus, respondents who think that hydrogen as a fuel provides a higher standard of safety than fossil fuels also feel safe when they are refueling their vehicles with hydrogen in a liquid form.

Table 50: Pearson Correlation between items 10 and 13

Correlations

		item10	item13
item10	Pearson Correlation	1	.458**
	Sig. (2-tailed)		.000
	N	586	586
item13	Pearson Correlation	.458**	1
	Sig. (2-tailed)	.000	
	N	586	586

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between items 10 and 15

An example of a negative correlation is the connection between item 10 and item 15. The purpose of item 10 has already been explained in the descriptive statistics, and item 15 tries to measure the consumers' feelings about an accident involving a hydrogen-powered vehicle in comparison with a vehicle powered by fossil fuels. In the crosstab the data concentrates in the lower left-hand corner. Again, the largest group of the crosstab is the one of respondents indifferent to items 10 and 15.

Table 51: Crosstab for items10 and 15

item10 * item15 Crosstabulation

Count

		item15							
		1	2	3	4	5	6	7	Total
item10	1	2	0	3	20	6	3	7	41
	2	1	0	18	33	12	5	5	74
	3	3	13	20	33	9	2	1	81
	4	1	9	42	119	20	0	3	194
	5	13	24	54	17	14	5	1	128
	6	15	13	12	0	4	3	3	50
	7	9	5	3	1	0	0	0	18
Total		**44**	**64**	**152**	**223**	**65**	**18**	**20**	**586**

The chi²-test shows that the two items are connected because the asymptotic significance column shows a value smaller than the required 0.05.

Table 52: Chi²-test of items 10 and 15

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	286.345[a]	36	.000
N of Valid Cases	586		

a. 20 cells (40.8%) have expected count less than 5. The minimum expected count is .55.

The table of the Pearson correlation shows items 10 and item 15 correlating in a negative way. The value of 41.0% describes that there is a middle correlation between the two items. Thus the more respondents are convinced that hydrogen as a fuel provides more safety than fossil fuels, the less dangerous they view accidents involving a hydrogen-powered vehicle in comparison to a vehicle powered by fossil fuels. As this negative connection sounds reasonable, consistency among these questions is given.

Table 53: Pearson correlation between items 10 and 15

Correlations

		item10	item15
item10	Pearson Correlation	1	-.410**
	Sig. (2-tailed)		.000
	N	586	586
item15	Pearson Correlation	-.410**	1
	Sig. (2-tailed)	.000	
	N	586	586

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between items 7 and 21

The correlation of Items 7 and 21 is interesting because Item 7 deals with the engine power of hydrogen-powered vehicles and item 21 is designed to establish what range a hydrogen-powered vehicle should have on a full tank. The crosstab of items 7 and 21 shows a concentration of the data in the middle and the upper right-hand corner of the table. The largest group of respondents in the crosstab is indifferent to item 21 and ticked option 3 in item 7, thus they would relinquish 20% of engine power for the sake of environmental protection.

Table 54: Crosstab of items 7 and 21

item7 * item21 Crosstabulation

Count

		item21							Total
		1	2	3	4	5	6	7	
item7	1	2	1	14	20	23	11	4	75
	2	1	4	12	25	20	8	0	70
	3	3	15	46	63	24	8	3	162
	4	0	16	52	44	25	3	2	142
	5	2	4	23	15	6	0	1	51
	6	4	7	17	17	5	2	0	52
	7	1	1	4	8	1	1	0	16
	8	1	2	3	4	1	2	0	13
	9	0	1	0	2	1	0	0	4
	10	0	0	0	1	0	0	0	1
Total		**14**	**51**	**171**	**199**	**106**	**35**	**10**	**586**

The chi²-test table shows that the connection between items 7 and 21 is significant because of the asymptotic significance value of 0.001.

Table 55: Chi²-test of items 7 and 21

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	92.841[a]	54	.001
N of Valid Cases	586		

a. 45 cells (64.3%) have expected count less than 5. The minimum expected count is .02

The Pearson correlation table shows that items 7 and 21 have a weak negative correlation of 23.3%. Thus respondents who are willing to relinquish only few percent of engine power are more likely to demand a wider range on a full tank of hydrogen. Those respondents might be hard to convince to buy a hydrogen-powered vehicle as more engine power usually increases fuel consumption and hence reduces the range of a vehicle. In the introductory stage of hydrogen-powered vehicles the state of technology may not be fully mature and sophisticated and therefore one parameter may have a negative influence on the other parameters.

Table 56: Pearson correlation between items 7 and 21

Correlations

		item7	item21
item7	Pearson Correlation	1	-.233**
	Sig. (2-tailed)		.000
	N	586	586
item21	Pearson Correlation	-.233**	1
	Sig. (2-tailed)	.000	
	N	586	586

**. Correlation is significant at the 0.01 level (2-tailed).

5.2.2. Correlation between topic-related and demographical Items

As the strongest correlations among topic-related items have been pointed out, it is now interesting to find connections between content-related items and demographic items. This analysis is important to define more closely target groups of consumers who have different preferences with regard to hydrogen-powered vehicles. For example, could there be differences in terms of gender or income levels. Demographic items in the questionnaire are dealt with between items 23 and 28.

