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The Green Evolution of the Car Industry

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Vi har inte ärvt jorden av våra föräldrar,
vi har lånat den av våra barn.

ABSTRACT

Title:	The Green Evolution of the Car Industry
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Authors:	Daniel Nackovski and Katarina Swane
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Key Words:	Green Cars, Alternative Fuels, Alternative Engines, Dominant Design and Standard Battles.
Purpose:	The purpose of this thesis is to map and discuss the alternative fuels and engines to petrol/diesel and the Internal Combustion Engine (ICE) and find out if there are any tendencies towards a dominant design within the green car market.
Methodology:	The research approach was inductive since it started with the collection of information about the concept of dominant design and the different alternative fuels. From that point the work moved on to the collection of primary data through interviews.
Theoretical Perspectives:	Theories concerning dominant design and the factors surrounding it, for example complementary products and installed base, were given most attention.
Empirical Foundations:	This part of the thesis was based on semi-structured or non-structured interviews. The interviewees were picked due to their involvement in organizations or companies relevant to our purpose or due to their technical knowledge.
Conclusions:	In the short perspective there are no tendencies indicating that one of the alternatives will become the standard and thereby replace the petrol/diesel as the main driving fuels for cars. Seen in a wider time horizon we did not find any obvious indicators saying that one particular technology will become the future market standard. However, it can be said that the fuel cell has the potential of becoming the standard winner.

SAMMANFATTNING

Titel:	The Green Evolution of the Car Industry
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Ämne/kurs:	FEK 591, Magisteruppsats, Strategic Management, 10 poäng
Författare:	Daniel Nackovski och Katarina Swane
Handledare:	Christer Kedström
Nyckelord:	Miljöbilar, Alternativa Bränslen, Alternativa Motorer, Dominant Design och Standard Battles.
Syfte:	Syftet med denna uppsats är att finna och diskutera de olika alternativa bränslena och motorerna till bensin/diesel och förbränningsmotorn. Vidare är syftet att se om där finns några tendenser till en dominant design inom miljöbils marknaden.
Metod:	Uppsatsen grundar sig i ett induktivt tillvägagångssätt, detta då den startade med insamling av information angående dominant design och alternativa bränslen. Därefter fortsatte arbetet genom att primär data samlades in genom intervjuer.
Teoretiskt Perspektiv:	Den största vikten lades på teorier angående dominant design och relaterade begrepp, till exempel komplement produkter och användare bas.
Empiri:	Den här delen av uppsatsen baserades på semistrukturerade och ostrukturerade intervjuer. Intervju personerna valdes utefter vårt syfte. Antingen för att representera sina organisationer eller företag eller på grund av sin tekniska kunskap**.**
Slutsatser:	I det korta perspektivet finns inga tendenser som indikerar att ett av alternativen blir standard och därmed ersätter bensinen/dieseln som primära drivkällor för personbilar. Sett i ett längre tidsperspektiv fann vi inga klara indikationer som pekade på att just en av teknologierna skulle komma att bli standard på marknaden. Däremot kan sägas att bränsleceller har potential att bli det.

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Lund, June 2006

This Master Thesis was conducted at The School of Economics and Management at Lund University. This assignment gave us the opportunity to utilize the knowledge gained during the years as business students. Even though the work has been hard and intense, it has also been very interesting and rewarding.

Throughout the work numerous people have contributed to the results, by giving us access to their knowledge and expertise. We would now like to take a moment to thank everybody that has taken their time to answer our questions. We are sincerely grateful for your efforts. This thesis would not have been possible to complete without your help. Furthermore, we would also like to thank our advisor Christer Kedström for the support and guidance he has provided and Jessica Swane for her comments on the written language.

Daniel Nackovski

Katarina Swane

TABLE OF CONTENT

1. INTRODUCTION

This chapter is divided into five sections, where the first one handles the background, the second and third deal with the problem formulation and the purpose of the thesis. Thereon follows the definitions and finally the layout of the thesis is presented.

1.1 BACKGROUND

For many years there has been a discussion among experts about the pollution of the environment as a result of petrol driven personal vehicles. There are about 700 000 000 cars roaming the streets of the world today. A car affects the environment during its entire life, from assembly to the junkyard, and 70 per cent of it comes from when in use (e.g. CO_2 emissions). Due to the development of society being underpinned by mobility, the number of cars is constantly increasing. (Dahlström, 2006-05-16)

Changes to the climate and the green house effect are issues of high concern today. From an historical perspective, the ten hottest years have occurred after 1990, the average temperature has increased with 0.6 degrees Celsius during the last decade. Furthermore, the number of hurricanes, floods and heat waves has doubled during the 1990s compared to the 1980s. Under the Kyoto agreement the world (through the signing countries) has agreed to lower the emissions of green house gases with an average of 5.2 per cent (2008 to 2012). Carbon dioxide (CO_2) is one of the green house gases included here. (SNF, a, 2006; Regeringen, e, 2005)

The environmental concern is one of the factors driving the discussion about “green cars”. The European Union (EU) has a 3-pillar strategy on CO_2 emissions and cars, which aims to reduce the average CO_2 emissions to a level of 120 grams per kilometre for all new cars marketed in the union. Included here is: a) voluntary commitment by the car industry to reduce CO_2 emissions from new cars, b) mandatory labelling of CO_2 emissions and fuel economy, c) stipulating governments to adjust tax systems for vehicles based on CO_2 emissions. Furthermore, the EU has in a directive stated that 5.75 per cent of the use of petrol and diesel shall be replaced (by renewable fuels) by 2010. (Environment for Europeans, 2005; EU Directive 2003/30/EG, 2003)

Another factor that speaks in favour of alternative fuels and green cars is the high oil price. This is a problem, which in the end affect the owners of the car, due to higher petrol prices. Many oil experts predict that the oil price will continue to rise in the future as well. They argue that the future demand will be larger than the oil companies' ability to supply, which will of course raise prices even more. (Näringsliv 24, 2005)

To be able to meet the needs and demands of current and future customers, many car manufacturers have been pursuing alternative solutions to petrol. This is, to manufacture cars that meet domestic regulations and international standards regarding the environmental effect of the cars. As a result of this many car manufacturers have come to the point where they invest more capital and knowledge in the R&D of the green car, since usage of alternative fuels and power trains can cut energy use in half and reach low or near-zero emissions of CO_2.We can today see that some car manufacturers have been able to provide the market with cars that are driven on alternative fuels and not solely on petrol. (Åhman, Nilsson & Johansson)

1.2 PROBLEM

The green car market is evolving, and due to EU directives and governmental actions it will continue to do so in the future. Several car manufacturers have provided the market with alternatives to the petrol driven car. However, the car manufacturers have problems, such as available fuels, available refuelling locations and high development costs, to mention a few. These all need to be considered when choosing which technology to manufacture. If another technology becomes the market standard the company's future earnings can be affected. This problem leads us to our main research question, which is as follows:

Are there any tendencies towards a dominant design within the green car market today?

The perspective used to answer this question was from the outside and in, meaning we have not tried to get the car manufacturers' or the environmentalists' perspective. Instead, an outsider's perspective was used in order to gain an understanding of the whole market.

1.3 PURPOSE

The purpose of this thesis is to map and discuss the alternative fuels and engines to petrol and the Internal Combustion Engine (ICE) and find out if there are any tendencies towards a dominant design within the green car market in the EU.

1.4 DEFINITIONS

Car manufacturer: A company that produces and sells cars for personal transportation.

Dominant design: A technology that becomes the industry standard.

Green car: A car that is equipped with technology that totally or partially enables it to be driven by alternative fuels like gas, ethanol or electricity.[1]

Normal car: A car powered by an ICE.

Technology: When this is used without any further explanation it is meant to represent the technology associated with the alternative fuels/engines.

1.5 LAYOUT OF THE THESIS

- *Chapter 1:* Covers the background, problem, purpose and the definitions of the thesis.
- *Chapter 2:* Deals with the structure of the thesis, which includes the methodological choices and the data collection process.
- *Chapter 3:* Covers the theoretical framework, meaning theories concerning the emergence of standards.
- *Chapter 4:* Here the different technologies are presented.
- *Chapter 5:* Under this heading an analysis of the green car market is given using stakeholder mapping.
- *Chapter 6:* Here an analysis is given related to the research question based on interviews.
- *Chapter 7:* Handles the conclusions of the research, the creditability of the thesis and suggestions for further research.

[1] As there is no common definition of a green car within the EU today, the authors have decided to use this.

- *Chapter 8:* Is a glossary of words that are not common in daily life.

2. METHOD

In this chapter we start by presenting an overview of the method before moving on to the methodological strategy of the thesis including the approach, purpose and philosophy. Thirdly the methodological limitations are presented and then follow a description of the data collection process and the problems that occurred.

2.1 RESEARCH OVERVIEW

Green cars have been on the market for some time and are increasing in number every year (Bilsweden, 2006). Research has been performed within the area of green cars and their future development. (Åhman, Nilsson & Johansson; Åhman, Modig & Nilsson; Hekkert & van den Hoed, 2006) However, we have not found any research that point towards a common platform technology. As stated in section 1.2 this is what we would like to investigate. In order for us to do this we needed to understand the different technologies that exist within this market segment. Collecting and reading, for example, articles and newspapers allowed us to achieve this. However, it is not only the superiority of the underlying technology that determines the winner; there are also other factors like compatibilities that drive the progress. In order to understand which these different factors were, we needed to study articles, books and reports covering the concept of dominant design and the underlying factors. When the different factors were mapped out the work moved on to look at the market to see which different stakeholder groups exist within the market. In order to get additional knowledge and input, interviews related to the research area were performed (for more information about the interviews see section 2.4.2. These interviews were then used as a base for the analysis, and eventually led to our conclusions.

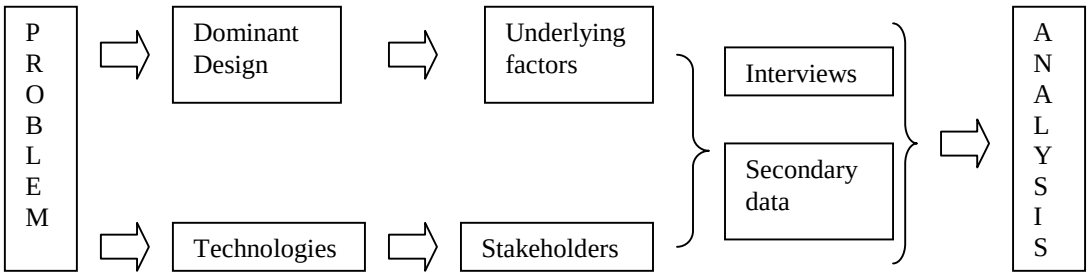

Figure 2.1 Research overview.

2.2 METHODOLOGY APPROACH

We moved from collecting secondary data, were we received an overall understanding about our topic, to gather primary data through interviews. The next stage was to interpret our data to see if there were any signs leading towards a dominant design, which allowed us to answer our research question. This implies that the research approach was inductive since it moved from data to theory and allowed an understanding of the research context. Furthermore, since we wished to see what the future would be like, our research purpose can be said to be of a descriptive and an exploratory nature. The descriptive nature was important because we needed to portray the green car market of today. Furthermore we wanted to see what was happening on the market, which lies within the exploratory purpose. (Saunders, Lewis & Thornhill, 2003).

The data collected through interviews was of a qualitative nature, since it was based on words and of an informative nature. The first set of interviews was performed to create an understanding of the market and the factors at work there. Further on, the second set of interviews was performed in order to see what the car manufacturers' expectations about the future were and to reach a higher level of knowledge about their platform technology. (Saunders et. al., 2003).

The overall philosophy of the thesis, based on the above, was interpretivism. The interpretivism came in, as we believe that the circumstances of today may not always apply tomorrow and that it was important to see what the underlying factors were in order to be able to grasp the greater picture. (Saunders et. al., 2003).

2.2.1 Choice of theory

The theoretical framework presented in chapter 3 covers a discussion about the concept of dominant design. Dominant design is a phenomenon where one technology becomes the market standard and all surrounding products adapted to fit that platform. In order to answer the research question an understanding about how a dominant design emerges was needed. The factors at work are plentiful, the theories used in this thesis to explain how a dominant design emerges, covers the areas of Positive Feedback, Discontinuities, Knowledge Webs, Learning Emphasis, Installed Base,

Compatibilities and Timing of Entry. These theories can be used to explain (or partially explain) how a company/technology can build advantages that lead towards a dominant position on the market.

2.2.2 Method for the analysis

Once the interviews were conducted it was time for analysing the answers given by the respondents. The interview questions were based on the thesis' theoretical framework. As a natural step the analysing and presentation of the answers were made simultaneously. The results were divided according to the different underlying factors (presented in figure 6.1) that decide what becomes the dominant design. This was done in order to make the link to the theories more apparent and allow the reader to receive a better understanding of which technology might stand ahead of the others. It needs to be stated that during the analysis information from the theoretical framework as well as from the interviews, together with facts from the technology chapter was used. Further on, as what the theories implied did not correspond with the respondent's believes about the future, these were presented in a separate section. The aim was that this process would provide an indication of which technology will become the future dominant design.

2.3 METHODOLOGICAL LIMITATIONS

Due to lack of time, this master thesis has some limitations in the following areas; geographical, segment of the market and the number of interviews.

Since different countries have different regulations, incitement, preferences and tastes we have chosen to narrow the investigated range to only cover the European Union (EU). Since the different governments that constitute the EU have the right to set their own rules to some extent, the examples on government incentives etc. comes from the Swedish government. We choose Sweden because Sweden is ahead of the rest of EU when it comes to reaching the EU directive on CO_2 emissions. Therefore we believe it to be good examples of what can be done in order to meet the EU directives. (BBC Newsnight, 2005)

Concerning the car manufacturers included in our research we looked at three of the companies represented on the market. The selection of these companies was made

based on the technology in use. We wanted to get at least one representative from each technology. Included in the interviews were Daimler Chrysler (Fuel cells, Synthetic diesel and Gas (Mercedes)), Toyota (Synthetic diesel (UK), Hybrids, Fuel cells and Electric (USA)) and Volvo (Gas and Ethanol). (Milöbilsprojekten, 2005)

The technologies presented in this thesis include bio gas, natural gas, electricity, fuel cells, ethanol and hybrids. Including more would have required more time then available. Moreover this thesis was looking at today and including technologies that was unfamiliar for the market did not seem appropriate. Therefore the above-mentioned technologies/fuels were the only ones examined.

