The Sustainable Market Model

-Strategic Market Analysis Emphasising Sustainability and Growth

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Preface

This project was carried out during the spring of 2015 in Lund, as the final part of our master studies in Industrial Engineering and Management, at the Faculty of Engineering, Lund University.

We found the topic and work interesting and it has been both challenging and rewarding to apply our acquired knowledge of market analysis and investigation in a completely new, unfamiliar industry and market. During this project, we have received helpful ideas, support and assistance that we would like to thank for:

First of all, we would like to thank our supervisor N.A at the Company for the helpful comments, support and brainstorming sessions. You have together with M.S at the Company been most helpful in sharing your thoughts and providing us with guidance and information.

Secondly, a warm thank you to all of those that were involved during the interviews, who took the time from their busy schedules to assist us and answer to our questions.

Finally, we would like to thank our supervisor Gösta Wijk for your input and guidance.

We hope that the reader will find the thesis interesting and provide you with new insights regarding sustainability and market mapping.

Lund, June 2015

Louise Gustafsson Mårten Wikner

Abstract

Title The Sustainable Market Model – Strategic Market Analysis Emphasising Sustainability and Growth

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Background Sustainability is a concept and term that has gained major attention and has moved from being a buzzword to a concept that is integrated in any given company. It interests the authors how actual business opportunities can be evaluated where sustainability is emphasized. This master thesis is conducted along with the Company, operating in the chemical industry, which where interested to map the Sustainable Chemistry market and to investigate current trends and find potential business opportunities within Sustainable Chemistry.

Purpose The primary purpose is to develop a theoretical framework and methodology, *The Sustainable Market Model*, which will help any given business to map and evaluate a market from a sustainability perspective in order to find business opportunities. The secondary purpose of this thesis is to perform a market mapping over the Sustainable Chemistry market, to understand the current trends, customer demand and competitors in order to provide the Company with a recommendation for potential business opportunities.

Methodology Since the purpose is related to market mapping, the project can be described as a descriptive study, with a deductive relation between theory and empirics. Both quantitative and qualitative methods have been used to gather data. The primary sources have to a majority been collected from interviews from key persons, and secondary sources were used in form of statistical data and general market information. All sources have been carefully evaluated to ensure the quality for the thesis.

Conclusions *The Sustainable Market Model* is seen as an effective tool to map a specific market or segment and evaluate trends in a structured and simple way in order to find business opportunities. One should note that the weights and ratings that are used in the selection process are subjective to the company in question and should be chosen carefully. Sustainable Chemistry is a growing market and there exists a demand both from B2B costumers and the general public. However, the Sustainable Chemistry market development is restricted by macro trends such as current crude oil prices, toll policies on the sustainable feedstock and the absence of long-term governmental policies. Due to the low crude oil price, Sustainable Chemistry products cannot, in a majority of the cases, be cost competitive with fossil derived product equivalents. Some product groups where evaluated to have a higher business potential, determined by using *The Sustainable Market Model,* namely: Bio-PE, Bio-PET and Cellulosic Ethanol where the first is seen as the most viable opportunity due to its applicability to the Company´s current business and core competence.

Key Words Sustainability, Sustainable Chemistry, Market Mapping, Market Analysis, Business Opportunity