Correlation between items 14 and 23

Item 14 tries to measure the consumer attitudes about refueling their vehicle with hydrogen in gaseous form, and item 23 asks for the gender of the respondents. The code for male respondents is 1 and for female respondents 2. As described above in the descriptive statistics, the general willingness of the respondents to refuel their vehicle with hydrogen in gaseous form is low, at a mean value of 4.28. But the crosstab of these two items shows that male respondents tend to feel safer when refueling their vehicle with hydrogen in gaseous form than female respondents. In contrast, women feel more at risk when thinking about refueling their vehicle with hydrogen in gaseous form.

Table 57: Crosstab of items 14 and 23

item14 * item23 Crosstabulation

Count

		item23		
		1	2	Total
item14	1	24	5	29
	2	38	5	43
	3	47	27	74
	4	107	81	188
	5	63	71	134
	6	28	49	77
	7	18	23	41
Total		**325**	**261**	**586**

The chi²-test shows that the connection between item 14 and item 23 is significant because the asymptotic significance has a lower value than 0.05.

Table 58: Chi²-test of Items 14 and 23

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	47.162[a]	6	.000
N of Valid Cases	586		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.92.

The Pearson correlation of 26.3% displays a weak to medium positive correlation between the two items. As shown in the crosstab, more men than women feel safe with regard to refueling their vehicle with hydrogen in gaseous form. The value of the correlation is not very high, but still significant.

Table 59: Pearson correlation between items 14 and 23

Correlations

		item14	item23
item14	Pearson Correlation	1	.263**
	Sig. (2-tailed)		.000
	N	586	586
item23	Pearson Correlation	.263**	1
	Sig. (2-tailed)	.000	
	N	586	586

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between items 2, 24 and 28

These correlations are not directly related to hydrogen-powered vehicles but they are important for defining important target groups for hydrogen-powered vehicles. The correlation of item 2, consumer commitment to environmental protection, item 24, the age of the respondents, and item 28, the level of net income per month, does not seem to be very striking at first sight.

But when taking at a closer look, it is obvious that hydrogen-powered vehicles are regarded as important instruments in environmental protection. As vehicles powered by alternative fuels are mostly expensive to acquire, middle to upper class consumers should be the most important target groups for the sellers of hydrogen vehicle. Therefore it is interesting to analyze the respondents' age and net income per month in connection with their commitment to the environment. The crosstab of items 2 and 24 shows that the data is concentrated on the left side of the table. As mentioned above, the questionnaire was filled out by far more respondents below 40 years than respondents above this age. However, there is still a noticeable tendency for older people to display more environmental commitment than younger people.

Table 60: Crosstab of items 2 and 24

Crosstab

Count

		item24						
		1	2	3	4	5	6	Total
item2	1	2	8	5	2	6	0	23
	2	1	40	17	13	8	1	80
	3	13	131	33	16	3	1	197
	4	10	91	21	5	9	0	136
	5	9	46	11	4	0	0	70
	6	4	32	9	0	1	0	46
	7	5	23	4	1	1	0	34
Total		**44**	**371**	**100**	**41**	**28**	**2**	**586**

The chi²-test shows that the connection between item 2 and item 24 is significant because the value of the asymptotic significance is lower than 0.05. Therefore age is really a relevant factor when it comes to commitment to the environment.

Table 61: Chi²-test for item 2 and 24

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	78.200[a]	36	.000
N of Valid Cases	586		

a. 23 cells (46.9%) have expected count less than 5. The minimum expected count is .59.

In the crosstab of item 2 and item 28 the data is also concentrated on the left side. As most of the respondents are younger than 40 years, a connection between the age of the respondents and the level of net income per month can be assumed. This connection is also analyzed in the Pearson correlation table. Respondents with a lower net income per month display a weaker commitment to the environment than people with a higher net income per month.

Table 62: Crosstab of item 2 and 28

Crosstab

Count

		item28							
		1	2	3	4	5	6	7	Total
item2	1	5	3	6	3	1	3	2	23
	2	31	9	12	11	5	4	8	80
	3	85	45	32	20	5	5	5	197
	4	67	27	11	15	13	1	2	136
	5	34	16	7	10	1	0	2	70
	6	30	8	5	1	1	0	1	46
	7	21	4	6	1	0	2	0	34
Total		**273**	**112**	**79**	**61**	**26**	**15**	**20**	**586**

The chi²-test of items 2 and 28 shows a significant relationship between the items 2 and 28 because of the value of the asymptotic significance is lower than 0.05. Thus both the age and the level of net income per month are relevant factors in defining the level of environmental commitment.

Table 63: Chi²-test of item 2 and item 28

Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	78.200[a]	36	.000
N of Valid Cases	586		

a. 23 cells (46.9%) have expected count less than 5. The minimum expected count is .59.

In the table of the Pearson correlation a weak to medium negative correlation between item 2, item 24 and item 28 can be observed. Thus older respondents and respondents with a higher level of net income per month are more likely to be environmentally committed. This suggests a positive connection between the age of the respondents and their level of net income per month. At 62.4%, this positive correlation exists between item 24 and item 28. As described above, the most important target group for vehicles powered by alternative fuels will be members of the middle or upper classes who care for environmental protection. The tendencies in the analysis suggested that people with a

higher level of net income per month and age are willing to actively protect the environment and therefore represent a target group for producers of hydrogen-powered vehicles.

