

Ethanol for Scania's Future?

– A Scenario Based Analysis

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Abstract

- Title:** Ethanol for Scania's future – A scenario based analysis
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- Problem:** Oil-based products are the dominating fuels in the transport sector but alternative fuels are currently challenging the world-wide dominance. The large number of alternative fuels that are under development at present makes the future fuel-market impossible to predict. Scania's ethanol project is associated with a number of uncertainty factors that are beyond the company's control. Some of these uncertainty factors can be associated with the company's stakeholders and their interests. Other uncertainties derive from available evaluations of ethanol, since they only consider the fuel from a single perspective, instead of making a holistic assessment.
- Purpose:** The purpose of this thesis is to identify uncertainties, from multiple perspectives, which will work as an early warning system that can create awareness of alternative futures regarding fuel ethanol. When this is done, strategies for the ethanol venture at Scania will be developed, with the help of Scenario Planning. The method used for fulfilling the purpose will be described in order to create a framework that can be used by Scania to make further assessments of other fuels.
- Method:** A qualitative method has been used for this study, which has also been conducted in an iterative way. Data has mainly been collected through literature-studies, but also interviews have been made. The working process has followed a number of steps with inspiration from O'Brien's Scenario Planning method.
- Conclusions:** The 4s Framework, which can be used for strategic planning in highly uncertain contexts, was created. For ethanol to have a chance of becoming one of the truly good fuel options, energy efficiency, environmental friendliness and security of supply have to be improved. The fuel has to be competitive without the support of legal and financial control systems. Scania's management need to decide if the company should take a proactive or a more careful preventive approach

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and communicate this strategy to the organisation. Scania's R&D department needs to prepare for a number of alternative fuel technologies and always have a plan B. The key to success is to pick up all signals that are provided by the actors on the marketplace. All stakeholders need to be monitored, since they all affect the most important stakeholders of them all; the company's customers.

Keywords: 4s Framework, Bioethanol, Heavy-duty vehicles, Scania, Scenario Planning, Stakeholder Theory, Standard Setting, Strategy under Uncertainty

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1 Background

*This chapter will give the reader background knowledge and an explanation of the practical and academic issues. It will contribute with an understanding of the present situation, how the problem has occurred and why it matters to **Scania**. The purpose of this thesis is defined and we introduce the theoretical framework that has been used throughout the study. The introduction also includes some basic information on **Scania**, ethanol and **Scania**'s ethanol-technology. Finally an outline of the report is provided so that the reader will get an overview of the contents in each chapter.*

The Swedish heavy vehicle producer **Scania** is venturing into alternatively fuelled vehicles. Such a venture is associated with a number of risks and uncertainties as multiple alternative fuels are emerging and the directions of the fuel and vehicle industries are unclear [152]. Oil-based products have for a long time been the dominating fuels in the transport sector [118] but due to both internal and external factors in the oil industry, alternative fuels are challenging the world-wide dominance [152].

This development was first made topical after the oil crises in the 1970s, when oil supply was heavily restricted and prices rose [12]. Governments then started to look for alternative fuels that could be produced on the domestic market with domestic raw material in order to make both fuel supplies and prices more easily controlled [103]. Also, the reliance on oil imports could be reduced, which was desirable due to the unstable international relations [12]. The added worry for the environmental impact of fossil fuels in later years and the uncertainty of the world's oil reserves has further sped up the process of finding alternative ways of fuelling the world's vehicles [137].

Scania has so far focused on ethanol in its development of engines powered by alternative fuels. Ethanol is today the biofuel that, to the largest extent, has replaced petrol [117] and is produced either synthetically or by fermenting and distilling simple sugars extracted from crops such as corn, sugar cane, and cellulose [153]. The latter is commonly called bio ethanol and is the kind of ethanol that will be of interest for this thesis.

There are, however, many different fuels under development, both fossil and biofuels [152] and a unified opinion on what or which fuels that are the best from a set of perspectives is yet to be formed. This fact has had the implication that producers of vehicles are pulling at different directions, developing competing engine technology for competing fuels. Multiple directions and ambitions regarding alternative fuels are also occurring in industries closely related to the vehicle industry. This makes it very hard for companies to assess what or which fuel that will be dominant alongside oil and set new standards [41].

1.1 Problem Discussion

A standard is a dominant design or specification to which products, processes, formats or procedures conforms [128] [94]. It may be dominant in a core product which means that configurations also need to be made in the end products. Oil is the dominant design and therefore the standard fuel in the transportation sector today. When a market is still in the process of selecting a dominant design, it is likely that many alternative technologies may be on offer. [128] This is certainly the case on the fuel market at present where a number of new, potentially dominant technologies are emerging, ethanol being one of them [152]. A venture into a new fuel technology is therefore associated with risks, due to the highly uncertain future [87]. In **Scania's** case, there are a number of factors affecting the success of the ethanol-project that are beyond the company's control. These factors might be difficult to see when very involved in the issue.

Stakeholders can be involved in setting standards, for example through influence on policy making, and there are multiple interests at stake [93]. A company's stakeholders are an important part of its external environment [75] and the interests of external actors need to be considered when making strategic decisions. Stakeholders exercise power over a company due to the fact that a company is dependent on its stakeholders for its survival, and is influenced by them. [66] It is thus possible that uncertainty factors regarding **Scania's** venture into fuel ethanol and the future outcomes can be associated with the company's stakeholders and their interests.

There are a number of risks and uncertainties associated with developing engines for new fuels that has not yet gained a reliable position on the market, and in high uncertainty contexts, traditional strategic planning is not enough, according to Courtney, Kirkland and Viguerie (1997). They believe that it leads to binary thinking where it is assumed that the world is either certain and therefore open to precise predictions about the future, or uncertain and therefore completely unpredictable. Underestimating uncertainty can lead to strategies that neither defend against threats nor take advantage of opportunities, while overestimating can lead managers to abandon analytical thinking for gut instinct. [34] Hence, strategic decision making regarding technological ventures is complicated. There are, however, tools for facilitating the decision making process and one of these tools is Scenario Planning [110]. This method is also advocated by Courtney, Kirkland and Viguerie (1997) [34].

As stated above, oil is currently being challenged due to political, economical and environmental reasons. This has also led to legal and technological measures that have affected the market [30] [25]. Ethanol research is however commonly conducted from one single perspective [24] [90] [93]. To make a fair and unabridged assessment of the risks and opportunities with ethanol in order to develop strategies for a continued commitment to the cause, it is important to include multiple and sometimes conflicting, perspectives [140]. Such an assessment can work as an early warning system for a continued venture on ethanol fuelled vehicles at **Scania Engine Development**.

1.2 Purpose

The purpose of this thesis is to identify uncertainties, from multiple perspectives, which will work as an early warning system that can create awareness of alternative futures regarding fuel ethanol. When this is done, strategies for the ethanol venture at **Scania** will be developed, with the help of Scenario Planning. The method used for fulfilling the purpose will be described in order to create a framework that can be used by **Scania** to make further assessments of other fuels.

With help from the future scenarios we wish to illustrate and create awareness about possible futures, which are not necessarily what most people expect. The aim with these, perhaps provoking, scenarios is to initiate fruitful discussions and to make **Scania**'s employees and management bring up some important questions on how to prepare for the future.

1.3 Focus and Delimitations

The geographic delimitation is set to include Europe which in this thesis often refers to EU25 and thus includes all 25 states that were members of the European Union in 2004. This is considered to be a manageable area to study and large enough to have an influence on the development of alternative fuels. It is also an interesting market for **Scania**'s ethanol fuelled vehicles.

The outlook into possible future scenarios will cover a timeframe of 15-20 years. This timeframe has been chosen since it is believed that this is how long it will take before any relevant and significant changes will occur.

In order to get such a complete view of the industry in which **Scania** is competing as possible, a number of perspectives will be examined. The perspectives that have been identified represent the areas which cause the most concern regarding the future of the ethanol venture and are environmental, political, legal, market, economic and technological. With these perspectives, we believe that this assessment will be more holistic.

1.4 Theoretical Discussion

To fulfil the purpose of this thesis, a cross-breed of the following three theories have been created and used:

- Standard Setting
- Strategy under Uncertainty
- Stakeholder Theory

The theories will be presented in Chapter 3 *Theoretical Framework*, but a short discussion of how they are linked together and how they will contribute to the thesis and be cross-bred will follow below.

The three theories presented above are both relevant for the topic of the study and can be linked together by a number of common denominators. *Standard Setting* points out the difficulties in going from one dominant design to another and how relatively small

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historical events may have great impact on the final outcome, a phenomenon called path dependency. These historical events are often initiated or controlled by one or more stakeholders so *Stakeholder Theory* will then provide an explanation as to how and why these historical events occur. *Standard Setting* also handles the difficulty in the transition from one standard to a new one where a number of potentially dominating designs are competing with each other. This makes a new standard very sensitive to uncertainties in the surrounding environment. *Strategy under Uncertainty* points out the issues regarding these uncertainties and the implications that they might have on the individual company and its strategies. This theoretical framework also puts an emphasis on the importance of trigger events which resembles issues presented in both *Standard Setting* and *Stakeholder Theory*.

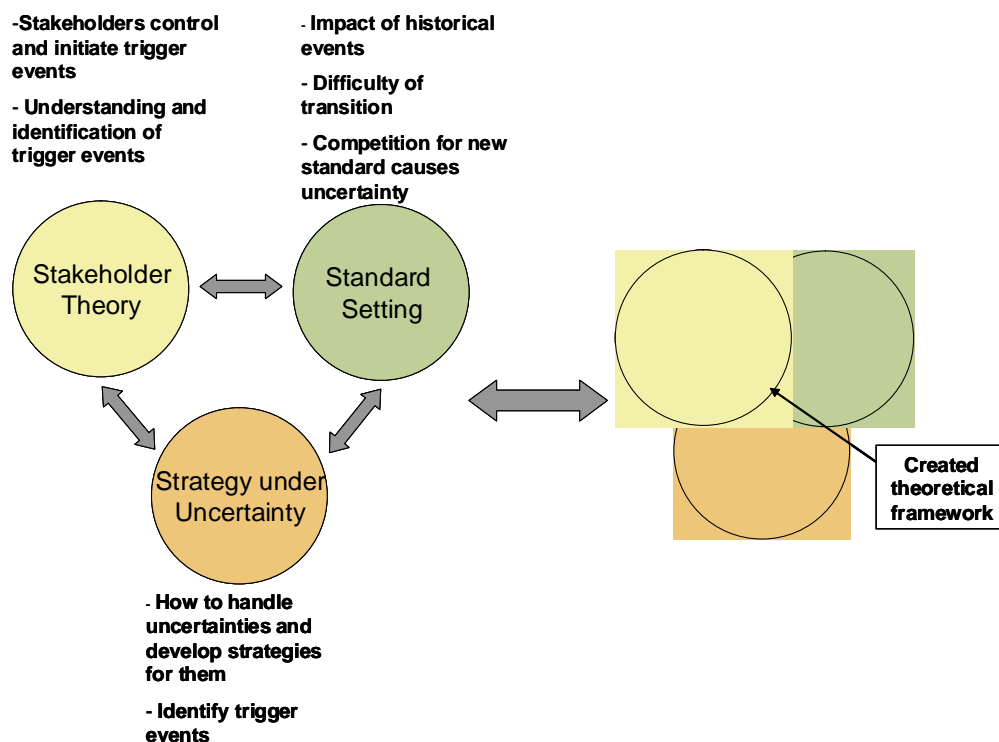


Figure 1.1 Key characteristics of the theories and the creation of the theoretical framework.

Theories are however not enough to solve a problem; a suitable research tool is also needed. *Strategy under Uncertainty* identifies different levels of uncertainty and how strategies are best formed in each of these levels. Strategies for the uncertainty level that is topical in **Scania's** case can be formed with the help of *Scenario Planning*. Scenario Planning enables strategic management to think outside the box and to include discontinuous events. This is why this method has been chosen. Discontinuous events are expected to appear on the alternative fuel market and we believe it is of value to **Scania** to think outside the box in this situation.

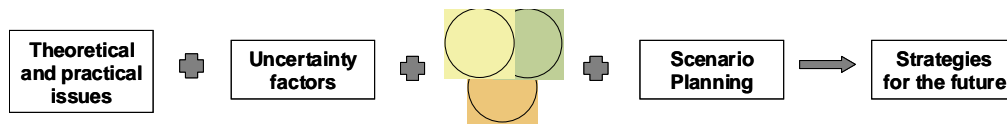


Figure 1.2 The main elements of the research process.

In order to face the issues that are associated with the identified uncertainties, methodological theories will also be used. These will not work as the theoretical foundation of the thesis but simply as an aid while investigating the impact and importance of the uncertainties. These theories will be presented when topical, mainly in Step 5.

1.5 Scania and Ethanol

Scania is a global company that develops, manufactures and sells trucks, buses, industrial- and marine engines. Parts, maintenance and financial solutions are also offered to **Scania**'s customers. The company is represented in five continents and have 30 000 employees worldwide. **Scania** was founded in 1891, and in 1996 the company was listed on the stock exchange in Stockholm and New York. Today, **Scania** is well-known for its modular product system which makes it possible to make each vehicle unique, based on customer preferences. Putting customers first is one of **Scania**'s core values as well as delivering high quality heavy vehicles. [1] According to Jonas Holmborn at **Scania** Engine Development, the company's core competence is its diesel engine technology and the flagship products are its trucks and long-haulers. Some of its competitors are MAN, Volvo, Iveco, and Mercedes [79].

Scania's venture on ethanol fuelled buses for city-traffic started some 15 years ago. The technology is unique, in the sense that a diesel-engine is used, unlike most other vehicle manufacturers who use Otto-engines for ethanol. Diesel technology is based on auto ignition, which occurs when the liquid fuel is put under a certain pressure. Also, **Scania**'s buses run on ethanol that is almost pure, apart from an ignition improver. The fuel is called Etamax D. The more commonly used ethanol based-fuel that is found in fuelling stations today is E85, which consist of 15% petrol and 85% ethanol. [49]

1.6 Fuel Ethanol

Ethanol is an alcohol that is produced either synthetically or by fermentation. They are chemically identical products but the synthetic ethanol is produced from fossil products such as coal, oil or natural gas while the fermented ethanol is a biofuel. [90] It is the biofuel that is topical in this thesis and from now on, ethanol will be synonymous with fermented ethanol.

The largest producers of ethanol are Brazil and the USA and together they produce approximately 90 % of the world's ethanol. In Brazil it is made from sugar cane and in the USA from corn. In Europe, the most common raw materials are wheat and sugar beet. The different raw materials require very different production techniques which means that from an environmental perspective, there are large differences in actual benefits compared to fossil fuels. American corn ethanol is often used as an

example of a biofuel with very limited or even negative greenhouse gas benefits while ethanol from sugar crops is easier to process and therefore requires less energy in production, i.e. produces less greenhouse gas. Ethanol does not have the same energy content as petrol which means that the amount of ethanol that is required to drive a certain distance is approximately 40 % higher than that of petrol. In many countries, for instance in the EU, ethanol is more expensive to produce than petrol or diesel which means that it is dependent on governmental support to be competitive. [90]

1.7 Outline

A brief description of the outline in this report is given here to facilitate the reader's understanding of the chapters' contents and the order in which they are presented. After the introduction provided in this chapter, follows a description of the methodological framework within which the work with this thesis have been conducted. Chapter 3 then provides the theoretical framework which is based on the cross-breed between three related theories that were presented above. Each theory will be presented and models for scenario and strategy generation will be described, followed by the working method that will be used during the research. It is a model for Scenario Planning based on O'Brien's methodology which has been modified to consist of a total of nine steps. The following chapters will then represent one step at a time as the scenario and strategy creation goes along. Thus, Chapter 4 to 12 represent step 1 to 9 in the Scenario Planning model. A short description of how the work was done and who were involved is given at the beginning of each step so that **Scania** is able to copy this process and do the same analysis on a different fuel. These steps combine theories and empirical findings with analysis and result in four scenarios and two different strategies for managing the uncertain future at **Scania**. Then, the key findings will be summarised and debated in Chapter 13, which also includes a discussion about our theoretical contribution. Our conclusions and recommendations will finally be presented in Chapter 14.

2 Methodology

In academic subjects, the method is the tool used to gather, process, and examine empirical material in order to answer a question, solve a problem or, like in this case, fulfil a stated purpose [122]. The methods that are used in a study can have large impact on the results. It is therefore important that researchers document the methods that have been used and explicitly reflect on how these methods might have affected the findings. Only then, can others get an insight in what has been done and from there, criticise the results. Openness is central since it allows the readers to decide for themselves whether they trust the methods that have been used or not. [86]

2.1 Working Process

The work with this thesis has been very iterative since the aim of the study was not quite clear when we started. The outline of the study as well as the purpose, theories and empirical data has changed a few times along the way in order for all stakeholders of this thesis to be satisfied with the result. Once the purpose for the thesis was set, a research tool that could facilitate the structuring of the problem, help the user to view a situation from a different perspective and create awareness and discussion, was needed. These are key characteristics of Scenario Planning [111], which is why this approach was chosen.

The Scenario Planning method developed by Frances O'Brien has worked as the foundation of this thesis and will be presented in further detail in Chapter 3. However, to make it more suitable for the context in which **Scania** finds itself, it has been adapted in an iterative process by applying topical theories to the method where it has been found necessary, in order to present relevant results. Whole steps in the method have also been added, where we have seen a need for further understanding of the subject. Steps have also been removed if we have found them to be redundant in this context. These changes will be further explained in section 3.4.1.

Since we have followed the steps in the Scenario Planning approach, the traditional separation of theories, empirical data and analysis has not been used. Instead the main theoretical framework and how it is used to solve the problem that this thesis is aimed at is presented in Chapter 3. The rest of the thesis has been based on an integrated approach which means that some steps might contain theories, empirical data, and analyses while others contain only empirical data, etc. We believe that this is necessary and the best approach for the chosen method, which to some extent require that the readers separate theory from empirical data and analysis themselves. We have, however, tried to facilitate this by dividing the different types of information into sections.

The whole process of working with this thesis has been very open and alive. Preconceptions and hypotheses have been left out, just like hard, quantitative data. Scenario Planning aims at discovering perceptions and opinions rather than hard data which calls for a qualitative analysis [111].

2.2 Qualitative Method

The suitability of different methods depends on the characteristics of a problem. In this case, the problem was to create structure in a phenomenon which is difficult to overlook. It was therefore best approached with openness towards the empirical information that was collected and an explorative attitude towards the problem itself. Further, there were no hypotheses concerning the result and the research covers an extensive range of data and information. Therefore, a qualitative method was most suitable for this study. Qualitative methods bring out nuances, details and uniqueness in the empirical findings and are typically open to interpretation. This helps to understand a phenomenon and to understand how the context affects it. Qualitative method is suitable when there is a lack of background-knowledge and the problem itself is unclear. [86]

2.3 Data Collection

Sources are generally divided into three groups, primary, secondary and tertiary sources [7]. Primary sources are the raw material that works as empirical information in the thesis. Secondary sources interpret the raw material and constitute the theoretical framework while tertiary sources summarises the secondary sources and gives an overview of the subject. Tertiary sources are often textbooks and encyclopaedias. [122] In this thesis, primary sources consist of interviews with people with different backgrounds at **Scania** and other experts in areas in which we needed to deepen our knowledge or confirm certain findings. Secondary sources that have been used are articles, reports, facts and figures and other literature that specialises on the subject. Tertiary sources are limited in this thesis, used only to explain certain concepts and as an introduction to the different subjects, and will therefore not be explained deeper.

2.3.1 Primary Sources

Access to the most recent and specific knowledge about fuels and the renewable fuels market has been collected through interviews. Interviews are conducted for a number of reasons and according to a number of methodologies. It is therefore important to decide how respondents have been identified and contacted, what interview technique has been used and how the material has been registered, compiled and analysed. [96]

Individual interviews bring out personal attitudes towards the subject [86] and it is of great importance to compare and critically question the answers that is collected to minimise the influence of personal opinions. In this thesis we have been interested in compiling soft data and let people express their opinion and motives. These are key characteristics of un-standardised interviews which is why this type of interviews has been performed. [96] The respondents for the interviews are people who are knowledgeable in the subjects we have aimed at examining. Employees at **Scania** who have valuable knowledge, independent specialists from Lund University and the like have participated. Interviews have been performed face-to-face when possible and otherwise over the telephone.

When possible, the questions have been sent in advance so that the respondent has been able take some time to think and reflect prior to the interview. The interviews

have been very open, without structured questionnaires or predetermined agendas. The conversations themselves have steered the interviews which have provided interesting findings and new directions. Also group interviews have been performed to get a discussion going, bring different views up to the surface, create more open mindsets, and to brainstorm about certain issues. We have had a reference group at **Scania** that consist of a number of persons with different background and with different positions in the organisation. The members of the reference group are presented in Appendix I.

In order to not forget important information, nuances or moods that have affected the interview, data have been documented as soon as possible after the interview or meeting. Otherwise, the reliability and validity of the interview might have been affected. It is impossible to present all data that is gathered in the process of writing a thesis. It is however, extremely important that all data that is relevant for the study is presented. Nothing can be left out because it does not support the expectations or views, because that will affect the reliability [110]. Instead we hope that by documenting deviant points of view, we have strengthened our objectivity and the reliability of our results.

2.3.2 Secondary Sources

The main method for data collection has been literature-studies, which have provided good knowledge about the theoretical framework and background-information about the subject as well as the different perspectives. Fundamental knowledge and more specialised facts were collected, depending on our needs throughout the research. In this case, where information have been quite dependent on stakeholders behind the study and their interests, extensive reviews of available information have been needed to gain such a complete view of the subject as possible. Books, articles and journals from libraries at Lund University, Malmö Stadsbibliotek and **Scania** have been used, as well as search-engines on the internet.

Reports and prognoses concerning the development of renewable fuels and the European market have had to be as recent as possible to ensure that the collection of data have been based on the latest information. Older reports might have been of lower quality when it comes to predictions of the development during the coming 15-20 years. Due to this, only recent documents regarding this issue have been included in the study. Documents covering the EU25 as a whole have been used to get the full picture. We have also used documents with information about a certain region or country in the EU, to get specific information about the differences and nuances that occur within the union.

2.4 Overall Validity

For this thesis to be valuable to **Scania** and the academic world, the overall validity of the study needed to be reviewed. One can say that the quality of the study consists of three parts: [85]

Reliability


- To what degree has the layout of the study affected the results?

Internal validity

- Have we measured what we wanted to measure?
- Do we have a good foundation for our conclusions?

External validity

- To what degree can we generalise our conclusions?



The overall validity of the study

To make this thesis as valid and credible as possible the precautions below have been taken into consideration.

2.4.1 Reliability

Reliability is a measure of to what extent a method gives the same result at different times but under the same circumstances. Since interviews collect information about a person's opinions, the reliability is quite difficult to control. Opinions can change depending on, for example, external factors or the person asking the questions. [8] When it comes to literature-studies, reliability is dependent on the reader's ability to stay focused on the text and not accidentally miss out on any valuable information [45]. Since this study was performed by two people, the risks of not noticing important details or making incorrect interpretations decreases. We have been able to discuss the contents of collected data with each other and the dual perspective has improved our understanding and made it more nuanced. Further, we have tried to be very observant on the possible source of errors and possible lack of objectivity of respondents and in secondary sources. [86]

2.4.2 Internal Validity

Internal validity means that the method actually measures or examines what is supposed to be examined [8]. It is of great importance to define the exact questions that needs to be answered and clarify what the search for empirical data is aiming at [45]. Interviews collect empirical data based on one person's opinions and knowledge but when interviewing a group, the collective opinions are measured [86]. To increase the validity in the group interviews that were performed, we let everyone speak their mind and noted everyone's personal opinion, rather than the collective opinion of the group. This has put focus on the working-process that was used throughout this study, which has involved many changes in the definition of the problem. It has been adapted to the findings that were made continuously. [149] By doing this, the

theoretical framework have repeatedly been compared with the parameters measured and thus the validity controlled. By being open in the research approach and let respondents with different backgrounds and sets of references talk freely and give their version of the problem area, we believe that a high internal validity is achieved. We also believe that the fact that we have gathered data from a number of sources with different interests has further increased the validity.

2.4.3 External Validity

External validity is about whether results are valid for a larger group and maybe also a larger timeframe than what has been studied. Qualitative studies are very context-dependent. Therefore many people mean that it is problematic to claim that you can draw general conclusions from such studies. The purpose of a qualitative study is usually not to draw general conclusions for a whole population, only for smaller units. It is possible to generalise from a smaller selection of units to a more theoretical level, where the theory is based on things that have been heard, read or seen. [86] Since the purpose of this thesis has been to, by studying ethanol, create a framework to identify risks and opportunities in high uncertainty contexts, a certain degree of generalisation has been needed. It has been done by using the theoretical and empirical patterns that we found and apply them on the framework that we created. The framework has worked as a tool that can be used by companies and organisations that are experiencing high levels of uncertainty and technology shifts. The practical findings i.e. the strategies and recommendations, can also be generalised to a certain degree and be valid for other heavy duty vehicle producers.

2.4.4 Triangulation

To further increase validity and reliability in a study, a principle called triangulation can be used [86]. It means that data is collected in more ways than one [8] and conclusions are controlled by combining different methods, interviewers, contexts, and people [86]. With many sources of information the data can be compared and contrasted in order to get a research that is as complete and balanced as possible [7]. We have collected data and information from both interviews and a number of reports and articles and compared these to each other as well as assessed what we believe why they differ or are alike. In some cases we have also discussed our results with other people to see if they had drawn the same conclusions. This form of triangulation is called methodological triangulation and is an effective way of controlling that what a specific researcher comes up with can be achieved by another researcher [86].

3 Theoretical Framework

As presented in Chapter 1, a combination of Stakeholder Theory, Standard Setting, and Strategy under Uncertainty constitute the theoretical framework for this thesis and is the tool for fulfilling the purpose of our study. The three theories are relevant for the topic of the study and can be linked together by a number of common denominators. The theories are further described below and introductions, definitions, and explanations that are typical for each theory are given. The basis of our research process is also described step by step, which is based on O'Brien's Scenario Planning method.

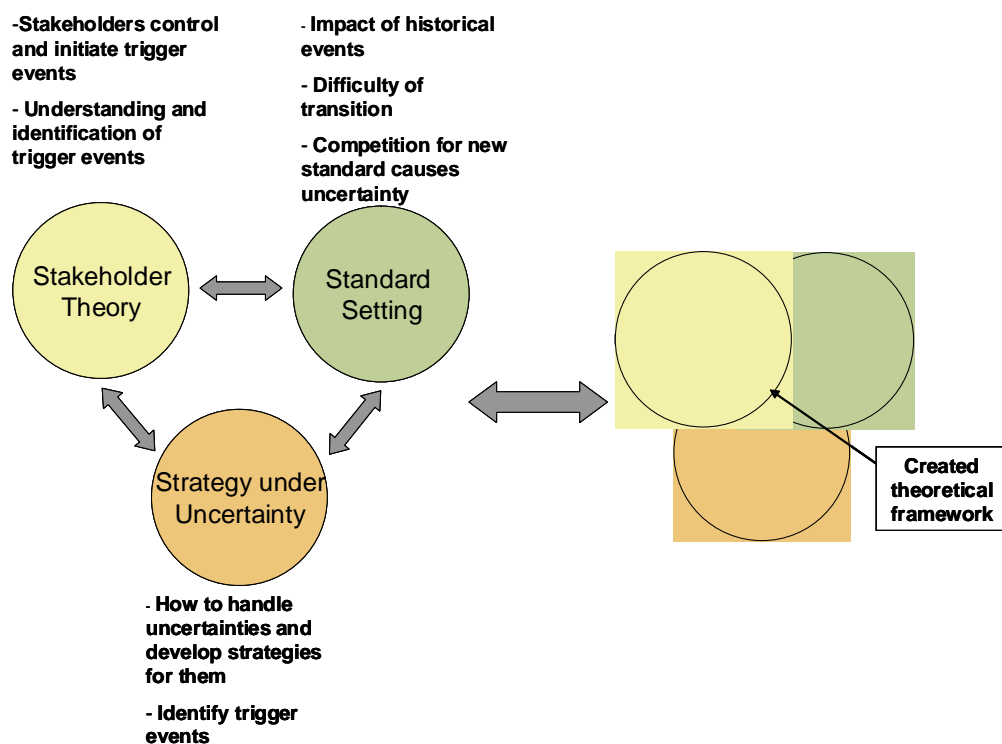


Figure 3.1 The theoretical framework consist of a combination of Stakeholder Theory, Standard Setting and Strategy under Uncertainty.

3.1 Stakeholder Theory

“Many technical controversies are primarily disputes over political goals and only secondarily concerned with the veracity of scientific issues which are related to these goals.” [102]

Allan Mazur wrote those words in his 1981 book *The Dynamics of Technical Controversy*. He had noticed that technical development rarely were a normal scientific procedure, but rather a social and political controversy. Scientists could be found on opposite sides with different facts, values and arguments that made it

difficult to come to any conclusions. [126] Perhaps this was an observation of stakeholder influence on research and technical development, and how powerful actors affect what new technologies will become popular and dominating. His point was that it is not the technology itself, its superiority or the excellent engineering behind it that decides whether it will become successful or not. Instead forces with a political, economic or social interest in the technology's existence or elimination will influence the development. These forces are the technology's most powerful stakeholders.