Sammanfattning

Titel	The Sustainable Market Model – Strategic Market Analysis Emphasising Sustainability and Growth
Författare	Louise Gustafsson & Mårten Wikner
Handledare	N.A Företaget Gösta Wijk - Docent Avdelningen för Produktionsekonomi vid Lunds Universitet
Bakgrund	Hållbarhet är ett koncept som har fått uppmärksamhet och som har gått från att vara ett ”modeord” till något som är integrerat i de flesta företags strategi. Författarna är intresserade av hur affärsmöjligheter kan bli utvärderade från ett hållbarhetsperspektiv och hur hållbara produkter kan skapa ett marknadsvärde. Företaget, som är verksamma inom kemi industrin, är intresserade av att kartlägga den hållbara kemi marknaden, nuvarande trender och hitta affärsmöjligheter inom marknaden för Hållbar Kemi.
Syfte	Syftet med denna uppsats är primärt att skapa ett teoretiskt ramverk och metodverktyg, *The Sustainable Market Model,* som ska underlätta för företag att kartlägga och utvärdera en given marknad ur ett hållbarhetsperspektiv samt att hitta och utvärdera affärsmöjligheter på denna marknad. Det sekundära syftet är att utföra en kartläggning över marknaden för Hållbar Kemi för att förstå nuvarande trender, kunders behov och konkurrenters agerande och bistå Företaget med en rekommendation för potentiella affärsmöjligheter inom denna marknad.
Metodik	Eftersom det syftet är att utföra en kartläggning av en befintlig marknad kan detta projekt beskrivas genom en så kallad deskriptiv undersökning, med en deduktiv relation mellan empiri och teori. Både kvantitativa och kvalitativa metoder har nyttjats för att samla in nödvändig data. Primär data har blivit insamlat via intervjuer som har genomförts med nyckelpersoner. Sekundär data, bestående i statistik och generell marknadsfakta, har också insamlats. Alla nyttjade källor har blivit noggrant utvärderade för att uppnå önskad kvalité på uppsatsen.

Slutsats

The Sustainable Market Model anses vara ett effektivt verktyg för att kartlägga och utvärdera trender på ett strukturerat sätt för att hitta affärsmöjligheter. Det bör poängteras att vikterna och poängsättningen som används i urvalsprocessen är subjektiva för företaget och borde bestämmas med eftertanke.

Hållbar Kemi är en växande marknad och det existerar en efterfrågan både från företag och slutkonsumenter. Dock så påverkas utvecklingen av marknaden för Hållbar Kemi utav makrotrender så som priset på råolja, tullar för den hållbara råvaran och frånvaron av långsiktiga politiska strategier. På grund utav det låga oljepriset har Hållbara Kemiska produkter svårt att konkurrenskraftiga ur ett kostnadsperspektiv. Vissa produktgrupper anses ha högre marknads potential, fastställt genom nyttjandet av *The Sustainable Market Model*, nämligen Bio-PE, Bio-PET och Cellulosic Ethanol. Den förstnämnda produktgruppen anses ha högst potential för Företaget baserat på dess kompabilitet med Företagets verksamhet och kompetens.

Nyckelord Hållbarhet, Hållbar Kemi, Marknadskartläggning, Marknadsanalys, Affärsmöjligheter

Abbreviations

BU – Business Unit
CAGR – Compound Annual Growth Rate
EMEA - Europe Middle East Africa
GC – Green Chemistry
GHG – Green House Gas
LA – Lactic Acid
PA – Polyamides
PE – Polyethylene
PET - Polyethylene terephthalate
PHA – Polyhydroxyalkanoates
PLA – Polylactic Acid
PU - Polyurethane
SA – Succinic Acid
SC - Sustainable Chemistry
VOC – Volatile Organic Compound
WTP – Willingness to Pay

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1 Introduction

This chapter will consist of a presentation of the background and a problem formulation that lays the foundation for this master thesis. The Company will be presented and the scope and limitations of the thesis will be stated. Finally, a presentation of the outline of the thesis will be specified.

1.1 Background

Today, most people are aware of the impact humanity has on our planet and the results our current habits probably will have in a long-term perspective. To counter a lifestyle that spends our planet's resources faster than they are generated, the concept sustainability has gained increased attention. As a reaction to this, sustainability is today part of most companies' agendas and the reasons for this are many: (Pedersen, 2010)

- Companies are encouraged to be sustainable by e.g. political agendas, policies, incentive systems and goals regarding e.g. reducing carbon footprint and upholding a non-toxic environment.
- Consumer awareness is increasing, demanding sustainable products.
- Technical innovations make it possible for companies to be sustainable, yet competitive.
- Legal restrictions, international laws and regulations forces organizations and companies to adapt, e.g. REACH forces companies to reduce the use of hazardous substances.