2.4 METHODOLOGY FOR COLLECTING DATA

2.4.1 Secondary data

Finding the relevant data has two challenges a) establish whether or not the required data is available as secondary data and b) locating where this data can be found. In our case the search for appropriate data started with a search on green cars, which gave us an understanding for what we needed to look further into. The second thing on the agenda was to find out which the available technologies were. Here the Internet was used since it allows a broad search for information. Once the technologies were established a further search was done on the different technologies themselves. The electronic library ELIN, Libris, university databases like Chalmers Publication Library and the Internet were used to gather reports, books and articles on the subjects. These sources of access to information were also used in the search for information on the concept of dominant design and the factors that drive an industry towards a common standard. In addition, the references in the articles were examined to see if they could give additional knowledge on the subject. For the market analysis, data was collected through searching government web pages, EU web pages and the web pages of other relevant organizations and companies. A more complete list of the secondary sources is shown in table 2.1 below. (Saunders et. al., 2003)

Sources:	Examples:
• Databases	Affärsdata, ELIN and Libris
• Published literature	Books and Articles
• Periodicals	Dagens nyheter, Ny teknik, etc
• Reports	e.g. EU Directives, KFB reports
• Internet	e.g. Bil Sweden, Periodicals
• Registers	Producers, CO_2 discharges
• Publications	Vägverket, EU, KFB, Newsletters
• Press releases	News papers, Internet

Table 2.1 Different sources of secondary information

2.4.2 Primary data

Primary data is new data collected especially for a specific purpose; this can be achieved through interviews and surveys amongst other things. In order for us to get a deeper understanding of the green car phenomena we used semi-structured and unstructured interviews. We believed that these two approaches were preferable since they allowed the interviewee to talk more freely and thereby the risk of excluding relevant information was reduced. As the interviewee was allowed to talk freely he/she was less likely to be affected by the interviewer and his or her point of view. These two forms of interviews also respond to the exploratory nature of the research purpose. (Saunders et. al., 2003)

The stakeholder mapping provided us with information on the different actors on the market and some of the interviewees were contacted due to their involvement in these organizations. Other interviewees were picked as a result of their expertise, since we felt that we needed additional knowledge in the corresponding area as well as their opinion about the future. Finally interviews were undertaken with representatives from the car manufacturers. These were done in order for us to get a better insight into the technologies and why the companies have chosen that particular technology. Furthermore, all respondents were asked to present their beliefs about the future and the factors leading to a dominant design. A further presentation of the different interviewees and the reason for their involvement can be seen in Appendix 1. As for the interview questions that were used, Appendix 2 includes a presentation.

For us to gain access to the interviewees different strategies were pursued depending on our own network of contacts and the level of contact information available on for example company web pages. In some cases the reference was given to us by a personal contact within the company and in other cases an email was sent to the company/organization asking for a contact person that may be interested in an interview. Another strategy was used when there was no telephone or email link to the person. Here we used Hitta.se and Eniro.se in order to find the telephone number to the person or company we were looking for. (Saunders et. al., 2003)

2.4.2 Problems when collecting Primary and Secondary data

When collecting primary and secondary data different problems arose. One of the major ones was whether or not it was the right data that was gathered. This problem can occur in both cases, but takes different forms depending on the forum. (Saunders et. al., 2003)

In our collection of secondary data problems arose, as the literature we were looking at was sometimes out of date. This problem was most apparent in the search for information on the different technologies on the market. Technology moves forward during for example five years, and giving that, old reports do not give a correct picture of today. Furthermore, these reports are not made on a yearly basis, making it harder to find an accurate update on the technology. One forum that included newer information was the Internet, but with this forum the date of print could sometimes be hard to find and one must also question the reliability of the source. In our work we encountered web pages that were sponsored by for example a car manufacturer. It may be well hidden but in some cases it was obvious, since the only models and technologies that were covered came from the same manufacturer. This made it hard to measure the creditability of the data since it may be biased. Another problem with the secondary data was that much of the data available came from the same authors making it hard to get a second opinion. (Saunders et. al., 2003)

During the collection of primary data other issues arose. First and foremost it was difficult to find the right persons, meaning the ones that have the knowledge we were looking for. There are many groups and organizations involved with an opinion on the green car, but not all of these have knowledge that could contribute to our work. In

some cases this did not become apparent until the interview was already in session. One way of solving this problem is that the person you are speaking with may be able to direct you to the right person. Once the right person was found the problem of getting hold of him/her came into the picture. These are people high up in organizations and as a result may not have the time or the motivation to help us. (Saunders et. al., 2003)

Since the distance limited us to telephone interviews and emails, we noticed another problem connected to telephone interviews. This was the need to keep the other party interested in the conversation. Having a long conversation with a stranger while you were typing and focusing on what was said sometimes made it hard to make inputs and directing the conversation in the right direction. A way of eliminating this problem would be to tape the conversations or to use a speakerphone (with one interviewer typing and one talking). But since we lacked the technology that would allow us to do this, the problem remained throughout the work. (Saunders et. al., 2003)

3. THEORETICAL FRAMEWORK

In this chapter our theoretical framework is presented. The theories included here are all linked to the phenomenon of dominant design. In other words, they describe what is necessary in order for a technology to become the market standard. In the end of the chapter a summary of the relevant factors needed are presented in a figure.

3.1 DOMINANT DESIGN

When a market is in the process of selecting a dominant design it may be provided with many different alternatives. Firms that represent a certain technology/design have a great interest in becoming the winners in the standard battle since they usually have invested large amounts of capital in both physical assets like plants, machinery etc as well as in intangible assets like personnel learning and knowledge. These investments may turn out worthless if the standard battle is lost or even worse, the firm can become locked out of the market if it is not able to adopt its technology/design to comply with the dominant design. (Schilling, 1999)

3.1.1 Positive feedback

Which factors are the ones that ultimately decide what becomes the dominant design? In order to understand this, we started with looking at what Brian Arthur (1994) calls negative feedback and positive feedback. Negative feedback (conventional economic theory) means that firms' returns are diminishing over time, which leads to a predictable equilibrium for prices and market shares. Even if this theory has proven correct in many sectors during decades it must also be said that it sometimes violates reality. In some cases there are no stabilizing factors that balance the market into a predictable equilibrium. This is where the theory of positive feedback comes in. This theory builds on the assumption of increasing returns. This framework may explain why a certain design/technology becomes dominant, when two competing technologies are introduced at the same time and experience the same market share in the beginning. Positive feedback indicates the existence of a certain amount of randomness when a certain design becomes the dominant one and experience increasing returns. Small historical events can have a great impact in the battle of standards, which in theory is named path dependency. This means that factors

unrelated to the technology's/design's superiority affect the final outcome and may explain why a design becomes "locked in". (Arthur, 1994)

3.1.2 Discontinuities

Before an industry reaches the state with a dominant design it might go through a state where there are many different technologies. Unless it is a new industry, the new technologies are technological discontinuities meaning innovations that changes and advances the industry's price vs. performance frontier. These discontinuities come from many small revolutionary breakthroughs. Another way to describe these discontinuities is through the way they build on the previous technology. If the new technology is completely new it is said to be competence destroying, as there is no longer any need for the old technology. The technology can also be competence enhancing, when it builds on the know-how from the previous technology (Anderson & Tushman, 1990).

Since there may be many actors within an industry there will most likely also be several versions of the new technology. This is due to the fact that the technology is not well understood and every rival wants to distance itself from the others. During this stage pressure is high due to threats of substitution and design competition. The duration of this stage depends on what kind of technology it is. If it is a competence enhancing technology the duration is usually shorter than with a competence destroying technology (Anderson & Tushman, 1990).

When the different technologies are on the market they create a competitive environment and the market moves on towards the next stage. Usually a stage of technological diversification ends with the emergence of a dominant design. The stage of a competitive environment could be said to resemble what Eneroth and Malm (2000) call a bifurcation point; an unstable point where random fluctuations may determine the outcome, or the path towards a new stable phase. The technology that becomes the standard out-performs the others due to social, political and organizational dynamics. These can be said to be the constraints of the market that affects the future outcome. When and if the market reaches a stable phase with a dominant design, the dominant design allows a firm to, a) make standardized and interchangeable parts, b) enables it to organize itself in order to increase volume

efficiency, c) allow firms to establish more stable and reliable relationships with suppliers, distributors and customers. When considering customers it decreases confusion about the different technologies and the costs associated with a purchase. Finally when looking at society as a whole the standard increases integration compatibility with other systems. (Eneroth & Malm, 2000; Anderson & Tushman, 1990)

The above description of how a dominant design may emerge (through technological discontinuities) is one of many. Other ways are when customers prefer one technology to others, which implies that the emergence is a direct result from customer demand. Customer demand is usually influenced by product possibilities and individual, governmental and organizational factors. This may lead to not be the best product on the market becoming the standard. Another way arises when one manufacturer is dominating the market and therefore can put enough weight behind its products or technology to push it to a dominant position. Furthermore, it can also be an industry committee that sets a standard for the industry or a group of companies that forms an alliance that together creates a platform. (Schilling, 1999; Anderson & Tushman, 1990)

3.1.3 Collaboration

In some cases one company alone cannot establish a dominant technology. This opens up for collaboration between companies or between companies and organizations. One factor working for collaboration is cost; the development of a new technology is usually an expensive procedure. If two or more companies are working together they can share these costs and gain cost advantages. This collaboration is also known as a knowledge web. Eneroth and Malm (2001) define a knowledge web as different actors that come together, united by one common goal. One factor mentioned as critical to the success of the knowledge web is generative relations between the members. This should be the base if the collaboration is to provide a competitive advantage. For a relationship to be generative it needs to have a) balance, in the knowledge exchanges, between novelty and confirmation, b) shared visions between members, c) complementary competences among members. (Johnson & Scholes, 2002; Eneroth & Malm, 2001)

Moreover, collaboration helps build switching costs since it raises barriers to entry and the fewer players on the market the lower the threat of substitution. Collaboration can also be a way to gain access to a market. (Johnson & Scholes, 2002)

3.2 FURTHER THEORIES CONCERNING DOMINANT DESIGN

Another recognized researcher named Melissa Schilling is contributing to the understanding of the phenomena of dominant design. One of her theories includes a model/list of factors that regularly and predictably influence the final selection of a winner in standard races. Thus, the section below will use Schilling's model as a base for describing which factors decide what becomes the dominant design. These factors are as follows: (Schilling, 1998)

- Learning emphasis
- Size of installed base
- Availability of compatibilities
- Timing of entry

3.2.1 Learning emphasis

One thing that limits a technology from becoming dominant are the resources needed in the development and production of that technology. There are different kinds of resources that a company has access to; these are physical, human, financial and intellectual resources. Furthermore, these resources can be divided into threshold resources and unique resources. The threshold resources are the ones a company needs in order to exist within a market. These are resources that are easy to imitate and/or are the same for everyone working within the market. Companies that want to stay within the market need to continuously improve these resources in order to stay in business. When the threshold becomes higher the barriers of entry rise, which makes it harder for new emerging technologies to get a foothold. Unique resources are the ones creating value in a product; they are also hard for competitors to imitate. These resources are linked to the market's critical success factors and a company needs these to gain a competitive advantage. (Johnson & Scholes, 2002)

As customers buy a technology it returns income to the firm who in turn can use this money to continuously improve the technology. The learning curve effect, which is a unique resource, can prove important in the battle of forms since it is difficult to imitate. (Schilling, 1999)

However, if the knowledge and experience in the firm is misused it may have a negative impact on the firm's chances of becoming dominant. A firm can become inflexible if it tends to solely rely upon existing core capabilities, rather than being able to assimilate new information as well (absorptive capacity). (Schilling, 1998) Thus as Schilling writes,

*"What the firm can hope to do technologically in the future is narrowly constrained by what they have been capable of doing in the pas*t"

(Schilling, 1999. p. 267)

3.2.2 Size of installed base

The size of the installed base is another factor that can work for or against a certain technology. A large installed base (customer base) can signal to possible future customers that this particular technology/design is, for example of good quality and performance and thus result in these possible customers choosing this particular product. Since buying a new product/technology involves capital expenditure, customers want to invest in the technology that will end up as the winner in the standard race. (Schilling, 1999)

A concept that is linked to the theory of installed base is diffusion of technology. The diffusion of a technology covers the extent and time it takes for a market to adopt the technology. This is influenced by different factors that can be summarised under two things, the nature of the technology and the process of bringing it to the market. There are two different models used to describe the pace of diffusion: (Johnson & Scholes, 2002)

The supply side models, which consider the product features to be of high importance. The features they look at are:

- *The degree of improvement* - is the performance of the new product better than that of the old, does it encourage customers to change?
- *Compatibility* - with other factors, does the new product work with the surrounding infrastructure?
- *Complexity* - meaning the complexity of the product itself or the marketing methods used. If the complexity is too high it might discourage a purchase.
- *Experimentation* - can the customer try the product before committing to it? This could be achieved either directly or indirectly by available information from other customers.

Demand side models, these models focus on the interaction between customers and how it drives the adoption of a new product. This is important to consider since the fast adopters and their behaviour, for example acceptance of the product, influence the late adopters. (Johnson & Scholes, 2002)

Moreover, Anderson and Tushman (1990) agree with Schilling (1998) when she says that the size of the installed base affects the amount of available complementary firms and vice versa. These two researchers stress that the diffusion of the technology is directly linked to whether or not it becomes a dominant design. Usually there are many different technologies before one emerges as the dominant design, and as a result the success of a technology depends on how quickly customers adopt to the new product and its features.

3.2.3 Availability of compatibilities

One of the main factors that drive the development of a dominant design is availability of complementary products. This is because they promote the product that they complement. The producers of these products often choose to support one of the different technological platforms that exist in the market. The more dependent the customers are of the complementary product the more incentives they give to the purchase of the corresponding platform. (Cusumano & Gawer, 2002; Schilling, 1999)

According to Cusumano and Gawer (2002) there are three types of players on the market, platform leaders, wannabes and complementors. In order for a firm to get the best competitive position it needs to be able to interact with outsiders and internal units with the other roles. When the relationships between the three groups work it can increase the market for everyone. A good relationship may include the following; a) sharing of market information between platform leaders, wannabes and complementors, b) offer complementors marketing support and c) venture investments. (Cusumano & Gawer, 2002)

The numbers of compatibilities for a certain technology are often related to the size of its installed base. Obviously, products that have a large installed base are better attracters of complementary products than those with small installed bases. The amount of compatibilities may then in turn affect the customer's choice of product, which in the end affects the size of the installed base. This two-way relationship between the installed base and the availability of compatibilities is illustrated by the figure below, "the virtuous cycle". (Schilling. 1999)

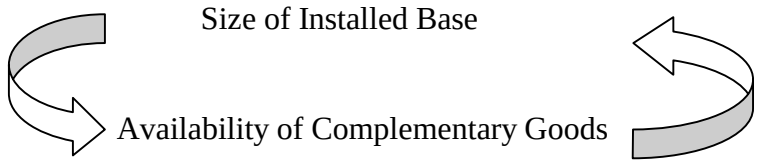

Figure 3.1. The Virtuous Cycle. (Schilling, 1999. p.268)

Another model that puts an emphasis on the importance of compatibilities is the Delta model. According to this, there are three different strategic decisions a company can make, total customer solution, best product and system lock-in. The last one deals with how a company can sustain a competitive edge by locking in the customers. If a company is successful in locking the system to its technology, it positions itself as the industry standard. The company, customers, suppliers and complementors are included in this system. But the key aspect is to identify, attract and nurture complementors. Complementors are important because the richness and depth of them help increase the value of the technology and thereby help the firm to lockout

competitors. As the industry standard, the company's competitors and other businesses have to adapt to the technology in order to survive. The technology thereby becomes the dominant design. (Johnson & Scholes, 2002; Hax & Wilde, 2001)

Furthermore, lock-in is likely to depend on a number of factors: (Johnson & Scholes, 2002)

- The size of the market - other organizations are less likely to adapt to the technology if they do not consider it to be dominant.
- The stage in the market life cycle - the development of a dominant design is more likely to occur in the volatile growth stage of the market than in the mature stage.
- Self-reinforcing - once the technology has gained some support, the incentives for others to follow increases, leading to a positive cycle for the technology.
- Insistence - the companies using the dominant technology will have to work hard for it to stay dominant.