3.1.1 Introduction and Definitions

All organisations interact with other actors through different exchange processes, such as raw material being purchased from a supplier or loans given to the organisation from a bank. All these actors are said to be its stakeholders. Stakeholder analysis can be used for the understanding of an organisation's external environment. [75] Stakeholder analysis can also help to understand the behaviour, intentions, interrelations, agendas, interests, influences, and available resources of the relevant stakeholders, and how this affects decision-making processes. All stakeholders of a company need to be taken into consideration in strategic planning and it is useful when evaluating opportunities and threats in times of change and for implementing and managing change. [20]

Clarkson (1995) has divided stakeholders into primary and secondary. Primary stakeholders are those who are essential for the survival of the organisation together with the public stakeholder group. This group comprises government, communities, and the like, who legislates and make decisions regarding taxes and other regulations. The primary stakeholders and the organisation are interdependent, and they interact through transactions with each other. Secondary stakeholders can be affected or influenced by the organisation, but can also affect or influence the organisation. Such groups are not immediately connected to the organisation through transactions, but can have large impact on public opinion and are thus important for the organisation's external environment. [26] A typical stakeholder analysis includes identification of the organisation's competitors, partners, customers, and suppliers as well as regulatory agencies, special interest groups, and unions [75].

3.1.2 Stakeholder Analysis and Stakeholder Power

Stakeholder analysis is helpful when trying to understand which stakeholder groups and political interests that might have an impact on the organisation and should therefore be considered in strategic management processes [66]. The aim of stakeholder analysis is to generate knowledge about all relevant actors and get an understanding of how they can influence a decision-making process. Such analyses are commonly described through a number of steps or stages. The analysis is about finding answers to a number of questions, such as: Who are the stakeholders, what are their interests, how powerful are they, what resources have they got and how does their support or resistance need to be managed? [20] Frooman (1999) means that there are three general questions that need to be answered: *Who are they? What do they want? How are they going to try to get it?* He also suggests that the third question, which handles stakeholder influence strategies, is often neglected in available

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research. The stakeholder influence strategies are of great concern since this enables understanding and managing of stakeholder behaviour. A stakeholder's influence is dependent on its power over the company, which in turn is decided by the resource dependence relation. This means that when a company is dependent on one of its stakeholders' resources, the stakeholder has power over the company and can influence the company's external environment. This can be done either through controlling whether or not the company gets the resources it needs or can use the resources as it wishes to. [67]

Others state that power can be of different nature and have different origin, and divide it into a number of categories. Bourne and Walker (2005) break down the concept of power into three main types. These are; *position power* which means the formal authority of an actor, *personal power* which relies on the relation the organisation has with a stakeholder and can be affected by for example loyalty or friendship, and *political power* which refers to the formal power that comes with control over decision processes, coalitions, or co-option. [18] Freeman and Reed's (1983) categorisation includes *formal/voting*, *economic*, and *political* power. They also mean that an organisation's stakeholders can be classified depending on their interest or stake and their power. The interest dimension range from *equity* interest to *economic or marketplace* interest to an interest as *influencer*. The two dimensions can form a matrix which shows how the stakeholders possess power and stake in the organisation. [66] This is illustrated in figure 3.2 below.

| Power Interest | Formal or Voting | Economic | Political |
|-------------------|------------------|----------|-----------|
| Equity | | | |
| Economic | | | |
| Influencers | | | |

Figure 3.2 Freeman & Reed's (1983) power/interest matrix.

3.1.3 Stakeholder Influence in Policy Making

Interest groups are important stakeholders in policy processes and have impact on the process through their influence and power in a specific issue [20]. Interest groups or coalitions are therefore often part of a company's stakeholder map. [134][76][73] The coalitions are using various resources for their movement towards a certain objective and for gaining power. An important resource is when members of a coalition are for example agency officials, legislators, or even judges, since the authority of these

persons can give direct political influence. Strong public support is another valuable resource for interest groups, since they can claim to argue for the public interest and use it for lobbying. Research on public attitude and opinion present a hierarchic set of beliefs which is characteristic for individuals. All individuals have beliefs that make out the individuals political foundation and they are very resistant to change. Other beliefs can change easily as a result of new information. Information is another political weapon as it helps stakeholders to build arguments and convince decision-makers. Financial resources are also helpful, since it can be used to fund research with valuable results for the specific interest or convince important profiles to promote a certain idea. [146]

3.2 Standard Setting

Standards have become increasingly important since it often gives a company financial advantage due to increasing returns [94]. A standard is a technological solution of a core product that forces related products to use a compatible technology and limits configurations of the end product. This should not be mixed up with product standards that are used for facilitating for customers and consumers, which guarantees a certain contents or quality of the product. Processes can also be standardised and do in those cases not refer to the product, but rather to the practice. Before a standard is set there are often several competing options available [128]. The standard technique is set after the encouragement of influential stakeholders who have an interest in the outcome of the technological development [94]. Technological development is therefore a socio-cultural evolutionary event, rather than an engineering issue, and the process of selecting the standard is steered by social, political, and organisational interests. These actions are performed by companies alone or by strategic alliances that have a collective stake in the Standard Setting. Strategic alliances can include industry associations and regulatory agencies, as well as suppliers, vendors, and customers. Technological development can also be influenced by sovereign states and governments in cases where the development is of national interest. [3] In a publication from 1994, England writes about some of the difficulties that would come with a shift from fossil fuels to an alternative energy technology. Many alternatives are readily available or under development, and can be considered to be potential substitutes for fossil energy. A shift from fossil energy is a technological evolution that is highly uncertain. England (1994) points out the risk of technological lock-in of an energy option that is unviable, hazardous or in some other way unsuitable to replace the fossil energy sources. [48] Technology lock-in is the extreme of Standard Setting, which can appear to be a rather random process.

Technical standards that develop from market mechanisms are called a *de facto* standard. *Formal* standards are developed with power from organisations that represent market participants and worked out by standardisation bodies, e.g. ISO. If the standard is set as a result of government legislation, it is said to be a *de jure* standard. [94] The Standard Setting that concerns **Scania** and alternative fuels will be a *de facto* standard since it is developed from market mechanisms.

3.2.1 Installed Base and Complementary Products

Apart from stakeholder influence, Standard Setting is also influenced by path dependency, which means that relatively small historical events can play a substantial role for the final outcome. Timing is also of high importance and it is sometimes better to be the first to reach the market than to be technologically superior. Path dependency and the right timing of entry are typical random events and are thus difficult to control or predict. There are some consistent patterns which have proved to influence the standard selection. It has been shown that a company can increase its chances of its own technology becoming the standard through the size of its installed base and the availability of complementary goods. It is also common to talk about self-reinforcing feedback effects or increasing returns to adoption (see figure 3.3). This means that once a technology begins to be adopted and consumers are starting to use it, the functionality and market attractiveness is improved. This can give the technology an advantage that is almost impossible to overcome. The phenomenon of increasing returns to adoption results in three major effects; learning curve, network externality, and signalling. These effects will be described in detail in the next section. [128]

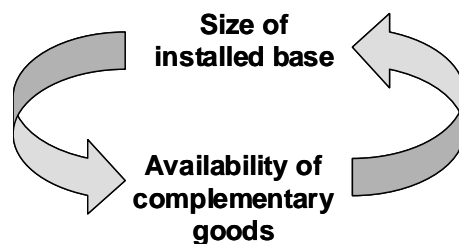


Figure 3.3 Increasing returns to adoption occur through a self-reinforcing feedback effect between size of installed base and availability of complementary goods. (Schilling, 1999)

3.2.2 Learning Curve, Network Externality and Signalling

This section, including the concepts of learning curve effect, network externality effect and signalling, is based on Schilling's publication from 1999, on how to win a standards race [128].

The more a technology is being used, the more it is developed and improved. This means that within a single company, implementation of the technology is hence becoming more advanced and improved. The more companies that use the technology, the more improvements can be made and the more attractive the technology becomes. This is the *learning curve effect* and it can give a technology a superior competitive advantage once the ball has started rolling. Such an advantage is often very difficult to imitate.

The *network externality effect* means that a user of a technology benefits from a large number of users of the same technology. A classic example is the telephone, which is not very useful if the owner of the telephone has no one to call. Instead, the telephone becomes an increasingly beneficial product with an increasing number of persons that

own and use a phone. An increasing number of ethanol fuelled vehicles would result in more fuelling stations, which would benefit the vehicle owners and make the ethanol fuelled truck or car a more attractive product. Complementary products can also be important for the network externality effect and can make a product more desirable. The availability of complementary products to the main product is affected by the size of the installed base, since a large installed base will attract more developers of complementary products. Consumers tend to be attracted by technologies with a lot of complementary goods, which in turn increases the installed base. This creates a close interconnection between the size of the installed base and the availability of complementary products.

Signalling is an effect which creates the impression of a certain technology being especially attractive. Such signals can be a large installed base which makes the consumer think that the product is high in quality and value. A proper evaluation of a product's quality is almost impossible for the consumer to make and do therefore rely on other consumers and the belief that they have made the right choice. Once the consumer have adopted a technology it is difficult to change into a competing technology, because of switching costs.

Trying to enhance and accelerate the effects of the interconnection between the size of the installed base and availability of complementary products can be done through using the inter-organisational linkages available to the company. Cooperation with important stakeholders, such as distributors, producers of complementary products and customers, is one way to speed up those effects. Inter-organisational linkages can be created through exclusive contracts, joint ventures and bundling agreements.

3.2.3 Winning a Standards War

Standard Setting is a phenomenon of the information age and is sometimes called standard wars or races, meaning that one single technology will come to dominate the market. Not all technologies go through a standards war and if a standards war occurs, it does not have to mean a fight to the death, but could rather end in a draw. Independently of the standards war outcome, there are some useful tactics and strategies for being successful in a standards war. As mentioned above, allies are of great importance. Companies need the support of consumers, suppliers of complementary products and perhaps even competitors. Pre-emption strategy is the second key, including rapid design cycles, penetration pricing and winning important consumers. Third, the company needs to manage customer expectations and be convincing as the winner-to-be. Signalling is one effective way of doing this, i.e. making early announcements of new products and make visible commitments to your technology. Once a company has won the race, it needs to keep up the good work, continue to be superior and continue to offer the consumers very attractive products. Finally, it is important for a company not to drop prices if it should fall behind in the race since it signals weakness. [130]

3.3 Strategy under Uncertainty

In contexts characterised by a large degree of uncertainty, planning for the future and making strategic decisions is difficult. Strategic thinking is needed to move away from short-term goals where profit maximisation is on the top of the “to do-list”. With strategic thinking, creation and preservation of requirements for future success is taken into account. [63] Subtle opportunities and threats are easily overlooked. Strategic planning therefore involves audits of the companies' vulnerabilities to change and disruption that may result from new competitors and regulations, special-interest-groups initiatives, scientific discoveries, and media disclosures. Such an audit will increase the awareness of and sensitivity to external forces [4]. By identifying success potential and developing them, businesses can improve their chances of future success. Strategic thinking is therefore a prerequisite for successful action in a complex and turbulent environment. [63]

Fink, Siebe and Kuhle (2004) have listed three main reasons for why strategic planning is needed [64]:

- To avoid suppression of uncertainties – Many companies reject uncertainties and plan as if there is only one predictable future. Planners should instead accept uncertainties and develop clear alternatives or a range of alternative futures.
- To avoid suppression of complexity – There are a variety of factors that needs to be taken into account, e.g. new technologies, deregulation, globalisation and customer demands. The more factors that affect the business environment, the more complex the environment is and traditional planning fails to cope with this complexity. Companies have to widen their horizon and think in larger business ecosystems.
- To avoid suppression of change – Too many companies are stuck in short-term thinking where profit maximisation is the central goal. Businesses that want to be successful in the long run have to focus on choosing a path that enables future success.

Strategic change involves changes in a company's scope, resource deployment, competitive advantages and synergies in order to make the company better suited to handle this change and allowing it to meet its objectives.

3.3.1 Levels of Uncertainty

There is no universal method for strategic planning. High context uncertainty calls for one type of planning while low context uncertainty calls for another [33]. Courtney, Kirkland and Viguerie (1997) have identified four levels of uncertainty and suitable strategic planning for each of them [34]. These are presented below [33]:

- *Level 1 A clear enough future* – In a level 1 environment the range of possible outcomes is so narrow that the uncertainty does not matter for the decision at hand. The future is however not perfectly predictable but predictable enough to identify a dominant strategy that is so good that it works well across the range of potential outcomes.

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- *Level 2 Alternative futures* – In level 2, a limited set of possible future outcomes can be identified, one of which will occur. The outcomes are mutually exclusive and collectively exhaustive and the best strategy depends on which outcome will occur.
- *Level 3 A range of futures* – Level 3 uncertainty is a lot like level 2 in some respects. A range of possible future outcomes can be identified but they are not mutually exclusive or collectively exhaustive. The uncertainties in this level are often created by customer demand, new technology performances and unstable macroeconomic conditions.
- *Level 4 True ambiguity* – In level 4, future outcomes are both unknown and unknowable. Not even the range of possible future outcomes can be identified by analysis. These situations are very rare and tend to degrade over time to level 3 and 2. They are most likely to occur during and immediately after major technological, economical and social discontinuities and in markets that are just beginning to form.

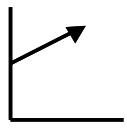
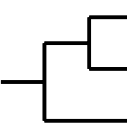
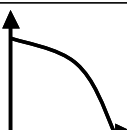

| Level of Uncertainty | Description | Example Sources of Uncertainty |
|---|--|--|
|  | A clear enough future: can define point forecasts that are "close enough" for the decision at hand | <ul style="list-style-type: none"> • Returns on "common" investments in mature, stable markets • Customer and competitor reactions to strategies that reposition well-established brands |
|  | Alternative futures: can define a limited set of possible future outcomes, one of which will occur | <ul style="list-style-type: none"> • Potential regulatory, legislative or judicial changes • Unpredictable competitor moves • All-or-nothing industry standards competition |
|  | A range of futures: can define a range of possible future outcomes | <ul style="list-style-type: none"> • Demand for new products or services • New technology performance and adoption rates • Unstable macroeconomic conditions |
|  | True ambiguity: cannot define even a range of possible future outcomes | <ul style="list-style-type: none"> • The outcomes of major technological, economic or social discontinuities • Market evolution in markets that are just beginning to form |

Table 3.1 The four levels of uncertainty (Courtney, 2003)

The case of **Scania**'s venture into ethanol fuelled vehicles is characterised by Level 3 Uncertainty. A number of possible future outcomes that are not mutually exclusive and collectively exhaustive can be identified and the company is facing changing customer demands and new technologies as well as changes in the macroeconomic conditions. This level will thus be examined deeper.

3.3.2 Strategising in Level 3 Uncertainty

A suitable method for strategic planning in Level 3 Uncertainty contexts is Scenario Planning [34]. Scenario Planning is identified as a processual approach to strategy development that allows a company to recognise that certain aspects of the corporate environment is unpredictable while others are predetermined [144]. A scenario is a generally intelligible description of a possible situation in the future, based on a complex network of influence factors [63]. Scenario Planning enables strategic management to think outside the box and to include discontinuous events. They are stories about the future showing how the future can diverge from the present and what fundamental forces that drive change. [16] A set of scenarios need to be developed that describes alternative future outcomes and the analysis should focus on the trigger events that signal that the market is moving towards one or another scenario [34]. The chosen Scenario Planning framework will be explained in further detail in section 3.4.

In order to develop scenarios, the uncertainties in the business environment need to be identified. Factors that might have an effect on a company can emerge from unexpected places, so a scan of the macro environment for social, economic, environmental, and political developments needs to be done. With the help of such a scanning, signals of change might be identified and these need to be closely monitored in order to forecast the duration, acceleration and amplitude of the signals. [4]

When developing scenarios, there are a number of general guidelines to keep in mind. First of all, the number of scenarios should be limited. Too many hinders the strategic decision making rather than facilitates it. Developing redundant scenarios that have no unique implications should be avoided and they need to be collectively possible to avoid extreme scenarios that are not perceived as credible. [33] The scenarios should focus on trigger events that might send signals to the market [34]. Probabilities should not be allocated to the scenarios since that implies that they are mutually exclusive and collectively exhaustive, which Level 3 Uncertainties should not be. All uncertainties are possible to happen simultaneously. [33] Since it is impossible to define a complete list of uncertainties and scenarios and their related probabilities, it is impossible to calculate the expected value of different strategies. [34]

In Level 3 Uncertainty it is not possible to find a strategy that is dominant across all scenarios so strategists need to choose between strategic options with different risk-return profiles across the different scenarios. Therefore the strategies will depend on how risk averse managers are, making qualitative business judgement play a prominent role in forming the strategies. [33] Fink, Siebe & Kuhle (2004) has created a framework for the main types of scenario-based strategies. They mean that there are three types of business strategies and the choice falls on the one that suits the specific planning situation and the corporate culture. *Planning oriented strategies* are suitable in situations characterised by “a clear enough future” where planners do not have to wait and react but instead make specific decisions and take action based on anticipation of forthcoming changes. *Preventive strategies* emphasise on reacting to environmental changes, accepting uncertainty, and protect against unforeseen change and can be regarded as a more risk-averse type of strategy. *Proactive strategies* are

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acceptant of the fact that a wide range of changes in the environment are unpredictable but attempts to do things ahead of time after anticipating events and exploit their arrival. This is done by shaping the environment in some desired direction so that unwanted changes will be less likely to occur. It provides a more risky type of strategy. In order to create these strategies one can choose two paths, either focused or future-robust. *Focused strategies* are based on one single reference scenario and are narrow and easily communicated. They can however be too narrowly focused and therefore be attacked by changes in the business environment. To be on the right track with these strategies, market research and early warning processes are vital, so is the need to be ready for fast strategy changes. *Future-robust strategies* are based on a number of scenarios and they are therefore flexible and open for change in the environment. The problem with these strategies is that they are very complex and therefore difficult to communicate. [64]

An appropriate approach for strategy formulation in uncertain business environments is the so called Design School Model for strategy making. This model balances internal and external situations and takes the application of Scenario Planning and SWOT analysis into account. [144] The model is illustrated in figure 3.4 below.

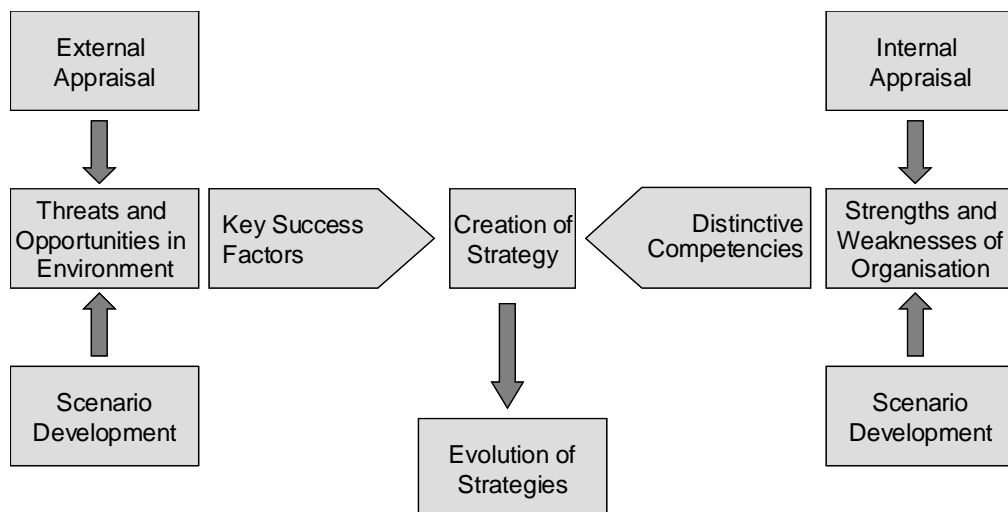


Figure 3.4 Strategy Development Model (Walsh, 2005)

3.4 Planning for the Future

The future is unknown to us all but for some this constitutes more of a problem than for others. Making strategic decisions regarding technological ventures is complicated since they can only be based on assumptions and estimations. There are however, tools for facilitating the decision making process and one of these tools is Scenario Planning. This tool will facilitate the identification of uncertainties that prevail in the ethanol venture. The creation of scenarios will generate awareness of alternative futures regarding fuel ethanol and help to form a strategy.

Scenario Planning is suitable for organisations facing certain conditions. The conditions that are topical in the case of **Scania** are [129]:

- High uncertainty relative to ability to predict or adjust.
- The industry has experienced significant change or is about to.
- The company wants a common language and framework, without stifling diversity.

A scenario is a story about how the future might turn out. These are of course guess works and not truths, but the importance of Scenario Planning is that managers have to expand their imagination to see a wider range of possible futures. This way they are better equipped to take advantage of unexpected opportunities. The advantage with Scenario Planning compared to other strategic planning tools is that it explores the joint impacts of a large number of uncertainties from different perspectives. Also, in Scenario Planning several variables are changed at the same time to gain an understanding of the impact of major deviations in key variables. [129]

Scenario Planning, as a way of structuring problems, is aimed to aid the understanding of a situation, rather than provide a single definite answer to a problem. The process is just as important as the result, since it helps the user to view a situation from a different perspective and encourages participation of multiple actors with a plurality of views. It focuses on perceptions and opinions and not as much on hard data which makes the analysis qualitative rather than quantitative. [111]

Scenario Planning is often focused on facilitating strategic decisions by company management and perhaps this is its most beneficial use. However, in a simplified form, it can also be used by departments to make individual decisions. [129] The version of Scenario Planning that will be constructed in this thesis will be done on the basis of the steps presented by O'Brien in the European Journal of Operational Research and is presented below.

3.4.1 The Research Process

O'Brien's framework consists of eight key steps [111]:

1. *Set the scene* – Gain an understanding of the organisation that the scenarios would be developed for. This means that the planning horizon will be set, and past and current changes and issues will be examined.
2. *Generate uncertain and predetermined factors* – Identify uncertain and predetermined factors by inviting individuals to expand their thinking by

brainstorming a large number of factors. The factor shall be expressed as a noun so that predictions will be avoided this early in the process.

3. *Reduce factors and specify factor ranges* – The large number of uncertainties from step 2 will be reduced in order to identify key uncertainties. The reduction will be made by scoring each factor in terms of importance to the organisation. Only the key uncertainty factors, i.e. those with highest score, are then used for creating scenarios later on in the process.
4. *Choose themes and develop scenario details* – Determine how many scenarios that should be developed, 2-4 is commonly recommended. Then, a theme for each scenario will be selected as a guideline for the contents of the scenario. This will be followed by a description of the scenario that is consistent with both the theme and the timeframes and result in a scenario table that summarises the state of each factor as it appears in each scenario, together with a brief description of each scenario.
5. *Check consistency of scenarios* – A cross impact analysis where the correlation and strength of the relationship between the different uncertainty factors is estimated should be made. The factors will be inserted in a table which is used to test the internal consistency of the scenarios. The purpose of this step is to eliminate scenarios that are contradicting.
6. *Present scenarios* – The scenarios should be presented in such a way that it helps people to think about the future and to believe that the presented possible futures might actually come true.
7. *Assess impact of scenarios* – The impact of the scenarios on the organisation will be assessed, for example with the help of a so called TOWS matrix.
8. *Develop and test strategies* – A set of strategic options should be created and these are checked under each scenario to see if they are deemed solid under the set of scenarios. The final step in the process will be to construct action plans for each of the different scenarios in order to prepare the company and the department for the future.

These eight steps will work as the foundation for the forming of a suitable framework for this topic and for **Scania**, but where needed, steps will be added, eliminated or modified in order to suit the specific characteristics that are topical in this thesis. The modified process will be presented below.

1. *Setting the Scene* - The step is about understanding the organisation and its surrounding environment. It has been modified compared to O'Brien's step to involve the defining of the scope and a review of past developments and the present status in the industry.
2. *Identify Stakeholders* - This step has been added to the framework because we find it important to identify stakeholders since they can have much impact on the development on a new standard as well as the fuel market at large.
3. *Generate Uncertainty Factors* - This step is based on Step 2 in O'Brien's framework with the exception of predetermined factors, which were eliminated because we did not find them interesting in this context, and with the addition of Stakeholder Theory and the stakeholders' ability to affect Standard Setting. The step is about generating a list of factors that are

considered to be beyond the organisations control, but important to the business. The number of uncertainty factors should not be restricted.

4. *Reduce Factors* - Step 4 is about reducing the factors in step three to identify the key uncertainties. The reduction was made by scoring each factor in terms of impact on the organisation. This is a modification of O'Brien's scoring, since it is not based on probabilities. This is in accordance with Courtney's theory of Level 3 Uncertainty where uncertainties are not mutually exclusive of collectively exhaustive, i.e. the uncertainties can come true regardless of the outcome of other uncertainties.
5. *Face the Key Uncertainty Factors* – This step means that the uncertainty factors will be examined in closer detail. It is not part of O'Brien's framework but has been added because we see a need for understanding the uncertainty factors and the impact that they might have on the industry and its standards in order to create scenarios and strategies.
6. *Choose Themes and Develop Scenario Details* – This step the deepened knowledge about the uncertainties will be used for choosing themes and developing scenario details. It starts by determining how many scenarios that should be developed. Then, a theme for each scenario will be selected as a guideline for the contents of the scenario. This will be followed by a subjective projection of the factors under each theme in a top-down fashion which will create a description of the scenario that is consistent with both the theme and the timeframes. The step is partly in accordance with O'Brien's fourth step with the addition of it being based on stakeholder view and Standard Setting thoughts.
7. *Check Consistency of Scenarios* - This step is the same as O'Brien's fifth step and consists of a cross impact analysis where the correlation between the different uncertainty factors is estimated. The purpose of this step is to eliminate scenarios that are contradicting.
8. *Present Scenarios* – This step corresponds to O'Brien's sixth step. The scenarios are presented in such a way that it helps people to think about a future 20 years from now, and to believe that the presented possible futures might actually come true. They are stories that each represents a future reality and are partly created with the help of the past and present perspectives as well as stakeholder and Standard Setting theories to make them plausible.
9. *Develop and Test Strategies* - This step is a combination of O'Brien's seventh and eighth step and is about assessing the impact of the scenarios on the organisation and developing strategies. These steps were combined because they constitute the main elements in The Strategy Development Model (presented in Chapter 3) that we find provide helpful guidelines for strategy development.

4 Step 1 Setting the Scene

The step is about understanding the organisation and its surrounding environment. It involves the defining of the scope and a review of past developments and the present status in the industry. The scope was defined in dialogue with tutors, both at the university and the company. To get an idea of past and present industry situations, literature studies as well as interviews with key personnel were conducted.

4.1 Scope

As defined in section 1.3, the scope of the study is EU25 and a timeframe of 15-20 years. We study bioethanol from the six perspectives; environmental, political and social, legal, market, economic, and technological.

4.2 Past and Present Perspectives

To create understanding of possible future development in the coming 15-20 years, a retrospect of each perspective is given below. The present situation is also described, as to describe the starting point.

4.2.1 Environmental Perspective

1987-1992

This period of time was characterised by a shift in environmental focus, from local to regional or global issues and the concepts of eco-efficiency and sustainable development were introduced [60]. The European Environment Agency was established, aiding member states to achieve improvement in meeting environmental goals and to provide the public and policy makers with information. [56]

Present

Today, the European Union's citizens' high standard of living puts large strain on the environment. The EU is constantly working towards a better environment and the current environment action programme for the EU runs until 2012. It focuses on four priority areas: climate change, nature and biodiversity, environment, health and quality of life, and natural resources and waste. The EU is also putting effort into substituting more of the finite sources of energy with renewable energy. [60]

4.2.2 Political and Social Perspective

1987-1992

The political debate on climate change started in the late 1980s and resulted in the European Commission's proposal on a strategy to stabilise emissions by using a mix of efficiency standards, fiscal instruments and research. At this stage the economic instruments for regulation became popular and a CO₂/energy tax was proposed in 1992. [78]

Present

The European Energy Policy of today presents new objectives with the aim of finding a balance between sustainable development, competitiveness and security of supply.

With emission-levels from year 1990 as a reference, the following goals have been suggested: [31]

- Reduce the greenhouse gas emissions from developed countries with 30% by 2020.
- Reduce the global greenhouse gas emissions with 50% by 2050, meaning that industrialised countries need to reduce their emissions with 60-80%.

In trying to fulfil those goals, alternative fuels for energy consumption in the transport sector are introduced with the target to replace 5.75% of the energy consumption with biofuels, by 2010 and 10% by 2020. [54]

4.2.3 Legal Perspective

1987-1992

In 1987, a directive from the European Commission stated that measures against emissions of gaseous pollutants from diesel engines for use in vehicles were to be adopted. Thus, the national regulations concerning carbon oxide, hydrocarbons and nitrogen oxides (NO_x) had to be replaced by a common agreement, called Euro I. [51]

Present

The Euro-agreements have been replaced regularly by stricter and stricter agreements and in 2005 Euro IV was taken into force. Currently, engine development is focusing on the new targets in Euro V which will take effect in 2008. [38] Since 2000, engines are tested with a simulated driving cycle [40] where different loads and speeds are simulated to secure that emission levels are acceptable during all driving circumstances. [39]

4.2.4 Market Perspective

1987-1992

An infrastructure for fuelling ethanol vehicles was built in Brazil which resulted in high vehicle sales. However, Brazil soon suffered from an ethanol shortage, due to high world market price of sugar which resulted in dramatic decreases in vehicle sales. [145] In Europe, demand was low but **Scania** delivered some 30 buses to the city of Stockholm as well as a handful of buses to Örnsköldsvik and Gothenburg.