Table 64: Pearson correlation between item 2, item 24 and item 28

Correlations

		item2	item24	item28
item2	Pearson Correlation	1	-.226**	-.207**
	Sig. (2-tailed)		.000	.000
	N	586	586	586
item24	Pearson Correlation	-.226**	1	.624**
	Sig. (2-tailed)	.000		.000
	N	586	586	586
item28	Pearson Correlation	-.207**	.624**	1
	Sig. (2-tailed)	.000	.000	
	N	586	586	586

**. Correlation is significant at the 0.01 level (2-tailed).

Other correlations between topic-related and demographic variables

Surprisingly, not many correlations above the 20% level could be detected in the data. Those described above were the only correlations which reached this level. Neither the variable which asked for the respondents' place of residence nor the variable which asked if the respondents have their own vehicle produced a correlation with a content-related variable larger then this 20%. Nevertheless, this fact also carries important information in itself, namely that there are no large differences in the preferences of the respondents no matter whether they are male or female, whether they have a driving license or not, whether they live in the city or in the country, or whether they own a vehicle already. This could be an interesting fact for marketers who do not have to concentrate on people living in the city or do not have to target their advertisements at a certain gender. The only demographic variable likely to have an impact on the definition of the target group for hydrogen-powered vehicles is income.

As most of the vehicles powered by alternative fuels are middle to upper class models, the target groups of these cars are environmentally committed, affluent consumers who are willing to invest in new technologies. Only with governmental subsidies for

hydrogen-powered vehicles, will the lower income segment ~~be~~ able to afford hydrogen-powered vehicles. As stated in an article in CNN Money in March 2012, vehicles powered by hydrogen fuel cells carry an average price tag of 100,000 dollars now, and the target price is around 50,000 dollars (Valdes-Dapena 2012).

These facts show that technological innovations and economies of scale need to be achieved before hydrogen-powered vehicles become available to lower-income groups without any governmental subsidies.

6. Management implications

The analysis of the data led to some major findings. The first finding is that the consumers taking part in the survey prefer features which are not provided by vehicles powered by battery. The second important finding is that people who live in cities do not differ in their demands regarding specifications of hydrogen-powered vehicles from people who live in the country, despite the differing infrastructures. The third interesting finding is that consumers believe hydrogen as a fuel is more dangerous than fossil fuels. The fourth important finding is that hydrogen as a fuel is only accepted if it is produced from renewable resources. The fifth finding is that consumers would pay higher prices for hydrogen powered-vehicles as long as hydrogen is cheaper than fossil fuels.

The first finding is based on 94.5% of the consumers surveyed, who feel that the refuelling process of vehicles should not take longer than ten minutes. As battery-powered vehicles take much longer to recharge, hydrogen-powered vehicles provide a big advantage in terms of convenience. Another issue that could promote hydrogen-powered vehicles is the expected range of 200-600km on a full tank. The current mid-size battery-powered vehicles on the market boast ranges of around 100km and a little over, but are not able to cover 200-600km on one tank (Goingelectric 2012). This suggests that battery-powered vehicles are more like a bridging technology leading to eventual independence from fossil fuels. But the demand of consumers is for vehicles with short refuelling times and a larger range. If hydrogen-powered vehicles provide these features, they have a huge advantage over vehicles powered by battery.

The finding that consumers in the country do not differ from consumers who live in cities as regards their demands on hydrogen-powered vehicles is based on missing correlations between content-related items and the demographic item. This is an interesting finding because the infrastructures in cities and in the country differ, for example, with respect to public transport and the number of gas stations. Two items which are important in a technological respect are that consumer demands, whether in cities or in the country, do not differ in matters of range and refuelling time. This allows companies to offer hydrogen-powered vehicles with the same technical specifications to the whole population of a country and therefore keep production costs and prices low. A question of

some interest for the future is whether there are differences in requirements when looking at different countries.

As mentioned in the chapter “Hydrogen,” the gas as a fuel, either in liquid or gaseous form, provides more safety than conventional fuels, like gasoline. The data of the questionnaire, however, showed that consumers think that hydrogen-powered vehicles and vehicles powered by fossil fuels do not really differ. It is still important for consumers that special precautions for storing the hydrogen are taken. The respondents prefer refueling their hydrogen-powered vehicles with hydrogen in liquid form, because perceived safety is higher than when refueling with hydrogen in gaseous form. Accidents involving hydrogen-powered vehicles are not considered to be more dangerous than accidents involving vehicles powered by fossil fuel. Thus consumers display a gap of information which could prevent hydrogen from becoming the fuel of the future. Therefore, information campaigns have to be launched to introduce the fuel hydrogen to the public and to convince people that hydrogen provides more or at least the same level of, safety as conventional fuels.

Results from the data analysis show that consumers who feel that hydrogen-powered vehicles provide a higher level of safety than vehicles powered by fossil fuels, feel safe with refueling their vehicle with hydrogen in either liquid or gaseous form. Thus, safety considerations do not depend on the form of hydrogen in the vehicle. In addition, consumers who perceive a higher level of safety when driving a hydrogen-powered vehicle than a vehicle powered by fossil fuels, consider accidents involving a hydrogen-powered vehicle to be less hazardous than accidents involving a vehicle powered by fossil fuels. This shows that there are consumers who take a realistic view of hydrogen-powered vehicles and who can act as lead users.