3.2.4 Timing of entry

When it comes to the timing of entry there is no correct timing that could be considered to be ultimate. Becoming the first mover may allow the firm to, for example, exploit scarce assets and it may also allow the firm to exploit buyer-switching costs. In addition, being the first mover can lead to market power through self-reinforcing positive feedback mechanisms, which in the end may have a great impact on the outcome of the standard battle. Despite the advantages that could be gained from being the first mover some researchers argue that being the later entrant can actually be favourable. They say that a later entrant can learn from the first mover's experience by not making the same, often costly, mistakes. The late entrant has the possibility to capitalize on the research and development invested by the first mover, and he/she also has the ability to provide the customers with a fine tuned product as the market becomes more certain. What could then be said here is that it is unlikely for an early entrant and its technology to become dominant if the technology is underdeveloped and if it does not meet customers' needs and demands. Furthermore, the likelihood of a technology becoming dominant in the early stage can be low because of the lack of complementarities that increase the value of the product.

However, if the technology turns out to be of great value and that there are signs showing coalescence around this technology being the first mover becomes advantageous. (Schilling, 1998)

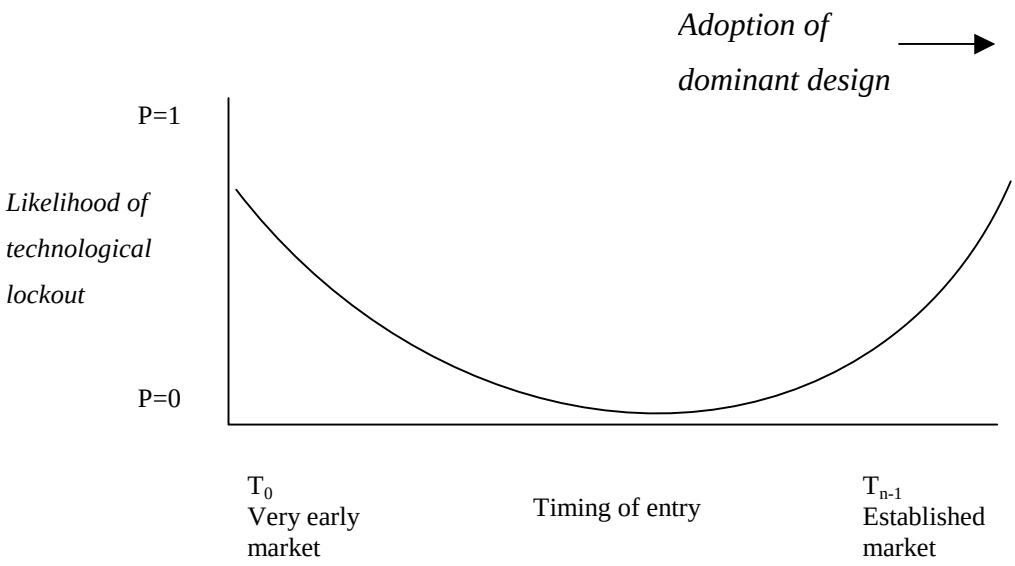

Figure 3.2 Timing of entry and likelihood of technological lockout (Schilling, 1998)
Timing of entry will have a U-shaped relationship with the likelihood of lockout: entering very early or very late will increase the likelihood of technological lockout.

The time of adoption can be of critical importance for the success of a new technology. Not only because the investments made in the technology but also a fast adoption raises entry barriers for competing technologies (Johnson & Scholes, 2002). These barriers may exclude newcomers from access to complementary products, since complementary producers usually choose to integrate their products with the dominant technology. Another reason showing the importance of timing is that customers may wait with a purchase until a dominant design has emerged. The reason for this is that there is a risk involved. Choosing the wrong technology means a new purchase later one (Anderson & Tushman, 1990).

3.3 SUMMARY

The documentation above has introduced a set of factors concerning how a certain technology becomes the dominant one. These factors set the foundation for our analysis of empirical data, presented in chapter 6.

The factors relevant for the understanding of why a certain technology becomes dominant can be summarized in a figure (Figure 3.3). This figure also serves as an answer to the introducing question of this chapter; which factors are the ones that ultimately decide what becomes the dominant design?

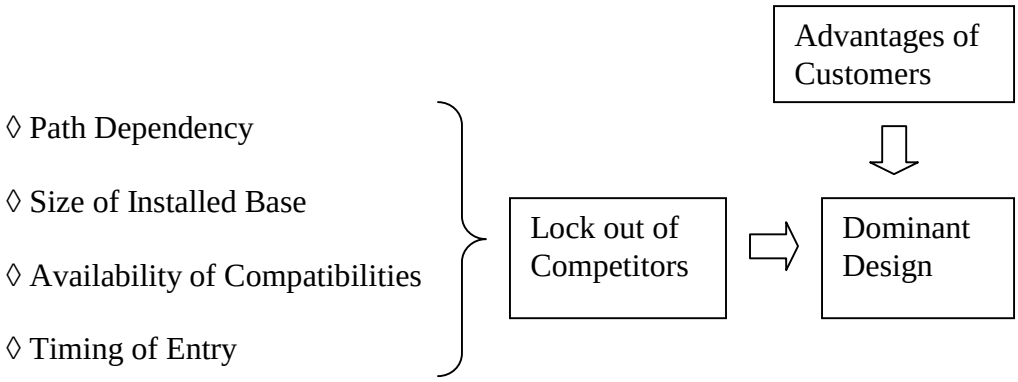

Figure 3.3. The road to dominant design.

The reason for adding path dependency to Schillings list of factors is that path dependency is linked to the company's learning emphasis. As small random events may change the market situation, companies that cannot learn from them will be worse of the next time it occurs. The more emphasis a company lays on preparing for changes in the market environment, the better prepared they will be for the future. Still, we have chosen not to include learning emphasis in the figure. The reason for this is that it is hard to study a company's ability to learn and develop from the outside and sometimes awareness does not exist within the company. (Schilling, 1999; Schilling, 1998; Arthur, 1994)

The size of installed base and availability of compatibilities are two other factors that are highly linked to one another. Which one of these two factors that comes first is hard to say. One might argue that the customers need to be there for the complementary producers to be interested. But on the other hand one might argue that without any complementary products there will be no customers. A product without

any customers will probably not survive and therefore we believe that these two factors are of high importance for the lockout of competitors. (Cusumano & Gawer, 2002; Schilling, 1999; Shilling 1998)

Timing of entry is the fourth factor shown in figure 3.3. This factor concerns the choice of time when entering a market with a new technology. Both an early entrance and a later entrance have its advantages, depending on what kind of market it is. As indicated in Figure 3.2, the most preferable would be to enter some time in between the early stage and the later stage. Even though it is hard to predict what the right timing is, its importance cannot be ignored and therefore it is included in the figure. (Schilling, 1998)

4. THE DIFFERENT TECHNOLOGIES ON THE MARKET

This chapter aims at providing the reader with knowledge about the different technologies that exist within the market of green cars. The technologies presented here are the ones we found most likely to succeed. It needs to be stated that there are other alternative fuels, which are not discussed here. In the end a summary of the different technologies is presented.

4.1 BIO GAS/NATURAL GAS

Bio gas and Natural gas are more or less the same fuel and are therefore presented under the same heading. The main difference between the two is that bio gas is based on life's own cycle were as natural gas is a fossil fuel and therefore increases the CO_2 level in the atmosphere. (Miljöbilar, a, 2004)

4.1.1 Technical classifications

It is methane gas that powers the car, leading to that both biogas and natural gas can be used as fuel. Bio gas has a higher level of methane (97-98 %) than natural gas (90%), but natural gas has higher energy content than bio gas. If the car is of the kind categorised as Bi-fuel it can be powered both by gas and by petrol, the driver shifts fuel by pushing a button. (Boisen, 2006-05-17; Ford, a, 2005; Miljöbilar, a, 2004)

4.1.2 Energy sources

Bio gas is produced when microorganisms break down biological waste like for example household garbage in an oxygen free environment. This means that the production of bio gas can take place in public cleansing departments, dumps and in all other places where biodegradable garbage can be found. When bio gas is produced under controlled circumstances it is purified until it consist of about 96-98 per cent methane, which is the driving fuel. (Miljöfordon, a, 2006; SBGF, 2006; Egebäck & Westerholm, 1997)

Natural gas is formed by transformation of plants and other organisms under high pressure and temperature under ground. This process takes millions of years and is the same as for oil and coal. Natural gas is the fastest growing energy source in the world,

as it is better from an environmental point compared to oil and coal. The biggest natural gas reserves are in the USA, Russia and the Middle East. (Vattenfall, 2006)

One of the advantages with natural gas is that it makes the transition to bio gas easier since both gases can be transported in the same pipelines. This means that some of the infrastructure costs associated with bio gas can be carried by the development of the natural gas net. (Miljöfordon, a, 2006)

4.1.3 Performance

A test performed by Vi Bilägare (no.1, 2006) showed some of the problems connected with a gas-powered car. These problems are mostly related to the performance of the car. One problem was that the power of the car is lower when driven on gas, since the torque is lower. However, this is not noticeable when the driver is taking it nice and easy. Another problem is that the range of the car is limited, which means that if the driver wants to be environmental friendly and use the gas function, the car needs to be driven within an area with access to gas refuelling stations. To sum up, some positive things with the gas powered car are presented. The first is that the driver can shift between gas and petrol by pushing a button. The second is that the car can be driven on both gas (bio gas or natural gas) and petrol, when necessary. The third is, gas cars have an advantage when it is cold over both bio diesel and E85 since it has no problem with cold starts. Finally it has to be below –163 degrees Celsius for the gas to turn into liquid giving that it always is a gas with good pressure. (Vi Bilägare, 2006; Boisen, 2006-05-17)

When safety is considered, certain conditions need to be fulfilled in order for the methane to explode. There has to be 5-15 per cent methane, 85- 95 per cent air and 540 degrees Celsius and since methane is lighter than air it is hard for these conditions to occur, even in case of a leakage. Gas is less risky than petrol since it is less inflammable, and if a car should be trapped in a closed environment with a violent fire surrounding it the gas tank has a safety valve, which is set to 105 degrees Celsius. If this limit is reached, the gas is lead out of the tank and the car, where it burns with a controlled flame. Afterwards, even if the car is burned out the gas tank is still intact. Tests have been performed in order to make sure that this is the scenario. (Boisen, 2006-05-17)

4.1.4 Environmental aspects

Bio gas is considered one of the purest sources of fuel used to power cars, since it does not contribute to the increase of the green house gas CO_2 in the atmosphere. How much the use of a bio gas car reduces the CO_2 level compared to a normal car is hard to predict, but it is thought to be about 70 to 95 per cent. When it comes to hydrocarbons the emissions from a biogas car is about 70 per cent lower that those of a normal car. As for natural gas it also reduces the hydrocarbons with 70 per cent but the CO_2 emissions only with 20 to 30 per cent. (Miljöfordon, a, 2006; Miljöbilar, a, 2004)

Other environmental gains associated with driving a gas car are: decreased eutrophication, less oil leaks during transportation, infrastructure underground and lesser health problems due to mark bound ozone. (Svenskbiogas, a, 2006)

Another important aspect is that the methane gas that is formed during putrefaction/decomposition is taken care of instead of emitting it to the atmosphere and thereby adding to the green house effect (Egebäck & Busch, 2000).

4.1.5 The market

The market for gas-powered cars differs from country to country within the EU. In for example, Italy the technique was developed 50 years ago and gas is well established as a fuel today. In Germany they have access to gas refuelling throughout the country, where as in Sweden only half of the country has access (the northern parts are excluded). Austria and Switzerland have between 35 to 60 refuelling stations, in the rest of the EU gas as a fuel is mostly used to power busses, garbage trucks and other heavy vehicles in city centres. (Boisen, 2006-05-17)

As of 2004 gas cars are produced by several manufacturers (Opel, VW and Volvo) and the additional cost for a car equals about 20 000 to 50 000 SEK. The price for the gas in Sweden lies around 70 per cent of the petrol price; in EU the price is about 50 per cent of the petrol price. The higher price in Sweden is explained by the additional money being reinvested in the gas infrastructure. (Boisen, 2006-05-17: Miljöbilar, a, 2004; Svenskbiogas, a, 2006)

Nevertheless, there are some aspects that can have a negative affect on the widespread of bio gas as a main commercial driving fuel. A common concern is the relative high cost for building facilities that can produce and clean the bio gas. Likewise, the cost for the adoption of engines and vehicles is also considered high. Another issue is that the bio gas is not capable of supplying all the vehicles with fuel and is therefore thought to become a niche fuel (Egebäck & Busch, 2000).

4.2 ELECTRICITY/ FUEL CELLS

Electrical vehicles are vehicles that use some kind of electric energy to power their engines. The technique that is associated with an electric car is as old as the ICE technique, with a start in the late 19-century. Yet the ICE became the dominant technology due to favourable fuel prices, and therefore the electric motor did not get the same development. The electric cars of today store their electricity in batteries and are therefore called battery-electric cars. (Miljofordon, b, 2006; Nationalencyklopedin, 2006)

The development of electrical cars has taken a turn in resent time towards the fuel cell technology therefore this technique is presented here as well. (SNF, b, 2006).