Present

In Europe, production and use of biodiesel is far more developed than ethanol for heavy duty vehicles, but ethanol fuelled vehicles are increasingly popular. According to Fredrik Morsing at **Scania** Buses & Coaches, several countries are investing heavily in infrastructure and the interest in ethanol fuelled heavy vehicles is growing significantly. **Scania** has recently sold ethanol buses to Poland, Italy, and Spain for example. [106] Even though the European production of fuel ethanol saw an increase in 2004 of 71 % compared to the year before [89], EU25 countries still consume more ethanol than they produce, which means that they have to import ethanol, most commonly from Brazil. [145]

4.2.5 Economic Perspective

1987-1992

An important parameter for ethanol fuel sales is its price relative to the price of oil products [144]. In the 1980s, oil prices dropped which meant that the ethanol plants struggled to survive. Producers had to shift focus to improve processes and technologies to make production more cost effective by increasing the ethanol yield and reducing operating costs. [109]

Present

Feedstock prices are a limiting factor for ethanol production in the EU [145]. Therefore the EU has imposed tariffs on foreign ethanol and introduced subsidies and tax exemptions to make European ethanol more competitive. [90] Each member state can decide to reduce or exempt biofuels tax as long as certain conditions are being followed [29]. This tax exemption is adjusted to the price of raw material so that the companies are not over compensated [90].

4.2.6 Technological Perspective

1987-1992

Together with USA and Brazil, some European countries, e.g. Sweden, has a long experience of using alcohol fuels. **Scania** took part of this development by making ethanol fuelled heavy duty diesel engines.[44] The first commercialised **Scania** ethanol engines reached the market as city bus engines[25].

Present

97 % of transport fuels are oil based. To reduce CO₂ emissions, the vehicle industry needs to invest in developing more low emission vehicles, especially the heavy vehicle industry since these vehicles contribute the most to the emissions increase. Ethanol production processes have improved substantially and further development is estimated at an even higher pace thanks to increasing support from the EU [27]. The second generation of fuel ethanol based on cellulose and biomass is being developed in laboratories.

4.2.7 Summary

Generally there has been an increased focus on environmental effects the past 20 years and the issue has gone from being a local concern to a global. It more or less started at the beginning of this period. Since then, laws and restrictions have been imposed to limit emissions and other substances that have a negative impact on the environment. These restrictions have focused on NO_x, CO and hydrocarbons but recently CO₂ has been very topical.

As a reaction to this development, alternative fuels have seen an increasing demand. The first generation of biofuels has been out on the market for many years but it is only in recent years that the development has really taken off. World production has increased significantly, so has the availability of ethanol fuelled vehicles. Production has however been very dependent on subsidies and other financial support and it still is today and most likely for many years to come.

5 Step 2 Identify Stakeholders

*The purpose of this step is to get an idea of possible directions of industry development. Being aware of the stakeholders is important for the understanding of uncertainties, possible future outcomes and ethanol's ability to become the new standard. The stakeholders were identified during a brainstorming session where the two of us tried to name all stakeholders we could think of as well as their impact on the industry. We later reviewed some relevant literature to see if there were any we might not have thought of and finally we consulted our reference group at **Scania** who has different backgrounds and interests to get their view on the stakeholders.*

5.1 Stakeholders

In this section an understanding for **Scania's** external environment will be provided through identification of the relevant stakeholders. To identify the stakeholders, we conducted an analysis based on the Stakeholder Theory presented in Chapter 3 and on information from the reference group at **Scania**. All stakeholders have been divided into primary and secondary stakeholders. Primary stakeholders are those who are essential for **Scania's** survival together with the public stakeholder group, which include government, municipalities and the like and thus are responsible for legislative actions. Secondary stakeholders are affected or influenced by **Scania** and the development of ethanol, but can also affect or influence the issue. [26] The stakeholders are listed and described below.

5.1.1 Primary Stakeholders

Producers of heavy vehicles are companies like **Scania** and its competitors. They need to adapt to changes in market, technology and legislation for securing continuous growth and profitability by getting their technology and products to the market. The way different manufacturers act regarding fuel options is of great interest since successful ventures on other alternative fuels than ethanol can threaten the establishment of ethanol and force the industry to change direction to set another standard. Reverse; the chances of success for ethanol increases with the number of competitors in the industry that develop engines and vehicles for ethanol. Regardless of what technology they promote, they will try to get their way by lobbying for their cause and market and promote their products to convince the customer that their alternative is the best.

Buyers of heavy vehicles are **Scania's** existing and potential customers, such as companies, municipalities and to some extent private persons. Customers are crucial for the success of **Scania** and their demands and preferences are of great importance in influencing the direction of Standard Setting. The buyers are in most cases those who also pay for the fuel and they want qualitative, reliable vehicles that are easy to fill up. Some even wants an environmentally friendly alternative and they steer the market by buying and demanding the type of vehicle they wish to drive.

Buyers of transport are passengers who need transport for travelling or companies that need freight for goods. They want to transport themselves or their goods fast and secure, preferably cheap and in some cases even environmentally friendly. They have the possibility to affect the market by buying the type of transport that matches their requirements. This group can be seen as customers of **Scania's** customers and have a strong influence on requirements on a vehicle's attributes.

The EU and its member states is a very strong stakeholder group since European and national policies and legislations forces a technical progress and dominant design as well as stimulating the market towards a wanted direction. In general they want to reduce emissions, increase employment, protect the European agriculture, etc. EU's standpoint is crucial for the future development and the support for fuel ethanol from the EU is more or less necessary at present. This also applies for the individual country which can govern the development with national or regional laws, financial aid or various stimulation methods.

Municipalities are dual stakeholders. On the one hand they want to protect their local environment to create a clean, noise-free community that people want to live in. With the same principle as described above, they are able to influence the ethanol market through local regulations and environmental targets or with economic instruments such as free parking or road tariffs for ethanol vehicles. On the other hand, municipalities are also important customers for **Scania**, especially on buses, since they often buy many buses at once for the local bus fleet.

Ethanol producers are those who manufacture fuel ethanol from raw material. Technological improvements regarding the production process is to a large extent dependent on the producers. Such improvements have impact on, for instance, the energy efficiency, land-use efficiency and price of the fuel, and are thus important for the competitiveness of ethanol and ability to set new standards. To facilitate this, they try to influence decision makers and companies to provide them with equity or research grants. Ethanol producers are also dependent on reliable cash-flow and demand as well as sufficient supply of raw material, which also makes them affected by future actions from other stakeholders, e.g. allocation of resources by the EU.

Companies that distribute and sell vehicle fuel to consumers are another stakeholder to take into consideration. This industry is positioned in a complex situation and the companies need strategies for complementing the core business, which is oil based fossil fuels, with alternative and renewable fuels. The situation is partly caused by market demand for alternative fuels and legislation, which is why fuelling station companies are affected by future outcomes. Their willingness to build infrastructure is crucial for increasing the installed base and to do this they will continue to lobby for financial support for installing ethanol fuel pumps so that signals can be sent to the market that ethanol is a good alternative.

In the case of ***raw material producers***, they have the choice of growing crops for food, fodder, energy or ethanol among other things which means they have an impact on both the availability and the price of the end-product. A strong demand for

biomass could mean new possibilities to earn a better income than from growing food crops, but policies, regulations, and economic incentives could also leave the farmer without any other option than to switch from growing food crops to energy crops. European farmers have a strong position since the EU conducts a favourable agricultural policy that supports domestic agriculture. The farmers also have strong trade associations and interest organisations that support them and lobby heavily to keep EU support and improve it.

Stockholders are stakeholders that want returns on their invested capital. They can influence the company and its strategies indirectly with their voting power. They elect board members at the general meetings and can therefore use their power as owners to elect the people that they think represent their interests the best. They also have the power to influence company by selling their shares if they are unhappy with the company's performance, which affects company equity and has a signalling effect to the market.

5.1.2 Secondary Stakeholders

Technological improvements of both the ethanol production process and engine performance are facilitated by the research performed at **universities**. They want to conduct research in order to contribute to development and make a name for themselves. This research is though largely dependent on funding and financing which make it possible for external interests to influence the research.

Media has a prominent ability to influence the market and the public opinion. Daily press and news reports often leave space for debate and strong personal opinions of those who want to make their voices heard. This is an effective way to create and spread the spirit of the times, creating and supplying the public with information on historical events which strongly influences consumers and the choices they make and thus affects the prospect of setting a standard. However, since the main objective for most media is to make money, sell ads and subscriptions, they need to report on subjects that create sensations and therefore attract viewers, readers, and listeners which could provide a distorted news flow.

Trade associations and interest groups are using lobbyism through different channels to influence others to agree with a point of view that benefits them and their members. They are also important and respected actors in communicating interests within the industry or organisation they are representing. It is mainly the communication with policy makers and the like that is likely to have impact on the future of fuel ethanol as a dominating design. ACEA (European Automobile Manufacturers Association) is one of the generally most important associations for **Scania**.

Substitute markets mean other alternative fuels and technologies that are competing with ethanol for the possibility to become established on the market, earn market shares and become a new standard. To do this, they often use the power of lobbyists and marketing or by publishing research, etc. At the time, there are large numbers of

potential options that could replace some of the fossil fuels, which is a possible threat to the future success of ethanol.

Producers of other vehicles, such as cars or aircrafts, affect the future of ethanol, and are thus important stakeholders. Their influence appears in the same way as the competitors in the heavy vehicle industry, as described above, but also by enforcing the expansion of infrastructure and distribution for ethanol as well as signalling to the market what the best alternative might be. They can help push the development forward and lobby for building infrastructure but they could also do this for another technology that suits their interface or compete for the limited fuel supply.

The area of agricultural land needed for growing biomass for production of ethanol might also be needed for other purposes, creating a conflict with **alternative users of land**. Instead of growing biomass, there could be a need for producing vegetables, grains and the like for providing Europe with food. Land is also needed for growing timber, raising livestock, building homes for an increasing population and having access to recreational areas. They try to get their message across via lobbyists who have the ability to affect decision makers. If raw materials are not allocated to ethanol production, the installed base will fail to grow.

We wanted to show how the different stakeholders influence and are dependent on each other as well as illustrate how complex the business environment is. The interrelations have been mapped out after discussions on how the different stakeholders interact and affect each other.

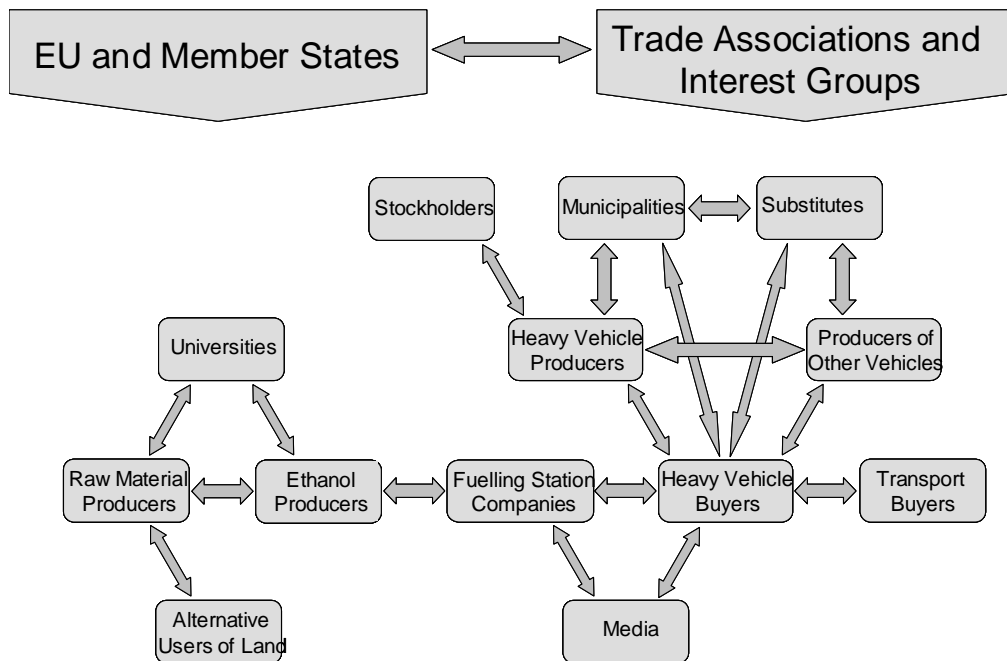


Figure 5.1 The interrelations between the stakeholders.

5.1.3 Power – Interest Matrix

The power and interest of each stakeholder has been evaluated and illustrated in the matrix below. According to Freeman and Reed (1983), stakeholder power has been categorised under formal/voting, economic or political power. The interest dimension has also been considered and the stakeholder interest is classified as equity, economic or marketplace or interest as influencer. [66] This will give an answer to what the stakeholders want and how they are going to try to get it.

| Power Interest | Formal or Voting | Economic | Political |
|-------------------|----------------------|--|---|
| Equity | Stockholders | | |
| Economic | | Producers of heavy vehicles Buyers of heavy vehicles Fuelling station companies Raw material producers Substitute markets Producers of other vehicles Ethanol producers | |
| Influencers | EU and member states | Buyers of transport Alternative users of land | EU and member states Municipalities Universities Trade associations Media |

Figure 5.2 Scania's stakeholders in a power/interest matrix.

5.1.4 Stakeholder Influence

An evaluation of stakeholder influence, i.e. its ability to affect **Scania** and the development of ethanol has been made. Stakeholder influence can range from Weak to Strong, where the Weak stakeholders are those who are affected rather than affective and have small possibilities to influence the future development of fuel ethanol. The Intermediately powerful stakeholders are in a sense both affected and affective, through interdependence, and can not always decide for themselves. Those stakeholders are likely to have a decisive impact, but they are sometimes in a subordinate position compared to the Strong stakeholders, whose acting will be crucial for the future of fuel ethanol.

Primary

Producers of heavy vehicles
 Buyers of heavy vehicles
 Buyers of transport
 EU and member states
 Municipalities

Influence

Intermediate
Strong
 Intermediate
Strong
Strong

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| | |
|--|------------------|
| Ethanol producers | Intermediate |
| Fuelling station companies | Intermediate |
| Raw material producers | Intermediate |
| Secondary | Influence |
| Universities | Weak |
| Media | Strong |
| Trade associations and interest groups | Strong |
| Substitute markets | Intermediate |
| Producers of other vehicles | Weak |
| Alternative users of land | Intermediate |

6 Step 3 Generate Uncertainty Factors

The step is about generating a list of factors that are considered to be beyond the organisations control, but important to the business. As many factors as possible were first gathered by us through brainstorming and by reviewing stakeholders and their interests. These were factors that we had come across in discussions, literature, reports and in the media. Then the reference group was contacted to aid in generating more uncertainty factors.

Some 60 uncertainty factors have been identified on the basis of the company's stakeholders and their behaviour, intentions, interrelations, agendas, interests, influence and available resources, i.e. their motives and abilities to influence Standard Setting. The stakeholders provide the company with both opportunities and threats in times of change and therefore need to be considered while implementing and managing change. The uncertainty factors were later listed under the corresponding perspective to get an overview of the importance of each perspective. The explanations of each factor can be found in Appendix II.

Environmental

Greenhouse gas
Pollutants
Land use
Biodiversity
Deforestation
Rainforest deforestation
Plant disease
Crop failure
Land depletion
Genetically modified organisms
Noise

Market

Supply of fuel ethanol
Supply of raw material
Customer attitude
Customer willingness to pay
Vehicle competitor direction
Road transport substitute direction
Fuel substitute direction
Fashion trends
Transport demand
Myths

Local/Regional establishment
Strategic alliances

Economic

Oil price
Prices of raw material
Price of fuel ethanol
Price of alternative fuel
Subsidies
Tariffs
Taxation
Exchange rates
Business cycles

Political and social

Debaters
Lobbyists
Competition for governmental funding
Employment
The Middle East
USA
China and India
Production in developing countries
Famine disaster

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EU's future and power

Supply of animal feed

Technological

Technological development of vehicle

Technological development of fuel ethanol production

Competing ethanol engine technology

Competing engine technology for other fuels

Research

Development of biomass

Energy balance

Infrastructure

CO₂ capture and storage

Ethanol quality

Legal

Regulations

Legislations

Bureaucracy

National and international standards

Classification

7 Step 4 Reduce Factors

Step 4 is about reducing the factors in step three to identify the key uncertainties. The reduction was made by scoring each factor in terms of impact on the organisation. The scoring was performed by the authors of this thesis and were first discussed, then reviewed and reassessed in order to secure that the key uncertainty factors were identified. Only the key uncertainty factors, i.e. those with highest score, will then be analysed further and used for creating scenarios later on in the process.

7.1 Key Uncertainty Factors

The following key uncertainty factors have been identified. They are listed under the corresponding perspective. The scoring and explanations for all uncertainty factors can be found in Appendix III.

7.1.1 Environmental Perspective

- ***Greenhouse Gas*** - The focus on greenhouse gas and global warming has had a large impact on development and sales of ethanol fuel and vehicles. Changing beliefs concerning the greenhouse effect would therefore have substantial impact. Also, the greenhouse gas savings that come with ethanol use are not yet fully established which causes criticism against the fuel.
- ***Other environmental consequences*** - Possible side-effects of ethanol-use are not fully investigated and it would hurt the reputation of ethanol if it was to be associated with pollutants that damage the environment or human health.
- ***Land use*** - We think that a conflict about how to use land in Europe is very likely to occur and that it can create strong opinions regarding fuel ethanol and cultivation of biomass.

7.1.2 Market Perspective

- ***Supply of fuel ethanol*** - A sufficient supply of ethanol makes it possible for the fuel to earn market shares and is hence highly important. We also think that the probability of this becoming an issue is likely, due to conflicts regarding energy supply.
- ***Supply of raw material*** - We believe that sufficient supply of biomass is a condition for sufficient supply of ethanol. We also think that this will become an important issue, due to land use conflicts.
- ***Customer attitudes*** - Our opinion is that positive customer attitude towards fuel ethanol are of great importance, and they can change significantly during the chosen time period.
- ***Vehicle competitor direction*** - The different vehicle manufacturers have always chosen different paths and technologies and we think that the direction of competitors will be very important for the establishment of a new fuel such as ethanol.
- ***Fuel substitute direction*** - We judge the technical improvements regarding other fuels to be an important threat against ethanol.

- **Strategic alliances** - Since new fuel markets are forming and the uncertainties are many, forming a strategic alliance might be the key to success. If left out of this strategic alliance, the company might completely lose the power to influence the market.

7.1.3 Economic Perspective

- **Subsidies** - Subsidies play an important role in creating demand for fuel ethanol and are currently a prerequisite for ethanol's competitiveness.
- **Tariffs** - Tariffs create an uneven competition between ethanol produced in Europe and in Brazil. Tariffs have large impact on the price of ethanol, and thus the demand, which makes it an important factor.
- **Taxation** - Tax exemption or reduction is one form of subsidy which is very costly for society. This is one reason why we believe that changes in ethanol taxation are likely to happen and this will have an immediate impact on ethanol price.

7.1.4 Political and Social Perspective

- **Debaters** - Debaters are recurring elements in the media today and we believe that the public listens to them to a large extent, especially when what they say is negative.
- **Lobbying** - We find that lobbying will have a strong impact on the fuel ethanol market if they represent strong stakeholders that have great influence.
- **EU's future and power** - A change in EU energy policies and support for biofuels, due to shifts in power and attitude, will have a huge impact on the fuel market.

7.1.5 Technological Perspective

- **Technological development of fuel ethanol production** - We believe that development in this area is of utmost importance since it might decrease energy consumption, cost, CO₂-emissions, etc.
- **Energy balance** - For ethanol to be considered an environmentally friendly fuel we believe that the energy balance will be of great importance.
- **CO₂ capture and storage** - A shift from carbon dioxide saving to handling the emissions with new technology would heavily reduce the advantages with ethanol and affect the demand negatively.

7.1.6 Legal Perspective

- **Legislations** - Legislation is very important, laws need to be followed or there will be consequences. Laws can work both for or against ethanol which makes it uncertain since the fuel is dependent on legal aid until it is thoroughly established.
- **Regulations** - Since regulations can differ from one region to another, we believe that regulation will be of as much importance as legislations because there will be many parameters for the company to adapt to.

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A number of these uncertainties are very closely related and can therefore be paired together in order to get the full perspective and a better understanding of the flows, impacts and consequences. The uncertainty factors that have been paired together are the following:

- *Land use, supply of raw material and supply of fuel ethanol* – In order to have sufficient supply of fuel ethanol there need to be enough raw materials which in turn is dependent on the amount of available land to grow crops. This key uncertainty factor will be called ***fuel ethanol supply chain***.
- *Vehicle competitor direction and fuel substitute direction* – Vehicle competitor direction is highly dependent on the direction of fuel substitutes since no new vehicle will be developed unless there is a fuel ready that it can run on. Therefore these to go hand in hand and the key uncertainty factor will be called ***substitute direction***.
- *Subsidies, tariffs and taxes* – These three uncertainty factors are all related to the price of the fuel and are all controlled by the same stakeholders, namely EU and its member states. Therefore they all constitute the key uncertainty factor ***financial control systems***.
- *Debaters and lobbying* – Debaters and lobbyists serve more or less the same purpose and do often represent similar interest groups or other stakeholders and are therefore paired together in the key uncertainty factor ***debaters and lobbyists***.
- *Legislations and regulations* – Legislation and regulations are very similar and have the same impact on **Scania** and its customers. The only difference is the geographical scope, legislation being regional or national and regulation being more local. This key uncertainty factor will be called ***legal control systems***.

Customer attitudes has also been identified as a key uncertainty factor. It is however much more than that, it is a prerequisite for the company's survival. The customers must have a positive attitude towards a product or technology or else the products will not be sold and the company or venture will fail. Customer attitudes are also affected by all the other key uncertainty factors and customers is the stakeholder that is most influenced and influential on other stakeholders, which can be seen in figure 5.1. It will therefore be included in the Scenario Planning and all scenarios, but will not be discussed as a key uncertainty factor in itself. The key uncertainty factors are therefore as follows:

- Greenhouse gas
- Other environmental consequences
- Fuel ethanol supply chain
- Substitute direction
- Strategic alliances
- Financial control systems
- Debaters and lobbyists
- EU's future and power
- Technological development of fuel ethanol production
- Energy balance
- CO₂ capture and storage
- Legal control systems

8 Step 5 Face the Key Uncertainty Factors

Facing the key uncertainty factors means that the uncertainty factors will be examined in closer detail. This will be done to get an understanding of the uncertainty factors and the impact that they might have on the industry and its standards in order to create scenarios and strategies. Some of these factors are assessed together in order to get a more complete view of the issues. This step has been carried out by the authors of this thesis with the help of reports, methodological theories and interviews.

8.1 Greenhouse Gases and Energy Balance

A significant source of greenhouse gas emissions is combustion of fossil energy carriers. Minimising fossil energy use is thus of relevance for minimising greenhouse gas. Effective use of fossil energy can be measured through calculations of energy balance. In this section, both greenhouse gas emissions and energy balance will be described and discussed, due to the close relation between those key uncertainty factors.

One main objective of using ethanol for vehicle fuel instead of petrol or diesel is to decrease the emissions of greenhouse gases. Recently, debaters have stated their opinion regarding fuel ethanol's true environmental advantages and many are giving an opposite version of the greenhouse gas and energy efficiency issues. Researchers are constantly trying to prove each other wrong in this question. Stakeholder interest is influential in this dispute and affects the contents of the versions provided.

8.1.1 Life Cycle Assessment

The tool for evaluating environmental impact, such as energy balance or emissions, is commonly Life Cycle Assessment (LCA) which considers a product from the raw material to a finished product and through to the using stage and end-of-life stage. LCA is based on a way of thinking that focuses on the entirety and how different parts of a system affect each other, instead of just looking at isolated areas. [123] LCAs for vehicle fuel are sometimes called well-to-wheel analysis. The well-to-wheel can be subdivided into a well-to-tank analysis and a tank-to-wheel analysis.

8.1.2 Differing Results in LCA Studies

There are a large number of available LCAs and well-to-wheel studies on fuel ethanol which show considerably different results. Several attempts have been made to create consensus regarding the results in those studies and to get an overall picture of the true environmental impact of biofuels such as ethanol, but it is not easy. The varying results in different LCAs depend on a number of factors, which also make it difficult to compare the calculations and results from the different LCAs. The most important problems, according to Pål Börjesson at Lund Institute of Technology, are listed and explained below [23]:

- *Allocation problems* – The raw material that are used for producing ethanol are either co-produced with other products or by-products and wastes from other production processes. Ethanol can for example be produced from wheat

starch which is a by-product of wheat processing. In such cases, the emissions have to be allocated on the two products. An option is to expand the study and calculate both product streams and account potential environmental benefits of the use of co-products. [6] The allocation method significantly affects the LCA result.[14]

- *Cultivation practice* – Assumptions regarding the cultivation methods is also affecting the LCA result. This includes fertilising types and methods as well as the use technological means and the degree of automation.
- *Quality of raw material* – The volume of fuel ethanol that can be extracted varies with different crops. Sugar, starch or cellulose has different energy contents. More ethanol can for example be extracted from one kilo of corn than from one kilo of sugar beet. This is described in more detail in section 8.3.2.
- *Extraction from crops* – To get one litre of ethanol, different land areas are needed depending on the crops. Sugar beet uses the land more efficiently than corn since a smaller area is needed for production of the same volume. This is described in more detail in section 8.3.3.
- *Transports* – Estimations concerning the origin of the raw material as well as the finished product can further affect the LCA result. Brazilian ethanol demands more transport than domestically produced ethanol. The transport type is another uncertain factor since different transport methods result in different emissions.
- *Production* – Large-scale production sites give different emission results per produced unit of ethanol than small-scale sites. The technology used is another important factor, since modern technology is more energy-efficient. Estimations concerning by-products also affect the result.
- *Energy supply* – In some LCAs all energy input is assumed to come from fossil energy sources, while others are calculating on small-scale production which for example uses the energy from a private wind power station. The supply of electrical energy is naturally important for the end result.
- *Quality of data* – The reliability of data is important for the quality of the LCA. The age of the data is another important factor.

Apart from this, there are further difficulties with the execution of an LCA and the interpretation of the results. One important difference is the inclusion or exclusion of *opportunity costs*. If corn, sugar beet or wheat were not cultivated for ethanol production, it would probably be cultivated and transported for a different purpose, such as providing consumers with food. The resource input needed, such as fertilizers, water, tractor fuel and transportation, is thus nothing unique for biomass production, and could occur anyhow. [146] The opportunity costs are not included in some assessments which results in more positive outcomes regarding energy balance and greenhouse gas emissions from fuel ethanol.

The assessments are also *vulnerable to small changes in the calculations* and the data that is being used. LCA is based on assumptions and estimates, which is why sensitivity analysis is a good complement. The differences in LCA results can depend on researchers' assumptions regarding any of the factors above. [65]

The LCA method has obvious weaknesses and unless one is very well aware of how LCA is conducted and how to avoid the pitfalls, it can be risky to rely too much on calculated figures and data. A serious judgement of fuel ethanol should be based on more than one single LCA and a critical attitude towards the figures and result is necessary.

8.1.3 Calculating Energy Balance and GHG

Energy balance is interesting to examine since this gives a picture of the fuel's energy efficiency and helps to build arguments in favour of, or against, the use of ethanol. Fossil energy is often used during the conversion of biomass to bioenergy which results in greenhouse gas emissions. The use of fossil energy during the conversion process can thus exceed the energy savings that the substitution of fossil fuel is aiming at. This can result in negative net-savings of fossil energy and greenhouse gas emissions. [15]

The exact definition of energy balance or energy ratio, and how to calculate it, varies in different studies and can thus give various messages dependent on the aim and angle of the study. [117] Energy yield ratio can be calculated in two different ways, depending on the main objective of the study. If the aim is to calculate how much fossil energy that is needed for producing ethanol, the ratio of energy output to fossil energy input ($E_{out}/E_{in, fossil}$), is calculated. This is a measure of the relative amount of energy received from the bio fuel compared to the fossil energy input. Perhaps more interesting, is the total energy input compared to output (E_{out}/E_{in}), which should be minimum 1, for the energy transformation to be considered efficient.[15]

Calculations of greenhouse gas emissions are usually made in the unit CO₂ equivalents, which is a measure based on carbon dioxide's greenhouse effect [15]. The emissions from combustion of biofuels are normally excluded in the calculation since the carbon has been combined in the biomass through photosynthesis, where carbon dioxide from the air has been absorbed. Tail pipe emissions from biofuels are therefore treated as zero. [6] This is illustrated in figure 8.1. An option is to calculate *avoided emissions*, which is a measure of reduction of fossil fuel use. Greenhouse gas emissions are avoided if fossil fuel is replaced by the use of biomass or if energy efficiency is improved. [15]

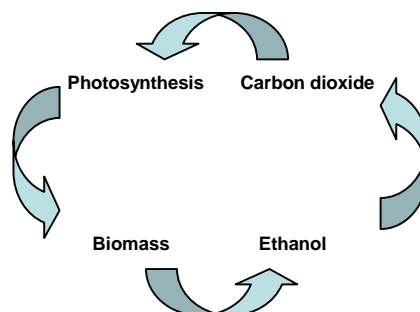


Figure 8.1 The carbon dioxide cycle leads to biofuels being considered to be carbon dioxide neutral.

8.1.4 Summary of LCA Studies

Below, a rough picture of available LCA results regarding the environmental impact of fuel ethanol is given. We would like to point out that no definite answers are given here, but simply a summary of a limited number of results. The initiators behind each study have been mentioned to expose what stakeholder influence might be behind the study.