Another important finding of the questionnaire was that consumers insist on renewable primary resources for the production of hydrogen for powering vehicles. As the purpose of hydrogen-powered vehicles is to provide an alternative to vehicles powered by fossil fuels, only the production of hydrogen from renewable primary sources of energy can have an environmental impact and reduce dependency on fossil fuels. This is not only true for hydrogen-powered vehicles but for all vehicles powered by alternative fuels, e.g. electricity. If hydrogen can be produced from renewable primary resources like wind or

solar energy and therefore guarantees independence from fossil fuels, consumers are likely to switch from vehicles powered by conventional fuels, like gasoline, to hydrogen-powered vehicles.

Another major finding of the questionnaire is concerned with the environmental benefits that the respondents ascribe to hydrogen as a fuel. All items concerned with the environmental friendliness of hydrogen achieved positive responses, except for the item asking if hydrogen could be the fuel of the future. Consumers think that hydrogen is a fuel that is environmentally friendly but are not really sure if hydrogen is the fuel of the future.

The price consumers are willing to pay for one liter of hydrogen is lower than the price they are paying for one liter of diesel. If hydrogen is produced from renewable resources and therefore available in infinite amounts, the price should decrease over time through economies of scale. Furthermore, there is a manifest tendency for consumers to be willing to pay a higher price for hydrogen-powered vehicles than for vehicles powered by fossil fuels. This may result from the supposed environmental friendliness of hydrogen-powered vehicles or the possibility that hydrogen-powered vehicles are cheaper to run in terms of insurance or maintenance.

Subsidies for hydrogen as a fuel are strongly demanded to make hydrogen-powered vehicles available also for the lower income groups of the population. The infrastructure of gas stations has to be well developed with every second or third gas station offering hydrogen as well, and the range on a full tank of hydrogen has to be between 200km and 600km. Furthermore, consumers think that the process of refueling their vehicle should not take longer than 10 minutes, which is close to the time that vehicles powered by fossil fuels take to be refueled. A longer refueling time, such as for example necessary for batteries, is rejected by consumers.

In conclusion, findings which could serve to promote hydrogen as a fuel of the future are that consumers see hydrogen as environmentally friendly and equal in terms of safety to fossil fuels. Furthermore, consumers are willing to spend more money on hydrogen-powered vehicles than on vehicles powered by fossil fuels if hydrogen is provided at a lower price. Findings which could prevent large-scale sales of hydrogen-powered

vehicles are that consumers demand a well-developed infrastructure of gas stations which provide hydrogen. Additionally, consumers demand a large range on one tank and they want hydrogen to be subsidized by the government to ensure that hydrogen-powered vehicles are not only the privilege of the upper income bracket. The pros and cons among the findings show that hydrogen could be well placed as the fuel of the future, but the implementation of the necessary infrastructure will be a long-term project.

7. Conclusion and outlook for further studies

There are many ways of collecting information about consumer behavior. Examining the literature and selecting the appropriate method is not an easy task. By choosing an online survey in combination with the instrument of a questionnaire, a flexible instrument with many different kinds of questions is offered to a broad range of people having access to the Internet. The online survey offers the advantage that a large number of people can be reached without incurring huge costs and without a large amount of time.

By using a systematic design process, a valid instrument for conducting the survey about the current level of information and the attitude of consumers towards hydrogen-powered vehicle was created. With this instrument, the required data could be collected for management implications. The results of the survey showed that consumers accept hydrogen-powered vehicles if the hydrogen is produced from renewable primary resources. Furthermore, consumers demand certain features in hydrogen-powered vehicles like a minimum range and a certain type of engine. In terms of safety, consumers think that hydrogen-powered vehicles provide an equal level of safety to that of vehicles powered by fossil fuels. Higher costs of hydrogen-powered vehicles are no problem if refuelling the vehicle with hydrogen is cheaper than refuelling it with fossil fuels and if there is a dense network of gas stations providing hydrogen.

Firstly, the object of the survey was to test how consumers feel about certain attributes of hydrogen-powered vehicles. Therefore, all variables were analyzed in a descriptive way. Furthermore, connections between the variables of the questionnaire were examined. These connections allowed closer insight into the collected data and made it possible to extract more information

Consumers do not greatly differ in their attitudes towards hydrogen-powered vehicles across demographic characteristics like age, and thus there are no groups of consumers who are not interesting target groups for manufacturers of hydrogen-powered vehicles. The demographic analysis in combination with the correlations showed that respondents are not completely convinced of hydrogen, but they admit that hydrogen-powered vehicles could provide an alternative to vehicles powered by fossil fuels if they are affordable and efficient. The only factor that prevents consumers from buying hydrogen-

powered vehicles could be the high price. This requires the subsidising of hydrogen-powered vehicles by governments to enable the lower income groups to acquire these vehicles.