4.2.1 Technical classifications

Fuel cell: the technology in use here can be said to resemble a battery, but does not need to be recharged or exchanged. A fuel cell transforms a flow of fuel to electricity without any combustion. Instead it is a reaction between oxygen and hydrogen that produces the energy. The fuel cell continues to produce energy as long as it has access to oxygen and hydrogen. As a source of power it can achieve much higher efficiency than an ICE. The efficiency of an ICE is about 20 per cent where as for a fuel cell it is about 70 per cent, which means that much more energy can be extracted from a fuel cell from the same amount of fuel. Another thing is that fuel cells have less moving parts compared with an ICE and the noise is therefore lowered. One of the major problems with this technique is the need for new infrastructure in form of fuel distribution, which will cost both time and money (when the natural gas net is not available). (SNF, b, 2006; Egebäck & Bucksch, 2000; Chalmers, 2006)

4.2.2 Energy sources

There are many different ways to produce electricity, for example water, wind and nuclear power plants to mention some. On an average the electricity produced in Sweden has a minor influence on the environment since more than 90 per cent are produced through waterpower and nuclear power. However, it needs to be mentioned that these production types have another impact on the environment with changes in the landscape, affecting the biological variety and risk of radioactive emissions to both air and water. Furthermore, the potential for electricity as a fuel depends on the total electricity consumption of society. (Miljöfordon, b, 2006; Åhman, Nilsson & Johansson)

A fuel cell uses pure hydrogen as a fuel; there are two different ways of providing the fuel cell with hydrogen. One way is by refuelling hydrogen directly into the car, and the other way is by using a hydrogen carrier. The usage of a carrier can be used as the infrastructure for direct hydrogen refuelling is built up. Petrol, methanol and natural gas can be used as carriers. If these substances are not used as carriers, hydrogen can be produced from electrolysis of water. (Åhman, Nilsson & Johansson)

4.2.3 Performance

The electric cars of today are more or less made for driving within the city since the batteries only have a range of 50-100 kilometres, depending on age, model and driving style. Three factors speaking against the battery of the electric car are: the weight and energy storing capacity of the battery. These two combined narrows the range of the car. The second factor is the energy density of the battery that is about 100 times lower than that of an ICE. The third factor is the reloading time of the battery; it can take up to 10 hours to fully recharge an empty battery. However by using a different reloading technique (pulse reloading) the time can be lowered down to an hour and it can then be recharged 1 000 times before replacement is necessary. (Nationalencyklopedin, Elfordon, 2006; SNF, b, 2006).

Fuel cells do not have limited range since they can be refuelled, but there is one problem due to the fuel cells working temperature (between 100 and 1000 degrees Celsius). In cold weather a catalytic converter is needed to start the reactions. These

catalytic converters are usually made of platinum, which is an expensive metal. (Miljöfordon, b, 2006; Chalmers, 2006)

4.2.4 Environmental aspects

Compared with diesel –or petrol driven cars, the electric motor is superior when it comes to utilising applied energy (SNF, b, 2006). Even when the production of the electricity is considered, the production of electricity has scale economy and gives lower energy losses than energy transformation in the car engine. Another aspect is that the electricity production plants are not located in city centres and the emissions are not as close to humans as the emissions from a car (Miljöfordon, b, 2006).

Fuel cells are highly environmental friendly, especially when powered by hydrogen. When this fuel is used the car's only emission is water steam. Another positive thing is that hydrogen can be transported in the already existing gas-net for natural gas. (Dahlström, 2006-05-16; Miljöfordon, b, 2006)

4.2.5 The Market

Today, the market for electric cars is limited, since the supply of new cars is low. In many of the European countries there are no new sales. The electric cars of today are most suited as service and distribution vehicles within a limited area, due to the short range of the vehicle. (Miljöfordon, b, 2006; Miljöbilar, b, 2004).

An increase in the market for electric cars would require new infrastructure for home recharging and public fast-recharging stations. (Åhman, Nilsson & Johansson)

The purchase price of an electric car is usually about 50.000 SEK higher than the price of a corresponding petrol car. After the purchase there is an additional leasing fee for the batteries, but apart from that the driving cost of an electric car is about 2 SEK per 10 kilometres. This is to be compared with the high petrol price of 10.99 SEK per litre (2006-04-20 Jet in Hässleholm). (SNF, b, 2006)

The market for fuel cells is very limited, since the technology is still in the development phase. According to Benny Dahlstöm at Toyota (2006-05-16) the

technique still needs to be improved before it can reach the broader masses. However, there are fuel cell cars rooming the streets of Japan.

4.3 ETHANOL AND E85

Ethanol is a non-fossil, renewable fuel, which can be produced from cellulose, sugar canes and industrial wheat. Ethanol is used in petrol as a low-level ingredient, but can also be used in E85, which consists of 85 per cent ethanol and 15 per cent petrol. (Ryden, 2006-05-18)

4.3.1 Technical classifications

There are two different ways of using ethanol as a fuel. The first and most common one is as a low level component in petrol. All car manufacturers today allow a mix of at least 5 per cent ethanol in the fuel. The second one is E85, where 85 per cent ethanol is mixed with 15 per cent petrol. This form is today more or less only used on cars in Sweden. This could be due to that the EU has not yet made any clear definitions stating its level as a fuel. (Shell, a, 2006; Miljöbilsprojekten, 2005; Etanol, 2004)

4.3.2 Energy sources

Ethanol as fuel can be produced in two different ways, either through biological processes or synthetically, but only biological ethanol is used to power cars. The most common and commercial approach for transforming biomass to ethanol is through fermentation. All biomass that contains sugar or that can be transformed into sugar (for example starch and cellulose) can be used to produce ethanol. (Ryden, 2006-05-18; Åhman, Modig & Nilsson; Egebäck & Westerholm, 1997)

The ethanol that is used today comes from Brazil, where it is produced from sugar canes. However, there is some production in Sweden where for example cellulose and industrial wheat is used. For the rest of the EU production plants are being built in Spain, Germany, Italy and England to mention some, in these plants corn and wheat are planned as raw materials. All these raw materials are biological and therefore giving renewable ethanol as an output. (Ryden, 2006-05-18; Dagensmiljö, 2006; Nationalencyklopedin, 2006)

4.3.3 Performance

Since E85 has a high octane rating, it is possible to compress it to a higher degree than petrol, which leads to more power being extracted. In addition, ethanol binds oxygen, which increases the efficiency; it also decreases fuel consumption and results in a more alert car. Nevertheless, the technology in a Flexi Fuel resembles the ICE technique. (Etanol, 2006; BAFF, b, 2006)

In order to make cold starts easier, the ethanol is mixed with petrol (therefore E85 and not E100). But the problem still exists and therefore all Flexi fuel cars are equipped with an engine preheater. The ethanol cars on the market today run just as easily on petrol as they do on ethanol; a sensor registers the mix in the tank and programs the engine after that mix. (BAFF, b, 2006; Miljöbilar, 2004)

A problem with E85 is that fumes from it are explosive at normal temperatures (-32 to +11 degrees). This problem is most impending while refuelling, since a spark can make its way down the hose and cause the tank to explode. One way of solving this problem is to attach a flame barrier, which stops the flame from reaching the tank. (Räddningsverket, a, 2006) Nevertheless, Charlie Ryden at BAFF (2006-05-18) considers ethanol to be less risky than petrol.

4.3.4 Environmental aspects

Ethanol like bio gas does not contribute CO_2 to the atmosphere since it is the plants own CO_2 that is let back to be used once again in the photosynthesis. In real numbers, usage of E85 decreases the CO_2 emissions with about 80 per cent compared to petrol. (Vi bilägare, 2006)

ICE cars have problems with high emissions during starts, but ethanol cars do not suffer from this. In the start up moment its exhaust fumes consists of 90 per cent ethanol, which is as dangerous as windscreen washer fluid. (Etanol, 2006)

4.3.5 The market

Brazil is the country where the implementation of ethanol as a fuel has made the most progress. Since the 1970:s there has been a mass production of cars that either solely or partially can be driven on ethanol. In Sweden during the 1990:s ethanol was mostly

used in busses and not that much in cars. Nevertheless, this fact has been changing during the last few years, which might be a direct result of the growing amount of alternatives (brands) provided by the car industry. Sweden is a European test market for E85, but E85 cars are available in 7 other European markets in order to start a dialogue with the countries. A dialogue is needed since there is no infrastructure for E85 outside Sweden. In Sweden on the other hand there are 347 refuelling stations and the number is increasing.
(BAFF, a, 2006; Walden, 2006-05-19; Nationalencyklopedin, 2006).

A price example for an ethanol car, is a Saab 9-5 BioPower which costs about 8 000 SEK more than the corresponding ICE car. The cost for the fuel is lower than for petrol even when considering that more fuel is needed per 10 km (about 30 per cent more). (Etanol, 2006; Vi bilägare, 2006)

4.4 HYBRID

A hybrid car is a car equipped with more than one energy transformer and energy storing system where the driver of the vehicle decides which one to use. The first hybrid car was presented in 1997 and usually it is an electric motor and an ICE that together with a battery drives the car (Egebäck & Bucksch, 2000; SNF, b, 2006).

4.4.1 Technical classifications

Series hybrid: According to Egebäck and Bucksch (2000) a series hybrid is a hybrid where the ICE and the electric motor that drives the car lie in a series. This means that the ICE drives a generator that creates electricity, which in turn powers the electric motor that is connected to the driving gear. In other words there is no direct connection between the ICE and the driving gear. In this system the combustion engine gives normally no more than 50 per cent of the maximum driving effect. This type of hybrid system is usually used in heavier vehicles like busses. (Egebäck & Bucksch, 2000)

Parallel hybrid: As the name explains the driving systems lie parallel to each other. The ICE powers the driving gear through the gearbox and the electric motor helps in situations that demand extra power. Compared to the series hybrid the combustion engine is larger, which leads to decreasing the potential for low emissions. The

batteries are smaller than on the series hybrid, which lowers the weight and the costs. Today the parallel hybrid technique is used on personal cars and there are several different things that can be done in order to lower the fuel consumption:

- Shutting down the ICE during low effect needs.
- Shutting down the ICE while stationary.
- Storing braking energy in the battery.
- Matching the combustion engine to the most fuel-efficient level of driving by using a step less gearbox.

Both the system of series and of parallel hybrids has advantages when it comes to low emissions compared to a normal car. But when comparing the two, the parallel hybrid is the most favourable one seen from an environmental perspective. (Egebäck & Bucksch, 2000)

The hybrid system that today dominates the market for cars is the parallel hybrid system (Dahlström, 2006-05-16), but there are different classifications of the parallel hybrid.

Full hybrid: This classification is used on hybrid cars that can use one of the two powering systems alone. This means that the electric motor drives the car and the combustion engine only steps in when the battery needs recharging. This type is most favourable in low-acceleration driving such as stop-and-go traffic. Since it is only the electric motor that is working it lowers the emission level of the car. (Fueleconomy, 2006)

Mild hybrid, Modular hybrid, plug in hybrid and Stop/start hybrids: These are other definitions associated with a hybrid car. The names are connected to the level of the hybriditization of the car. However, most manufacturers today are going for the full hybrid or are producing full hybrids therefore these types are not further explained. (SiemensVDO, 2006; Fueleconomy, 2006)

4.4.2 Energy sources

According to Nils-Olof Ollevik (Syd Svenska Dagbladet, 2005) the alternative engine construction that is most current is the hybrid technology where a combination of electricity and petrol is used. However, the type of fuel used is of high importance

since the goal is to decrease emissions and fuel consumption. Other alternatives can be considered:

- Diesel is one of the options to be used in the hybrid cars. It has advantages when compared to petrol due to lower fuel consumption and therefore it also lowers emissions. One negative aspect is the emissions of particles connected to diesel. (Egebäck & Bucksch, 2000)
- A hybrid can also be fuelled with ethanol, which then together with the electric motor powers the car. The new Saab 9-3-cab hybrid is an example of this. (Smålandsposten, 2006).
- According to Egebäck and Bucksch (2000) fuels like natural gas, liquid petroleum gas (LPG) and methanol can be used instead of petrol in a hybrid vehicle.

4.4.3 Performance

One of the hybrid cars on the Swedish market is Toyota Prius, which has a CO_2 emission level of 104 g per kilometre (km) (SNF, b, 2006). When comparing this to the average emission of a new car in Sweden, which is 190 g per km (Nilsson, 2006-05-05), it comes out looking good. The fact that the emissions are this much lower than for a "normal" car has to do with the fact that the ICE can work in a narrower capacity interval, since the electric motor helps drive the car during accelerations. (Miljöfordon, c, 2006)

Due to the fact that the electric motor helps the ICE, the fuel consumption is lowered. Another reason for the lower level of fuel consumption is that the battery is storing energy, for example, from braking. This energy is then used by the electric motor while driving. (Miljöfordon, c, 2006)

According to the Swedish rescue service agency, petrol is classified as an inflammable fluid and due to this there are special rules and regulations that needs to be followed when handling it. (Räddingsverket, b, 2006) But, since it is the battery that separates a hybrid from an ICE car, further precautions are needed. For example, in the Prius the battery is placed above the rear axle and it is protected in case of a collision, in addition there are censors that shut down the battery in case something should happen. (Dahlström, 2006-05-16)

4.4.4 Environmental aspects

In an interview with Realtid, Maria Grahn (doctoral candidate at Chalmers Tekniska Högskola) says that with help from hybrid cars in combination with alternative fuels it is possible to reach zero emission (Realtid, 2006). A hybrid car can decrease the energy consumption with 30-40 per cent compared to a petrol driven car. When looking at city traffic the technique has the conditions for low emissions of nitric oxides and hydrocarbons or even zero emissions. (Egebäck & Bucksch, 2000; SNF, b, 2006)

An advantage that the hybrid technology has over the other techniques described in this thesis is that the driver whether he/she chooses it or not is "forced" to drive environmentally, since it is only the electrical engine working when the driver is running at a slow pace, for example in the city core. With gas and ethanol the driver can choose to refuel with the green alternative or with ordinary petrol. (Dahlström, 2006-05-16)

4.4.5 The Market

The market for hybrid cars is growing, especially in the US where previously you could buy a hybrid car and drive it home the same afternoon, while today the waiting period is up to one year and increasing (Dahlström, 2006-05-16).

Hybrid vehicles are manufactured by most of the big producers on the European market, Toyota, Saab and Honda to mention a few. According to Benny Dahlström at Toyota, Toyota Prius is often compared to Ford Focus when looking at prices. He thinks that this is wrong since they represent different sizes, instead he would like to use Toyota Avensis. Well when comparing Toyota Prius with Ford Focus the price difference is 70 000 SEK (252'' vs. 180'') and when using Toyota Avensis it is 3000 SEK (252'' vs. 249'').(Dahlström, 2006-05-16; Smålandsposten, 2006; Miljöbilsprojekten, 2005)

Since most of the hybrid cars of today use a combination of petrol and electricity there are no greater problems in finding a suitable refuelling location. Every petrol station carries the fuel to power the ICE that then powers the battery. In the case of a series

hybrid there is also the possibility to recharge the battery using the electricity mains. This leads to no further costs in new infrastructure due to no need of new types of fuel stations. (Egebäck & Bucksch, 2000)

4.5 INCITEMENTS FOR A GREEN CAR

If a car manufacturer is to launch a car on a market it has to be profitable. If a car is to be profitable customers need to buy it. Factors considered by customers before buying a car are infrastructure for the fuels and the total cost for the driver, for example second hand value, fuel price and taxes. Governments control many of these factors, since they are the ones handing out subventions and making decisions about taxes. (Miljöbilsprojekten, 2005)

Below, some of the main EU and governmental[2] incentives and activities that we found are presented. There is a great diversity among the incentives, pointing them all out would have given a far too long list. Instead a few were selected in order to show that no technology is favoured over another.