IFEU

The German Institute for Energy and Environmental Research (IFEU) published a report in 2004 which analysed and compared 800 studies of environmental impacts of biofuels from transports [117]. The study was initiated by the Research Association for Combustion Engines that also financed the study together with the Union for the Promotion of Oil and Protein Plants and the German Association for Research on Automobile-Technique. Data concerning automobiles with gasoline engines have been used in the IFEU study.

The authors draw a few general conclusions regarding ethanol and biofuels as a whole but the authors also express that it is important to take the advantages and disadvantages of each individual fuel into account in decision-making. It is also pointed out in the report that the findings in available LCAs vary greatly. The conclusion is that biofuels are favourable, if the savings of fossil energy is in focus. The authors believe that all the considered biofuels from cultivated biomass have favourable energy and greenhouse gas balances compared to the fossil substitutes, even though some studies state the opposite. There are also environmental disadvantages with the use of biofuels, such as higher levels of eutrophication, acidification and ozone depletion, as a result of fertilizing. When it comes to ethanol, it is sometimes better and other times worse than biodiesel, which depend on the choice of raw material. Other advantages are dependent on the geographic area of energy crop cultivation, which is the case for Brazilian sugar cane. [117]

JRC, EUCAR & Concawe

The well-to-wheel study made by JRC (the Joint Research Centre of the EU Commission) together with EUCAR (European Council for Automotive R&D) and Concawe (Conservation of Clear Air and Water in Europe) is a very extensive study which focuses on the greenhouse gases, carbon dioxide, methane and nitrous oxide, that are emitted during the life cycle of a wide range of alternative fuels. [14] The authors emphasise that the study is not an LCA. The representatives behind this work come from JRC, Concawe, EUCAR as well as a number of different car manufacturers, such as Renault, Ford, BMW, Volvo and VW and companies from the oil industry, such as Shell, BP, and Exxon Mobil. **Scania's** diesel engine technology is not included in the study.

The study from 2006 evaluates ethanol from sugar beet, wheat and woody biomass and ethanol from Brazilian sugar cane is used as reference. A range of manufacturing options for the different raw materials have been studied and the savings of fossil energy and greenhouse gas emissions are modest compared to gasoline. The conclusion is that the fossil energy and greenhouse gas savings of liquid biofuels,

such as ethanol, are highly dependent on the manufacturing process and possible by-products. The actual benefits with ethanol can in some cases be questioned. Because of uncertainties regarding nitrous oxide emissions in agriculture, the greenhouse gas balance is especially difficult to rely on. Even if the use of fossil energy is reduced, this does not mean that the use of biomass for producing fuel ethanol is energy efficient. Calculations in the Concawe report regarding total energy use show that this is several times higher than the fossil energy use alone. This use of biomass is thus considered to be fundamentally inefficient. Even if reduction of greenhouse gas emissions is of prime concern at present, efficient use of energy resources and energy conservation should also be highly prioritised. It is shown in the report that reduction of greenhouse gas generally result in an increased use of primary energy. [42]

von Blottnitz & Curran

This study from 2005 includes a summary of 47 LCAs on ethanol. Many LCA studies describe ethanol made from sugar crops as the currently most energy efficient option, even though tropical sugarcane is far better than sugar beet from temperate regions. This is measured both in terms of net replaced fossil energy per land area used and as an energy ratio comparing energy output from the biofuel and the input of fossil fuel. Ethanol from starch crops, such as potato and wheat, replace significantly less fossil energy and result in a poorer energy ratio. Ethanol made of American corn is subject to a lot of doubt and many state that this raw material is unable to give a positive energy ratio and has a relatively poor performance. Ethanol made from lignocellulosic feedstock replaces a similar amount of fossil energy as the sugar crops and energy yields are generally very encouraging.

Only seven of the reviewed studies include environmental impacts beyond fossil energy use and greenhouse gas emissions. These seven studies show a distinct lack of consensus on the environmental benefits of fuel ethanol, apart from the broad agreement that fossil energy carriers can be avoided to some extent which also results in reduced GHG emissions. Acidification, human toxicity and ecological toxicity are generally more unfavourable than favourable for ethanol. [15]

8.1.5 Discussion

No LCAs or well-to-wheel studies including the engine-technology that **Scania** uses for ethanol have been found during this research. As the Concawe study showed, the total energy use and greenhouse gas emissions are highly determined by the vehicle performance. This is why it is relevant to make a specific well-to-wheel analysis on a heavy duty vehicle with this particular use of ethanol. The results can work as a foundation for internal evaluations on fuel ethanol and the potential of future ventures, but it can also help **Scania** in responding the criticism against ethanol.

The criticism against fuel ethanol which state that ethanol is bad from a greenhouse gas point of view and that it is energy-inefficient, need to be judged in a nuanced way. It is not as black or white as the debaters put it and one should keep in mind that the studies are influenced by stakeholders and their particular interest. Regardless of what sources and calculations that have been used, the studies are unable to give the full picture and show all possible interpretations. These varying results affect

consumer attitudes and make it difficult for them to know if ethanol is appropriate as a fuel or not. The inconsistent signals sent to the market affect ethanol's chances of becoming a standard.

Even if the findings in different LCAs vary greatly, one can be quite certain of a few things: The raw material and the production process truly matters for the energy balance and greenhouse gas savings of ethanol. Apart from this, the evaluation of ethanol is much a result of assumptions and different allocation techniques and it is likely that important stakeholders behind the evaluations have influenced the result to some extent.

8.2 Other Environmental Consequences

Due to the focus on reduction of greenhouse gas that is currently prevailing, other serious environmental consequences can easily be forgotten [77]. There are some environmental disadvantages with biofuels, but they are often neglected thanks to advantages in fossil energy savings. Available LCAs have shown that biofuels is associated with higher levels of eutrophication, acidification and ozone depletion, as a result of fertilizing. [117] Human and ecological toxicity are generally more unfavourable than favourable for ethanol [15]. Apart from chemical substances, pollutants and emissions that can be released into ecosystems, we also bring up loss of biodiversity and deforestation as examples of large-scale environmental problems that can be a consequence of a widespread use of biofuels.

In the report from IFEU (The German Institute for Energy and Environmental Research) 800 studies of environmental impacts of biofuels from transportation was analysed and compared. Apart from only greenhouse gas emissions, this includes eutrophication, acidification and ozone depletion, photo smog and toxic substances. The first conclusion that is made in this report is that there is a lack of studies concerning further environmental impact. On the basis of 800 reports, only 12 included a thorough study of these aspects. [117] von Blottnitz and Curran's summary of 47 LCAs on ethanol state the same and show that the studies indicate very mixed results. [15]

Biofuels cause emissions of nitrogen such as NO_x , N_2O , NH_3 , NO_3^- and NH_4^+ , due to the use of fertilizers during cultivation of biomass. These emissions cause eutrophication, acidification, and the forming of ground-level ozone. [117] Ozone is poisonous when it occurs at ground-level and it causes damage to humans and plants. It is transformed from sunlight, nitrous oxides and hydrocarbons. [142] Emission-levels are higher than for the fossil fuels, independently of how the calculations are made. The effect on eutrophication and acidification from biofuels made from organic residues is ambiguous and need to be evaluated for each unique case. The same applies for photo smog, which is complex to measure. Knowledge is also lacking regarding toxic compounds that are associated with ethanol. This includes particles, hydrocarbons, formaldehyde and benzene, which are very toxic and can cause damage to humans and ecosystems. [117]

Loss of biodiversity is already a problem within the EU and the aim is to halt this negative development by 2010 through protection of so called high nature value farmland in Europe. An extensive conversion of farm-land into production areas of energy-crops, as a result of increasing demand for land, will have severe impact on biodiversity. This is due to intensified production patterns [58] which cause deterioration of watersheds and loss of soil fertility [133] and also the widespread homogenous vegetation [58].

Increase in agricultural area will also have impact on forest-areas which are important for sequestration, i.e. storing of atmospheric carbon [119] and as habitats for a large number of species. If timber from the forest is used in a combustion-process, methane is emitted [101]. Deforestation or combustion of timber will thus contribute to an increase of greenhouse gases. The impact can be reduced by cultivation of crops which lock in carbon dioxide and contribute to a reversed sequestration [119]. Further, forests are the most important carbon sinks [108], which means that it stores carbon dioxide and thereby stops it from affecting the atmospheric chemistry [43].

8.2.1 Discussion

In addition to greenhouse gas savings and energy resource consumption, there are further environmental impacts from the use of fuels that need to be evaluated. This is often neglected in available studies and leaves a gap in the knowledge on fuel ethanol. Pollutants and hazardous substances can cause serious damage and should not be ignored in favour of greenhouse gas reductions. Such damage can strike against humans and ecosystems, but also against the reputation of **Scania** and the customer attitude towards the company. These are all examples of significant historical events that affect Standard Setting. Sudden recoveries of ethanol being harmful for humans, animals or ecosystems would strike hard against the fuel as well as **Scania**. In order to avoid unpleasant surprises, more research needs to be conducted in this area so that the overall environmental performance of fuel ethanol can be mapped out. This way, **Scania** can be one step ahead of the critics and other stakeholders that have an interest in seeing ethanol fail. Also, the possibility of negative environmental effects from the ethanol use that are completely unknown should not be excluded.

8.3 Fuel Ethanol Supply Chain

As explained previously, the key uncertainty factors regarding supply of fuel ethanol, supply of raw material and land use have been consolidated to one key uncertainty factor, namely Fuel Ethanol Supply Chain. It involves the process of providing the customer with fuel ethanol, a process that is associated with a number of vulnerabilities. In order to identify these vulnerabilities, the supply chain of fuel ethanol will be identified which means that these three key uncertainty factors will be examined from a supply chain management perspective.

The typical fuel ethanol supply chain starts at farms around the world. The different feedstock, e.g. corn, wheat, sugar beet and sugar cane, are planted, watered, fertilised, and harvested to be picked up at the farm and transported to a mill. In the mill, the feedstock is grounded into flour after which it is moved to the distillery where it is fermented, distilled and dehydrated. When the ethanol is done it is transported to a

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bulk terminal or redistribution terminal before being shipped to its final destination terminal where it is blended with petrol or stored neat. From here, the ethanol is transported to the fuelling stations where the different vehicles go to fill their tanks.

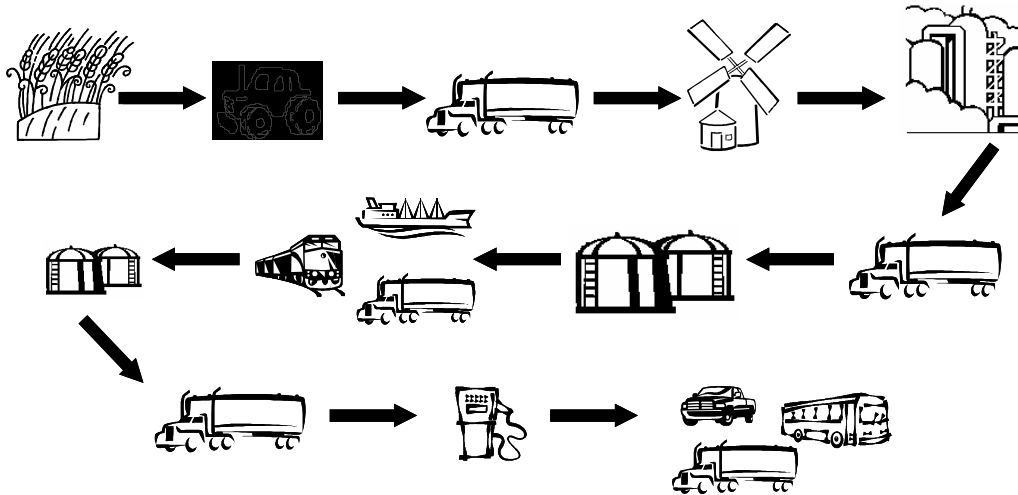


Figure 8.2 The fuel ethanol supply chain.

8.3.1 Supply of Fuel Ethanol

In order to decide whether it is feasible for Europe to have sufficient supply of fuel ethanol in the future, estimations of the future supply needs to be made. These estimations will be based upon an assumed achievement of the goals that were set by the EU which means a replacement of 5.75 % of all transportation sector energy by 2010 and 10 % by 2020 [29]. Also, the EU25 goal of reducing imports in order to be more self-sufficient when it comes to fuel, will also work as a foundation [12]. The calculations will be presented in Appendix IV.

The most recently published numbers of total energy consumption in the transport sector show that 350 million tonnes of oil equivalent (Mtoe) was consumed in the EU25 countries in 2003 [57]. The International Energy Agency (IEA) estimates that global energy consumption will grow by 1.6 % annually until 2030 [84] but this number is said to be smaller in Europe due to low population growth, high taxes on transportation fuel and environmental policies [47]. Our calculation, based on the numbers presented by the European Environment Agency, show that annual growth rate in the transport sector was approximately 1.82 % between 1990 and 2004 [57]. However, growth has been lower since the year 2000, namely 1.18 %. This is lower than the 1.6 % proposed by IEA but seems like a plausible development for the oncoming years, considering the factors mentioned above. We also believe that increases in energy consumption due to increased transport demand will be dampened by more efficient engines. Therefore an annual growth of 1.2% will be used for our calculations. At an average annual growth rate of 1.2 %, energy consumptions in the transport sector of 463 Mtoe by 2027 can be expected.

The goal for EU25 is to have 5.75 % of transport fuel to come from biofuels by 2010 and 10 % by 2020. There are no goals set for energy consumption beyond 2020, however assuming a continued replacement and replacement rate; approximately 13 % energy consumption in transports can be expected to come from biofuels in 2027. This means that according to these assumptions the amount of biofuels that needs to be supplied in 20 years is 60 Mtoe which corresponds to 118 billion litres. In 2005 33 billion litres of fuel ethanol was produced world wide, mainly in Brazil and the USA. In Europe the production volume for fuel ethanol was 0.913 billion litres [145] which is significantly less and far from the volumes needed in 20 years. Since the EU is aiming at being self sufficient when it comes to fuel [29], it needs to see a 120 fold increase in production over the next 20 years. Not only European production needs to see a significant increase, the world production would have to get almost four times as large in the next 20 years, only to supply Europe. Reaching the fuel substitution goals only with ethanol is possible, but major improvements in production capacity and efficiency is needed. To get an idea of the likelihood of this being achieved; an assessment of the raw material supply will be presented below.

8.3.2 Supply of Raw Material

In the production of fuel ethanol around the world, approximately 61 % of the raw material is sugar crops; the remaining 39 % is produced from grains, mainly corn. The raw materials are largely used for foods which mean that only a small amount of produced raw materials is available for ethanol production. This results in competition for the crops which is played out on four markets; the domestic and export market for the crop and the domestic and export market for fuel ethanol. There are however opportunities for ethanol thanks to the fact that it can be produced from a number of raw materials, e.g. being able to take advantage of excess production of some grains. This results in low prices and has occurred in, for example Italy and Germany where wine alcohol and rye was offered to ethanol production. This means that the price of raw materials can be affected by different action plans. [90]

The European Union implemented a common agricultural policy in 2003 which meant that the income support for farmers was separated from the crops that was produced. This means that farmers can freely adapt their production to the increased demand for energy crops. In this reform, a specific support for energy crops was introduced as well as the possibility of using set areas for growing these crops. [29] The separation of income support from type of crops means that farmers can grow whatever pays best at the moment and still get support from the EU which in the long run means that prices drop as supply increases. This could be a good opportunity for European ethanol production that has trouble competing with imported ethanol due to, among other things, high prices of raw material.

In Europe today, ethanol is produced from three main crops; sugar beet, corn and wheat [29]. To achieve the goals of a 13 % share of all transport fuels, a lot of raw material is required. To visualise how much crops will be needed and how large these amounts are compared to current production, calculations have been made. The results of the calculations are presented in Table 8.1.

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| | Yield (l/tonne) [90] | Amount needed (million tonnes) | Amount produced in 2005 in EU25 (million tonnes) [62] |
|------------|-------------------------|-----------------------------------|--|
| Wheat | 384.6 | 306 | 124 |
| Corn | 387.6 | 304 | 21 |
| Sugar Beet | 97.1 | 1214 | 132 |

Table 8.1 Overview of future demand of ethanol crops compared to current production.

To be able to produce the amounts of ethanol needed to achieve the EU biofuels goals, production of raw materials needs to be increased substantially. Even if all the wheat that is produced in Europe was used for ethanol production, wheat production needs to be increased about 150 % in the next 20 years for ethanol supply to be sufficient. Corn is not such a common crop in Europe today which means that the increases in production will be pronounced, almost 6 times larger by 2027. Even sugar beet, which is stirring up controversy already today for its uneconomical farming in the EU, will have to be produced at significantly higher volumes. A production 10 times the size of today by 2027 is needed, if all sugar beets are dedicated to ethanol production. To decide whether this production increase is plausible, available agricultural land and land use will be assessed below.

8.3.3 Land Use

As a result of future needs for ethanol, larger agricultural areas will be needed to produce the raw-material for vehicle-fuel. If the target of a 13 % proportion of biofuels in 2027 shall be met with only European-grown crops, significant parts of the land area will have to be used for this sole purpose. Today, almost half of the landscape in EU25 is used for agriculture, and is thus the dominating type of nature. [22] This represents 97 million hectares of agricultural land available in EU25. In 2005, 23 million hectares was used for growing wheat, 6 for corn and 2 for sugar beet [62].

The Swedish Board of Agriculture has presented numbers regarding yield for these crops. One hectare of land can produce 5.9 tonnes of wheat, 8.4 tonnes of corn, or 60 tonnes of sugar beet [90]. These numbers have been cross checked with actual numbers of yield and land use in 2005, and they seem accurate [62]. If all available agricultural land was used for wheat production 50 % of available European agricultural land would have to be used solely for ethanol production. Ethanol production from corn would demand less use of land. To reach the 2027 goal, 37 % of agricultural land would be needed. The crop with the most potential regarding land use is sugar beet, due to the high yield per hectare. 21 % of available agricultural land would be sufficient for achieving the goals, by substituting all fossil fuel solely with ethanol.

The question of land use is unfortunately not that simple. Except from producing biomass for biofuels, land is needed for agricultural crops (i.e. food-products), pasture for livestock, forests, and other land uses. [101] The availability of land to grow energy-crops on is often seen as a constraint and causes conflicts with other land-use

requirements. For example, food-production should be of higher priority as of the fact that under-nourishment still is a large problem in some parts of the world [133]. There is however a possibility to import food or food crops rather than ethanol or ethanol crops and use the European crops for ethanol production instead.

If all wheat, corn and sugar beet that were produced in 2005 would be used for ethanol production, ethanol yield would be 80 billion litres which is about 38 billion litres less than needed to replace 13 % of the energy consumption in transports in 2027. When the amounts of wheat (48.5 million tonnes), corn (3.8 million tonnes) and sugar beet (104 million tonnes) that is demanded for human consumption is subtracted from the total possible production, the ethanol yield will be approximately 50 billion litres. This is almost 70 billion litres too little for the 2027 target. Large amounts are needed for fodder however, which means that the amounts of feedstock available for ethanol production are a lot smaller and would result in significantly less ethanol. There is also the dimension of the growing population which means that larger volumes of agricultural products will be needed in food production in the future.

The conflict regarding land use also includes the questions about effectiveness in use of biomass as an energy-crop. Some studies show that generating electricity from biofuels creates more useful energy per area than it does when the fuel is combusted in an engine [59]. From an over-all energy-perspective, there are conflicts associated with the use of land for biomass production, such as using the land for wind farms or solar photovoltaic installations. The different options for energy production should be evaluated with respect to the energy-production in relation to their land use, for optimisation of the comprehensive energy-supply in Europe. [116] The use of land as agricultural production area causes emissions of greenhouse gases, such as carbon dioxide and nitrous oxide [59]. Carbon dioxide is released from soil when organic matter is biodegraded. This process is speeded up when the land is being ploughed, especially if the land is fallow since it is rich in organic matter. The switch to biofuels could therefore result in significant greenhouse gas emissions, especially if the change demands large areas of fallow land to be used for biomass production. [58]

8.3.4 Discussion

The numbers presented above show that it is possible to reach biofuels targets in the EU with domestic production, although it would require significant areas of land and significant change in the choice of crops and land use which could lead to land depletion, emissions of greenhouse gases and reduced biodiversity. Even the most land efficient crop, sugar beet, would require 20 % of available land by 2027, land that might be put to better use.

The risks regarding security of supply of European fuel ethanol are that the fuel is too expensive to the customer or too expensive to produce for various reasons, that subsidies and supports are decreased so that no fuelling stations will install ethanol pumps, that tariffs and duties are reduced so that European ethanol can no longer compete and that there is not enough raw material. Other threats could be reductions in subsidies, or fierce competition with other products, e.g. foods. Without subsidies,

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farmers will have difficulty getting economy in their business and might stop production in favour of other crops or businesses. The competition for raw materials with other products is a threat both because it will increase prices and because products like food will be more important.

The supply can however be secured with the help of the EU and its member states which is an extremely important stakeholder in this context. They can stimulate the growing of crops by keeping up the subsidising of crops for ethanol production until production is fully established. They can also grant money for research so that the production processes can be improved. Further, interest groups and trade associations that work for the farmers are powerful and have influence on the agricultural policy in the EU. Domestic farming is a prioritised issue within the EU. Another way for individual member states to help secure supply is to help finance ethanol fuel pump installations. If there are pumps available there will be increased pressure on suppliers to deliver ethanol. This could at first lead to higher prices if producers need to buy more expensive raw material but could initially be helped by tax reductions and tax exemptions in order to lower the prices to the customer. In the long run, it should however lead to increased pressure on developing more efficient production processes. Production will then be cheaper and it could make it possible to get more ethanol out of the raw material. However, if there still is a lack of ethanol, the EU can reduce tariffs so that ethanol from countries with cheaper production can be imported to supply Europe with fuel. This raises the question of what is most important, supplying Europe with ethanol or supplying Europe with European ethanol. Legal actions can also be taken to secure the supply of that product, e.g. allocate fixed volumes of raw material to certain products. The EU can also use preventive measures to stimulate the production of raw materials used for fuel ethanol. These measures could be monetary as well as legal, forcing production away from crops that are excessively produced in the EU. Since there is excess production of many crops in the EU [92], this could shift production away from those crops that are likely to end up dumped on the world market anyway, and steer production against something useful instead. Security of supply is extremely important for ethanol's chances of becoming the new alternative fuel standard. Distortions in the supply chain will inhibit the installed base to grow; it can even cause it to reduce which would send devastating signals to the market.

There are also threats against getting access to the land needed in order to secure supply of agricultural products. There is a possibility that land use might be subject to quotas which means that certain amounts of land will be earmarked for certain production, may it be for food, fodder, biomass for electricity or wind farms to substitute fossil fuels in the overall perspective. Land use issues might also result in restricting the use of fallow land in order to limit the release of carbon dioxides into the atmosphere. These threats are not necessarily negative for the European economy or environment; they are simply threats to the supply of European ethanol.

One can certainly say that the production of fuel ethanol in Europe comes with a number of issues in many stages of the supply chain. This does not mean that ethanol is unfit as a new standard fuel for European vehicles but it could mean that the EU

should look around to find other ways of getting ethanol to the European roads, i.e. imports from countries that are better suited for ethanol production thanks to warmer climate and cheaper labour. Even though this moves the issues to other parts of the supply chain, e.g. increased emissions in long transports, it is worth considering. At least until Europe can produce ethanol from more efficient crops by more efficient production processes as processes can absorb the effects of risks in the supply chain [91].

8.4 Substitute Direction

This key uncertainty factor was from the beginning two; vehicle competitor direction and fuel substitute direction. They were combined because vehicle competitor direction is highly dependent on the direction of fuel substitutes since no new vehicle will be developed unless there is a fuel ready that it can run on.

There are a number of alternative fuels, both fossil and renewable, under development, many of them with equal or even better potential than ethanol of becoming a new alternative fuel standard.

Biodiesel

Biodiesel is the most commonly used biofuel in the EU and is often used as a diesel blend [89]. It is a synthetic diesel fuel that is produced from fatty feedstock, e.g. soybean oil and recycled cooking oil. It is more expensive than conventional diesel, but an important advantage is that it can be used in existing diesel engines since it is very similar to conventional diesel. This means that vehicles need no or only small adjustments, an advantage for both vehicle owners and producers. The use of biodiesel (B20 or higher concentrations) leads to substantial reductions in emissions of carbon monoxide and particulate matter. [152] However, NO_x emissions tend to increase with the use of biodiesel. Greenhouse gases are reduced to approximately half, compared to conventional diesel.

Methanol

Methanol, the simplest alcohol, is also called “wood alcohol.” It is usually derived from natural gas, but can also be derived from coal or biomass. As a motor fuel it has many benefits, but also many drawbacks. One concern with methanol is its high cost compared to petrol. In addition to the fuel cost, incremental vehicle cost is higher with the use of methanol due to higher vehicle prices and significant corrosion. Another barrier to the wide use of methanol is the lack of fuelling infrastructure. [152] However, existing gasoline tanks and pumping equipment could be easily converted to store and deliver methanol. Another key performance drawback with methanol vehicles is a reduction in vehicle range. A key benefit is the improved general environmental performance compared to petrol vehicles. [152]

Methanol could be considered to be the main competitor to ethanol since it can be produced from the same raw material. Some experts mean that it is much better to use biomass to produce methanol with gasification technology than to produce ethanol with fermentation technology since it yields twice as much fuel per tonne raw

material. There are dependable methods for methanol production from coal but no large-scale production sites for methanol from biomass in the world today. [13]

Biogas

Biogas is produced by anaerobic decomposition of organic material. It can be either produced in dedicated facilities from organic wastes or recovered from municipal solid waste landfills. The biogas that is produced consists mainly of methane and carbon dioxide [89]. The recovery of biogas is therefore important not only as a resource, but also for avoiding the discharge of a greenhouse gas in the atmosphere [12], a certain amount of leakage is however inevitable [132]. It is commonly stated that the use of biogas emits 70-95% less carbon dioxide compared to conventional fuels in light vehicles and 50-90% less in heavy vehicles [132]. It can even lead to negative greenhouse gas emissions if the biogas is recovered from certain waste such as liquid manure [42]. Another benefit of using biogas is its cost compared to conventional fuels; it is about 15% cheaper than petrol per energy unit and about the same price as diesel [135]. The vehicles are however more expensive to buy due to the required tanks.

Electricity, Hybrid Technology and Fuel Cells

An electric vehicle is powered by an electric motor, as opposed to an internal combustion engine. Rechargeable batteries supplies to the engine with energy. When the vehicle is not being used, these batteries are recharged. There are no emissions from the vehicle because no fuel is burned, which makes the vehicle a zero emissions vehicle. However, the production of the electricity that fuels the vehicle results in emissions. When the entire fuel life cycle is considered, pollutant emissions from electric vehicles are low relative to gasoline vehicles but varies a lot dependent on how the electricity has been produced. Electric fuel is significantly less expensive than petrol, but the vehicle is more expensive to buy due to the batteries which are very expensive to produce. Another drawback is the infrastructure which involves some major issues. For example, with existing technology, only a few vehicles can access a single charger in one day since it takes between 3 and 8 hours to recharge, as opposed to a petrol or ethanol pump which can serve a new vehicle every few minutes. The short range of the vehicle is also an issue. [152]

Hybrid electric vehicles combine a petrol or diesel engine with an electric motor that uses the energy from breaking to recharge the batteries [132]. This means that the vehicle has high fuel efficiency and low emissions while avoiding some of the problems associated with pure electric vehicles. Most hybrids operate solely on conventional fuel, with the engine providing power to the wheels and to an electric generator simultaneously. Therefore, hybrids can be fuelled as quickly and conveniently as conventional vehicles, while achieving even longer ranges. [152] The models that are on the market today have a fuel consumption that is approximately 40% less than that of a corresponding petrol model [143].

Fuel cell vehicles uses a chemical reaction (as opposed to combustion) to produce electricity to power an electric motor. Unlike a battery-powered electric vehicle, fuel cell vehicles have a fuel tank which eliminates the long recharging time. These systems can be very efficient, although the technology is far from commercialisation

[152]. The greatest challenges that the technology is facing at the moment is to find a way to safely and space-efficiently store the energy carriers in the vehicle and to cut costs. Fuel cell vehicles are expected to be on the market in a few years but only to niche applications. The major benefits with fuels cells, if fuelled with hydrogen, are that they basically only emit water and that they can use the fuel very efficiently. [143]

LPG

Liquefied petroleum gas (LPG) is a by-product of natural gas processing and petroleum refining. Because the components of LPG are gases at normal temperatures and pressures, the mixture must be liquefied for use in vehicles. LPG is a commonly used alternative fuel, used in both light- and medium-duty vehicles and has high energy content. [152] The infrastructure is quite extensive in many countries across Europe, especially in Germany, Italy and France who has about 4500 fuelling stations combined.[69] Regarding environmental benefits, LPG emits about 20% less CO₂ than petrol but about the same as diesel, according to a British study. It does however only emit considerably less NO_x and particulates than diesel, 95% and >99% respectively. There is also the benefit of by-products coming to use. [17] Fuel costs for LPG are more or less the same as petrol. The price of the vehicle is however higher, mostly due to the high pressure fuel tank that is required. Another disadvantage is the vehicles decreased range compared to petrol vehicles. [152]

Natural Gas

Natural gas is a fossil fuel, produced either from gas wells or as a by-product of petroleum production. Since it is used extensively in residences and by industry, it is widely available. Natural gas must be stored onboard a vehicle either as compressed natural gas (CNG) or as liquefied natural gas (LNG). CNG is most common for light-duty vehicles, while both CNG and LNG are used in heavier vehicles.[152] The European infrastructure for natural gas is quite extensive, with for example more than 1 000 CNG fuelling stations in France and more than 1600 in Italy [69]. However, for countries that are not connected to the European natural gas grid, investments in infrastructure would be so significant that they are unlikely to happen if they are only aimed at distribute CNG. LNG on the other hand is transported in tanks and could therefore be an alternative in these countries. Natural gas is a relatively inexpensive fuel but equipment costs are quite high. The environmental performance is good and show significant reductions compared to petrol vehicles on NO_x (30% less), CO (80% less). [152] Greenhouse gas reductions are at the moment quite low with these fuels and even if improvements are expected to be made, the difference between diesel and CNG/LNG is quite small [42]. A major disadvantage with natural gas vehicles is their significantly shorter range. Therefore, natural gas vehicles have been popular for use as delivery trucks or other fleets that operate more locally. [152]

DME

Dimethyl Ether (DME) is another fuel which is most commonly produced synthetically from natural gas but can also be extracted from other fossil fuels such as coal, oil residues, biomass and black liquor. It is a colourless gas in room temperature but can easily be handled and stored in liquid form and is then very similar to LPG.