Although it was possible to gather a lot of interesting information in this thesis, there are other fields that are worth investigating. As already mentioned, it could be interesting to research the thoughts and feelings of consumers about hydrogen being used in the public transportation sector. Furthermore, there are options to concentrate more on one part of the questionnaire, for example, the convenience of hydrogen-powered vehicles and thus conduct research into the topic in greater depth.

Appendix

Deutsche Zusammenfassung

Diese Diplomarbeit handelt von der Abfrage des derzeitigen Status der Kundeninformationen zum Thema wasserstoffbetriebene KFZ. Die aufgetretene Forschungsfrage war: „Wie ist der derzeitige Informationsstatus von Konsumenten zum Thema wasserstoffbetriebene KFZ?“ Diese Abfrage wurde mit dem Instrument des Online-Fragebogens durchgeführt. Zu Beginn der Arbeit wurden die theoretischen Bereiche Wasserstoff, Kundeninformation und die Strukturierung des Forschungsprozesses behandelt, um valide Ergebnisse im empirischen Teil zu gewährleisten. Dabei wird im Kapitel über die Strukturierung des Forschungsprozesses ein zehn Schritte Prozess zur Erstellung des Fragebogens verwendet. Dieser Prozess beinhaltet unter anderem einen Pre-test, dessen Ergebnisse mit bereits durchgeführten Studien verglichen wurden, um Tendenzen in die gleiche Richtung aufzuzeigen und damit Konsistenz zwischen den zwei bereits durchgeführten Studien und dem Pre-test.

Die Studie wurde über eine Internetplattform durchgeführt, über welche 586 Personen zum Thema wasserstoffbetriebene KFZ befragt wurden. Die Zielgruppe des Fragebogens bestand aus allen Personen über 18 Jahren, also all jenen, die zumindest in der Theorie mögliche Konsumenten? von wasserstoffbetriebenen KFZ darstellen. Der Fragebogen umfasst die Bereiche Kosten von wasserstoffbetriebenen KFZ, deren Sicherheit, sowie deren Beitrag zum Umweltschutz und schlussendlich den Komfort von wasserstoffbetriebenen KFZ. Der Fragebogen wurde über einen Zeitraum von vier Monaten durchgeführt, angefangen im April und im Juli beendet. Die dabei gesammelten Ergebnisse wurden im empirischen Teil der Arbeit ausgewertet und danach wurde die Forschungsfrage beantwortet.

Die gesammelten Ergebnisse wurden statistisch ausgewertet. Zuerst wurde jede Frage einzeln deskriptiv ausgewertet und danach wurden Korrelationen zwischen zwei Fragestellungen gebildet, um Zusammenhänge aufzuzeigen. Dabei wurde offensichtlich, dass eher ältere und besserverdienende Umfrageteilnehmer sich mehr für den Umweltschutz engagieren. Es wurde auch ersichtlich, dass die Umfrageteilnehmer wasserstoffbetriebene KFZ nur dann akzeptieren, wenn der Wasserstoff aus erneuerbaren

Ressourcen gewonnen wird. Ein weiteres wichtiges Ergebnis ist, dass die Umfrageteilnehmer wasserstoffbetriebene KFZ als genauso sicher empfinden wie KFZ, die mit Benzin oder Diesel betrieben werden. Auch sind die Umfrageteilnehmer dazu bereit, mehr Geld für wasserstoffbetriebene KFZ zu bezahlen, wenn der Kraftstoff selbst günstiger als Diesel ist. Außerdem würde auch eine geringere Motorleistung bei wasserstoffbetriebenen KFZ akzeptiert werden, wenn damit ein höherer Grad an Umweltschutz gewährleistet wäre.

Am Ende der Arbeit stehen eine Zusammenfassung und ein Ausblick für weitere Studien. Dabei wird der nichtberücksichtigte öffentliche Verkehr als mögliche erster Verwendungsplattform für Wasserstoff als Treibstoff genannt.

Questionnaire

Umfrage zu alternativen Kraftstoffen für KFZ

Lieber Teilnehmer,

dieser Fragebogen wurde von mir, Nikolaus Koller, im Zuge meiner Diplomarbeit am Betriebswirtschaftlichen Zentrum der Universität Wien gestaltet. In diesem Fragebogen werden Vorstellungen von Konsumenten zum Thema Wasserstoff als Treibstoff abgefragt. Mit dem Ausfüllen dieses Fragebogens tragen Sie maßgeblich zum Erfolg dieses Projekts bei, wofür ich Ihnen herzlichst danken möchte. Der Fragebogen besteht aus fünf Seiten und wird ca. 10-15 Minuten in Anspruch nehmen.

Vorab-Infos zum Thema Wasserstoff als Treibstoff:

Wasserstoff ist ein farb- und geruchsloses Gas, welches über einen Prozess aus Primärenergiequellen gewonnen werden kann. Wasserstoff kann als Alternative zu Benzin/Diesel genutzt werden. In diesem Fragebogen wird die Nutzung von Wasserstoff sowohl über einen Verbrennungsmotor als auch über Brennstoffzellen behandelt. Die Brennstoffzelle generiert elektrischen Strom aus Wasserstoff für einen Elektromotor. Die blau unterstrichenen Wörter in den Angaben stellen Werbelinks zu Webpages dar, da der Fragebogen auf einer kostenlosen Plattform erstellt wurde.