- EU published a directive promoting the usage of bio fuels in May 2003. In this directive it is stated that member nations shall lay down guidelines for the implementation of bio fuels. Referential values are presented and for 2010 the goal is that 5.75 per cent of petrol and diesel usage should be replaced. Furthermore, the member nations should inform the public about the availability of alternative fuels and bio fuels. The member nations had until the 31 of December 2004 to implement the laws and regulations necessary to achieve this. (EU Directive 2003/30/EG, 2003)
- EU is starting a new research project that is to develop cost and environmental efficient methods to mass-produce ethanol. The project is financed with 12.8 million Euros, and has a life span of four years. (Miljöfordon, d, 2005)
- Drivers of green cars do not have to pay congestion charges (at least in Stockholm) and are offered free parking in city centres. (Realtid, 2006)
- Decreased tax imposed on fringe benefits, for electric, hybrids and gas driven cars. The amount to be paid is 60 per cent of the amount due for a corresponding ICE car. For cars powered by Ethanol the amount is 80 per cent of the amount for a corresponding ICE car. (Skatteverket, 2006)

[2] As stated earlier governmental examples refers to the Swedish government if nothing else is stated.

- Out of all new cars bought by government authorities 75 per cent shall be green cars starting in 2005. Some exceptions exist, for example for emergency vehicles. (Svensk författningssammling, 2005)
- CO_2 neutral fuels are freed from CO_2-tax and energy- tax for a five-year period 2004 to 2008. Furthermore, as of the 1st May 2006 new cars are to be taxed due to their fuel and CO_2 emissions, the tax has a basic fee of 360 SEK and even owners electric cars have to pay a small amount. (Vägverket, 2006; Regeringen, b, 2005)
- A new law was introduced in Sweden on the first of February 2006. The law says that all refuelling locations with a capacity above 1000 cubic meters should supply an alternative fuel to their customers. (Regeringen, d, 2005)
- Government investment programs have put in 340 million SEK in investments in production facilities for bio gas. Another 150 million has been made available for the promotion of bio gas as a fuel. As for R&D 20 million SEK has been put in and programs for developing the production process has received about 10 million SEK. (Regeringen, c, 2005)
- The British government has decided to blend 5 per cent of ethanol in petrol, which is now the only kind available at Tesco. Further on, British sugar is investing 300 M SEK in a production facility for ethanol in Norfolk. (Automotive Sweden, 2006)
- The French environmental minister, Nelly Olini has stated that a 2000 € tax reduction for green cars, for example, hybrid cars and natural gas cars is due. (Automotive Sweden, 2006)

4.6 SUMMARY

To make the information more understandable, table 4.1 below will be explained before presented to the reader. As a base for the numbers concerning CO_2 emissions the ICE was used. In the following three columns the alternative fuels have been given a grading between 1 to 9, this grade was appointed to the fuel based on our believes about the fuels advantage/disadvantage over the other alternative fuels. These grades was received through the evaluation of the facts earlier in the chapter.

Criteria / Fuels	**CO_2 Emissions**	**Fuel Availability (1-9)**	**Availability of cars (1-9)**	**Associated costs (1-9)**	**Total (1-9)[3]**
Bio Gas	70-95 % Reduction[4]	4	8	6	6.75
Natural Gas	20-30 % Reduction[5]	7	8	6	6.25
Electricity	~ 0	3	2	5	4.75
Fuel Cells	Only H_2O	1	1	1	?[6]
Ethanol (E85)	80 % Reduction	1 (only in Sweden)	3[7]	8	5.25
Hybrid	45% Reduction[8]	9	8	5	7.5

Table 4.1 Summary of the different techniques and fuels
As for the grades 1-9, 1 represents not good at all and 9 excellent.

The different technologies and fuels presented above differ from one another in many ways. However, when comparing the green cars to a normal car, cars powered by bio gas, natural gas and ethanol do not require extensive alterations to the power train. Nevertheless, the overall positive factor with the green car (all the studied fuels) is the lower emissions of CO_2 to the atmosphere, compared to petrol. To what degree the

[3] Based on an average from column 2-5
[4] Compared to petrol
[5] Compared to petrol
[6] Still in the development face.
[7] Available in 8 EU countries but only used in Sweden
[8] An average Swedish car has CO_2 emissions of 190 g/km, Prius = 1-(104/190)

emissions are lowered differs from fuel to fuel. An electric car has zero emissions (when the production of the electricity is excluded) while natural gas, which is a fossil fuel increases the CO_2 level. Ethanol and bio gas are renewable fuels and the CO_2 emissions from them are part of natures own life cycle. (miljöbilar, a-c, 2006; miljöfordon, a-c, 2006; Vi bilägare, 2006; Egebäck & Bucksch, 2000)

The most essential problems connected to the green car are associated with the availability and infrastructure of the fuels. For example, bio gas and ethanol are limited both due to low scale production and implementation of new infrastructure. On the plus side, bio gas can be transported in the pipelines for natural gas which are more widely represented. A plus for ethanol is that it can be transported in trucks so the need new infrastructure is limited to underground tanks. Hybrid cars are not limited by these factors since they are fuelled with petrol and therefore do not require any new infrastructure. Electric and fuel cell cars have other obstacles to overcome. The electric car needs to be able to travel greater distances in order to be competitive. Whereas the fuel cell is still in the development phase and is limited by for example costs of the fuel cell itself and for the hydrogen infrastructure. (Åhman, Modig & Nilsson; Egebäck & Bucksch, 2000)

5. STAKEHOLDER MAPPING

In this chapter we will try to paint a picture of the green car market. In order to do this Stakeholder mapping was used. This model shows the different interest groups and their main objectives. At the end a short summary of the results is given. It must be stated that this chapter is not a theoretical review; it is an analysis including our own remarks.

Mapping out the different stakeholders and interest groups gives an insight into who has an influence over the future development of the green car market. Usually this model is used on companies but we believe that it also provides a useful tool in this analysis. The model uses two factors when mapping out the different stakeholders: level of interest and power. The level of interest covers how interested the stakeholder is in, in this case, the green car and the power factor indicates if the stakeholder has the means to influence the development in his/her preferred direction.

In this thesis stakeholder mapping is used to gain knowledge and understanding about the different stakeholders/actors on the green car market. Moreover, the information provided by this analysis was used when searching for interviewees, though we needed people with knowledge and insight in the market in order to answer the research question.

5.1 THE STAKEHOLDERS FOUND WITHIN THE GREEN CAR MARKET

One definition of a stakeholder can be as follows: a stakeholder is any individual, group or organisation with an interest in the company (here green car) (Olsson & Skärvad, 2000). The different stakeholders found are:

- *Car manufacturers:* these are the ones that produce the green cars and they thereby have both a high interest and a high level of power when it concerns the future of the green car market. The more models a producer has in production or/and development the more interest it has. Similarly the more models from the same producer the higher the power to influence. Since a manufacturer usually decides on one technology (Teknikens Värld, 2006), the more models put on the market by the producer the more aware the customers become of the technology and this raises the need for

complementary products, like refuelling locations (Cusumano & Gawer, 2002). Furthermore, the more refuelling locations for a technology for example, the greater the incentive for the customer to choose that technology when considering a purchase of a green car, leading to a positive feedback loop (Arthur, 1994).

- *Customers:* the customers are the ones buying the green car (not buyers of all new cars). They have a high interest in the green car, because they are spending their money and expect a quality car in exchange. Buying a new car is a purchase that is connected with a complex buying behaviour, since it is expensive, an infrequent purchase and requires learning about the product. The phenomena of the green car is new, for example the first hybrid was introduced in 1997 by Toyota (Vi Bilagare.se, 2006), which means the customer has to collect information on the different technologies and models on the market before making a purchasing decision. The more effort put into a purchase the higher the interest. The power of the customer is low, even when considered as a group, in relation to the power of the manufacturers. The customer can influence the market by their buying behaviour, which shows their preferences, and thereby guide the producers on what might be a lucrative investment. (Kotler, Armstrong, Saunders & Wong, 2002)

- *Environmentalists:* In this group organizations like Green Peace are included. Because these groups have the world's well-being as their primary concern, they can be said to have a high interest in the future of the green car, due to the lower CO_2 emissions it represents amongst other things. The power of the group is more or less concentrated to lobbying of different governmental organisations and representatives. How much difference this activity makes is hard to predict so therefore we consider the level of power to be low. (Greenpeace, 2006)

- *European Union (EU):* Is one of the regulating parties within the European community and has the power to publish directives, which the member states have to follow. This gives it a high level of power to influence the topics it considers important. CO_2 is a topic that is considered important; the EU has a 3-pillar strategy on CO_2 and cars. The aim is to lower the CO_2 emissions with the help from automotive industry, customers and governments. The European Commission has also released the EURO 4 and EURO 5, which are the emission standards applicable within

the EU. With consideration to the EU's interest in the environmental future and its legislating power, we affirm that they have both a high level of interest and power. (Environment for Europeans, 2005; Euro Active, 2006)

- *Fuel producers:* (are to be separated from petrol producers, who are handled separately). This is a large group consisting of a number of different producers ranging from producers of gas to electricity. It may not be right to deal with them as a group but we believe that their interest and power are much the same despite of their different products. This group has a great deal of interest since they have a lot to gain or lose depending on the dominating technology, but since the fuel for cars is only a minor segment of their market the overall interest can be said to be low. The power to influence the market in their preferred direction consists of different marketing, lobbying and pricing strategies, since the availability and price of a product, in this case the alternative fuel, has an impact on customer buying preferences. Furthermore, availability and favourable fuel prices are also incentives for a car producer to develop a car with the corresponding technology. A car that cannot be refuelled will not sell; therefore the power of the fuel producers is high. (Kotler, et.al., 2002)

- *Government and other regulating parties:* Most nations have their rules and standards for emission levels that needs to be held. Sometimes there are other governmental bodies above the nations own, for example the EU and the UN, that have standards that the member countries must adjust to. Due to this the interest is high since the EU for example can take actions against the countries that do not fulfil the directives. In Sweden for example the government has stated that 75 per cent of all new cars bought by government authorities should be green cars. In Germany they are promoting the advancement of bio fuel usage. The power is also high, since it is the government that rules for example on tax reductions, free parking and exclusion from congestion charges and thereby giving incentives to the corresponding technology. (Regerningen, a, 2004; Ufop.de,2006)

- *Others*: Here organizations like Bil Sweden are put together with companies that use green cars as leasing cars or company cars. It is difficult to predict and describe their level of interest and the power they may have over the future of the green car. Due to this the conclusion is that both the level of interest and the power to influence are low.

(Bilsweden.se, 2006; Miljofordon.se,2006)

- *Petrol producers:* These are another group of stakeholders with both a high level of interest and of power in the development of the green car market. Their interest comes from the fact that the green cars are to some extent competitors since they use alternative fuels. Except for hybrids cars that use petrol to power their second engine. Petrol producers do control the refuelling stations which results in them to some extent controlling which alternative fuels are available to the drivers. A further factor is that gas findings are sometimes located together with oil findings, giving that petrol producers can also become gas producers and by this serve both markets. (Shell, b, 2006; Statoil, 2006)

- *Society:* Society is a stakeholder with a high level of interest and a low level of power to influence the market. Societies as a whole are responsible for the environment pollution and therefore also the ones that can make something about the level of damage. One of today's global topics is the green house effect and CO_2 is of high concern in the debate. Car emissions include a high level of CO_2 and lowering these can therefore be said to be of high interest to society. The power of society differs depending on what part of society you are looking at. But as a whole it most likely have a low level of power to influence since it includes large groups of people that do not care or want to promote a change.

- *Workers:* Here we mean people that are involved in the production of the cars. This group has little power to influence the market, if not to say none at all. On the other hand they do have an interest in the market, since the more cars that their employer produces and develops the more jobs are available for them.

5.2 SUMMARY

The different stakeholders that have been presented above are here displayed in table 5.1 where they are divided into groups depending on their level of interest and power.

		Level of Interest	
		Low	High
Level of Power	High	Fuel producers	Car producers Petrol Producers Government EU
	Low	Others Workers	Customers Environmentalists Society

Table 5.1 Summary stakeholder mapping

As a final remark, it needs to be stated that governments and the EU are under the influence of lobbying from all other stakeholder groups. Further on, the EU is influenced by the national governments and the national governments by the EU. This leads to that a part of their high level of interest and power comes from the underlying groups.

6. ANALYSIS OF THE GREEN CAR FUTURE

In this chapter we present the results from the empirical study (the interviews) directly connected to a discussion based upon the theoretical framework that was presented in chapter 3.

The discussion below will consider some of the factors that were highlighted in the summarizing figure in chapter 3. The factors that are going to be discussed are:

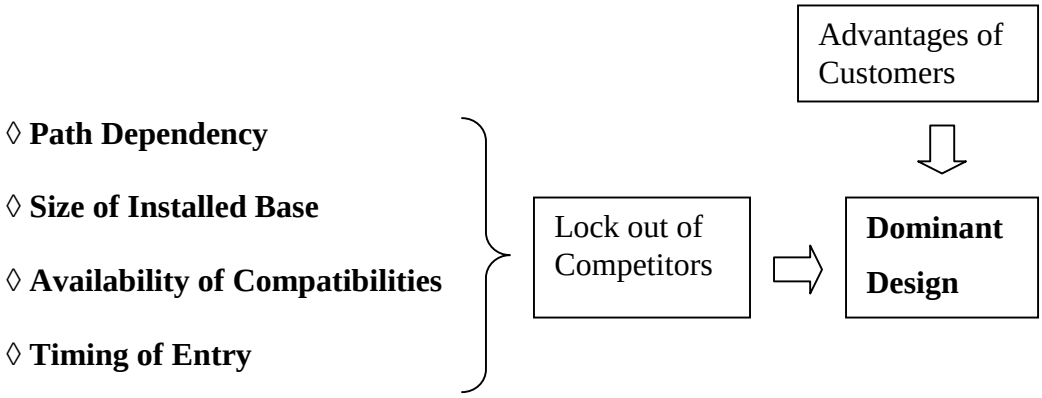

Figure 6.1 The road to dominant design.
Factors typed in bold will be used in the discussion below.