The production process is very similar to that of methanol but has a higher cetane number, which allows it to perform better as a diesel fuel. When used as a diesel fuel NO_x – emissions are reduced but CO- and HC- emissions tend to be higher but can be easily controlled by an oxidation catalyst. The greenhouse gas emissions are highly dependent on how the fuel is produced. DME from biomass has proven significant reductions compared to diesel while DME from coal could emit more than twice as much as conventional diesel. Because the characteristics of DME are so different from diesel, the entire fuel system needs to be redesigned and a pressurised fuel tank is needed. The production processes are currently under development so many things are still uncertain. The fuel is expected to cost about the same as diesel if it is produced at large scale from fossil fuels. DME from biomass is expected to cost about three times as much as diesel. [37] This is the alternative fuel that Volvo ventures into at the moment and they have even invested in a black liquor gasification company [71].

Oil

Oil based products constitute the majority of all fuels in transport. It is being challenged by other alternative fuels in order for nations to reduce reliance on fuel imports and protect the environment from emissions. The oil industry does however have powerful advocates and lobbies for continued production. Combined with a development of more fuel and emission efficient vehicles, petrol and diesel still stands a chance on the fuel market.

8.4.1 Discussion

There are many competitors in the fuel standards race and there are both advantages and disadvantages with the different alternatives. One of the most general disadvantages is their shorter range compared to petrol and diesel, which is due to lower energy content. This makes the fuel quite unfit for long haulage vehicles. The gaseous fuels also have the disadvantage of expensive tanks and equipment which leads to high initial costs. This is however outweighed by cheap fuel prices. One should remember that, since many of these fuels are not on the market yet, all of their disadvantages may not yet have been discovered as they have been with ethanol which has been around for a while.

Even the alternative fossil fuels seem to have better environmental performance than petrol and diesel, with reductions in greenhouse gas emissions, NO_x and particulates. The savings are however dependent on fuel production processes and driving. For example, electric vehicle emission over the whole life cycle is very dependent on how the electricity is produced, hybrid vehicles are more beneficial in city environments since the traffic results in a lot of breaking, and biogas needs to be produced in such a way that emissions are controlled. The most exciting alternative to reduce emissions is fuel cells and hydrogen technology which basically only emits water and requires very little fuel. The technology is however far from mass production which makes time and cost major issues. If methanol or DME can be further improved in terms of cost, production processes and infrastructure, it could be an interesting alternative if the estimated properties regarding yield per unit of raw material and lower costs can be exploited.

Ethanol does not only compete with other alternative transport fuels but also fuels for other energy production from biomass since they compete for the same raw material. Therefore, Europe needs renewable fuels that can be produced at a low cost with raw materials that give high yields and requires small amounts of land for growing. The EU and the market is however very eager to start the substitution of fossil fuels and might not be patient enough to wait for the best alternative to be developed but might settle for an alternative that is good enough. Other conditions than technological superiority are often decisive in setting a new standard which could make timing, powerful advocates and strong allies crucial for success.

8.5 Strategic Alliances

A strategic alliance is a “long-term co-operative arrangement between two or more independent firms that engage in business activities for mutual economic gain” [70, p.391]. These arrangements can help companies to create competitive advantage and do often take form of joint ventures, licensing agreements, supply chain agreements or joint programmes for research and development.[88, pp.612, 616]

Strategic alliances lead to reduced risk and lower product development costs. It can also be helpful in trying to access new markets or distribution channels and companies can gain new knowledge and skill from a partner. [88] The concept of strategic technology partnering means that companies cooperate in the development of new products and technologies. A technology alliance is one way of getting access to new competitive technologies and to reduce the risks and costs associated with technical ventures. [88] The aim can also be to work jointly with lobbying for standards or patents [32]. Through cooperation, companies can learn from each other, accelerate the development of capabilities and reduce uncertainties that come with changes in technology [88].

Despite the potential for strategic alliances, many of them fail. One major contributor to this is tension between cooperation and competition and the risk of losing core competence [32]. Gil and de la Fé state that one problem with technology alliances is that the alliance consist of one student company, i.e. the learning company and one teacher company, i.e. the company with valuable competence. Such relationships often lead to a dependency situation, where the student is dependent of its teacher. Another reason for the absent success is the lack of a well-defined strategy. [88] Bronder and Pritzl call this phenomenon *strategic fit* and mean that the strategic alliance and the goal for the cooperation must be based upon both companies' overall strategies. The companies' business plans must harmonise regarding the strategic goals on value potentials, products, markets, regions and time frame. In addition, the strategic alliance must offer *fundamental fit*, which means that the companies' activities and competencies complement each other so that value is increased. Third, the companies' *cultural fit* should not be ignored, i.e. the two corporate cultures have to work well together, for the alliance to become successful. [19]

The process of selecting a standard is controlled by social, political, and organisational interests. These actions can be performed by strategic alliances that

have a collective stake in standard setting. [3] Support from allies is of high importance when companies venture into new technology with the aim of making it a standard [130]. As mentioned above, the risk and cost is reduced and the ability to adapt to changes is improved, which is helpful when managing the uncertainties in the external environment. **Scania** cooperates with the Stockholm Public Transport Authority (SL) in a project for fuelling 400 buses in the city of Stockholm with ethanol. Other stakeholders in this project is Baff (BioAlcohol Fuel Foundation), Sekab (Svensk Etanol kemi AB), Stockholm County Council and the City of Stockholm.[50] This way all important resources are secured: **Scania** provides the ethanol bus, Sekab produces and delivers the fuel ethanol and there is an automatic demand for transport with ethanol buses through SL's customer base. This means that the risk for all actors has been minimised and the project can be considered to be a successful cooperation.

8.5.1 Discussion

Strategic alliances can be successful if strategic, fundamental and cultural fit is achieved, dependence situations are avoided and there is a good balance between cooperation and competition. Finding the right strategic partner is thus of great importance. The alliance can then lead to competitive advantages, avoided risks and costs as well as the ability to set standards. Also, the uncertainties in the environment can more easily be dealt with, which characterises the situation for **Scania** and fuel technology. **Scania** can choose to go into ventures on its own or find support from a related stakeholder. Competitors who adapt the same or a similar technology to **Scania**'s do not have to constitute a threat, but is rather helping to increase the size of installed base and supply of complementary products. This way, the fuel station infrastructure is more likely to evolve to suit the fuel that **Scania**'s vehicles run on and the chances of setting standards are improved. Forming an alliance can cause a dependence situation or be restricting, in case the alliance partner is unable to expand its business fast enough to satisfy increasing demand. One should also be aware of the possibility of competitors forming alliances which can constitute a threat against **Scania**.

8.6 Financial Control Systems

Taxes, tariffs and subsidies are three uncertainty factors that are merged into one key uncertainty factor, namely financial control systems. The ethanol industry has been subject to a lot of criticism because of its reliance on financial aid from both the EU and its member states. This aid comes in the form of subsidies to fuelling stations for installing ethanol fuel pumps [108] and to farmers who grow crops, in the form of tax exemptions for "environmentally friendly" vehicles and in the form of tariffs to make imported ethanol more expensive and less competitive [123].

Financial control is used by authorities when the signals sent to the actors on the market are unwanted [21]. The objective of financial means of control is to put a price on the wanted effect of the control system [21] and to imitate the mechanisms of market economy [114]. The economic mean of control thus creates an incentive for the consumer to change behaviour or an income for society in case the consumer prefers to take the cost, which theoretically can be used for restoring the exploited

natural resource. [114] Another way to create incentives is subsidies, which is a financial support from the authorities. This is, for example, investment-support or eliminated tax on renewable fuels and aims to encourage consumers to change behaviour in the direction the authorities wishes to. [21]

The member states of the EU are in general using fiscal policies to promote the use of ethanol and the like. The fiscal policies mean that a member state can decide to reduce or exempt biofuel tax. Such changes do not need approval from the European Commission as long as some conditions are being followed. Tax reduction or exemption is instead subject to state aid control. [29] The price on fuel is mainly dependent on national taxes, which together with excise duties make up the major part of the price. By reducing the relative tax-burden for biofuels compared to oil-based fuels, the consumption is stimulated as well as the production of biofuels. [55] Thirteen states in the EU have received state aid approval for biofuel tax exemptions since 2005. In 2005 and 2006 many states also introduced biofuel obligations which mean that the fuel suppliers are incorporated to include a certain percent of biofuels in their total amount of products that they place on the market. [31] This system is an attractive solution for many countries since it overcomes practical problems and difficulties that are associated with tax exemptions and makes it possible to reach the targets cost efficiently. One of those problems is that the Energy Taxation Directive limits the duration of tax exemption to six years, which creates a great deal of uncertainty for investors [29].

For biofuels to be competitive alternatives today, they need help from financial control systems, either as taxes and fees imposed on those who choose not to drive an environmentally friendly vehicle, or as subsidies to those who choose to do just that. Subsidies are also needed for raw material used in ethanol production to make it an economically viable alternative and to help improve infrastructure. For European biofuels to stand a chance in the competition with corresponding foreign fuels, tariffs need to be imposed. This constitutes a huge uncertainty for the fuel since it loses most of its competitive power if all financial support was to be stopped in the near future, which automatically makes it an uncertainty for the ethanol vehicle industry.

8.6.1 Discussion

The financial control systems cost our society a lot of money, so there is a lot of truth behind the criticism against ethanol today but the fact is that EU tax exemptions and subsidies are aimed at all biofuels as a whole, not at ethanol specifically [29]. The same goes for subsidies to the agricultural industry. Both biogas and ethanol fuelled vehicles are exempted from CO₂ tax in Sweden [123], corn for food receives the same subsidies as corn for ethanol or biodiesel production and the subsidies to fuelling station is not a fixed sum which would benefit cheaper installations but adjusted to the cost of the investment [125]. Thus, there are no specific benefits for fuel ethanol. So, the reason for why it has seemed to benefit ethanol in particular is because of the choices that the stakeholders that are subject to the financial aids and control systems made themselves. That means that market powers rather than financial control systems have steered the biofuel market towards ethanol. Therefore, the focus on ethanol in the discussions regarding financial control systems is not quite fair. The

criticism might definitely be just, but only if it is aimed at the control systems as a whole, since all biofuels have the same opportunity to take advantage of them.

The fairness of tariffs is also questioned quite heavily. In deciding whether it is just or not, one must look at the goals that are at the top of the agenda. If fair trade and an open world market for biofuels are the goals, tariffs are most definitely wrong. But, if European fuel self sufficiency is on the top of the agenda, tariffs are vital in order to secure European production. However, as production processes are improved, new sources of cheaper raw materials can be used and especially if ethanol will be set as a standard with the volumes that it conveys, ethanol will increase its ability to be competitive on its own.

8.7 Debaters and Lobbyists

Media and the debaters that make their voices heard in TV and news papers have an impact on peoples' attitude towards an issue and can affect public opinion. Mass communication, as well as interpersonal communication, is an important tool for political information and for changing political attitudes. [5] Lobbyists on the other hand have influence on authorities through communications between organised stakeholders and state actors [107]. Dominant interest groups can thus affect the outcome of important decision or legislative processes [98].

8.7.1 Influence from Debaters in Media

For ethanol to gain market share and become successful, support from consumers is necessary. The consumers are citizens in for example the European Union and each person can be more or less affected by the messages in debates on TV or in papers, dependent on their political awareness. People who are less politically aware are likely to be affected by and change their opinion dependent of messages in media. Politically sophisticated people tend to be affected by interpersonal communication instead. This is valid for one sided communication, which are messages that provide a consistent directional favouritism. Two-sided message flows have no proven effect on peoples' opinions. [141] The exposure of fuel ethanol in media has not been entirely one-sided, even though many critical voices have been heard in Swedish television and papers recently. A continuing flow of negative messages can thus affect the public opinion towards fuel ethanol negatively and decrease the over all support from consumers. Reversely, the attitude against ethanol can be more positive if media provide all the pros with the fuel.

8.7.2 Influence from Lobbyists

Industrial groups have more lobbying power over policy making than for example environmentalists and consumer organisations, due to their size and budget [98]. Lobbyists work through interest groups that are incorporated in a policy making or policy implementation process, for example through membership of boards, councils, committees and the like or consultations and other formalised contacts. Lobbyism can also be based on informal relations between organised interests and authorities and is based on an initiative from the interest organisation. [107]

Woll (2007) states that trying to determine power or influence of an interest group is problematic since it can not be measured and is context specific. Instead the focus should be on the interest groups' resources and the interdependence of both sides that this creates. That is more visible and easy to examine and helps to understand the evolution of long term relations between businesses and government. The influence of an interest group depend on its resources and how it can be used to create pressure on or access to those who have control over legislation and decisions. Actors with a good resource base will try to create a long term relation with governments while those with fewer resources focus their efforts when issues actually are at stake. An actor who is able to maintain a stable relationship can reach a higher level of political power than for example consumer groups who have access to less resources. Successful lobbying depends on the governments' receptiveness to the demands, which is decided by what strategic advantages they can see for themselves. These advantages consist of access to resources that typically are financial resources, social capital, legal or technical expertise or other useful information and media campaigns with focus on public opinion. [150]

8.7.3 Discussion

Promoting ethanol to consumers, the public, governments, and legislators will have significant influence on the establishment and future of fuel ethanol, as well as the possibility of setting a standard. The stakeholders who have a particular interest in any of the dimensions that are affected by ethanol are likely to try to influence relevant authorities. The most influential will be those who are of considerable size and who has enough resources to create access to the legislators. For **Scania** it will be important to provide a clear message on their preferences and to communicate this on their own or through the interest groups who advocate them. This will have better effect the stronger the interrelationship between the company and government is. The European citizens on the other hand can be affected by the contents in media and for **Scania**, a lot of positive articles would naturally be the best scenario. At present, the message is mostly negative and this is likely to affect the attitude negatively, unless the debate becomes more nuanced. It is likely that negative messages make people more interested and that catastrophic and disastrous pictures that are given of ethanol are absorbed more easily and remembered for a longer time. Since positive customer attitudes are absolutely vital for a fuel to succeed and gain market shares, negative publicity can make it difficult, if not impossible, for ethanol to become successful. Positive publicity can on the other hand increase customers' willingness to pay a little extra for the fuel and accept shifting costs that can be associated with starting to use a new vehicle fuel.

8.8 EU's Future and Power

As stated in the section of legal control systems, in a world of uncertainty and incomplete knowledge, rules are necessary. But for these to function, the institution needs to be credible and stable [113]. This means that for the control systems to work, both legal and financial, the institution behind them, i.e. the EU, needs to be credible.

There is a growing dissatisfaction with the EU and its policies. The new EU constitution was rejected by both France and the Netherlands in 2005 which

disappointed many people within the EU who believed that the new constitution was necessary to get the political and legislative structure that is needed for a union with 25 members [52]. It is also said to lessen Europe's competitiveness and weaken the EMU cooperation [136]. A major influence on the dissatisfaction is the alleged economical inefficiency, agricultural subsidies, inflation, unemployment and high consumer prices and excess production of agricultural products. The British Prime Minister Tony Blair said in 2005, that the whole EU is in a state of crisis after the Dutch and French rejection of the constitution, due to a widespread frustration with the EU. [52] The EU could however also become stronger and more influential. More and more member states are entering the union so the size in itself could make it stronger. Also, new members in the EMU could make the European currency stronger.

Another issue is the redistribution of power among states and markets. National governments are losing autonomy in a globalised economy. They share their political, social, and security power with businesses, international organisations, and a multitude of citizens groups. Resources and threats, including money, information, pollution, and popular culture are shared and shape economies without being limited by political boundaries. Even the most powerful states are experiencing that the marketplace and international public opinion is forcing them to follow a particular course. There are also a number of new threats that have proved to impact the markets and governments to a large degree, e.g. terrorism, organised crime and ethnic conflict, as well as the combination of rapid population growth, environmental decline, and poverty that breeds economic stagnation, political instability, and, sometimes, state collapse. [100]

8.8.1 Discussion

Rules and policies need a stable and credible foundation in order to have an impact on the market and if the EU continues to attract dissatisfaction, the necessary power and credibility will be lacking. In the extreme case, the union might be disbanded and all common policy ground will cease to exist which would certainly affect the current support for biofuels. The power relationships within the union might also switch, which could lessen the focus on biofuels to benefit whatever issues at the top of those governments agenda.

The EU could also loose power globally to other unions, regions and governments, even to individual organisations that appeals to the public, or uses other methods to get their message across. If these entities want to promote their pressing issues it could have a large impact on the European market, e.g. USA finds large oil depots on American soil and wants to promote a continued use of oil products, or Mercosur and WTO gains more power and forces the tariffs on South American biofuels to be abolished.

8.9 Technological Development of Fuel Production

Ethanol production in Europe today is expensive, emits large amounts of greenhouse gases and consumes a lot of energy and raw material. For ethanol to be a sustainable alternative to fossil fuels, the production processes generally need to be improved

since it is significantly less expensive to produce petrol than it is to produce an energetically equivalent amount of ethanol [2].

8.9.1 Ethanol Production Today

Nearly all fuel ethanol is produced by fermentation of glucose or sucrose, fermentation processes from any material that contains sugar could derive ethanol. The raw materials used for ethanol production are classified into three main types: sugar, starch and cellulose materials. Sugars can be converted into ethanol directly while starches first need to be hydrolysed to fermentable sugars by the action of enzymes. Most agricultural biomass containing starch can be used as potential substrates for ethanol fermentation, e.g. corn, wheat, oats, rice and potato. [95]

In ethanol production, grains are grounded into flour which is slurried into a mash and enzymes are added to convert the starch into dextrose. Ammonia is also added to control the pH and as a nutrient to the yeast. The mash is processed at high temperature to reduce bacteria ahead of fermentation and then cooled and transferred to fermenters. In the fermenters yeast is added to begin the conversion of sugar to ethanol and carbon dioxide, which generally takes about 40-50 hours. After fermentation, the resulting "beer", is distilled to 190 proof and then dehydrated to approximately 200 proof. Before shipment a denaturant, usually petrol, is added to make it undrinkable. [121]

There are a number of steps involved in the production of fuel ethanol which means that there are a number of improvement potentials. The following key issues concerning fuel ethanol production has been identified:

- Raw material – Consumption is high and supply is limited
- CO₂ emissions – Due to the production of ethanol itself and the production of energy required for production.
- Cost – High energy and raw material consumption leads to high costs. (Large volumes of fluid needs to be heated to high temperatures (140-180°C) numerous times which consumes a lot of energy and costs a lot of money [95]; enzymes are expensive and need to be improved.)

8.9.2 Development Potential

In ethanol production a lot of raw material is consumed, raw material costs are high and comprise more than 20% of production costs [95]. The high consumption is not only a problem because it is expensive but also because supply is limited. This leads to competition with other products that demand either the same crop or the land that the crop is grown upon as well as increased raw material prices. As land and supply are limited, further increases need to come from other feedstock, i.e. biomass [71]. Biomass and its use in cellulose ethanol production processes could be the future of fuel ethanol. There are various forms of biomass resources in the world which can be grouped into four categories [95]. *Wood residues* are currently the largest source of biomass for energy production and come from the wood product industry, e.g. paper mills, saw mills and furniture manufacturing. *Municipal solid waste* is the second largest source and is a good way of recovering organic waste products, e.g. newspapers, and attaining raw material for free or at a low cost. *Agricultural residues*,

for example wheat straw and corn cobs. These are currently wastes in the ethanol production process and could thus be used for production instead. *Dedicated energy crops* are a promising, future resource of biomass because it has the ability to obtain numerous harvests from one single planting which reduces the average annual costs for establishment and management.

In sugar crops the carbohydrate is simple sugars, in grains it is starch and in biomass it is cellulose. Just as with grains, cellulose needs to be converted to sugar before fermentation. There are three major steps in the conversion from cellulose to ethanol [71]:

1. Thermo chemical pre-treatment – Raw untreated biomass is very resistant to enzymatic digestion which requires a chemical pre-treatment that disrupts the plant cell wall and improves the enzyme's access to the substance.
2. Enzymatic saccharification – The cellulose is hydrolysed by enzymes to glucose.
3. Fermentation of the released sugars – Specialised organisms to convert sugar to ethanol and carbon dioxide.

Since cellulose is much more compact and complex than starch, it is much more difficult to degrade with enzymes to fermentable sugars. This means that the production costs for one litre of ethanol is higher in production from cellulose than production from starch. This is largely due to the cost of enzymes which are expensive and not efficient enough to make the cellulose production process cost competitive. Also, in the fermentation process the conversion into ethanol is less efficient when using cellulose than when grain is used due to the different characteristics of the sugar types. [71]

Cellulose is a good alternative for solving issues regarding lack of supply. Ethanol production from cellulose is however still at a laboratory stage, there are some pilot plants for ethanol production from biomass around the world, for instance in Örnsköldsvik, Sweden. With biomass, new sources of raw material; both plants, previously unusable parts of plants and production waste, are made available and waste from industries and municipalities can be reduced. However, for it to be a viable alternative, it needs to be less costly and tested for industrial use. There are also other downsides to using biomass, for instance increased warehousing costs [81].

There is great potential for developing the biomass industry in Europe. Calculations presented by the European Commission claim that the 2003 level of biomass production of 69 Mtoe could be increased to 239 Mtoe by 2020 and up to 316 Mtoe by 2030 without affecting domestic food production or put extra strain on the environment [29]. These numbers far exceed the goals for biofuels for transportation of 33 and 60 Mtoe by 2017 and 2027. Since transport consumes about 30% of all energy it would be possible to reach the overall goals for bioenergy substitution, with biomass, if these volumes can be produced and to a large degree be used in ethanol production. It is however important to remember that in all energy transformation, energy is lost along the way in the form of for example heat.

Another alternative to conventional sugar or starch ethanol production is cell-free ethanol production. Cell-free ethanol production only uses enzymes in converting sugar to ethanol and is said to be a more efficient than the microbial process. It allows for more flexibility in the process since it can operate at higher temperatures and higher ethanol concentrations which mean that the process conditions would no longer have to be constrained to keep the organism viable. It also gives more freedom to manipulate enzymes and alter enzyme levels. The main advantages are that ethanol can be made much faster and that enzymes can be recycled. The high temperatures could also make it easier to hydrolyse more resistant feedstock such as cellulose. [2]

This method has so far only been tested in labs which raises the question of whether it is really possible to improve production efficiency. It might for example not be economical to raise temperatures that are already high and constitutes a very costly step in the production process. It would however mean shorter lead times and lower enzyme costs, but there will probably be a trade-off between the three. Also, there seems to be a long way to go before production-efficient and cost-efficient enzymes will be developed.

There are also improvements to be made in starch ethanol production. New chemicals are being tried out in order to lower chemical costs which constitute a significant part of total costs as well as new kinds of enzymes and micro-organisms that are more efficient and resistant. Since ethanol has a toxic effect on yeast, the production of ethanol eventually slows down and stops but with other types of more resistant micro-organisms the production process could be prolonged, which would improve ethanol yield. Improvements in this area are however considered to be limited, which means that more research into new production processes is needed, e.g. cellulose or cell-free production. [2] One thing that can be done is recovering the waste from ethanol production and use it in, for example animal feed production and energy production to reduce the conflict with other users of raw material [71].

8.9.3 Discussion

It seems that in order to make ethanol production more cost-efficient, chemicals and enzymes need to be made cheaper, alternative raw material needs to be used and energy consumption needs to be lower. There are ways of achieving all these things by using waste products, lowering production temperatures, reusing enzymes and using cheaper chemicals, as well as reducing process times. These improvements can however not be implemented all in the same process simultaneously but will probably be further developed for different raw materials by different producers. Alternative raw materials is also a way of increasing raw material supply and reduce the competition between food and ethanol which could further decrease the price on conventional raw materials. Ethanol can also be produced in such a way that the waste from ethanol production can be used as animal feed and thereby share the resources with the former competitor for raw material. Lowered temperatures, i.e. lower energy consumption, will also decrease the greenhouse gases related to ethanol production. This means that there are ways to solve the issues concerning ethanol production today so that prices can be lowered and ethanol can become more competitive in comparison to fossil fuels. The question is only how long it will take

before these solutions are economically viable and can be put into industrial use. If it takes too long, other fuel alternatives might be viable which could mean that ethanol loses the standards race. But with the attention and financial aid brought to the industry by strong financiers and philanthropists, there is improved potential for getting there in time before interest has cooled off.

A continued development of fuel ethanol production requires large monetary resources and a lot of the research today is highly dependent on grants. Therefore, it is important that the EU, the individual member states and corporations continue to provide universities and companies with research grants. The increased interest in the industry has however pulled private equity and their funds are now important backers of different kinds of alternative energy. The good thing about private equity is not only that they can provide companies and researchers with money but also with knowledge and relationships with governments and other stakeholders as well as access to new markets [138]. Lately, financiers like Bill Gates have invested in ethanol production [10], which not only contributes with money but also attention and PR for the industry and its products.

8.10 CO₂ Capture and Storage

The technology for capturing CO₂-emissions and storing it is becoming more and more accepted and realistic [82]. CO₂ capture and storage (CCS) is one suggested method for stopping the increasing levels of greenhouse gases [83]. Commercialisation of this revolutionary technology could lead to a weakened focus on other measures that increase greenhouse gases, as for example the use of renewable fuels. This could in turn lead to decreased interest and demand for ethanol fuelled vehicles. However, if applied to the production of alternative fuels, the greenhouse gas emissions of the fuel can be reduced and provide very low emissions. These possibilities have so far been identified for DME, LNG, CNG and other natural gas applications [42].

Separating CO₂ from smoke emissions that is released during energy production can be done with a few different technologies. The most developed and cost-effective technique is to spray a solvent over the smoke which adsorbs the carbon dioxide. This is followed by heat-induced CO₂ recovery which separates the gas from the solvent. The solvent is then recycled and the gas is compressed and transported to a depot. [82] Pipelines can be used for transporting large amounts of compressed carbon dioxide. If long distance overseas transportation is needed, the gas can be shipped since this is less costly. [85]

Carbon dioxide can be stored in either the ocean or geological reservoirs. There are considerable uncertainties in research on ocean storage and it is further complicated by legal and environmental obstacles, as well as a lack in acceptance. Geological storage is offering some more realistic options that are safe and durable. Oil fields are well sealed and more or less leak-proof spaces which make them suitable for gas storage. Injection of carbon dioxide is done in many oil fields today, so that more oil can be recovered (Enhanced Oil Recovery). Oil and gas fields have a total storage capacity of 900 billion tonnes of carbon dioxide, even though gas fields are less

appropriate to use for this purpose. Some 15 billion tonnes of gas can be stored in black coal with a technique called Enhanced Coal Bed Methane. Carbon dioxide is then adsorbed into black coal which releases methane, a valuable resource. Another option that is currently being researched is pumping the compressed gas into deep saline aquifers. Experiments are currently being conducted in the North Sea. [82]

The CCS technique costs approximately 0,10-0,15 SEK/kWh of electricity which make the price on “clean fossil energy” comparable with the cost of renewable fuels [82]. The main future challenge is to reduce the cost. It will also be important to gain acceptance as a safe, reliable and long-term solution and it is of great importance to prove that losses are insignificant. [83] International legislation that is adapted to CCS and support the building of necessary infrastructure is another prerequisite for the establishment of the technique as well as improved technology concerning energy efficiency of the process [82].

8.10.1 Discussion

A considerable amount of CO₂ can be removed with CCS technology and make the greenhouse gas issue less problematic. The technology can also improve the chances of alternative fossil fuel gaining recognition as a good alternative. Such methods could therefore be a threat against renewable energy solutions, since it would reduce the need and demand for these fuel options. Ethanol and other biofuels could thus be substituted by a well developed and commercially available CCS technology which would lead to decreased interest and demand for ethanol fuelled vehicles. Nevertheless, many gaps in the knowledge on this technology are still remaining as well as public acceptance, legislative approval and economic issues.