Nikolaus Koller

1 **Wie umweltbewusst schätzen Sie sich selbst ein? (Pflichtfrage)**

- 1 Sehr umweltbewusst
- 2
- 3
- 4 Indifferent
- 5
- 6
- 7 Nicht umweltbewusst

2 **Wie sehr engagieren Sie sich für den Umweltschutz? (Pflichtfrage)**

- Sehr viel
- 2
- 3
- 4 Indifferent
- 5
- 6
- 7 Sehr wenig

3 **Zur Herstellung von Wasserstoff sind Primärenergie und Wasser erforderlich. Welche primäre Energiequelle würden Sie am ehesten zur Herstellung von Wasserstoff akzeptieren? (Pflichtfrage)**

(Mehrfachnennungen sind möglich)

- Windkraft
- Wasserkraft
- Solarenergie
- Atomenergie
- Kohle
- Erdöl
- Erdgas
- sonstiges

4 **Welche alternativen Energiequellen könnten Sie sich neben Wasserstoff als Treibstoff der Zukunft am besten vorstellen? (Pflichtfrage)**

(Mehrfachnennungen sind möglich)

- ☐ Biogas
- ☐ Biomasse
- ☐ Biosprit
- ☐ Batterie/Strom
- ☐ sonstiges

5 **Wie umweltfreundlich empfinden Sie Wasserstoff als Treibstoff für KFZ im Vergleich zu Diesel oder Benzin? (Pflichtfrage)**

- ○ 1 Viel umweltfreundlicher
- ○ 2
- ○ 3
- ○ 4 Gleich umweltfreundlich
- ○ 5
- ○ 6
- ○ 7 Viel weniger umweltfreundlich

6 **Wie hoch schätzen Sie das Potential von wasserstoffbetriebenen KFZs ein, zum Umweltschutz beizutragen? (Pflichtfrage)**

- ○ 1 Sehr hoch
- ○ 2
- ○ 3
- ○ 4 Mittelmäßig
- ○ 5
- ○ 6
- ○ 7 Sehr niedrig

7 **Wie weit dürfte Ihrer Meinung nach die Motorleistung eines wasserstoffbetriebenen KFZs unter dem Aspekt der Umweltfreundlichkeit leiden? (Pflichtfrage)**

- 0% weniger Leistung
- 10% weniger Leistung
- 20% weniger Leistung
- 30% weniger Leistung
- 40% weniger Leistung
- 50% weniger Leistung
- 60% weniger Leistung
- 70% weniger Leistung
- 80% weniger Leistung
- 90% weniger Leistung

8 **Wie hoch glauben Sie ist das Einsparungspotential von CO2 Emissionen durch die Benutzung von Wasserstoff als Treibstoff im Vergleich mit Diesel oder Benzin? (Pflichtfrage)**

- 1 Sehr hoch
- 2
- 3
- 4 Gleich hoch
- 5
- 6
- 7 Sehr niedrig

9 **Ist Wasserstoff Ihrer Meinung nach als Treibstoff für KFZ in der Zukunft geeignet? (Pflichtfrage)**

- 1 Ganz sicher
- 2
- 3
- 4 Vielleicht
- 5
- 6
- 7 Sicher nicht

10 **Wie schätzen Sie die Sicherheit von Wasserstoff als Treibstoff für KFZ im Vergleich zu Diesel oder Benzin ein? (Pflichtfrage)**

- 1 Sehr sicher
- 2
- 3
- 4 Gleich sicher
- 5
- 6
- 7 Sehr unsicher

11 **Wie wichtig wäre es für Sie, dass besondere Sicherheitsvorkehrungen im Bezug auf die Speicherung des Wasserstoffes im KFZ vorherrschen? (Pflichtfrage)**

- 1 Sehr wichtig
- 2
- 3
- 4 Indifferent
- 5
- 6
- 7 Sehr unwichtig

12 **Bei welchem Gedanken fühlen Sie sich sicherer: flüssigen Wasserstoff zu tanken oder gasförmigen Wasserstoff zu tanken? (Pflichtfrage)**

- 1 Flüssiger Wasserstoff
- 2
- 3
- 4 Weder noch
- 5
- 6
- 7 Gasförmiger Wasserstoff

13 **Wie sicher bzw. unsicher fühlen Sie sich bei dem Gedanken, flüssigen Wasserstoff in Ihr KFZ zu tanken? (Pflichtfrage)**

- 1 Sehr sicher
- 2
- 3
- 4 Indifferent
- 5
- 6
- 7 Sehr unsicher

14 **Wie sicher bzw. unsicher fühlen Sie sich bei dem Gedanken, gasförmigen Wasserstoff in Ihr KFZ zu tanken? (Pflichtfrage)**

- 1 Sehr sicher
- 2
- 3
- 4 Indifferent
- 5
- 6
- 7 Sehr unsicher

15 **Wie schätzen Sie die Situation eines Unfalles mit einem wasserstoffbetriebenen KFZ im Vergleich zu einem benzinbetriebenen KFZ ein? (Pflichtfrage)**

- 1 Viel gefährlicher
- 2
- 3
- 4 Gleich gefährlich
- 5
- 6
- 7 Viel ungefährlicher