6.1 PATH DEPENDENCY

As described in chapter 3, path dependency means that small events unrelated to the technology itself may affect the final outcome of the battle of forms. During the discussions with the interviewees it appeared obvious that the future choice of a dominant design may be affected by random happenings. This information rose to the surface in accordance with the question concerning who/which ones have the most power to influence the market's choice. As a result of this question, answers like the car producers and the end consumers were brought up. Nevertheless, it cannot be stated that there was a common agreement among the respondents about the power to influence held by these two groups.

However, there was coalescence among the respondents that it is the politicians that have the most power to influence the final outcome. The common understanding was that politicians within the EU have the ability to direct the development towards a certain direction by the usage of legislation. Therefore they have the greatest influence

on both the green car producers as well as the end consumers on what to produce and on what to consume. One example of legislation that may have an affect would be legislation that to a certain degree provides consumers with economical benefits (tax laws) connected to the purchase of one alternative instead of another. A further example of the effects of legislation can be described by the law that was introduced in Sweden on the 1 of February 2006, which said that larger petrol stations must provide consumers with an alternative fuel. A result of this, all the respondents agreed that legislation helps the widespread of ethanol (E85) since this is the alternative most favourable for the petrol stations from an economical perspective. This choice results in less cost than the cost of providing other alternatives, for example gas.

Many respondents said that even though politicians' decisions are well based on important aspects they are not always related to the characteristics of the different technologies. This may be one explanation why some alternative fuel has gained a strong position in some countries while having no market share in other. This is the case with for example ethanol (E85). Ethanol is considered to be the alternative fuel that has the biggest market share in Sweden while its market share in the rest of the EU is non-existent, since cars with ethanol technology (E85) are only sold in Sweden. (When looking at a low blend of ethanol (5 %) in petrol there is a market outside Sweden)

Considering what has been said above there is no doubt that the future standard technology may to some extent be helped to its position by certain happenings that are not directly related to the technology itself. This indicates that what Arthur (1994) said about path dependency and its affect on the battle of forms, stands to be correct in this particular race. What this also indicates is the difficulty of predicting the future winner among the different technologies, since it is impossible for us to predict future legislations and other random happenings that may affect the final outcome.

6.2 SIZE OF INSTALLED BASE

The size of the installed base is the second factor affecting the choice of a dominant design according to the figure above. All the respondents held the belief that, the larger the size of the installed base, the better chances for the underlying technology to corner the market. We asked the respondents to explain why they thought that the size of installed base could affect the standard race. After analysing the answers provided by the respondents on this question it appeared that this particular factor plays many roles. During the interviews two aspects were frequently highlighted.

The first important aspect considered the relationship between the size of the installed base and the second-hand value of the car. The reasoning was that, if there is a low number of a certain alternative it makes the car somewhat unique, which may lead to questions about the quality and reliability of that alternative. This has an indirect affect on the second hand value since it may scare potential customers from buying it. This in turn may affect first buyers to act in a certain way. The respondents, especially the three car representatives, argued that it is in the human nature to take the safe road. Meaning that the alternative that is most likely to have an acceptable second-hand value is chosen in order to avoid too much of an economical gamble. As a result of this reasoning it is most likely that a small installed base in relation to other alternatives will have a negative affect on the car's chances to become the market standard.

The second aspect considered the connection between installed base and the number of compatibilities. The car representatives claimed that this connection is important when trying to pin point the future of a technology. They said that the more users of one specific alternative the more incitements for complementary firms to adapt to this particular technology/alternative. Likewise, raising the amount of complementary products increases the value of the technology, which may have a positive affect on the size of the installed base. One example and maybe the most important complement in this particular case, is the refuelling/recharging stations. This argument confirms the thoughts of Schilling (1999) about the virtuous cycle.

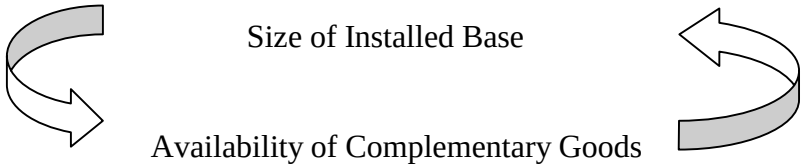

Figure 6.2. The Virtuous Cycle. (Schilling, 1999. p.268)

Taking these two aspects into consideration it is possible to see where the market is headed. If we consider the Swedish market it is the ethanol technology that currently has the largest installed base in relation to the other green car alternatives. According to the theoretical framework this indicates that the ethanol technology has a huge chance of becoming the standard in Sweden. The same reasoning could be applied to the rest of the EU but for another fuel. Today it is the gas powered cars that have the largest size of installed base in the EU (Sweden not included), which indicates that the gas technology has a good chance to become the future standard in the EU (Sweden not included).

Even if the theory about dominant design says that the size of the installed base plays an important role in the final outcome, it should not be exaggerated when paying attention to the thoughts from some of the respondents. The car representatives had an interesting opinion. They said that in the end it is the corporate earning that decides what a car manufacturer chooses to produce. Even if one technology has a huge installed base it will not stop the car producers from choosing to produce a technology that currently has a smaller installed base in case there is a profit increasing opportunity. A real life example of this concerns the change of action from General Motor (GM), Ford and Daimler Chrysler. They went from saying that the hybrid technology is a short-lived technology that will not succeed in the long run, to the huge investments of today for the development of hybrid cars. This sudden change of opinion and action is based on the fact that Toyota has made a huge success with its hybrid technology on the market. This indicates that hybrids are a profit increasing opportunity, which in turn explains the actions of the three American car manufacturers.

6.3 AVAILABILITY OF COMPATIBILITIES

Another factor that may affect the outcome of the standard race is availability of compatibilities. Once again the respondents were unanimous about the huge affect of complementary firms and products on a technology's success. By far the most important complementary is the infrastructure, that is, the availability of refuelling stations. All the respondents stated, particularly the representative from shell and Svenska Petroleum Institutet together with the car representatives, that to be able to use a car of a certain technology it needs to be known if it can be refuelled/recharged.

The availability of refuelling stations is something that works against the green car (not hybrids) alternatives in EU. If we take Sweden for instance, there are only ¼ of refuelling stations for alternative fuels in relation to those available for conventional fuels. The fact that there is no need for new infrastructure, refuelling stations, as regards of ethanol as a low level ingredient (5 per cent) and hybrids powered by petrol may explain the fast growth of these technologies.

On the other hand, there are no refuelling opportunities for ethanol (E85) in the rest of the EU, except for the low level mix (5 per cent ethanol and 95 per cent petrol) which automatically minimises the chances of this technology to become the market standard. Rather it is the gas-powered cars together with hybrids that have the best availability of refuelling stations, which indicates that these two technologies stand ahead of the other alternatives in EU.

However, it must be considered that the hybrids of today are first generation and that the next generation might be driven on something else than petrol. This in turn may have a negative affect on the future widespread of the hybrid technology since needs for new costly infrastructure may arise.

In addition, according to the car representatives, important firms that complement the technologies are the ones producing spare parts and those that repair the cars. Extra service appointments, etc. may increase costs for the buyer and therefore also limit the widespread of that technology. A new technology requires new expertise and tools for repairing the cars, which at first might not be common knowledge at every

workshop/garage. This may frighten customers from buying the new technology until the expertise and costs for the repairing of the cars are acceptable.

6.4 TIMING OF ENTRY

Last but not least is the phenomenon of timing. One of the questions that were presented to the respondents was the importance of timing and its affect on the final outcome. More or less all the respondents said that “correct” timing of entry is very important in the standard race. However, they found it more difficult to specify when the right time is for entering a market.

They all agreed that being the first mover could have a positive effect of the widespread of one technology. However, it was mentioned that being the first mover is not automatically a guarantee for success. There are some criteria that have to be met in order to be able to gain the advantage of being the first mover. What is most important according to the respondents is that the technology is satisfactory regarding function and costs. The technology must also meet the expectations from customers and other stakeholders. If this is the case, the technology is considered to be mature for commercially entering the market.

What must be noticed here is that the discussion above does not indicate the “perfect” time for entering the market. One of the conclusions based on the interviews was that entering a market too early, meaning not to be able to provide an adequate technology that meets the cost and function expectations from the customers decreases the possibilities for a technology to become dominant. As support to this conclusion the example of the electrical car is presented. This technology was first introduced in the late 1900-century. Thus, it must be considered to be the first green technology available on the market. Nevertheless, this technology did not prosper and was defeated by another alternative, the ICE. The problem with the technology of the electrical engine was that it was underdeveloped and did not satisfy the customers’ needs as regards function and cost. As a result of this, the technology was outmanoeuvred from the market. This short historical review clarifies what the respondents meant when saying that entering a market early with an underdeveloped technology is destined to fail.

If we concentrate our discussion to more recent events, it is the ethanol technology that is considered to be the first entrant of the green technologies in the Swedish market while as in the rest of the EU it is the gas technology that was the first entrant. What is also known is that these two technologies today have the biggest market share in their region. If this is a coincidence or if it to some extent can be explained by the time of entry is hard, not to say impossible, to determine.

In the case of timing of entry, an early entrance might be favourable presupposed that the technology is adequate. This is because an early entrance will indicate to complementary firms that this is the technology for the future. As a natural step these complementary firms may adapt their products/technologies to the one presented by the early entrant. As discussed in previous sections the increasing amount of complementary firms may have a direct positive effect on the installed base. Likewise the increasing installed base will positively affect the interest of complementary firms to adapt to this particular technology.

Having this in mind one might have the opinion that being the first mover may have a positive affect on the widespread of one technology and thereby on the final outcome of the standard race. This points towards that the gas technology has a favourable situation in the EU because of its early entrance.

Even though Schilling (1998; 1999) does not discuss the connection between “Timing of entry” and the other factors we consider it to be of relevance when discussing standard wars. After revising all the relevant information gathered it appeared that this interconnection could help explain were the future is headed. During the interviews the respondents expressed that the interaction between the different factors is what ultimately affects a technology’s future success.

6.5 WHAT DO THE RESPONDENTS SAY ABOUT THE FUTURE

Having the results based on the theoretical framework does however not always present a correct picture of the real world. The respondents were asked to answer what they thought would become the future dominant design. The answers provided by the respondents on this question shows that it is difficult to say what will become the future standard. For the coming 20-30 years it is not likely that any green alternative

fuel/technology will replace the conventional fuels (petrol and diesel). This is based on the fact that cars that are sold today have a long lifetime and conventional fuels power the majority of them, which means that the conventional fuels will dominate as long as they are available. During this period of time a minority of the respondents agreed with the conclusions based on the theoretical framework. They said that the ethanol would continue to grow in Sweden, much because of E85 and ethanol as a low level ingredient in petrol, while the gas will do the same in rest of the EU.

Criteria / Fuels	CO_2 Emissions	Fuel Availability (1-9)	Availability of cars (1-9)	Associated costs (1-9)	Total (1-9)[9]	Short term success %[10]	Long term success %[11]
Bio Gas	70-95 % Reduction[12]	4	8	6	6.75	~27 %	~22 %
Natural Gas	20-30 % Reduction[13]	7	8	6	6.25	~27 %	~22 %
Electricity	~ 0	3	2	5	4.75		
Fuel Cells	Only H_2O	1	1	1	3		~33 %
Ethanol (E85)	80 % Reduction	1 (only in Sweden)	3[14]	8	5.25	~18 % Low blend	
Hybrid	Prius: 104 g/km[15]	9	8	5	7.5	~27 %	~22 %

Table 6.1 The technologies and the respondents' believes about their future.

The figure above shows among other things the respondents' beliefs about the alternatives short-term and long-term future. When looking at the short-term there was no specific alternative that stood out. Bio gas, Natural gas and the hybrid all got the same amount of answers. That bio gas and natural gas got the same results could be

[9] Based on Sales figures.
[10] The amount of respondents (% of 11 respondents) believed that this technology will become the standard in the short-term.
[11] The amount of respondents (% of 9 respondents) believed that this technology will become the standard in the long-run.
[12] Compared to petrol
[13] Compared to petrol
[14] Available in 8 EU countries but only used in Sweden
15 An average Swedish car has CO_2 emissions of 190 g/km.

explained by the fact that the respondents considered gas cars as one alternative. When looking at the hybrids the respondents expressed opinions about the fuel. In the future it could be that it is not petrol that is used, instead alternative fuels like gas or ethanol may be used. It may not be one of the alternatives that becomes the standard but instead a combination of two.

However, in the long-term there is a small tendency towards the fuel cell technology, at least according to the respondents' opinions in table 6.1. Even though some of the respondents had no opinion on this because they thought that it might be one of the technologies currently in the pipeline that becomes the future standard. The majority of the respondents that actually had an opinion said that the future standard in the longer perspective (30 years-) is the fuel cell technology powered by hydrogen. But before the fuel cell technology can become widespread the costs of the technology must be lowered so consumers can afford to buy it and it also has to reach a higher performance level.

6.6 SUMMARY

When reviewing the discussion related to the factors presented in figure 6.1 (theoretical framework) a hint of the future direction is provided. Many things indicate that it is the gas technology that will prosper in the EU. Moreover, hybrid cars are another technology that may have the possibility to take a big market share. A problem with the analysis based on the theories is that it does not provide a base for conclusions for a longer perspective.

The discussion based on the theoretical framework does to some extent say the same thing as the respondents when considering a short-term perspective. Here both theory and the respondents point out gas and hybrid technologies as the most likely to succeed. However, when looking at a long-term perspective the respondents leaned more towards the fuel cell technology.

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7. CONCLUSION

In this chapter our conclusions are presented, followed by a discussion of the creditability of the thesis. The next section covers our own criticism, and in the last section our suggestions for further research is presented.

7.1 THE FUTURE OF THE GREEN CAR

In this final section of the thesis a presentation of the answer regarding the research question will be presented. The research question of this master thesis is:

Are there any tendencies towards a dominant design within the green car market today?

The discussion that takes place in the analysis is a foundation for the conclusions presented in this section. What must be considered is that the answer provided here are two folded. One part clarifies if there is any tendencies toward a dominant design in the short perspective (0-30 year) while the other concerns the longer perspective (30-year). The reason for presenting a two-folded answer is that the theoretical framework that serves as a base for the analysis is only considering technologies currently available for customers. This indicates that the theoretical framework is insufficient to provide an accurate answer about the long-term perspective since it excludes the possibility of technologies currently in the development stage to become the market standard. Thus, the conclusions about the long-term perspective are solely based on the opinion of the respondents.