8.11 Legal Control Systems

Legal control systems are used by authorities when the signals sent to the actors on the market are unwanted. Creating the wanted signals can be done with new laws and regulations. Examples of legal control systems are; a limit on cars' maximum allowed petrol-consumption per kilometre, a new law saying that all industries must have a filter which cleans the air-borne emissions from the industrial process and a ban on loud vehicles in city centres. [21] In a world of uncertainty and incomplete knowledge, rules are necessary. If the institution is credible and stable, a major function is that they reduce transaction costs of human interactions by making their behaviour predictable. [113] Rules are even more crucial for business activities since they provide the market with guidelines and help prevent anticompetitive behaviour and are often needed because the market has failed to move in a wanted direction by itself [68]. The substitution of fossil fuels and technologies is to a large degree driven by regulators and not the market place. They demand standards for emissions of air pollutants, alternative fuels and more stringent fuel economy standards. [97]

Legislation and policies regarding biofuels and transports are usually passed by the EU and therefore applies in all member states. The companies that are affected by these new laws often have a few years to adapt their products to meet new demands. Regulations however, differ from country to country and region to region, they can even differ in individual cities and municipalities. This fact makes it complicated for

vehicle producers who have multiple demands and requirements to consider when developing new vehicles and platforms.

8.11.1 Energy Policy and Goals in the EU

In January 2007, the EU Commission presented the objective regarding the future development of energy supply in Europe in combination with significant reductions of greenhouse gases. This proposal contained the following goals: By 2020 the emissions from developing countries should be reduced by 20 % compared to the level of 1990. By 2050 the global emissions should be reduced by 50 %, meaning that developing countries need to reduce their emissions with 60-80 %. [31] One part in trying to fulfil those goals is to introduce alternative fuels for energy production. EU's target is to replace a 7 % share of total energy consumption with biofuels by 2010. By 2020 a 20 % substitution of all fuels to alternative fuels should be realised. [54] The EU sees a potential in three types of alternative fuels, namely biofuels, natural gas and hydrogen. Each of the substitutes is expected to have the ability to develop up to the level of 5 % or more of the total automotive fuel market by 2020. [27]

The specific target for biofuels in the transport sector is a minimum proportion of 5.75 % by 2010, according to the directive on the promotion of biofuels or other renewable fuels for transport on May 8th 2003. The corresponding target for 2020 is 10 %. The goal for 2005 of 2 % was not met so development needs to speed up if the coming targets are to be reached. [29]

Another legal outline in the EU is the Euro framework. It was introduced as an emission standard, and specifies the maximum amount of pollutants allowed in exhaust gases discharged from a diesel engine in heavy-duty vehicles and buses. It includes maximum limits for emissions of carbon oxide, hydrocarbons, NO_x, particles and smoke. It also includes even stricter limits for so called enhanced environmentally friendly vehicles (EEVs), even though these are voluntary. Current rules are those of Euro IV which came into force in 2005 and engine development is now focusing on the new targets in Euro V which will take effect in 2008. [38] The exact limits for each emission are not yet established.

8.11.2 Discussion

Since the demand for biofuels and environmentally friendly vehicles is driven by legislators and regulators to a large degree, the ethanol fuel market will initially be dependent on continued support from them and continuously stricter laws and regulations. A sudden shift in legal support for renewable fuels would change the prerequisites for ethanol's ability to be competitive significantly. However, if the installed base gets bigger there is an increased possibility for the fuels and vehicles to drive the market themselves. The problem is that the size of the installed base is growing quite slowly.

The EU energy policy constitutes a great opportunity for biofuels in general, since it encourages the use of them but the problem is that they are not forcing which makes the transition to biofuels quite slow. It might be a good idea for the EU to make them

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forcing if results really are to be seen. The EU might also change its focus to set rules for vehicle makers to lower emissions from standard engines instead of being committed to biofuels.

9 Step 6 Choose Themes and Develop Scenario Details

After the thorough examination of the key uncertainty factors in Step 5, the Scenario Planning will continue. In Step 6 the deepened knowledge about the uncertainties will be used for choosing themes and developing scenario details. This step starts by determining how many scenarios that should be developed. Then, a theme for each scenario will be selected as a guideline for the contents of the scenario. This will be followed by a subjective projection of the factors under each theme in a top-down fashion which will create a description of the scenario that is consistent with both the theme and the timeframes.

The recommended number of scenarios in a scenario plan is 2-4. We chose to develop 4 scenarios in order to get a more extensive and varied perspective of possible future outcomes. We also wanted to make sure that there were enough scenarios so that all key uncertainty factors will have room to be of importance.

In order to select meaningful themes we decided to construct a 2×2 matrix, divided by two axis and chose to use the top two uncertainties as a foundation for creating the themes for each axis. We believe that technological development of either fuel ethanol or substitute fuels and the focus on greenhouse gases are what really drive the future of fuel ethanol. A continued environmental focus is vital for the interest in ethanol and technical improvements is vital for ethanol to be considered a sustainable and environmentally friendly alternative.

Each field in the matrix constitutes a scenario and a theme for each scenario was chosen. The themes are meant to clarify the outcome of each scenario and are as follows:

Loss in Standards Race – There will be a continued focus on greenhouse gas emission but ethanol will loose the standards race to other alternative fuels which are developed so that the customers perceive the alternative fuel as superior.

Knock-Out – There will be a continued focus on greenhouse gas emissions and ethanol will be further developed in terms of production processes and raw material and can be considered to be a sustainable alternative fuel. This will make customers positive to the fuel and ethanol will come out of the standards race as winners.

Respiratory Success – The interest in greenhouse gas issues will fade but the EU and other stakeholders are finding other reasons for keeping the ethanol production venture alive, e.g. self sufficiency of fuel products and oil independence. Therefore the development of raw materials and production processes will continue in order to make the fuel a competitive alternative.

Return of the Fossils - The interest in greenhouse gas issues will fade and there are no major improvements in fuel ethanol production. This will shift the focus back to fossil fuels, e.g. petrol, diesel and natural gas, since there are no major advantages with ethanol and therefore the fossil fuel processes will be improved.

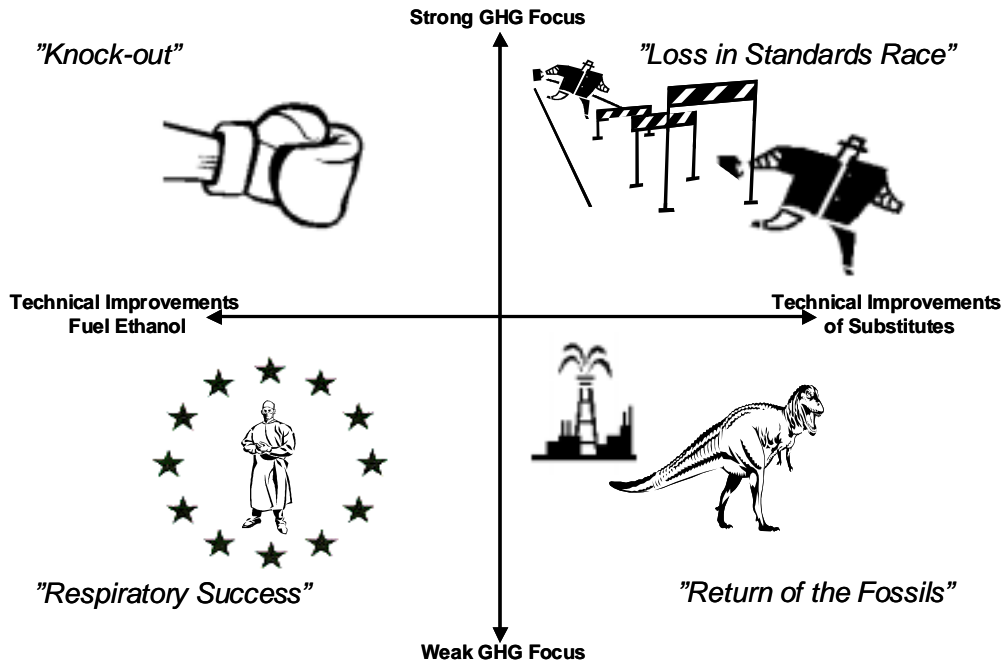


Figure 9.1 Scenario themes

When the themes had been chosen, all key uncertainty factors and their respective impact was assessed under each theme in order to describe the outcomes of each scenario. The uncertainty factors that are deemed *not important* will be excluded from the scenarios in order to make the scenarios more concise and focused on what is really important. The assessments are expressed as short comments and are presented in the table below.

Ethanol for Scania's Future? – A Scenario Based Analysis

| | Loss in Standards Race | Knock-out | Respiratory Success | Return of the Fossils |
|---|---------------------------------|------------------------|----------------------------|------------------------------|
| Greenhouse gas | Important | Important | Not important | Not important |
| Other environmental consequences | Important | Important | Important | Important |
| Fuel ethanol supply chain | Disturbed | Improved | Improved | Not important |
| Substitute direction | Successful (alternatives) | Failure | Failure | Successful (fossils) |
| Strategic alliances | Ethanol excluded | Ethanol included | Ethanol included | Ethanol excluded |
| Financial control systems | No support for ethanol | Support for ethanol | Strong support for ethanol | No support for ethanol |
| Debaters and lobbyists | Not important | Ethanol advocates wins | Both sides are active | Not important |
| EU's future and power | Important for alternative fuels | Important for ethanol | Very important for ethanol | Not important |
| Technological development of fuel ethanol production | Failure compared to substitutes | Very important | Important | Not important |
| Energy balance | Important | Very important | Important | Not important |
| CO₂ capture and storage | Benefits alternative fuels | Not important | Not important | Benefits fossil fuels |
| Legal control systems | Support of alternative fuels | Support of ethanol | Strong support of ethanol | No support for ethanol |

Table 9.1 Key uncertainty factor impact in the different scenarios.

10 Step 7 Check Consistency of Scenarios

This step consists of a cross impact analysis where the correlation between the different uncertainty factors is estimated. The purpose of this step is to eliminate scenarios that are contradicting. The uncertainty factors were inserted in the table below and each correlation was discussed and reassessed before the final table was formed. When this was done, the outline for each scenario was designed.

The aim of this step is to control that the uncertainty factors correlate within the created scenarios in order to avoid internal contradictions. A matrix was used in which each key uncertainty factor was checked against the others. Positive correlation is symbolised with a (+) and means that the development of one factor in a certain direction will affect the other factor in the same way, and vice versa. If the key uncertainty factors are independent of each other and can change in any direction regardless of the other factor, there is no correlation and this is illustrated with a (0). Negative correlation (-) mean that the key uncertainty factors affect each other in reverse directions, meaning that the development of one key uncertainty factor will make the other factor develop in the opposite direction. The result of the consistency check is presented in figure 10.1 and it shows mostly no correlation (0), a few positive correlations (+) and no negative correlations (-). One reason for the large number of uncorrelated key uncertainty factors is that the most similar uncertainties were consolidated in Step 4. Most of the twelve key uncertainty factors are thus naturally independent of each other.

- | | |
|-------------------------------------|---|
| 1. Greenhouse gas | 7. Financial control systems |
| 2. Energy balance | 8. EU's future and power |
| 3. Other environmental consequences | 9. Technological development of fuel ethanol production |
| 4. Fuel ethanol supply chain | 10. Energy balance |
| 5. Substitute direction | 11. CO ₂ capture and storage |
| 6. Strategic alliances | 12. Legal control systems |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
|----|---|---|---|---|---|---|---|---|---|----|----|----|---|
| 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | + | + | + | 0 | |
| 2 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | | | | 0 | 0 | + | 0 | 0 | + | 0 | 0 | + | |
| 4 | | | | | + | + | 0 | 0 | 0 | 0 | 0 | + | |
| 5 | | | | | | 0 | + | 0 | 0 | 0 | 0 | 0 | |
| 6 | | | | | | | + | + | 0 | 0 | 0 | 0 | |
| 7 | | | | | | | | 0 | 0 | 0 | 0 | + | |
| 8 | | | | | | | | | 0 | 0 | 0 | + | |
| 9 | | | | | | | | | | + | 0 | 0 | |
| 10 | | | | | | | | | | | 0 | 0 | |
| 11 | | | | | | | | | | | | 0 | |
| 12 | | | | | | | | | | | | | 0 |

Figure 10.1 Consistency check of the uncertainty factors.

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Once the consistency check was done, the positively correlated key uncertainties were controlled against the scenario themes. For each (+) we made sure that it could be applied on the scenarios so that no contradictions existed in the chosen themes. Some contradictions were found which led to small modifications of the themes. Through this iterative process the themes were adjusted until they were internally consistent and more specific characteristics of the four scenarios could be identified. These characteristics are presented in figure 10.2 below and complement the brief description of the scenarios that were presented in Step 5.

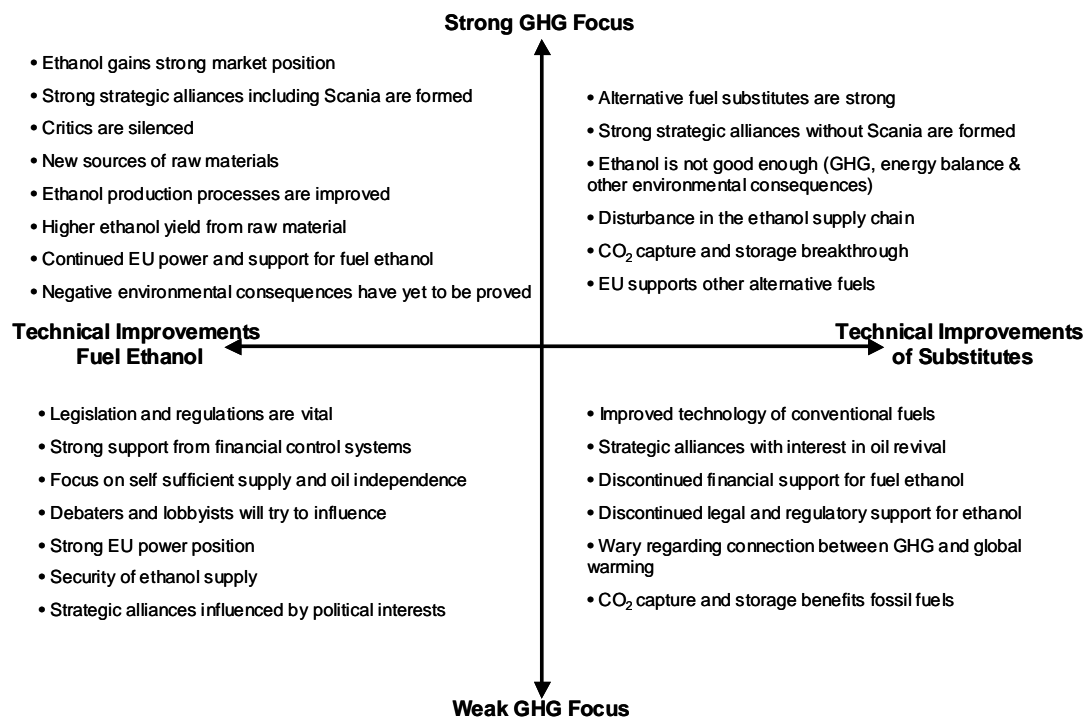


Figure 10.2 The main characteristics of each scenario.

11 Step 8 Present Scenarios

In this step the scenarios are presented in such a way that it helps people to think about a future 20 years from now, and to believe that the presented possible futures might actually come true. They are stories that each represents a future reality and are partly created with the help of the past and present perspectives as well as stakeholder and Standard Setting theories to make them plausible. After these scenarios were constructed they were reviewed by the reference group at Scania.

11.1 Knock-Out

In a world where greenhouse gas emissions are being battled and major technical improvements of ethanol production is a reality, fuel ethanol has come out of the alternative fuel standards race as the winner. This means that ethanol has a strong market position, which is largely due to the strong strategic alliance of positive stakeholders with a high level of fundamental fit that has successfully promoted the use of fuel ethanol. The strategic alliance consists of **Scania** and other heavy and light vehicle producers that together work and lobby for using ethanol as vehicle fuel and continue to increase the size of the installed base. Environmental agencies, energy agencies, fuel companies, ethanol producers and governmental agencies are also included, as well as agricultural interest groups who benefit from higher crop prices and volumes to the ethanol industry. Together, the alliance-members have been able to create competitive advantages, a secure flow in the supply chain and they have avoided unnecessary risks and costs. The lobbyists who represent this alliance have really succeeded in their task while anti-ethanol lobbyists, representing negative stakeholders and critics have been silenced since the negative environmental effects of fuel ethanol are yet to be proven. Research is continuously being conducted so that possible effects can be avoided and reduced. An improved and stricter standard for conducting life cycle assessments have helped researchers to show that ethanol is favourable for reducing emissions of greenhouse gases. This is mainly thanks to improvements on raw material and the production process which have resulted in a good energy balance and significant greenhouse gas savings. Ethanol is thus much appreciated among consumers and the environmental benefits has a positive impact on customer attitudes.

The EU goal of a 10% share of all transport fuels to come from biofuels in 2020 got the ball rolling and the share in 2027 has increased to 15 %. Although other minor and local alternative fuels exist, ethanol accounts for 13 % of the fuel in the transport industry, largely due to continued legal and financial support from the EU. This has been made possible thanks to the use of biomass and waste in production so that the available agricultural land can be used both for food and ethanol. The substitution was slow at first but thanks to the effects of a growing installed base, the increase in ethanol fuelled vehicles really took off. As the installed base grew, more and more companies produced vehicles compatible with the ethanol technology. As more vehicles started rolling the streets, fuelling stations could take advantage of network externality effects. The more ethanol fuelled vehicles, the more incentive there is for fuelling companies to improve infrastructure and build fuelling stations, and the more

readily available the fuel is, the more incentive there is for vehicle buyers to buy ethanol fuelled vehicles. This has sent out signals to the market that ethanol is a good alternative to fossil fuels. The customers believe that ethanol is both a good quality and high value product. Thus, a virtuous circle and a new alternative fuel standard have been created.

Positive customer attitudes, as a result of benefits in greenhouse gas savings, made customers more willing to pay slightly more for ethanol. This increase in demand has enabled ethanol producers to achieve improved economies of scale. At first, the profits that this created was used for continued investments in better production processes and development of raw material, enzymes, chemicals and micro organisms. These investments paid off which meant that the price of the fuel has been lowered, making it less dependent on subsidies and more competitive compared to other fuels. Ethanol is to a large degree produced from cellulose which has significantly reduced the amount of land needed for growing energy crops thanks to its higher yield.

11.2 Respiratory Success

Even though there is a weak focus on greenhouse gas emissions, the ethanol venture has survived and ethanol has become an alternative fuel standard thanks to a lot of financial and legal aid from the European Union. The main motive behind a continued venture has however changed from CO₂-reduction to supplying Europe with European-produced fuels and also putting more emphasis on independence from oil altogether, due to fear of oil supplies running out.

The low interest for greenhouse gas savings means that the public does not have strong enough incentives to replace their fossil fuelled vehicles with other alternatives. There are, however other environmental issues that are causing concern, such as particulate emissions from fossil combustion. Therefore, the EU has been forced to take further action by imposing new legislation and financial control systems in order to steer the market to where they want it. This has been made possible thanks to the increasingly strong power position and credibility of the EU. The EU has gained its strong position both globally and domestically due to new member states and the development of the Euro, which now applies to all member states. The EU has also used this power in the WTO to keep tariffs on ethanol high, which keeps foreign ethanol away from the European market. This has unfortunately complicated the substitution of fossil fuels in the energy sector as a whole, since there are not enough raw materials to supply the entire energy industry.

Since ethanol production processes has been developed with the help of governmental funding, the fuel can now be produced at a low cost. The problem is that raw materials are still expensive which makes production reliant on subsidies. Agricultural interest groups are involved in the strategic alliance which drives the ethanol and fuel security of supply issues. They are making sure that the subsidising of crops continues, that prices are kept under control and that raw materials are allocated to ethanol production. The strategic alliance also has some other strong political interest groups represented which facilitates the survival of fuel ethanol,

interest groups that are reliant on the ethanol business, e.g. sugar beet growers and fuel companies who have invested heavily in ethanol infrastructure.

There are however loud lobbyists, representing negative stakeholders, who are trying to put an end to the preferential treatment that ethanol is receiving at the expense of other issues. They represent the oil industry, other alternative fuel industries and organisations that compete with ethanol for governmental funding, e.g. schools and health care. Lobbyists and debaters representing positive stakeholders are also actively trying to convince the public and decision-makers of the benefits with using ethanol as vehicle fuel. The debate is very frequent in the media which makes the ethanol industry quite uncertain, still in 2027.

11.3 Return of the Fossils

The black gold has finally got its revenge and fossil fuels have proven its superiority as an energy-carrier. A period of intense global warming scaremongering have caused weary and lack of public and governmental interest for climate change. People have in general changed their opinion as a result of the contents in media that send out recent messages from scientific research. Many scientists have, for a significant period of time, stated that there is no connection between emissions of greenhouse gas and climate change, which have affected what the public, decision-makers and **Scania's** customers have chosen to believe. CO₂ capturing and storage from industries, including fuel production, has also had a breakthrough which benefits fossil fuels and makes the focus on greenhouse gases even weaker. Simultaneously, technical improvements have been achieved on engine and production technology for fossil fuels and the fossil fuel products themselves. As a result, the energy efficiency of fossil fuels is superior and cheap enough for all other fuels to seem uninteresting. These good old fuel products are familiar to consumers and the negative environmental effects, like pollutants, are accepted and not considered to be a real threat. The refined technology has made the combustion processes good, efficient and clean enough. Customer attitudes are positive towards the well-known fuels and efficient vehicles that are cheap to run, due to reduced fuel consumption. The amount of oil in the reserves is still not constituting a problem, even though new technology for extracting oil and gas is developing as well as technology for synthetic fuels made from e.g. black coal.

Behind the revival and improvements of the fossil fuels stand strong strategic alliances that have made joint efforts to support fossil fuels on the market. The alliances consist of powerful stakeholders who can gain advantages from increased demand and use of petrol and diesel. These stakeholders have exercised formal, economic and political power on the fuel market development through their control over important resources, financial strength and stable relations with government and legislators. Stakeholder influence on politics has lead to an interrupted support for the alternative fuels, including ethanol. Legislative and financial control systems are no longer giving ethanol any advantages and this has lead to ethanol prices that are unable to compete on the market.

Despite the total dominance of fossil fuels, there are some regions or communities within Europe that still use ethanol for fuelling vehicles. The ethanol is produced in small scale factories out of raw material from local farming and it is only meant to satisfy local consumption. This is the case on some self-supporting farms, which run their vehicles on their own fuel. It is also used in public transport in some cities and for distribution vehicles, since the distribution of fuel ethanol can be solved easily. Occurrence of ethanol use in some places maintains some demand for ethanol fuelled vehicles at **Scania**.

11.4 Loss in Standards Race

Strong focus on greenhouse gas and significant improvements of other alternative fuels than ethanol have weakened the market position for fuel ethanol. Ethanol has not managed to dominate the standards race which is partly due to strong stakeholders with interest in the development of fuel ethanol's competitors. Instead, continuous technical improvements of the competing fuel have contributed to the success of other renewable fuels than ethanol. This is mostly thanks to higher fuel yield from cheap raw materials and CO₂ capture and storage applications. These fuels have also been subject to facilitating actions for the supply chain and the fuel infrastructure. This has made it more and more difficult for fuel ethanol to keep its position on the market, which with time has become dominated by other alternative fuels that instead has become the standard. The stakeholders have formed a strategic alliance through which they have managed to create the highly important self-reinforcing feedback effect and have thus had a continuously growing installed base of users. Researchers have proved that ethanol is underperforming regarding greenhouse gas emissions, energy balance and other environmental effects. It is not energy efficient, since large amounts of fossil energy is still needed and there are serious side-effects associated with ethanol that are harmful for ecosystems. These are useful arguments for the critics against ethanol and ethanol's bad image threatens support and demand from environmentally aware consumers. The customers prefer and demand as environmentally friendly vehicles as possible and try to avoid all fuels that can harm local or global ecosystems.

EU's energy policy is still focused on reducing emissions of greenhouse gases and it is thus indefensible to give continued support to ethanol. The financial as well as legal support systems are instead applied on better alternative fuel options which mean that ethanol has lost vital financial and legislative support from the EU and the member states. A sudden shift in legal support for ethanol has changed the prerequisites for ethanol's ability to be competitive. The price on ethanol is too high for customers wanting to buy it and the demand is thus very low. Another reason for ethanol's absent success is problems with security of supply, due to the large land areas needed, questions on how agricultural land should be used and inefficient ethanol production processes. The failure of fuel ethanol is partly a result of the absent technological developments of ethanol production and raw materials.

12 Step 9 Develop and Test Strategies

This step is about assessing the impact of the scenarios on the organisation and developing strategies. The Strategy Development Model (presented in Chapter 3) provides helpful guidelines for strategy development and will be used to facilitate the understanding of what the scenarios mean for the company or department. With the help of the model, strategies and action plans for different combinations of threats, opportunities, weaknesses and strengths will be generated. The strategic options will then be checked under each scenario to see if they are deemed solid under the set of scenarios. The SWOT analyses were made with the help of the reference group at Scania.

This step has been performed with the help of the Strategy Development Model. This model separates internal and external factors that affect the company. The external factors, i.e. opportunities and risks, are analysed in each scenario and they result in Key Success Factors of the company. On the same note, the internal factors are analysed which result in Distinctive Competences. The Key Success Factors and Distinctive Competences give a good view of what possibilities the company has and are finally combined and matched to form strategies for how risks can be avoided and opportunities can be taken advantage of.

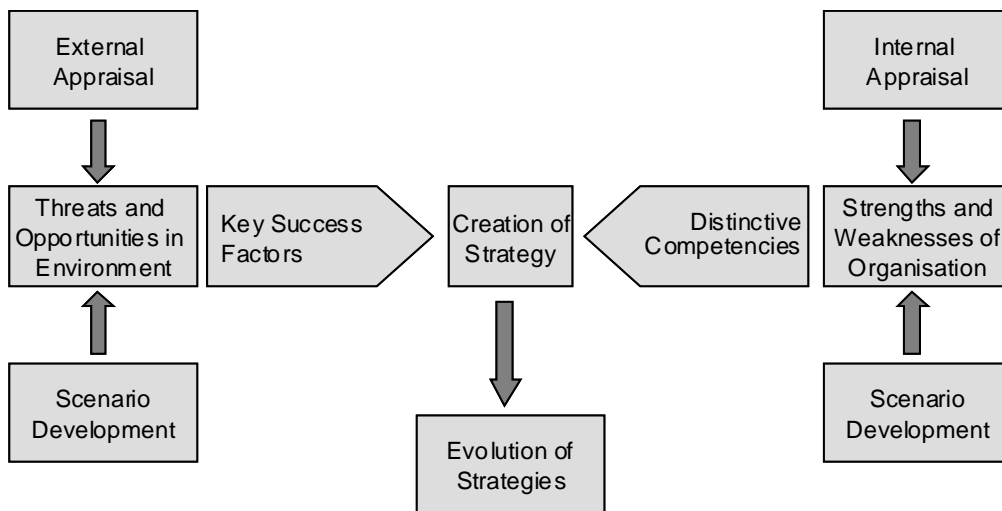


Figure 12.1 Strategy Development Model (Walsh, 2005)

12.1 Knock-Out

Strengths

- **Scania** has 15 years of experience in ethanol diesel technology.
- Few parts are replaced in the engine to make it compatible with ethanol which facilitates economies of scale.
- **Scania** has a good reference in SL that has had a large fleet of their buses for quite some time which could constitute a competitive advantage.
- **Scania's** diesel vehicles are established in Brazil which has a well built infrastructure for ethanol.

Weaknesses

- **Scania** might settle and feel content, move resources to other issues and loose its position on the market due to the favourable situation.
- **Scania** is quite a small company which means that the company could be run over by the larger competitors.
- **Scania** is not represented on the American market which will become very important for ethanol fuelled vehicles.

Opportunities

- **Scania** can become market leaders and will have a good opportunity to set the rules on the market.
- Ethanol's favourable image can be used in PR to strengthen **Scania's** brand as environmentally friendly.
- Competition within the strategic alliance, with ethanol and other vehicle producers, will hurry up infrastructure building and technology improvements.
- SL markets their ethanol venture quite heavily which also promotes **Scania**.
- **Scania** can take advantage of the position it has regarding diesel vehicles on the Brazilian market to promote their ethanol vehicles.

Threats

- Competition from other vehicle producers.
- Even if ethanol becomes the dominating fuel, other ethanol engine technology, e.g. Otto-engines that will run on E85 could become the standard which is not compatible with **Scania's** technology.
- Unexpected discoveries of previously unknown negative environmental effects of fuel ethanol.
- **Scania** rushes the development of ethanol vehicles without really taking the time to research the effects of the fuel which could lead to unwanted surprises and harm ethanol's reputation.
- If **Scania** is still the only producer that uses diesel technology, there is a risk that they can not meet demand which could lead to significant demand decreases.
- Too much reliance and dependence on the alliance is dangerous if the alliance threatens to dissolve.

Key Success Factors

- Maintain the relations within the alliance and benefit from strategic partners without becoming too dependent.
- Encourage, show interest in and assimilate ethanol research to minimise the risk for unpleasant surprises and to be a step ahead of the market.
- Use ethanol's good image for marketing purposes and as good PR.
- Seek new markets and business opportunities in order to grow and create revenues that can be used for further development and to avoid being run over by the larger competitors.

Distinctive Competencies

- Continue to drive R&D forward, do not settle and think the product is good enough, continue to develop and be a market leader with superior products.
- Take advantage of the experience and module production but do not let that limit the development of new products.
- Take the time to think about why **Scania** is the only producer who uses diesel technology for ethanol vehicles.
- Tend to the relationship with SL which is an invaluable resource.