16 **Wenn sich Wasserstoff als Treibstoff durchsetzen sollte, wie hoch dürfte Ihrer Meinung nach der Preis für einen Liter Wasserstoff sein, angenommen dass ein Liter Wasserstoff gleich effizient ist wie ein Liter Diesel (Angabe in Euro, Vergleichswert: Preis pro Liter Diesel 1,50€)? (Pflichtfrage)**

17 **Wenn ein benzinbetriebenes Mittelklasse KFZ 20.000 Euro kostet, welchen Preis würden sie, bei gleichen Treibstoffkosten und bei gleicher Effizienz der Treibstoffe, für ein vergleichbares wasserstoffbetriebenes KFZ bezahlen? (Quelle des Wasserstoffes sind erneuerbare Primärenergien) (Pflichtfrage)**

18 **Sollte Wasserstoff als Treibstoff staatlich gefördert werden? (Pflichtfrage)**

- Ja
- Ja, aber nur wenn der Wasserstoff aus erneuerbaren Primärenergien erstellt wird
- Nein
- Indifferent

19 **Wie viele Tankstellen, die Wasserstoff als Treibstoff anbieten, wären für Sie mindestens erforderlich? (Pflichtfrage)**

- Jede Tankstelle
- Jede zweite Tankstelle
- Jede dritte Tankstelle
- Jede vierte Tankstelle
- Jede fünfte Tankstelle
- Jede zehnte Tankstelle
- Jede zwanzigste Tankstelle

20 **Wie lange darf für Sie der Tankprozess von Ihrem KFZ dauern (allgemein, nicht auf Wasserstoff bezogen)? (Pflichtfrage)**

- Weniger als eine Minute
- Weniger als fünf Minuten
- Weniger als zehn Minuten
- Weniger als 30 Minuten
- Weniger als eine Stunde
- Weniger als drei Stunden
- Mehr als drei Stunden

21 **Welche Reichweite müsste ein mit alternativen Kraftstoffen (Wasserstoff, Batterie) betriebenes KFZ für Sie haben? (Pflichtfrage)**

- Bis 100 km
- Zwischen 100 km und 200 km
- Zwischen 200 km und 400 km
- Zwischen 400 km und 600 km
- Zwischen 600 km und 800 km
- Zwischen 800 km und 1000 km
- Über 1000 km

22 **Wie empfinden Sie die Tatsache, dass typische Motorengeräusche, die der Verbrennungsmotor (Diesel, Benzin) verursacht, bei Fahrzeugen mit Wasserstoffantrieb nicht mehr auftauchen würden? (Pflichtfrage)**

- 1 Sehr gut
- 2
- 3
- 4 Indifferent
- 5
- 6
- 7 Sehr schlecht

23 **Welches Geschlecht haben Sie? (Pflichtfrage)**

- Männlich
- Weiblich

24 **Wie alt sind Sie? (Pflichtfrage)**

- 16-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- älter als 71

25 **Leben Sie vorwiegend in der Stadt oder am Land? (Pflichtfrage)**

- in der Stadt
- am Land

26 **Besitzen Sie einen Führerschein der Klasse B? (Pflichtfrage)**

- Ja
- Nein

27 **Besitzen Sie ein eigenes KFZ? (Pflichtfrage)**

- Ja
- Nein

28 **Wie viel verdienen Sie? (Netto/Monat) (Pflichtfrage)**

- Weniger als 1.000€
- Zwischen 1.001€ und 1.500€
- Zwischen 1.501€ und 2.000€
- Zwischen 2.001€ und 2.500€
- Zwischen 2.501€ und 3.000€
- Zwischen 3.001€ und 3.500€
- Mehr als 3.501€

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Literature

Written sources

Abbasi, S.A., Abbasi, N., 2006, Renewable energy sources and their environmental impact, Prentice: New Dehli

Ball, M., Wietschel, M., 2009, The Hydrogen Economy, University Press: Cambridge

Blackwell, R.D., Miniard, P.W., Engel, J.F., 2001, Consumer Bevahior, 9th edition, South-western: Mason

Blaikie, N., 2010, Designing social research, 2nd edition, Polity Press: Cambridge

Brace, I., 2008, Questionnaire Design, 2nd edition, Kogan Page: London

Breidert, C., Hahsler, M., Reutterer, T., 2006, A review of methods for measuring willingness-to-pay, *Innovative Marketing*, Vol. 2 (4), p. 8-32

Busby, R.L., 2005, Hydrogen and fuel cells, PennWell: Tulsa

Case, D.O., 2012, Looking for information, 3rd edition, Emerald Group Publishing: Bingley

Chen, C.J., 2011, Physics of solar energy, Wiley: Hoboken

Churchill, G.A., Iacobucci, D., 2010, Marketing research, 10th edition, Cangage Learning: Mason

Curasi, C.F., 2001, A critical exploration of face-to-face interviewing vs. computer-mediated interviewing, *International Journal of Market Research*, Vol. 43 (4), p. 346-375

Davis, C., Edelstein, B., Evenson, B., Brecher, A., Cox, D., 2003, Hydrogen Fuel Cell Vehicle Study, *A report prepared for the Panel of Public Affairs, American Physical Society*, p. 1-39