If we concentrate the discussion to the short-term perspective it is not possible to say that the market of the EU is showing any tendencies toward a particular technology. Rather that one of two technologies has the best possibility for continued growth during this time of period. These are, the gas technology (both bio- and natural gas) and hybrid technology. This conclusion is based on the fact that both the analysis based on the theoretical framework as well as the one based on the respondents showed that this is most likely to be the case. However it must be stated that the analysis did not indicate that one of these technologies will be able to lock-out the

conventional technologies related to petrol and diesel and thereby become the market standard.

As regards the long-term perspective it is not possible to say which one of the technologies that will become the future standard. According to our findings from the interviews the winner of the standard battle seems to be the fuel cell. Nevertheless, if the gas and hybrid cars gain a large advantage during the nearest future they cannot be excluded from the future market. However, there may be fuels and technologies, which still are in the development face, and their impact on the future of the green car market is therefore unknown. Based on this, it is not possible to determine any tendencies that indicate that one of the alternative technologies will become the future standard in the long perspective. It is most likely to be that the future market will be served by a number of these technologies, if not all of them.

Another interesting conclusion is that it is a combination of a number of factors that ultimately result in dominant design. The analysis in this thesis has proved that the factors presented in the summarizing figure in the end of chapter 3 are relevant for understanding the market choice of dominant design in this particular case. It cannot be said that one of the four factors has a bigger affect on the final outcome than the others. It is rather so that the interplay between these factors is what ultimately determines the market standard. This interplay is displayed below:

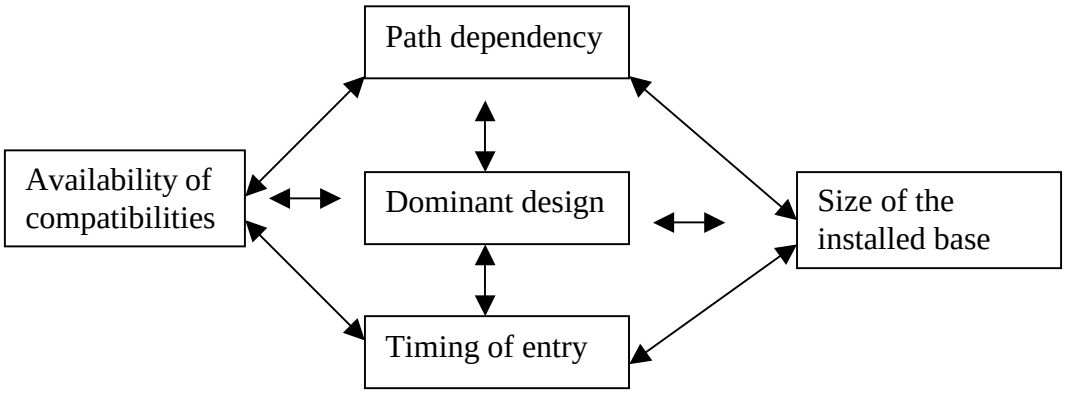

Figure 7.1 Interaction between the factors.

The different stakeholders on the market in turn regulate this interplay. If the power of influence by some reason changes it may change the development of the future green

car. It is likely to believe that the petrol producers have a different interest than for example environmentalists. Thus, the group with the most power to influence will have a dominant position in the development of a market standard. This fact is also something that confirms the conclusion that states that it is difficult to determine what the future will hold, due to it being unknown how the future power relationship between the different stakeholders will be, or if it will change at all.

7.2 CREDITABILITY OF THE RESEARCH

7.2.1 Reliability

This research was based on interviews with different people relevant to our purpose. Since these interviews were semi-structured or unstructured (in-dept interviews) some questions to the reliability could occur. This may result in research performed at other occasions and/or by other researcher not yielding the same answers. Another problem with these kinds of interviews is that bias may occur, as the interviewer may impose his/her own beliefs through the questions or when interpreting the answers. But on the other hand, using these two types of interviews may also increase the reliability. Especially in the situation where the data was collected in order to give a picture of today, since the flexibility of these forms can be used to explore the complexity of the subject. As technology sometimes can move forward rapidly this thesis aims at giving a picture of today, and the same results are not likely to be drawn from similar research in the future. (Saunders et.al., 2003)

7.2.2 Validity

Validity looks at whether the results are really about what they appear to be about, i.e. if the research answers the research question. Our research question was: Are there any tendencies towards a dominant design within the green car market today? In order for us to answer this, we read articles from different authors about the concept of dominant design. After that, several persons from different organizations were interviewed in order for us to get diversity among the interviewees. Still, a larger amount of interviewees would have been preferable and some interviews (for example, Swedish government and EU representative) were not performed due to our inability to get a hold of the interviewee. The conclusions and the answer to our research question were then drawn from our interviews. We believe that the validity of

this thesis is good but not of the highest degree, since more interviews could have been performed and thereby given a better foundation for the conclusions. (Saunders et.al., 2003)

7.2.3 Generalizability

In order to be able to generalize the results, the findings need to be equally applicable in other research settings. Here this means if the results would apply to other parts of the world, for example Asia or North America. This is not very likely since other continents constitute other markets and the EU is a very special market environment. In other parts of the world other rules apply, other resources are available and other techniques may have advanced earlier. So, with our hands on the heart we cannot claim that our results can be generalized, but then that was not our intention. (Saunders et.al., 2003)

7.3 CRITICISM OF THE RESEARCH

Research can be done in different ways, but due to various kinds of limitations (time, money, language, distance, etc.) the researcher is not always able to do it, as he/she would have preferred. The list below includes some of the more obvious drawbacks of our research. (Saunders et.al., 2003)

- The results of this thesis may have been different if interviews had been performed with people from organizations and companies from all over the EU. Since this would have given a broader perspective and a greater insight into what is done in these countries to promote the green cars.
- What becomes the dominant design amongst the different green cars of today is not only influenced by factors at work within the EU. What happens on the global car market outside the EU also has a great impact. The rest of the world's preferences and resources will have a great influence on the development within this area. By not using the whole world as a base for the research the results may not be as accurate as we would have hoped.
- There are many fuels that can be used as a substitute to petrol and/or diesel. In this research only the major ones were included. Fuels like bio diesel, LPG, dimethylether and methanol, to mention some, were not included. Just because they were not included here does not exclude them from being the fuel associated with the future dominant green car.

- The theories used in this thesis could have been more plentiful. Theories concerning the state of the market could have been included to see if it is a mature market or if the market is in a growth stage and what behaviour that is most likely to occur. Many of the different actors on the market are linked to each other; therefore it could have been of interest to look at networks theories. The green car is what can be called an innovation; therefore it could have been useful to look further into this. Furthermore, other theories that would be interesting to include in this study are the theories concerning Disruptive technologies and Time pacing which may present an alternative view of the standard battle and thereby present a different conclusion. Finally, theories concerning the macroeconomic environment of the market could have been studied to see which factors have the most influence on the future.

7.4 SUGGESTIONS FOR FURTHER RESEARCH

As shown in the previous section there are other ways in which this research could have been done. During the work with this thesis ideas that may be interesting to look at surfaced. These ideas are presented below.

- There is a great variety amongst the different fuels/technologies on the market today. For example, some are approved in one country but not in another. Doing an in-depth study of one of the fuels to see if it has the potential to become the standard could be an interesting way of approaching the subject. This is because it will allow the researcher to achieve a higher level of focus and more time to analyse a larger area.
- Building on the discussion above, it might also be interesting to look at a specific segment/niche of the green car market. During the interviews, opinions about some fuels having a future as niches within the green car segment/market arose. It would be interesting here to look at the segment of gas or ethanol, to see if the future leans towards bio gas or natural gas. Or in the case of ethanol towards E85 or a low blend of 5 per cent ethanol in all petrol.
- The last suggestion is related to geography. In this thesis the EU was used as a research area, but it would also be interesting to see what the situation is like in other parts of the world, like North America or Asia (who is going to win Chinas growing middle class). Further still, the most challenging and time consuming task

would be to use the whole world as a research area. This would be a realistic task since the car industry is a global industry, but the size of the workload makes it unrealistic for a master thesis (covering 10 credits).

8. GLOSSARY

Since this thesis has technical data and specifications in it that are not used in normal conversations we hope that this section will lead to help raise the reader's understanding. If nothing else is stated nationalencyklopedin was used as a source for the different clarifications below.

Bifurcation point: an unstable point in a firm's life, where many different outcomes is possible. (Eneroth & Malm, 2000)

Bio fuel: Energy resource produced from biomass e.g. plants.

Biogas: Is the gas that is produced when organic materials are decomposed by methane producing bacteria in an oxygen free environment. Inputs when producing biogas can be manure, wastewater from industries, silt from sewage treatment works and household garbage among others. Biogas normally consists of about 60 per cent by volume of methane and about 40 per cent by volume of CO_2.

Biomass: Material with a biological origin, used in the production of bio fuels.

Cellulose: The most important part of a plant's cell walls and nature's most common organic substance.

Compatibilities: Products and/or firms that are compatible with the platform technology. (Cusumano & Gawer, 2002)

Carbon dioxide (CO_2): Is a gas consisting of oxygen and carbon, the gas is formed when fuel is burning completely. CO_2 exists everywhere and plants use it to regenerate. CO_2 is the major part in the contribution to the greenhouse effect.

Dominant design: The market standard, which is used as a base for the products on the market. (Schilling, 1999)

Electric motor: Is a machine that transforms electric energy to mechanic energy.

Eutrophication: Is caused by high levels of nitrogen and phosphor in the ground or in water. These substances ends up here due to among things rain containing CO_2 from traffic. (miljömålsportalen, 2006)

Flexi fuel vehicle: Is a car that can be powered by both ethanol (E85) and petrol. Ford, b, 2006)

Fuel Cells: Electrochemical cell, where an external supply of fuel (hydrogen) and an oxidant (oxygen). The reaction only leaves water as an end product.

Renewable fuels: Included here are fuels like ethanol, natural gas and bio gas. The big advantage with renewable fuels is that the access to raw material is unlimited and they do not contribute to the greenhouse effect. (Naturvårdsverket, 2003)

Green car: a car with low emissions of CO_2 and other health hazardous substances.

Hybrid car: this factor refers to a car that is powered by a gas-electric engine.

Hydrocarbons: Is a chemical union that includes carbon and hydrogen.

Installed base: The group that uses a product/technology. (Schilling, 1999)

Internal combustion engine (ICE): Here fuels like petrol and diesel are used. Together with air (oxygen), the fuel ignites and the energy from the heat is transformed into mechanic action.

Liquid petroleum gas (LPG): is a standardized fuel, with rules regulating its content of hydrocarbons like propane and butane. LPG has good potential for low emissions. (Egebäck & Bucksch, 2000)

Methane gas (CH_4): colour and scentless gas. The gas is formed during decomposition of organic materials and is one of the most important components in natural gas.

Natural gas: Is a mixture of different gases that lies in the bedrock. The high pressure makes it easy to bring the gas up to the surface for further transportation. Natural gas is not a renewable energy source but has less damage on the environment compared to oil.

Nitric oxides: This is a group name for the unions between nitrogen and oxygen. There exists at least seven different unions but only a few are of technical and environmental interest.

Otto engine: combustion engine with pistons, were a spark starts the combustion.

Photosynthesis: the process where plants transform CO_2 and water into energy with the help of light.

Platform technology: Is the technology produced by platform leaders, which are the ones that drive industry wide innovation for an evolving system of separately developed pieces. (Cusumano & Gawer, 2002)

Power train: Is the name for the gear and connected parts that transmits power from the engine to the drive axle. (The free dictionary, a, 2006)

Range: The distance a vehicle can go without refuelling. (The free dictionary, b, 2006)

The Greenhouse effect: The heating mechanism of the atmosphere. Where it absorbs or transmits radiation of different wavelengths.

Threshold resources: resources that a company needs in order to stay in business. (Johnson & Scholes, 1999)

Unique resources: resources that create value in a product. (Johnson & Scholes, 1999)

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Appendix

Appendix 1

Presentation of the Interviewees

Bio Gas/ Natural Gas:

- *Peter Boisen*, Head of the Board, ENGVA (European Natural Gas Vehicle Association). During the research it became apparent that further knowledge about gas cars was needed. To turn to ENGVA was a natural choice since the organization works to promote the usage and development of these cars. The organization has members ranging from big energy producers and car/engine manufacturers to Universities. Therefore, the information that was received here felt up to date and accurate.[16]

Car Manufacturers: (The aim was to get one representative from the different green car alternatives on the market and with the three companies below that was achieved)

- *Anders Waldén*, Environmental Executive, Volvo. Volvo was chosen to represent gas cars and ethanol (E85) as they have two models for each fuel. Even though E85 is only available in Sweden Volvo is trying to start a dialogue by having the car listed on the pricelist in 7 other European countries.[17]
- *Benny Dahlström*, Fleet Sales Manager, Toyota. Toyota was the first car manufacturer to launch a hybrid car; they also represent fuel cell technology, synthetic diesel and electric cars. It can therefore be said that they have a great interest and knowledge in/about the green car.[18]
- *Peter Björkman*, Product department, Daimler Chrysler. Daimler Chrysler and its "brands" (Mercedes-Benz, Smart, Jeep, Chrysler and Maybach) are all well established on the European market. Furthermore, the company has made a

[16] http://engva.org/default.aspx
[17] Walden, 2006-05-19)
[18] http://www.toyota.se/

commitment to the green car as it works to develop fuel cell technology and has both gas cars and cars that can be powered by synthetic diesel.[19]

Ethanol:

- Charlie Rydén, BAFF (BioAlcohol Fuel Foundation). BAFF works to develop the technology for producing and promoting the usage of ethanol. Therefore, a representative from BAFF felt reliable since further knowledge about E85 and ethanol was needed.[20]

Others:

- Charlie Magnusson, Information Executive, Motormännens Riksförbund (MRF). MRF is an industry organization for professional car dealers and car repair shops. They therefore seemed to have the knowledge and insight that was needed in order to answer the interview questions.[21]
- Eva Sunnersted, Project leader, Miljöbilar Stockholm. This organization works for increasing the number of green cars in Stockholm, furthermore they work to increase the availability of models and refuelling facilities. In order for them to do this they have to have knowledge about regulations and other market factors. As a result of this the seemed qualified to answer the interview questions.[22]
- Lars Nilsson, Environmental Executive, Vägverket (The Swedish Road Administration). This organization has been commissioned by the Swedish government to have the overall responsibility over the road and transport systems, included here are among things is the environmental impact. The organization represents a broad knowledge of the transportation sector and therefore we believed their opinion to be of interest. [23]
- Michael Stjerna, Reporter, Teknikens Värld. This interview was performed in order for us to get the opinion of an objective respondent. The magazine is the largest independent car magazine in Sweden. They test new cars and compare

[19] http://www.daimlerchrysler.se/
[20] http://www.baff.info/
[21] http://www.mrf.se/
[22] http://www.miljobilar.stockholm.se/
[23] http://www.vv.se/

different models to one another; this gives them a high level of knowledge both when looking at the market as a whole and of the different models. [24]

Petrol Producers:

- Börje Kronström, Technical support and product specialist, Shell. Shell is one of the petrol suppliers/producers in Europe. That they are represented on the Swedish market leads to that they also have knowledge about the development of E85. This together with their knowledge about the European market qualified them to answer our questions.[25]
- Ebba Tan, Product Specialist, Svenska Petroleum Institutet, SPI, (The Swedish Petroleum Institute). SPI is an industry organization for the oil companies in Sweden, it works to safeguard and promote the interests of the oil industry. In the stakeholder mapping analysis petrol producers were pointed out and this organization together with Shell was selected to represent the group.[26]

Taxes and Incentives:

- Elisabeth Sjögren, Fordonsskatteverket, Skatteverket. For us to gain knowledge about the different tax laws and regulations applicable to green cars, as well as knowledge about where to find additional information, this interview was performed.