12.2 Respiratory Success

Strengths

- Limited financial efforts in alternative fuel research make it easier to drop the projects if radical changes in the external environment would occur, such as withdrawn financial support. The company also has experience in killing projects if they are not leading to where it should.
- Co operations with for example SL could make the venture survive.
- The diesel technology is more fuel efficient than Otto-engines.

Weaknesses

- The company could get blinded by their own venture and not see the matter objectively.
- Efforts in influencing decision makers in order to affect the market are limited.
- **Scania** hardly uses their ventures into alternative fuels for PR purposes at all.
- The fact that they are the only producer of diesel ethanol might limit their chances of convincing buyers that it is a good alternative.

Opportunities

- Use the European fuel self sufficiency and the other social benefits that it brings, to create a good image.
- If the focus shifts back to biofuels and environmentally friendly alternatives, **Scania** will have a head start.
- **Scania's** ethanol vehicles are ready to drive now; both the fuel and the vehicles are readily available which could give the company a head start.

Threats

- The financial control systems will be withdrawn which means that the fuel will be so expensive to the consumer that it will be almost impossible to sell. Only small niche markets will demand ethanol vehicles.
- The EU self sufficiency on fuel will be vulnerable to issues that affect the supply of raw materials, i.e. bad weather conditions, plant disease, etc.
- The legal control systems might stop promoting the use of ethanol which heavily reduces the incentive to use the fuel.
- Lobbyists that are against the use of ethanol will have a lot of influence.
- Low oil prices will undermine the financial support for ethanol and make it hard to defend.

Key Success Factors

- Make sure to have a plan B.
- Use the European self sufficiency in marketing the products.
- Strengthen the positive attitude amongst politicians, via lobbyists or the strategic alliance, in order to influence decision-makers for a continued support for legal and financial support for ethanol.

Distinctive Competencies

- Influence important stakeholders to secure and take advantage of further financial and legal aid and promote a positive image of ethanol.
- Kill the project if it will only cost the company money.
- Attract new partners across different geographical markets in order to explore new business opportunities to create a more solid ground.
- Convince the public that ethanol is a good alternative and convince the customers that ethanol diesel technology is the way to go.

12.3 Return of the fossils

Strengths

- **Scania** has a strong market position and a very strong competence in engine technology as well as great experience in conventional fuels to fall back on which is an advantage in times of high demand for fossil-fuelled vehicles. This gives the company good prerequisites for managing this scenario and provide traditional high-quality engines.
- **Scania** is a well respected company with a prestigious brand and strong brand identity.
- The ethanol engine is built on a conventional engine platform which means that improvements and new experiences can be used also on the diesel engine.

Weaknesses

- A lot of pride is associated with the ethanol venture and the wish for recognition in this field is strong. If **Scania** holds on too strong to ethanol and is unable to realize when it is time to let go of the ethanol venture.

- Incomplete knowledge in fossil synthetic fuels can become critical for **Scania** if it becomes widely used.

Opportunities

- Work for improving diesel technology is constantly in progress, regardless of the ethanol venture, which is why **Scania** has good chances of managing a revival on fossil fuels. Therefore, do not forget core competencies.
- Fuel saving measures can be taken to further improve energy efficiency, such as improvements on vehicle design, materials and components as well as hybrid technology.
- Small-scale, local vehicle fleets running on ethanol can keep up some demand for ethanol vehicles, parts and service.

Threats

- **Scania** will still have customers with ethanol engines that will need parts and service, long after the ethanol venture has been abandoned which means that the venture can not be entirely dropped.

Key Success Factors

- Continuous efforts in development of diesel engine technology.
- Stop manufacturing ethanol fuelled vehicles and discard the ethanol venture.
- Go back to “business as usual”, i.e. diesel technology and fossil fuels.

Distinctive Competencies

- **Scania**'s core competence is its diesel engine technology which is of great value in this scenario.
- The decision to eliminate the ethanol venture requires courage, due to the pride connected to ethanol. Letting go of ethanol can become necessary and it is important to accept that and think about the company's best.

12.4 Loss in Standards Race

Strengths

- R&D and manufacturing at **Scania** are located at the same site, which means a lot for flexibility, speed and close communication. The organisation at large is rather non-hierarchic. **Scania**'s ability to adapt and work quickly is strengthened by this fact.
- **Scania** has a good reputation which can dampen the effects of a damaged image if ethanol turns out to be a non-environmentally friendly fuel.
- **Scania** has enough financial resources to survive a failed venture into ethanol.
- Good experience and competence in engine technology facilitates a sudden need for a vehicle fuelled on other alternatives than ethanol.
- **Scania** is preparing for a number of alternative fuels and keeps an eye on the development on these fuels. This increases the ability to adapt quickly to whatever direction the market or the competitors take.

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- A standardised engine with highly-compatible components as well as a modular-system is used at **Scania**, which means that changes can be made with only small modifications so that different fuels can be used.
- Since **Scania** has its vehicles on the market already, the company will have time to hopefully get back and even make some money while other alternatives are being developed. This money can then be used to make up for lost time in another technology.

Weaknesses

- **Scania's** relatively small size can lead to a lack of human resources if attention and development is needed on many areas simultaneously. Important competence can be difficult to allocate for a new venture on a new fuel if those are busy on other projects.
- Diesel technology is **Scania's** specialty and it is used in many engine applications, including the ethanol engine. Focusing too much on diesel technology can thus create deadlocks and hinders thinking outside the box, which can be necessary in some cases for finding the best solutions.
- **Scania** has a conservative culture, which means that they do not seek to be first out with new technology which is not risk free, especially if competitors create barriers of entry to a new market. The conservatism also reduces the possibility of acting proactively. It can be difficult to bring up controversial ideas which are exactly what is needed sometimes.
- **Scania** is a relatively small company compared to some of its competitors. In the business most producers allocate roughly the same share of revenues to R&D, which means that a smaller company uses less money in absolute terms.
- **Scania's** efforts in influencing the political direction are limited and the company is not given a lot of attention in the media. This gives **Scania** few chances to affect the future.
- **Scania** does not have a well communicated strategy on alternative fuels or analyses on the issue which makes the company very vulnerable in times of high uncertainty.

Opportunities

- Instead of initiating development of new and risky ventures itself, **Scania** usually keeps a more conservative position. This gives the company experience in quickly catching up with precursors, which could be useful for the company in some situations.
- **Scania** uses modular systems in manufacturing processes and uses standardised components to a maximum extent. This means a possibility to adapt to sudden changes with only small modifications, which means that a compatible vehicle can reach the market relatively fast.

Threats

- This scenario can come as an unpleasant surprise since it involves a distinctive change in the fuel market direction and could even result in a new standard.

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- In case of new Standard Setting, **Scania** can fall far behind or even be locked out unless ventures on other options than ethanol are prepared.
- A venture that turns out to be unfavourable in terms of environmental performance can cause damage to **Scania**'s image and reputation in times of high environmental awareness.

Key Success Factors

- Keeping an eye on the competitors, customers and other stakeholder and their moves.
- Prepare for multiple potential technologies and stay flexible.
- If ethanol becomes an unfavourable option – drop it and move on.

Distinctive Competencies

- Due to the uncertain future and a multitude of different options, flexibility and an open mind will be a key for having a good chance independently of what fuel becomes dominating.
- Preparation on many fuels and openness to possible futures will facilitate flexibility. **Scania** needs to keep a proactive posture towards the market and technological developments.
- Speed will help **Scania** to avoid falling behind and to adapt to new fuel market directions fast enough to satisfy changes in customer preferences and demand.

12.5 Fuel and Future Strategies

We have chosen to develop preventive and proactive strategies since we want both strategies that emphasises on reacting to environmental changes to protect the company against unforeseen change, and strategies that attempt to anticipate events and do things ahead of time so that the company can be there to take advantage of opportunities when they arrive. The strategies are thought to be implemented within the next few years in order to reach full effect by the end of the 2020s.

Two different risk-return strategy profiles have been generated to secure that diverse strategic approaches are available. Both are useful, depending on what approach to risk taking and upcoming opportunities **Scania** wishes to have and how the company prefers to manage the uncertain future. The decision on what sort of strategy to follow depend on how risk averse managers are. The preventive strategy is called *Create Flexibility* and is a middle way focusing on maintaining flexibility. This is a suitable strategy for followers, i.e. companies that do not want to take lead in an uncertain environment and is regarded as a more risk-averse type of strategy. *Focus on Opportunities* is a proactive strategy which is more risky, since it demands initiatives and acting from the company. This strategy is based on finding and maximising opportunities in all possible futures.

The strategies that will be formed as a result of this assessment will be based on all the identified scenarios because this provides a flexibility that we believe necessary in this case due to changes in the business environment. Therefore future-robust scenarios have been chosen.

12.5.1 Create Flexibility

This strategy is suitable if **Scania** wishes to have a cautious and rather passive posture towards the future fuel market. **Scania** will not actively try to influence the development of a new standard but instead watch and observe other important stakeholders so that useful signals and indicators can be captured. Basically, this strategy is about being open to all options and being as well prepared as possible for a wide range of possible outcomes. This demands flexibility and adaptability from the organisation. Below, the main features of the strategy *Create Flexibility* are described.

- **Scania's** strategy regarding alternative fuels is not entirely clear to everyone in the organisation today. It is important that the strategy is communicated in the organisation so that the overall direction as well as **Scania's** approach and attitude are well-known to everyone involved. The strategy should not be too narrowly focused and it is vital to stay open to other alternatives. Questions to find answers to and communicate are: What message will be communicated to customers, what image does **Scania** want to have in this context? How can this image be used? Further, the company needs to make up its mind concerning its role in the future development. If **Scania** wishes to be successful in ethanol fuelled vehicles it should put some effort into pushing its technology out to the customers, gain a first-mover advantage, and work hard to protect the image of ethanol through internal and external channels.
- **Scania** should make sure that they have a plan B in case ethanol suddenly loses its potential. Prepare for a wide range of fuel options so that unpleasant surprises can be avoided and so that **Scania** is well prepared in Standard Setting situations. Such preparation will make it possible for **Scania** to catch up with customer demands that rise quickly or with dominating technologies that the competitors have great knowledge in. To follow the competitors' direction and copy will be characteristic for this strategy.
- Keep an open mind and encourage preventive measures on all levels in the organisation. Collect information from the external environment and use the signals for analysing the market's direction. Customer attitudes and preferences are vital and it is also of great importance to keep a close eye on the competitors and the directions they are taking, as well as other stakeholder actions.
- Encourage close relations between involved departments within the organisation so that feedback and decisions are quickly communicated, which strengthens flexibility and ability to adapt. Good cooperation, particularly within R&D and production, creates speed and adaptability and gives **Scania** good prerequisites for competing in a standards race.
- Keep focused on ethanol technology for buses but develop the business through forming alliances similar to the cooperation with SL outside of Sweden to secure future demand of ethanol fuelled vehicles abroad. This is also useful for the new alternative technologies that **Scania** chooses to deepen its knowledge in, since this gives **Scania** both publicity and references.
- **Scania** should stay committed to its core competencies and earmark resources, both human and financial, for a constant development of diesel

engine technology. Highly efficient fossil energy will be needed and used for a long time ahead.

12.5.2 Focus on Opportunities

This strategy involves an active commitment to making ethanol one of the dominating fuels. In order to achieve this, **Scania** will have to make an effort in trying to influence decision makers and customers and work more with PR. At the same time, the business environment and its stakeholders need to be monitored, especially customers and competitors, to discover promising technology that **Scania** can venture into. This is a more risky strategy since a lot of resources are spent on the ethanol venture, risking that they will be nothing but sunk costs if ethanol fails.

- In order to succeed in this venture, **Scania** needs to work intensely on fuel ethanol's image and use it for PR. Use for example European self-sufficiency, environmental benefits and the fact that it is a domestically produced as arguments, but only after deep assessments of the fuel in order to secure that all arguments are valid.
- Look into what new markets have to offer, e.g. the American market. This is a very big step but it could be vital in order to make this ethanol venture actually profitable and not just create goodwill for the company. For this to be possible, these markets need to be monitored as well so that products compatible to the infrastructure are developed.
- If **Scania** wants to be part of setting a new standard, the company needs a strategy to make that happen. Be part of strategic alliances to quickly build an installed base and possibly get someone to help push the technology out to the customers and create demand. The company could for example partner with fuelling companies to help build infrastructure or with companies that produce ethanol and develop the production process technology. Use the alliance to send signals to the market, its size and power is a valuable tool.
- Market the ethanol venture internally, sell it to the employees so that the whole company has a positive attitude towards it and everyone realises that it is a good alternative. Report progress internally and externally to create PR for **Scania's** ethanol ventures within and outside the company.
- Work with powerful lobbyists who can influence both customers and decision makers to support fuel ethanol both financially and legally.
- Use the first-mover advantages for creating a secure position and quickly accomplish an installed base. Use this leading position for influencing the rules of the game, for example by marketing the company as technology leaders to make customers confident that diesel ethanol is the best alternative and encourage them to buy this type of vehicle. However, in order for this to work it is vital that vehicles and fuel is readily available to the customers, or they will turn to another supplier.
- At the same time as a lot of effort is put into making ethanol successful, a time limit should be set for when this should be achieved. This time limit should contain goals for the fuel's and vehicles' market share, profit, greenhouse gas savings, energy efficiency, etc. This way, there are clear criteria for when to reassess or drop the ethanol venture. External opinions on

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this matter are useful, since it can be difficult to stay completely objective to the ethanol venture if you feel personally involved.

- Choose two (or more) additional options except ethanol, for which knowledge is deepened. Gamble a little with one of these options by allocating time, money and personnel to the project. There is however no need to be too crazy, since wild ventures does not fit the company culture. This wild card should instead be somewhat compatible with **Scania's** technology and with the help of this technology, **Scania** should lead the way towards superior technology.
- Allocate marketing personnel to pick up signals from the business environment and if a fuel begins to look promising, follow that track, parallel to ethanol. Customers and their attitudes are highly important as well as competitor direction and the actions of other stakeholders. Further, updates of policies as well as legal and financial control systems will also be vital. Signalling is a useful tool in Standard Setting that **Scania** also should use for its fuel ventures.
- Create a corporate environment where it is OK to bring up conflicting and controversial ideas on all levels in the organisation and take these suggestions seriously. Examine potential opportunities and use them if they seem promising.

13 Discussion

*The discussion is aimed at emphasising the key findings that are the results of this thesis. The discussion has been divided into two sections; Key Findings which is a discussion and reflections regarding the more practical issues at **Scania** and Theoretical Contribution which is a discussion regarding how the theories have been used and added to provide a theoretical contribution which we hope will be useful for the academy.*

13.1 Key Findings

To make the right decisions in an external environment characterised by uncertainty is naturally a very complex process. The fuel market has until today been dominated by petrol and diesel and as this market opens up to other fuel options, the race for creating competitive advantages has begun in many concerned industries. The heavy duty vehicle industry is one example, but they do not alone influence Standard Setting and affect the market. Other related industries, such as fuel distributors and fuel producers, have their stake in how the market develops. Political interests are influential and can use powerful channels to steer consumers and strongly affect their attitudes. In **Scania**'s case it will be impossible to know the best direction since external conditions and prerequisites can change rapidly, due to other stakeholders' actions. Each action made by any of the stakeholders will create a path dependency and will thus influence the development of the future fuel market. Taking risks will be unavoidable, but there will also be opportunities and possibilities along the way. The uncertain future is only partly due to stakeholder acting in the standards race, since uncertainty also derives from the lack of knowledge on the short and long term consequences of intense use of a new fuel.

Ethanol is one fuel option that currently seems promising and has gained a small market share. It is, however, a new and not so widely explored fuel which still has a lot to prove and many are sceptical. For ethanol to have a chance of becoming one of the truly good fuel options, energy efficiency, environmental friendliness and security of supply have to be improved. Sooner or later the fuel will have to be competitive without the support of legal and financial control systems, which is what creates demand today to a significant extent.

Scania's challenges ahead are to construct a clear strategy on alternative fuels and to find out how the ethanol technology could be further developed. Not having any strategy at all, which is what some employees experience today, involves a great risk to loose advantages in a standards race. The standards race situation mean that **Scania** need to make up plans on how to create a large and growing installed base and how to stimulate the occurrence of complementary products. The main objective must however not be to win the standards race; it could be beneficial if it ends in a draw with other fuels, especially if they do not compete for the same raw materials and agricultural land. Regardless of whether **Scania** wants ethanol to become the dominating design or not, it could use some of the presented tactics and strategies to at least make it as dominating as possible. Allies, rapid design cycles, winning

important customers and signalling by making announcements and using PR are some straightforward suggestions.

We believe that it is time for **Scania** to make up its mind on how to act in this situation since future changes is an unavoidable fact. In strategy making, the multiple perspectives and the uncertainty factors within each perspective, described in this thesis, work as a helpful tool for understanding the external environment and what stakeholders should be given extra attention due to their power and ability to influence. In general, the primary stakeholders have the largest immediate impact on the company and should therefore be monitored closely, particularly competitors, customers, the EU, and ethanol producers. The secondary stakeholders are however very important as well, especially media, interest groups and substitute markets. They can therefore not be forgotten since they seem to have a more indirect influence on issues and threats that could really hurt **Scania** if the company is not prepared. Using multiple perspectives give a holistic view and minimises the risk of sub optimisation. The environmental perspective is given much focus at present but have to be complemented with an economic perspective since they often conflict with each other. The political and legal perspective is better understood if it is complemented with a market perspective, since political attitude affects customer attitude. Technology is affecting all other perspectives. All perspectives have been valued to be equally important since all perspectives had similar mean impact scores of the uncertainty factors.

Four scenarios have been generated in order to expand mindsets concerning future development and make a wider range of alternative futures conceivable and accepted. It is dangerous to become too affected by the spirit of the times since this creates deadlocks and inability to think outside the box. Our aim has therefore been to create awareness of possible challenges, risks, opportunities, and obstacles, even if some parts of the scenarios can appear to be very unlikely at present. We believe that an open mindset and increased awareness on all levels of **Scania's** organisation could help the company in its preparations for the uncertain future. We consider Scenario Planning to be an effective and illustrative tool for creating awareness of alternative futures. This is why an open mind is needed for being able to absorb the new impressions and keep from viewing the scenarios as too extreme and farfetched.

As the reader will have observed, three out of four scenarios describe a rather pessimistic view of fuel ethanol and this might come as a surprise to those at **Scania** who feel dedicated to this fuel and the technology around it. Our impression is that **Scania's** employees feel mostly positive about ethanol and are proud for what the company have accomplished in this area. There is a risk of ethanol not becoming the success that some would like to believe and therefore it has been important to point out what could go wrong. We also wanted to contribute with alternative scenarios, but our purpose was also to create as objective scenarios as possible. The more or less negative outcome in three of the scenarios is indicating that many threats and obstacles need to be removed for ethanol to become successful. A complete evaluation of the fuel has not been made, but from the information collected during our work with this thesis, our judgement is that ethanol is not competitive enough

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today to become one of the good fuel options on the market. However, ethanol still has potential if improvements are made in a few areas:

- Most important are improvements on energy efficiency in the production process, which today accounts for a great deal of the energy input. Better production processes can also make it possible to maximise the use of biomass and as a result use smaller areas of land for the same amount of fuel extracted. Cost savings can be made in the production step by keeping temperatures down, making cheaper chemicals and enzymes available and use alternative raw material. This way ethanol will become more cost competitive, which is an absolute condition for becoming well established.
- If ethanol becomes cheaper, financial control systems are no longer needed for creating demand. Dependence on financial and legal support is dangerous and can be devastating if the support is suddenly terminated.
- Once the ethanol is produced it needs to be delivered to customers efficiently, which is why investments in infrastructure are needed. This is perhaps the most important complementary product, since **Scania's** vehicles are worthless if the driver can not fill up the tank. Forming a strategic alliance with a fuelling company could therefore be a smart strategic move to make to achieve network externality effects.
- Ethanol's environmental features are not yet fully demonstrated and there is a problem with life cycle assessments only focusing on greenhouse gas benefits, while other environmental impacts are neglected. Another problem is the widely differing results that different LCAs present, which make it impossible to know how good or bad ethanol is. For customers who wish to use an "environmentally friendly" fuel, this can create confusion and uncertainty, since some ethanol products are good, energy efficient and saves a lot of greenhouse gas emissions, while other ethanol products are clearly inappropriate. Customers' attitudes towards a fuel are affected by the product's features and performance. A system where the customer easily can find information on origin, raw material and the ethanol's environmental features would benefit the good ethanol products and customers who want to make a conscious choice.

The four scenarios have worked as the foundation for two strategies which we hope can give **Scania** some suggestions on how to prepare for the uncertain future. The strategies handle stakeholder influence and Standard Setting behaviour in different ways and they differ in their attitude towards risk-taking. There are suggestions on how to take advantage of strategic alliances and on using PR more actively. We would like to point out that the strategies only are proposals that can work as guidelines when **Scania** formulates its much needed strategy for alternative fuels. Most important is that a strategy is being made and that **Scania** decides how it is going to act in those matters from now on. As a result, it is likely that more analyses will be conducted, knowledge collected and possibilities discovered, since the strategy-making demands information. All this information will contribute to good decisions being made. Options and having a plan B will also be vital for managing the

future, so that the chances of having technology available for the next big thing on the fuel market are maximised.

These strategies are not necessarily exclusive for **Scania**, but can be valid for other companies in the industry since they all face the same reality. This is especially true for the smaller and medium-sized companies that do not have the same ability to affect the market. No company has access to a crystal ball that will unveil the true future scenario and how to do everything right. Trying to predict the future is therefore pointless and instead it will be important to focus on preparing in the best possible way, stay open minded to what the future will bring, construct a strategy and hope to become lucky.

13.2 Theoretical Contribution

An important part of this thesis is to provide the academy with theoretical contributions. This has been done by combining three theories; *Stakeholder Theory*, *Standard Setting* and *Strategy under Uncertainty* with *Scenario Planning*, a method for planning for the future. This was done in order to create a strategic planning framework that could be used in environments characterised by high levels of uncertainty, technological shifts and strong stakeholder and political interests. The framework will be named 4s (read force) which stands for Scenario, Stakeholder, Standard and Strategy. The framework and how the theories contribute to clarifying the issues will be explained below.

Stakeholder Theory was included because we believe that it is important to understand stakeholders and their driving forces in order to understand the market and where it is expected to move. We also found that stakeholders and their motives was a good foundation for identifying uncertainties in the company's business environment as well as in facing the key uncertainty factors. Therefore we have found it important to include stakeholders expected views and impacts in the scenarios and how certain stakeholders can be used as allies to try and affect the market in such a way that it benefits the company. In the added step 10, the internal stakeholders are included for the first time. We want that this thesis creates discussion between internal stakeholders that have different views and interests to tend to. The stakeholders have also been one of the foundations of formulating the strategies.

We found that *Standard Setting* contributes to the framework because it shows how easily susceptible new technology is even to small changes in the environment which also enforces the impact of stakeholders, their actions and the key uncertainty factors. And as stated above, in highly uncertain environments where a new standard might become reality, these issues are important to point out. Standard Setting has been incorporated in the thesis in a number of ways. It is part of step 2 and 3 to point out which stakeholders have the ability to cause historical events and affect or create a new standard. It serves the same purpose in step 5 where the key uncertainty factors are faced. The scenarios are also based on the ideas of Standard Setting to a large extent, because new standards will establish the boundaries and set the rules on the market. It can also create great opportunity for those on the right side of the border

and problems for those who are not. The possibility of setting a standard has furthermore been used in the formulation of the strategies.

Theories regarding *Strategy under Uncertainty* were incorporated in the framework for three reasons. First of all, we found it necessary to find a way of identifying key characteristics and the level of uncertainty in the business environment in order to know whether Scenario Planning is at all applicable in this case. The characteristics of the level were also used to identify the correct key uncertainty factors and create proper and meaningful scenarios. Secondly, to know what kind of strategies should be formulated, the theories of main types of scenario-based strategies have been used. Third, we found that we needed more precise guidelines for how to create strategies to face the uncertainties that were identified, which is why we added the Strategy Development Model to the framework. Our contribution to the academy is thus the *4s Framework for Strategic Planning in Highly Uncertain Contexts*.

13.2.1 The 4s Framework for Strategic Planning in Highly Uncertain Contexts

| Step | Description |
|------|---|
| 0 | <i>Uncertainty Identification</i> – The very first step, before starting the Scenario Planning process, is to identify which level of uncertainty that prevails in the business environment in order to decide whether this framework is suitable. Only level 3 uncertainties apply to this framework. This step should answer the question; <i>Does level 3 uncertainty characterise our business environment?</i> |
| 1 | <i>Setting the Scene</i> – Get an understanding of the organisation and its surrounding environment. Define the scope and review past developments and the present status in the industry. This step can be quite time-consuming so try and limit the effort to a couple of days. This step should answer the question; <i>What is the scope of this Scenario Planning and what are the key events that have shaped the industry so far?</i> |
| 2 | <i>Identify Stakeholders</i> – The company's stakeholders can have much impact on the development on a new standard, it is therefore important to know who they are and review their motives and driving forces to get an idea of the direction of the industry development. This step should answer the questions; <i>Who are the company's stakeholders, what do they want and how do they plan to get it?</i> |
| 3 | <i>Generate Uncertainty Factors</i> – Generate a list of factors that constitute risks, challenges, opportunities and obstacles that are considered to be beyond organisations control but important to the business. Keep an open mind and brainstorm freely, preferably together with employees from different functions in the company to get a more complete view. The uncertainty factors should be formed as nouns to avoid predictions this early in the process. This step should answer the question; <i>What could constitute risks, challenges, opportunities and obstacles in our business, that are beyond our control?</i> |
| 4 | <i>Reduce Factors</i> – Reduce the factors in step three to identify the key uncertainties by scoring each factor in terms of its impact on the |

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| | |
|----|--|
| | organisation. Merge key uncertainty factors that are closely related to avoid repetition. Do not include the probability of it occurring since all uncertainties can occur simultaneously and the company should be prepared even for the unexpected. This step should answer the question; <i>What uncertainty factors constitute the largest threats and opportunities to the company?</i> |
| 5 | Face the Key Uncertainty Factors – Examine the uncertainty factors in closer detail. This is probably the most time-consuming step (1-2 weeks), but it is believed necessary to understand the uncertainty factors and the impact that they might have on the industry so that plausible scenarios and relevant strategies can be created. This step should answer the question; <i>How can the key uncertainties be expected to develop in the chosen timeframe and how can they affect the company's business?</i> |
| 6 | Choose Themes and Develop Scenario Details – We recommend that 4 scenarios are developed by taking the most significant uncertainty factors, put them on two axis with a high and low value to create four fields, i.e. four scenarios. Make a subjective projection of the factors under each theme to create a description of the scenario that is consistent with both the theme and the timeframes. This step should answer the question; <i>In what direction can the key uncertainty factors be expected to move given the conditions presented on the axis?</i> |
| 7 | Check Consistency of Scenarios – Make a cross impact analysis where the correlation between the different uncertainty factors is estimated so that contradicting scenarios are avoided. This can be done by inserting the factors into a table to compare them to each other, one by one. This step should answer the question; <i>How is each key uncertainty factor related to the others and does this relation match what is in the scenarios?</i> |
| 8 | Present Scenarios – Present the scenarios as stories that represent future realities to help people to think about the future and to believe that the presented possible futures might actually come true. This step should answer the question; <i>How can the imagined futures be described?</i> |
| 9 | Develop and Test Strategies – Assess the impact of the scenarios on the organisation and develop strategies that take advantage of opportunities and protect against threats. This step is performed with the help of the Strategy Development Model. When the strategies have been formulated, they should be checked under each scenario to see if they are deemed solid under the set of scenarios. This step should answer the question; <i>What do we need to do in order to face the threats and take advantage of opportunities that can be expected in our industry and how can we do it based on our competencies?</i> |
| 10 | Discuss the Results – One of the main goals of this process is to bring risks and opportunities up to the surface in order to create awareness and discussions at the company. It is therefore suggested that a meeting is summoned with participants representing different internal stakeholders within the company. Together they should discuss the uncertainties, the SWOT analysis, strategies and key finding so that as many perspectives as possible are made visible. This should then influence and improve the final strategies. |

14 Conclusions and Recommendations

*In this last and final chapter we return to the purpose of this thesis to discuss how it has been fulfilled. We suggest what we think **Scania** should do next and how they can go from here. A final conclusion on the stakeholder perspective as well as the chances for ethanol to succeed is also given.*

Scania is venturing into alternatively fuelled vehicles. Such a venture comes with many uncertainties and calls for an early warning system. In this case, a system has been created with the help of Scenario Planning which, during the working process, has given multiple results. Key stakeholders and uncertainties from different perspectives have been identified, the impact of these uncertainties has been assessed, and strategies have been formed on the basis of four alternative futures. In this process we have also created a framework that is general enough to work as an evaluation tool for other fuels or products, but specific enough to be suitable for the situation in which **Scania**, and other companies, finds itself today. Using the framework will lead to the identification and collection of important information and knowledge. Further, the framework will give rise to important questions that constitute a basis for needed, perhaps necessary, discussions.