DiPippo, R., 2012, Geothermal Power Plants, 3rd edition, Butterworth-Heinemann: Oxford

Erjavek, J., Automotive Technology, 2010, 5th edition, Delmar: Clifton Park

Evans, J.R., Mathur, A., 2005, The value of online surveys, Internet research, Vol. 15 (2), p. 195-219

Evers, A.A., 2010, Hydrogen society: More than just a vision?, Hydrogeit: Oberkraemer

Geitmann, S., 2004, Erneuerbare Energie und alternative Kraftstoffe – mit neuer Energie in die Zukunft, Hydrogeit: Kremmen

Griffis, S.E., Goldsby, T.J., Cooper, M., 2003, Web-based surveys: a comparison of response, data, and cost, *Journal of Business Logistics*, Vol. 24 (2), p. 237-258

Groves, R.M, 2004, Survey methodology, Wiley: Hoboken

Hair, J.F., 2010, Essentials of marketing research, 2nd edition, McGraw-Hill: New York

Hair, J.F., Bush, R.P., Ortinau, D.J., 2006, Marketing research, 7th edition, McGraw-Hill: New York

International Energy Agency, 2006, Hydrogen production and storage, *Head of publication service*, pp. 1-38

Kardes, F.R., Cronley, M.L., Cline, T.W., 2008, Consumer behavior, Cangage Learning: Mason

Kothari, C.R., 2004, Research Methodology, 2nd edition, New Age International: New Dehli

Kotler, P., Armstrong, G., 2008, Principles of marketing, 12th edition, Pearson education: New Jersey

Kumar, C.R., 2008, Research Methodology, APH Publishing Corporation: New Dehli

McDaniel, C.D., Gates, R.H., 2008, Marketing research essentials, 6th edition, Wiley: Hoboken

Mehta, R., Sivadas, E., 1995, Comparing response rates and response content in mail versus electronic mail, *Journal of the Market Research Society*, Vol. 37, p. 429-439.

Meyvis, T., Janiszewski, C., 2002, Consumers' beliefs about product benefits: the effect of obviously irrelevant product information, *Journal of consumer research,* Vol. 28, p. 618-634

Monette, D.R., Sullivan T.J., DeJong, C.R., 2011: Applied Social Research: A Tool for the Human Services, 8th edition, Brooks/Cole: Belmont

Morris, N., 2007, Geothermal Power, Smart Apple Media: North Mankato

Muijs, D., 2004, Doing quantitative research in education, Sage Publications: London

Nessim H., Dodge R., 1995, Pricing-Policies and Procedures, MacMillan Press: London

Oxlade, C., 2008, Energy technology, Evens Brothers Ltd.: London

Roster, C.A., Rogers, R.D., Albaum, G., Klein, D., 2004, A comparison of response characteristics from web and telephone surveys, *International Journal of Market Research,* Vol. 46 (3), p. 359-373

Rubin, J., 2000, Online marketing research comes of age, *Brandweek*, Vol. 26, p. 26-27

Scheaffer, R.L., Mendenhall, W., Ott, R.L., Gerow, K.G., 2012, Elementary Survey Sampling, 7th edition, Brooks/Cole: Belmont

Schiffman, L.G., Kanuk, L.L., 2010, Consumer Behavior, 10th edition, Pearson education: New Jersey

Scholl, N., Mulders, S., Drent, R., 2002, Online qualitative market research: interviewing the world at a fingertip, *Qualitative Market Research*, Vol. 5 (3), p. 210-223

Sheehan, K.B., McMillan, S.J., 1999, Response variation in e-mail surveys: an exploration, Journal of advertising research, Vol. 39, p. 45-54

Sörensen, B., 2012, Hydrogen and Fuel Cells, 2nd edition, Academic Press: Oxford

Strauss, A., Corbin J., 1998, Basics of qualitative research, 2nd edition, Sage Publications: Thousand Oaks

Taylor, G.R., 2005, Integrating quantitative and qualitative methods in research, 2nd edition, University Press: Lanham

Turner, J.A., 2004, Sustainable Hydrogen Production, *Science*, Vol. 305, p. 972-974

UNESCO, 2003, Water for people water for life, Bergbahn Books: Oxford

White, C.M., Steeper, R.R., Lutz, A.E., 2006, The hydrogen-fueled internal combustion engine: a technical review, *International Journal of Hydrogen Energy*, Vol. 31, p. 1292-1305

Wrenn, B., Stevens, R.E., Loudon, D.L., 2007, Marketing Research, 2nd edition, Haworth Press: Binghampton

Online sources

Clean Energy Project, Wasserstoff als Kraftstoff für Verbrennungsmotoren, 2011

GoingElectric, Elektroauto Reichweite – mehr als ausreichend, article of 16th May 2012, http://www.goingelectric.de/2012/05/16/wissen/elektroauto-reichweite-mehr-als-ausreichend/ [Access on 20.10.2012]

LMI, Summary of Results DDWG Hydrogen Fuel Cell Survey, 2009

Valdes-Dapena, P., Hydrogen-cars: a zero emission longshot, article of 19th March 2012, http://money.cnn.com/2012/03/15/autos/hydrogen-fuel-cell-cars/index.htm [Access on 14.08.2012]

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