Technical Specialists:

- Karl-Erik Egebäck, Autoemission K-E E Consultant AB. Mr Egebäck has co-authored reports within the area of green cars and green fuels, two of these reports have been used as references in this thesis. His level knowledge and expertise is high, which provided us with an objective view on the subject.
- Max Åhman, Former member of Energy and Environment Systems Studies, Lund University. Mr Åhman has done research within the area of green cars and green fuels. His involvement in projects both within and outside the University of Lund establishes his knowledge to be both reliable and objective.

[24] http://www.bonnier.se/294.aspx?compId=149
[25] http://www.shell.com/home/Framework?siteId=home
[26] http://www.spi.se/

Appendix 2A

Interview guide, Bio Gas/Natural Gas

(Since, the interview language was Swedish, these questions are presented in italics)

1. From a fuel perspective, what are the differences between bio gas and natural gas?
   Vad är skillnaden mellan biogas och natur gas ur bränsle synpunkt?
2. How risky is the usage of gas as a fuel compared to petrol?
   Hur riskfylld är användningen av gas som drivmedel jämfört med bensin?
3. Bio gas can use the distribution system for natural gas, but it does not cover all of Sweden, are there any plans for any enlargements?
   Biogasen kan använda naturgas nätet, dock täcker inte detta hela landet, finns det planer för att bygga ut det?
4. The new law regarding alternative fuels at petrol stations, could be of an advantage to ethanol since it is cheaper to implement, what are your thoughts about the future, will the availability of gas increase?
   Den nya lagen om alternativa bränslen på mackarna, kan ge fördel till etanol då den är billigare att införa, vad tror ni om gasens framtid, kommer tillgängligheten att öka?
5. The market for gas is different in Sweden compared to the rest of the EU, how much larger is the usage of gas in the rest of the EU?
   Marknaden för gas i Sverige skiljer sig från resten av EU, hur mycket större är användningen ute i EU?
6. How many gas-refuelling stations are there in Sweden and the EU, today?
   Hur många tankställen finns det i Sverige och i EU i dags läget?
7. Do you think that the low availability of gas deters people from buying a gas-powered car?
   Tror ni att den relativt låga tillgängligheten avskräcker folk från att köra en gas bil?
8. a) Are there any specific subventions/incentives aimed at gas as a fuel or the enlargement of the gas net?
   Finns det några speciella subventioner/incitament riktade mot gas drift, utbyggnad av gasnätet?
   b) Which are they?
   Vilka är de?
9. What raw material is it that is used to produce bio gas in Sweden and the EU?

Vad är det som i störst utsträckning används i dag vid produktion av biogas i Sverige och EU?

10. a) What do you believe the future of bio and natural gas to be, will they be able to dominate the market?

    Vad tror ni om biogasen och naturgasen som drivmedel, kommer det att kunna dominera marknaden i framtiden?

    b) If so, why?

    Om i så fall, varför?

    c) If not, why not?

    Om inte, varför?

11. Do you have anything further to add concerning bio gas and natural gas and their future?

    Har ni något ytterligare att tillägga angående biogas, naturgas samt dess framtid?

Appendix 2B

Interview guide, Car manufacturer

(Since, the interview language was Swedish, these questions are presented in italics)

1. Do you see any tendencies on the market towards a dominant design?
   Ser ni några tendenser på marknaden till en dominant design?
2. Underlying factors can influence which of the existing technologies that in the end becomes the dominant one. Considering the below listed factors, do you believe that they (individually) could affect what eventually becomes the dominant design within the green car segment?
   Bakom liggande faktorer kan påverka vilken av de existerande teknikerna som tillslut blir dominant. Vad anser du om nedanför listade faktorer, är de (individuellt) något som kan påverka vad som blir den dominerande miljöbils designen?
   - Time of entry
   - Available resources
   - Complementary products
   - Collaboration
   - Diffusion of technology
   - Size of installed base
3. Considering the above-mentioned factors, have we missed any that you believe to be able to affect the future of a technology?
   Baserat på de ovan nämnda faktorerna, har vi missat någon som ni anser vara högst påverkande för en tekniks framgång?
4. Which of the different green car technologies do you believe have a chance of becoming the dominant one?
   Vilken miljöbils teknologi tror ni kommer att ha störst chans att bli en dominant design?
5. Why would this technology move forward faster?
   Varför kommer just denna teknologi att gå framåt fortare?
6. Which are the strongest incentives to produce a green car today?
   Vilka är de starkaste incitamenten för att producera en miljöbil idag?
7. The EU has a three-step strategy for decreasing the CO_2 emissions. Included here is collaboration with car manufacturers; is your company involved here?

EU har en tre stegs strategi för att sänka CO_2 emissionerna. Inom detta ingår att öka samarbetet med bil producenter, ingår ni i detta samarbete?

8. Do you believe that the involvement of the EU will drive the green cars forward faster, i.e. be a larger success on the broad customer market?
   Tror ni att EUs engagemang kommer att driva miljöbilarna framåt fortare, dvs få större genomslag på den breda kundmarknaden?
9. The infrastructure in the EU and Sweden are different, for example are there no refuelling stations for ethanol in the rest of the EU while in Sweden there are about 340. Is the complicated infrastructure necessary for some of the alternative fuels a hinder for the development of these fuels?
   Infrastrukturen i EU och Sverige ser olika ut, till exempel finns det inga idag tillgängliga tankställen för etanol i resten av EU medan det i Sverige går att tanka på ett 60-tal platser (kan vara flera i dagsläget). Är den komplicerade infrastrukturen som krävs för vissa av de alternativa bränslena ett hinder i utvecklingen?
10. According to you, what are most important complementary products for a green car, (for example, batteries)?
    Vilka är de viktigaste komplement produkterna till en miljöbil, till exempel batterier, enligt er?
11. What is the situation regarding the development of these complementary products, (batteries, refuelling locations) compared to the corresponding technology (the green car itself)?
    Hur ligger utvecklingen av dessa komplement (T.ex. batteri, gas försörjning) i förhållande till utvecklingen av den tillhörande tekniken (miljöbilen i sig)?

Appendix 2C

Interview guide, Ethanol

(Since, the interview language was Swedish, these questions are presented in italics)

1. In The EU ethanol is not classified as a fuel, why is that?
   I EU anses inte etanol vara ett drivmedel, hur kommer det sig?
2. Sweden is used as a test market for ethanol, which means that the fuel is heavily subsidised, what will happen if EU approves ethanol as a fuel and the subventions disappear?
   Att Sverige används som test marknad för etanol ger att drivmedlet är högt subventionerat, vad händer om EU godkänner etanol som drivmedel och subventionerna försvinner?
3. Ethanol exists as both synthetic and biological, which one is used as a fuel?
   Etanol finns som både syntetisk och biologisk, vilken är det som dominerar som fordons bränsle?
4. In Brazil they use sugar canes when producing ethanol, what is used in Sweden?
   I Brasilien tillverkas etanol av socker rör, vad använder man sig av i Sverige?
5. Is there any ethanol production being planned in the rest of EU?
   Finns det etanol produktion tilltänkt som bränsle i resten av EU?
6. a) Today we import ethanol from Brazil, since our own production is not enough, as of today the ethanol produced in Sweden only allows 10 cars per day to be refuelled. Is this correct?
   Idag importerar vi etanol från Brasilien, då vår inhemska produktion inte räcker till, i dagsläget räcker den svensk producerade etanolen till att tanka 10 bilar om dagen. Stämmer detta?
   b) If more people are to buy an ethanol powered car or if the rest of EU starts driving ethanol cars, are there any plans of enlarging the existing production plants?
   Om fler köper etanol bil eller om resten av EU börjar köra på etanol, finns det planer på utbyggnad av produktions anläggningarna?
7. Which advantages come from driving on E85 instead of petrol?
   Vilka fördelar finns det med att köra på E85 istället för på bensil?
8. a) Regarding the new law regarding alternative fuel at petrol stations, how do you believe it will affect the availability of ethanol?

Den nya lagen om alternativt bränsle på landets mackar, hur tror du den kommer att påverka tillgängligheten av etanol?

b) The sale of ethanol powered cars?

Försäljningen av etanolbilar?

9. Which risks are associated with the usage of ethanol compared to petrol, as ethanol is explosive between –30 to + 30 degrees Celsius?

   Vilka risker finns med användningen av etanol som bränsle jämfört med bensin, den är ju explosiv mellan –30 till + 30 grader?

10. Which gains can a private person make by driving an ethanol-powered car?

    Vilka besparingar kan man som privat person göra genom att köra på etanol?

11. Are there any governmental or EU subventions appointed to the usage of ethanol?

    Finns är statliga eller EU subventioner riktade direkt mot etanol?

12. Does it require any extra activities from the driver in order to drive or refuel an ethanol car?

    Krävs det något extra av föraren för att kunna tanka/köra en etanol bil?

13. What do you at BAFF do to promote ethanol as a fuel?

    Hur jobbar ni på BAFF för att driva fram etanolen som drivmedel?

14. Do you have anything else that you would like to ad?

    Något övrigt att tillägga?

Appendix 2D

Interview guide, Miljöbilar Stockholm, MRF, Petrol Producers, SPI, Technical specialists and Teknikens Värld

(Since, the interview language was Swedish, these questions are presented in italics)

1. Can you see any tendencies that would lead to one of today's "greener alternatives" (bio gas, natural gas, ethanol, electricity, fuel cells and hybrid cars) becoming the future standard within the EU and thereby locking out the other alternatives?
   Kan Ni se några tendenser som skulle kunna innebära att ett av dagens "miljöalternativ" (biogas, naturgas, etanol, el, bränslecell och hybrid) blir framtidens standard inom EU och därmed slår ut de andra alternativen?
2. Which alternative has the most favourable position and why is that particular alternative more likely to succeed?
   Vilket alternativ ligger bäst till och i så fall varför?
3. What speaks against the other alternatives?
   Vad talar emot övriga alternativ?
4. Have we missed any alternative fuel (apart from bio gas, natural gas, ethanol, electricity, fuel cells and hybrid cars) that could be of high importance in the future?
   Har vi missat något alternativt bränsle (förutom biogas, naturgas, etanol, el, bränslecell och hybrid) som kan vara av stor betydelse i framtiden?
5. a) How important are complementary firms/products for the widespread of green cars (e.g. Refuelling stations and batteries)?
   Hur viktiga är kompletterande företag/produkter för utbredningen av miljöbilar (ex tankställen och batterier)?
   b) What is the situation regarding the development of compatibilities compared to the corresponding technology?
   Hur ligger utvecklingen av dessa i förhållande till utvecklingen den tillhörande tekniken?
6. According to researchers, installed base (i.e. the number of buyers a specific alternative has) is a central factor in the standard battle. Do you believe that an alternative with a large installed base has an advantage over an alternative, which at the moment has a small installed base?
   Enligt forskare är användarbas/kundstock (dvs. hur många som har köpt ett specifikt miljöalternativ) en central faktor i kampen om standard. Tror Ni att en stor

användarbas/kundstock medför större möjlighet för ett alternativ att gå segrande ur kampen om standard än ett alternativ som för tillfället har en mindre användarbas/kundstock?

7. Timing of entry is another factor that is often mentioned in this situation. Do you believe that the timing for a commercial establishment of a green alternative plays a part in the markets choice of a possible standard?
   Timing är en annan aspekt som ofta nämns i dessa sammanhang. Tror Ni att tidpunkten för kommersiell etablering av ett miljöalternativ spelar in i marknadens val av en eventuell standard?
8. Which organizations/companies/individuals have a great influence over the development of a standard and if so, why?
   Vilka organisationer/företag/individer har störst inverkan på utvecklingen av en eventuell standard och i så fall varför?
9. Do you have anything else that you would like to add regarding the different alternatives or the future of the green car?
   Har du något övrigt att tillägga angående de olika alternativen, eller miljöbilens framtid ?

Appendix 2E

Interview guide, Vägverket

(Since, the interview language was Swedish, these questions are presented in italics)

1. What is your (The Swedish Road Administration) definition of a green car?
   Vilken är er (Vägverkets) definition på en miljöbil?
2. How much CO_2 emissions does an average car emit, today?
   Hur mycket CO_2 släpper en medel bil ut idag?
3. According to you, which ways exist to lower the energy usage?
   Vilka sätt att få ner energiförbrukningen finns där enligt dig?
4. And the other fuels?
   Och de andra bränslena?
5. Which incentives exist today, aimed at green cars?
   Vilka incitament för miljöbilar finns idag?
6. What do you believe about the future of the green car?
   Vad tror du om miljöbilens framtid?

Appendix 2F

Interview guide, Taxes and Incentives

(Since, the interview language was Swedish, these questions are presented in italics)

1. Which reductions, tax relief can be made if you buy or own a green car?
   Vilka bidrag, skatte lättnader kan man som köpare eller ägare till en miljöbil få idag?
2. a) Is there any difference made concerning tax reductions between the different forms of green cars?
   Finns där några skillnader mellan subventionerna mellan de olika typerna av miljöbilar?
   b) If so, which?
   Om där finns några, vilka är de?
3. Do you know if the same reductions apply for all EU-member states?
   Vet du om de subventioner som gäller i Sverige också gäller för de andra medlems länderna?
4. If not, do you know what the differences are or where we can find information about these differences?
   Om inte, vet du vilka skillnaderna är eller var vi kan hitta denna information?
5. a) Are there any tax reductions related to the ones producing the green car?
   Finns det skatte lättnader relaterade till de som tillverkar miljöbilar?
   b) If so which?
   Om så är fallet vilka är de?
6. What do you consider as the strongest incentive for a green car, today?
   Vilket du anse är det starkaste incitamentet för en miljöbil idag?
7. Will there be a change in the future regarding the tax reductions on green cars?
   Kommer det att ske en förändring i framtiden angående skatte lättnaden på miljöbilar?