This thesis has only scraped the surface of the issues related to fuel ethanol. The next step is to absorb what this thesis has come up with and bring it up for discussion on a strategic level. The challenge for **Scania**'s management will be to form a strategic direction for alternative fuels and to decide if the company should take a proactive or a more careful preventive approach. Next, this strategy needs to be communicated so that everyone in the company knows where it is going and are aware of the importance of that direction. The R&D department will have to deal with some customer issues, apart from technical improvements on available technology and development of new alternatives. A deepened knowledge on some of the issues brought up in this thesis will also be useful. Customers are very sensitive to what they see and hear and therefore we believe that it is vital that a thorough and reliable life cycle assessment of fuel ethanol is made, so that **Scania** knows exactly what they are getting themselves into. For the assessment to be useful for **Scania**, it has to be done on Etamax D combusted in a diesel engine, since this is the fuel and technology that **Scania**'s vehicles run on. If the results are in favour of ethanol, **Scania** then has the opportunity to silence critics once and for all.

Through this Scenario Planning process we can conclude that any venture comes with many risks, but also a number of opportunities that need to be taken advantage of. The key to success is to keep eyes, ears, and mind open in order to pick up all signals that are provided by the actors on the marketplace. All stakeholders need to be monitored, because in one way or another, they all affect the most important stakeholders of them all; the company's customers. We also hope that the company bears in mind how even the seemingly insignificant stakeholder can have huge impact on a product's future and possibility to become a dominating design. One should also not ignore the impact of internal stakeholders and the influence they have on **Scania**'s R&D-related and strategic choices. Those stakeholders are the people who put time and effort into the ethanol project or the co-workers who are reliant on the same

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resources. Their pride, hard work and strong belief in **Scania**'s capacity can make it seem provoking to even consider a failure for ethanol. To avoid the influence of each person's bias and personal opinion on our research, the number of interviews has been limited. This has been necessary to stay objective, but one can also imagine that some small nuances and valuable information have been lost, due to this trade-off.

Ethanol and ethanol fuelled vehicles are far from finished and complete products. One should also keep in mind that it is more likely that a number of different products, rather than a single dominating fuel, will represent the future fuel-market. It is therefore important to be open to other alternatives and not to exclude any option. By using the 4s framework, important issues and questions regarding other fuel options can be brought up and a first evaluation of the fuel can be performed. One of ethanol's advantages is that it is readily available today and therefore has the time to gain a significant installed base before the second generation of biofuels has been introduced. However, a lot of improvements need to be made in order for ethanol to be considered a sustainable alternative and become established on the fuel-market. Today, there are too many disadvantages with ethanol for it to be considered competitive. Lots of research, technical adjustments and development will be necessary for the fuel to become a true competitor. Again, preparation for a multitude of options and an open mind will be the keys to stay competitive on the highly uncertain fuel-market and in the vehicle industry.

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Appendix I The Reference Group at Scania

Erlandsson, Olof, *Advanced Combustion*, Engine Development
Henstedt, Anna, *Environmental Performance Responsible*, Truck Development
Holmborn, Jonas, *Head of Advanced Combustion*, Engine Development
Kleinschek, Günter, *Senior Engineer*, Legal Demands
Löf, Per-Erik, *Senior Technical Advisor*, Components
Morsing, Fredrik, *Director Alternative Fuels*, Buses & Coaches
Wästljung, Urban, *Public Affairs*, Corporate Relations

Appendix II Uncertainty Factors

Environmental Perspective

Greenhouse gas – The focus on reducing emissions of carbon dioxide and other greenhouse gases gives carbon dioxide neutral fuels and “environmentally friendly” fuels an advantage. Ethanol is said to be one of those products, but voices that state the opposite are making themselves heard more frequently.

Pollutants – Apart from greenhouse gases, several pollutants and emissions released from the fuel itself, during combustion and during the production of the vehicle that can cause serious health damage or damage to the local or regional environment. When a new fuel is introduced, those effects need to be carefully examined to avoid unpleasant surprises.

Land use – The biomass that needs to be produced for making ethanol can also be used for growing crops for food or for generating electrical energy. Some state that electricity is a more energy-efficient product and that it is a waste to make ethanol from the crops, since large amounts of energy is lost. The issue is that there is not enough land for all of this, forcing priorities to be made.

Biodiversity – The need for land for cultivation of biomass creates extensive areas with very homogenous vegetation, which can lead to increased biodiversity in parts of Europe and in worst case extinction of species. This can be used as an argument against fuel ethanol as an environmentally friendly fuel option.

Deforestation – The extensive agricultural areas can be created by devastating European forests and decrease the wooded areas of land. Deforestation could be another problem that ethanol users need to deal with.

Rainforest deforestation – The production of ethanol is often blamed for deforesting the rainforest in order to clear land for growing sugar cane. Regardless of the truthfulness of these accusations, rainforest deforestation might affect the public's view on ethanol and therefore also affect the market demand.

Plant diseases – If the crops grown to produce ethanol are attacked by plant disease, supply will be affected, which in turn affects the price of the fuel.

Crop failure – There are a number of reasons for smaller crop yields, e.g. unfavourable weather. Small yields of crops means a reduction of ethanol supply and an increase in price.

Land depletion – There is a constant struggle to get as much yield as possible from the plots of land available for agriculture. In the struggle to supply the market with the crops it demands, there is a risk of depletion which means that hardly anything can be grown until the land has recovered again, which takes years.

Genetically modified organisms – There are both opportunities and threats with GMO regarding fuel ethanol. Modified crops might earn higher yields. On the other hand, there is resistance against the use of GMO which might hurt the reputation of ethanol if it were to be used.

Noise – Increased traffic, especially in towns and cities, has led to demands regarding engine noise levels. These noise levels might be affected by the fuel that is being used in the engine.

Market Perspective

Supply of fuel ethanol – The supply of ethanol is of course correlated with the supply of raw material. However, since ethanol production competes with food production, raw material suppliers will sell to whoever pays best, fuel producers or food producers. Either way, shortage of supply leads to higher prices and decreased demand, due both to the price and the unavailability of the fuel.

Supply of raw material – The raw material for ethanol needs to be grown which makes it sensitive to weather and is limited by available land and the competition with food. The cultivation of biomass thus needs large areas of agricultural land which might not be available for this particular use. These limitations could mean that there will not be enough ethanol to fuel the demanded vehicles which constitutes a problem.

Customer attitudes – The consumers' attitudes towards ethanol are dependent on trade-offs between for example, environmental issues, vehicle performance, and economic factors. **Scania** needs customers who are positive to fuel ethanol.

Customer willingness to pay – Ethanol is currently a more expensive fuel option than petrol or diesel, despite subsidies in many European countries. Although, this varies with the price of oil. For the consumer, this means a trade-off between cost and environment and is dependent on the consumer's motivation to contribute to environmental progress.

Vehicle competitor direction – The wide range of available options of alternative fuels means that different manufacturers of heavy vehicles can take different directions in their ventures for new fuel. If one of **Scania's** competitors choose another fuel option than ethanol and this becomes a success, **Scania** might find itself shut out from the market.

Road transport substitute direction – The substitutes for road transport are air-, train-, and sea transports. These substitutes' ability to satisfy the customer will decide how popular road transports will be, and therefore also affect the demand for heavy ethanol vehicles.

Fuel substitute direction – If another fuel gets a grip on the market, chances that ethanol will do the same decreases, especially if that fuel is proven to be superior to ethanol.

Fashion trends – Fashion trends have a lot of impact on what the public wants, buys and drives.

Transport demand – The demand of transport in general is highly decisive for the demand of transportation vehicles.

Myths – There are all kinds of myths surrounding ethanol today which affects people's opinions and demand for fuel ethanol. Positive myths might work in favour for the fuel while negative ones might really hurt its reputation.

Local/Regional establishment – Depending on the supply of raw materials, etc., certain fuels might be easier to establish in certain areas which means that there will be no "universal" fuel. This might constitute a problem for both auto makers and fuel suppliers who will need to supply the market with a number of fuels and engine types. This means that they can not take advantage of economies of scale to the same extent.

Strategic alliances – Competitors, trade associations, fuel companies and other stakeholders might form a strategic alliance in order to promote, develop and market a specific fuel.

Economic Perspective

Oil price – Fluctuations in the world market price on oil affect the chances for an establishment of ethanol. High price on oil can positively affect the demand on alternative fuel, such as ethanol, and low price can reduce consumers' incentive to choose alternative fuels.

Prices of raw material – The price of raw material is derived from the supply and demand. If there is an over production of raw material it will be cheap but since ethanol competes with, for example food, there is a chance that the price will be quite high. High prices of feedstock means high prices on ethanol which leads to a decreased demand of ethanol and ethanol fuelled vehicles.

Price of fuel ethanol – This is basic economics; the price of the fuel affects the demand of the fuel. In this case, the price in relation to petrol and diesel is decisive. If ethanol is cheaper than oil based fuels, there is an incentive to change to ethanol fuelled vehicles and vice versa. The price of ethanol is highly dependent on tariffs, taxes, exchange rates and world market prices on raw material as well as production processes.

Price of alternative fuel – There are a number of alternative fuels on the market today and they all compete with ethanol. If they are cheaper, chances are that the buyers of vehicles will choose an engine technology that is compatible with that fuel instead of ethanol.

Subsidies – EU provides monetary support to the establishment of fuel ethanol both direct and indirect by supporting farming of energy crops, installations of ethanol fuel pumps and purchases of environmentally friendly vehicles. Some are questioning if it is correct to support fuel ethanol, considering the large energy consumption during the production process of ethanol.

Tariffs – European governments are using tariffs to protect domestic production of fuel ethanol from cheaper, usually Brazilian, ethanol. If these tariffs were to change, trade and prices would be affected.

Taxation – Fuel ethanol is highly dependent on taxation in order to compete. There are two issues with tax regarding ethanol. First, the appropriate tax needs to be set on the fuel. Second, the tax exemptions need to be decided.

Exchange rates – Exchange rates always impact trade between countries since it affects the price of the product that is being traded. A weak SEK means that imports are expensive and a strong means that imports are cheap.

Business cycles – Fuel ethanol is dependent on the business cycles for a number of reasons. For example, in good times it is easier to get tax reductions and subsidies and in good times people are less concerned of the fuel price and the prices of transports. The opposite is true for bad times.

Political and Social Perspective

Debaters – The opinion regarding ethanol can have significant influence on how successful fuel ethanol becomes on the market. This is highly dependent on what is said and written in media and the picture given in newspapers and news reports.

Lobbyists – Attitudes and political views are influenced by lobbying, which can steer the development of fuel ethanol in a certain direction.

Competition for governmental funding – Today, ethanol relies heavily on tax reduction and subsidies to be able to compete with oil based fuels and foreign ethanol. This means that it competes with the general good for funding. If the situation of the general good was to be worsened and therefore need money, it might be at the expense of ethanol which would make it less competitive.

Employment – Increased ethanol fuel production could lead to higher employment, both in agriculture and in production. This might make it easier to get governmental funding and approval among the public.

The Middle East – The Middle East is one of the largest oil producing areas. The unstable political climate in this area affects the supply and price of oil which, in turn, affects the demand for fuel ethanol.

USA – Being one of the most powerful nations in the world, USA affects the world markets in many ways. The country has previously shown scepticism regarding global warming and other issues that affects the countries energy consumption. This seems to be about to change however, which could lead to an increased demand as well as increased production of biofuels. The country's strained relationship to the Middle Eastern countries is another incentive to relieve itself from its oil dependency.

China and India – The world's two largest populations are under rapid development which means that production and consumption is increasing fast. This constitutes both a business opportunity and an environmental health risk, which for ethanol means a double business opportunity. There is concern around the world of what will happen when these to huge population starts consuming energy the way we do in the western world, which is an opportunity for all biofuels. Ethanol vehicle producers could also venture into selling vehicles to these countries.

Production in developing countries – Production in developing countries could be a good opportunity for these countries to find new sources of income. It might however, constitute a threat for European ethanol as larger volumes of cheap ethanol will be available on the world market.

Famine disaster – Starvation in developing countries is an ongoing problem that the world is struggling with. A sudden famine disaster which would worsen the situation could give rise to a land use conflict between fuel production and food production. Production of ethanol could be threatened by the urgent need for food in large parts of the world.

EU's future and power – Depending on how the EU is developed, with new member states and shifts in international power and attitudes, the energy policies and support for biofuels can be affected.

Supply of animal feed – Another land use conflict comes from the need for grazing grounds for cattle and livestock and the land needed for cultivation of animal feed.

Technological Perspective

Technological development of vehicle – Technical improvements of ethanol fuelled vehicles, such as engine efficiency, fuel economy and vehicle performance can result in progress for fuel ethanol. Improvements on mature technology, such as conventional Otto or diesel engines, or on other alternative fuel vehicles could instead be a threat against fuel ethanol.

Technological development of ethanol production – A more efficient cultivation and production process would mean better energy efficiency and energy balance, and hence more savings in greenhouse gas emissions. This would support the promotion of ethanol as an environmentally friendly fuel.

Competing ethanol engine technology – This might be a problem for **Scania** if one or more of the company's competitors have superior technology. This means that **Scania** will have trouble selling its vehicles. The opposite is true if **Scania** has superior technology.

Competing engine technology for other fuels – There is a chance that some manufacturers come up with a fuel technology that is superior to the ethanol technology which could have the consequence that ethanol will not have a breakthrough at all.

Research – Scepticism and critique against the fuel can be rebuffed if the critical parameters related to ethanol are improved. Research and development on fuel ethanol, the engine and the vehicle, is important for achieving low total emissions of greenhouse gases, good energy balance and vehicles with good performance. Research can also prove that ethanol is not a sustainable fuel alternative.

Development of biomass – The feedstock might be improved, for example by fertilising, other crops, and plant refining, to accomplish higher yields which could decrease the need for land and reduce production costs.

Energy balance – The use of fossil fuel energy during production and transportation of ethanol varies depending on the raw material, the production process and the distance between manufacturer and consumer. Some claim that the amount of energy used for taking ethanol from well to tank, exceeds the savings in greenhouse gases that the use of ethanol brings. In this case, ethanol has a negative energy-balance and using it would mean that more greenhouse gases are released during well to tank compared to what is being saved during combustion.

Infrastructure – A new fuel needs to be distributed and easily available for consumers which is largely dependent on a well functioning and built out infrastructure. This type of distribution network relies on funding and joint efforts from all industries concerned, which is a challenge for a real establishment of ethanol.

CO₂ capture and storage – Techniques for capturing and storing CO₂ is being developed and could change the focus from carbon dioxide saving to handling the carbon dioxide that is being emitted.

Ethanol quality – Ethanol is made from many different crops and production processes. This could mean that there is variation in the quality of the fuel which could have serious consequences. If these variations are experienced by the consumer as something negative, e.g. the performance of the vehicle is worsened, the credibility of the fuel will probably be damaged.

Legal Perspective

Regulations – Regulations made by municipalities, nations or the EU can serve as support for the establishment of a fuel or vehicle on the market, and depends on the over-all policy that is practiced. Regulations can thus either create advantages or disadvantages for ethanol and ethanol fuelled vehicles.

Legislations – Laws work in the same way as regulations, but the consequences might be more serious, which makes legislation more forcing and powerful.

Bureaucracy – There is a lot of paper work involved in imports and trade with alcohol is even stricter than most trade. The processes are slowed down and costly in getting ethanol approved.

National and international standards – The use of standards might facilitate world trade of fuel ethanol. Governments will then know what is being brought in to their country and consumers know what they are buying.

Classification – Today there is concern about how to classify all different varieties of ethanol and what this classification should be based upon. This could complicate import, production and sales of ethanol.

Appendix III Assessment of Uncertainty Factors

Environmental Perspective

| <i>Uncertainty Factor</i> | <i>Impact Score</i> |
|--|---------------------|
| <p><i>Greenhouse gas</i> The focus on greenhouse gas and global warming has had a large impact on development and sales of ethanol fuel and vehicles. Changing beliefs concerning the greenhouse effect would therefore have substantial impact. Also, the greenhouse gas savings that come with ethanol use are not yet fully established which causes criticism against the fuel.</p> | 5 |
| <p><i>Other environmental consequences</i> Possible side-effects of ethanol-use are not fully investigated and it would hurt the reputation of ethanol if it was to be associated with pollutants that damage the environment or human health.</p> | 5 |
| <p><i>Land use</i> We think that a conflict about how to use land in Europe is very likely to occur and that it can create strong opinions regarding fuel ethanol and cultivation of biomass.</p> | 5 |
| <p><i>Biodiversity</i> We believe that the multitude of flora and fauna will be threatened by large areas of homogenous agricultural land, but production of biomass will be prioritised.</p> | 3 |
| <p><i>Deforestation</i> We think that deforestation is a probable outcome of the increased agricultural areas, but production of biomass will be prioritised.</p> | 3 |
| <p><i>Rainforest deforestation</i> If deforestation would occur, we think that it would create some negative publicity for fuel ethanol.</p> | 3 |
| <p><i>Plant diseases</i> A plant disease would cause large problems with ethanol supply which could hurt the ethanol market for many years ahead.</p> | 4 |
| <p><i>Crop failure</i> Significant reductions of biomass harvest would have impact on ethanol supply and price and thus have an impact on the ethanol market.</p> | 3 |
| <p><i>Land depletion</i> Intense cultivation of biomass will be necessary for a sufficient supply of ethanol and this can lead to land depletion. Again, ethanol production will be prioritised.</p> | 2 |
| <p><i>Genetically modified organisms</i> If crops that are better suited for ethanol production would emerge it could mean both advantages for ethanol production and disadvantages due to the resistance against GMO.</p> | 4 |
| <p><i>Noise</i> Problems with engine noise from the use of ethanol can most likely be</p> | 1 |

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| solved with technology. | |
|-------------------------|--|

Mean score: 3.45

Market Perspective

| Uncertainty Factor | Impact Score |
|--|--------------|
| <i>Supply of fuel ethanol</i> A sufficient supply of ethanol makes it possible for the fuel to earn market shares and is hence highly important. We also think that this will become an important issue, due to conflicts regarding energy supply. | 5 |
| <i>Supply of raw material</i> We believe that sufficient supply of biomass is a condition for sufficient supply of ethanol. We also think that this will become an important issue, due to land use conflicts. | 5 |
| <i>Customer attitudes</i> Our opinion is that positive customer attitudes towards fuel ethanol are of great importance, and they can change significantly during the chosen time period. | 5 |
| <i>Customer willingness to pay</i> We think that customers' unwillingness to pay a little extra for ethanol could cause problems, but this is managed by authorities through subsidies and tax exemptions. | 4 |
| <i>Vehicle competitor direction</i> The different vehicle manufacturers have always chosen different paths and technologies and we think that the direction of competitors will be very important for the establishment of a new fuel such as ethanol. | 5 |
| <i>Road transport substitute's direction</i> We think that road transport is fairly unthreatened by the available substitutes. | 3 |
| <i>Fuel substitute direction</i> We judge the technical improvements regarding other fuels to be an important threat against ethanol. | 5 |
| <i>Fashion trends</i> Trends are likely to affect the market and external factors that affect ethanol, but we do not think that they will sustain and have an important impact. | 2 |
| <i>Transport demand</i> We believe that the demand for transport is important for the establishment of ethanol, but we are quite certain that Scania and its ethanol-venture can be successful independently of this factor. | 2 |
| <i>Myths</i> Myths and rumours are unfounded allegations and can therefore quickly be eliminated and do therefore have a very limited impact. | 1 |
| <i>Local/Regional establishment</i> Our opinion is that local and regional establishments of alternative fuels and fuel production will have influence on the establishment of fuel ethanol. This is due to national and regional legislation as well as | 4 |

Ethanol for Scania's Future? – A Scenario Based Analysis

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| geographically varying possibilities to produce biomass or fuel. | |
| <p>Strategic alliance</p> <p>Since new fuel markets are forming and the uncertainties are many, forming a strategic alliance might be the key to success. If left out of this strategic alliance, the company might completely lose the power to influence the market.</p> | 5 |

Mean Score: 3.72

Economic Perspective

| <i>Uncertainty Factor</i> | <i>Impact Score</i> |
|---|---------------------|
| <p>Oil price</p> <p>We believe that the price of oil will have an impact on the demand for alternative fuels since consumers want the cheaper alternative.</p> | 4 |
| <p>Prices of raw material</p> <p>We think this will constitute important influences on fuel ethanol, mainly through price changes but the price changes will be corrected with help from subsidies and the like.</p> | 4 |
| <p>Price of fuel ethanol</p> <p>We believe that prices of other fuels will have a high impact on the market since fuel costs are so high for both the private person and the transport company and therefore will turn to the cheaper alternative.</p> | 4 |
| <p>Price of alternative fuel</p> <p>We believe that prices of other fuels will have a high impact on the market since fuel costs are so high for both the private person and the transport company and therefore will turn to the cheaper alternative.</p> | 4 |
| <p>Subsidies</p> <p>Subsidies play an important role in creating demand for fuel ethanol and are currently a prerequisite for ethanol's competitiveness.</p> | 5 |
| <p>Tariffs</p> <p>Tariffs create an uneven competition between ethanol produced in Europe and in Brazil. The tariffs have a large impact on the price of ethanol, and thus the demand, which makes it an important factor.</p> | 5 |
| <p>Taxation</p> <p>Tax exemption or reduction is one form of subsidy which is very costly. This is one reason why we believe that changes in ethanol taxation are likely to happen and this will have an immediate impact on ethanol price.</p> | 5 |
| <p>Exchange rates</p> <p>Exchange rates are always changing but it will have the same impact on ethanol as on oil and all other substituting products.</p> | 2 |
| <p>Business cycles</p> <p>We think that new products can be thought of as especially uncertain and risky in times of bad economy, but we also think that business cycles are affecting whole markets rather than one single product, and therefore we think importance is quite low.</p> | 4 |

Mean score: 4.2

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Political and Social Perspective

| <i>Uncertainty Factor</i> | <i>Impact Score</i> |
|---|---------------------|
| <i>Debaters</i> Debaters are recurrent elements in the media today and we believe that the public listens to them to a large extent, especially when what they say is negative. | 5 |
| <i>Lobbying</i> We find that lobbying will have a strong impact on the fuel ethanol market if they represent strong stakeholders that have great influence. | 5 |
| <i>Competition for governmental funding</i> If ethanol subsidies go to other parts of the public good it would affect the price of the fuel which we believe is of importance. | 4 |
| <i>Employment</i> We do not think that employing people in ethanol production will have any significant impact on ethanol's success as a fuel. | 2 |
| <i>The Middle East</i> There has been instability in the Middle East for many years now and this has turned a few heads towards ethanol but we do not think that it will have any major impact. | 3 |
| <i>USA</i> USA has lately turned to alternative fuels which might open a few doors for ethanol and have an impact on the market. | 3 |
| <i>China and India</i> The countries' increasing energy consumption might lead to a larger focus on alternative fuels which we believe will affect the market to a moderate degree. | 3 |
| <i>Production in developing countries</i> We believe that a move of production to developing countries will improve supply and lower prices which will impact the industry. | 4 |
| <i>Famine disaster</i> We believe that the fact that famine exists in the world today is only proof that a famine disaster will not have a significant impact on the issue fuel vs. food. | 2 |
| <i>EU's future and power</i> A change in EU energy policies and support for biofuels due to power- and attitude shifts will have a huge impact on the fuel market. | 5 |
| <i>Supply of animal feed</i> We do not believe that ethanol producers will take a shortage of animal feed supply into consideration to any significant degree. | 2 |

Mean Score: 3.3

Technological Perspective

| <i>Uncertainty Factor</i> | <i>Impact Score</i> |
|--|---------------------|
| <i>Technological development of vehicle</i> | |

Ethanol for Scania's Future? – A Scenario Based Analysis

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| It is important that the vehicles are being developed so that they emit less, consume less fuel, can run longer on every tank, etc. | 3 |
| <i>Technological development of fuel ethanol production</i> We believe that development in this area is of utmost importance since it might decrease energy consumption, cost, CO ₂ -emissions, etc. | 5 |
| <i>Competing ethanol engine technology</i> We believe that competition in this area is of importance. Scania might loose market share but at the same time have greater incentive to improve its products. | 4 |
| <i>Competing engine technology for other fuels</i> Competing technology exists today and has not had great impact on Scania's ethanol venture. Major advantages will however affect the company. | 4 |
| <i>Research</i> Research on production processes and fuel utilisation is very important. | 4 |
| <i>Development of biomass</i> We believe that it is very important to develop the biomass so that it can be utilised more efficiently. | 4 |
| <i>Energy balance</i> For ethanol to be considered an environmentally friendly fuel we believe that the energy balance will be of great importance. | 5 |
| <i>Infrastructure</i> We believe that it is very important to have extensive infrastructure supporting ethanol fuelled cars but less important for local vehicle fleets. | 4 |
| <i>CO₂ capture and storage</i> A shift from carbon dioxide saving to handling the emissions with new technology would heavily reduce the advantages with ethanol and affect the demand negatively. | 5 |
| <i>Ethanol quality</i> We do not believe that ethanol quality will constitute a problem, and if it would be, the impact will only be moderate. | 2 |

Mean Score: 3.89

Legal Perspective

| <i>Uncertainty Factor</i> | <i>Impact Score</i> |
|--|---------------------|
| <i>Legislations</i> Legislation is very important, laws need to be followed or there will be consequences. Laws can work both for or against ethanol which makes it uncertain since the fuel is dependent on legal aid until it is thoroughly established. | 5 |
| <i>Regulations</i> Since regulations can differ from one region to another, we believe that regulation will be of as much importance as legislations because there will be many parameters for the company to adapt to. | 5 |
| <i>Bureaucracy</i> | |

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| We do not think that the bureaucracy involved with ethanol trade will impact the ethanol vehicle market to any noticeable degree. | 2 |
| <i>National and international standards</i> We believe that standards will only slightly facilitate world trade of fuel ethanol. | 2 |
| <i>Classification</i> We believe that there will be some trouble with the classification but we think it will have little impact on ethanol vehicle sales. | 2 |

Mean Score: 3.2

Appendix IV Ethanol Supply Calculations

| | | |
|---|------------|--------------|
| Biofuel share of total transports: | 2017 | 8% |
| | 2027 | 13% |
| Fuel demand in transports 2003 (toe) | 1131564000 | |
| Energy Consumption in European transports 1990-2003 (toe) | 1990 | 272000000 |
| | 1991 | 276000000 |
| | 1992 | 284000000 |
| | 1993 | 289000000 |
| | 1994 | 291000000 |
| | 1995 | 295000000 |
| | 1996 | 305000000 |
| | 1997 | 311000000 |
| | 1998 | 323000000 |
| | 1999 | 332000000 |
| | 2000 | 334000000 |
| | 2001 | 336000000 |
| | 2002 | 339000000 |
| | 2003 | 344000000 |
| | 2004 | 350000000 |
| Average Annual Increase in Transport Energy Consumption 1990-2004 | | 1,82% |
| Average Annual Increase in Transport Energy Consumption 2000-2004 | | 1,18% |
| Future Energy Consumption (toe) | 2017 | 412281233 |
| | 2027 | 463444262 |
| Future Biofuel Demand (toe) | 2017 | 32982499 |
| | 2027 | 60247754 |
| Energy Contents in Ethanol (MJ/l) | | 21,4 |
| Energy Contents in 1 tonne of oil equivalents (MJ per toe) | | 41 850 |
| Future Biofuel Demand in MJ | 2017 | 1,36032E+12 |
| | 2027 | 2,52137E+12 |
| Demand Fuel Ethanol in litres | 2017 | 64500820868 |
| | 2027 | 117820958330 |

Ethanol for Scania's Future? – A Scenario Based Analysis

| | Wheat | Corn | Sugar Beet |
|--|--------------|-------------|-------------------|
| Ethanol Yield (Litres per tonne of raw material) | 384,6 | 387,6 | 97,1 |
| Ethanol Yield (toe per grown hectare of raw material) | 0,9 | 0,9 | 2,9 |
| Raw material consumption in ethanol production (kg per litre) | 2,6 | 2,58 | 10,3 |
| Raw material yield (tonnes per hectare) | 5,9 | 8,4 | 60 |
| EU Production 2005 (million tonnes) | 124 | 51 | 131,6 |
| EU Production 2005 (million hectares used) | 23 | 6 | 2 |
| Available agricultural land in the EU (million hectares) | 97 | 97 | 97 |
| Human consumption in the EU (million tonnes) | 48,5 | 3,8 | 104,075 |
| Raw Material Available for ethanol production (million tonnes) | 75,5 | 47,2 | 27,525 |
| Possible raw material production if all available land is used (million tonnes) | 572,3 | 814,8 | 5820 |
| | | | |
| | | | |
| Possible production of ethanol with today's production volumes (million litres) | 47690,4 | 19767,6 | 12778,36 |
| Possible production of ethanol with today's production areas (mtoe) | 20,7 | 5,4 | 5,8 |
| Possible production of ethanol if all available land was used for ethanol crops (mtoe) | 87,3 | 87,3 | 281,3 |
| Possible production of ethanol with today's production volumes less human consumption (million litres) | 29037,3 | 18294,72 | 2672,6775 |
| | | | |
| Cross check ethanol yield with actual values (tonnes per hectare) | 5,4 | 8,5 | 65,8 |
| | | | |
| | | | |
| Raw Material required to produce future demand of fuel ethanol (kg) | Wheat | Corn | Sugar Beet |
| 2017 | 1,67702E+11 | 1,66412E+11 | 6,64358E+11 |
| in million tonnes | 168 | 166 | 664 |
| 2027 | 3,06334E+11 | 3,03978E+11 | 1,21356E+12 |
| in million tonnes | 306 | 304 | 1214 |