The authors of this master thesis have the ambition to investigate sustainability and how the concept actually creates business opportunities. The authors also want to develop a model, *The Sustainable Market Model* that can investigate and evaluate those opportunities. The thesis is conducted in collaboration with a large chemical corporation, herby referred to as the Company.

1.1.1 Presentation of the Company

The master thesis will be conducted in collaboration with the Company, more specifically a commercial hub within the Company that focuses on the United Kingdom, Ireland and the Nordic region. The Company is a chemical, multinational corporation with presence in approximately 160 countries and employs over 50.000 people worldwide. The Company is engaged in many different markets such as agricultural sciences, plastics, basic- and speciality chemistry where plastics is one of the Company's key markets.

The Company's goal is to create value in the intersection of chemical, physical and biological sciences in order to address challenging problems occurring around the world such as the need of clean water, clean energy generation and conservation and agricultural productivity. In order to reach this goal, the Company has an integrated and market-driven portfolio with over 6000 products. The Company is divided into operating segments with a structure that emphasise high-growth and high-margin businesses. This structure has therefore resulted in a strategy that addresses market opportunities closer to end markets where sustainable long-term value can be found. The key factors investment, innovation and integration are central when approaching a new market. (BJ & AN, 2015)

Sustainability, innovation and growth are three words the Company values and strive to infuse into its organisation, which is why the Company announced an interest regarding the subject of this master thesis. The Company has earlier conducted projects to identify growth opportunities in the Nordic region. Recently, a master thesis was performed at Lund Faculty of Engineering where two students did an in-depth market analysis on the Nordic region to find growth opportunities in order to increase sales for the Company. (Emanuelsson & Nilsson Orviste, 2014)

One growth area this earlier performed master thesis found relevant was Sustainable Chemistry, and the Company was recommended to further explore this area (Emanuelsson & Nilsson Orviste, 2014, p. 118), why the Company issued a new master thesis in Sustainable Chemistry.

One reason for the interest in Sustainable Chemistry is that the Company perceive that several of their competitors are involved in this development. It is therefore of great importance to investigate this particular market to understand current trends and potential business opportunities and threats if the Company where to involve themselves or not in the Sustainability Chemistry market. The Company is interested in both new products being developed within Sustainable Chemistry, how these affect the Company´s existing market and if it is possible to enter new markets with these products.

1.2 Problem Definition

Based on the information provided in the previous section, the problem definition for this master thesis can be put into context by the following main problem:

- How should a theoretical model be developed and used in order to evaluate and investigate a market to find business opportunities, where sustainability is emphasized?

To support the main problem, an investigation of the market will be made. The following problem definition puts this into context:

- How can the Sustainable Chemistry market be mapped, what are the current trends and what business opportunities can be found and applied on the Nordic market?

1.3 Scope

The master thesis will focus on the Nordic market and be a continued in depth analysis of one on the growth areas Emanuelsson & Nilsson Orviste identified in their master thesis (Emanuelsson & Nilsson Orviste, 2014). This master thesis will therefore use the conclusions provided by Emanuelsson & Nilsson Orviste when suitable.

1.4 Purposes

1.4.1 Primary purpose

The primary purpose is to develop a theoretical framework and methodology hereby called *The Sustainable Market Model*. This model is intended to make it possible to map and understand a defined market and function as an evaluation and investigation tool for business opportunities within that market. The model is also consistently emphasizing sustainability. The objective for *The Sustainable Market Model* is to create a model that is structured, understandable and applicable in different industries.

1.4.2 Secondary Purpose

The secondary purpose is to perform a market mapping regarding Sustainable Chemistry with a focus on the Nordic region by using *The Sustainable Market Model.* This research should result in a complete mapping of the current trends in the defined market, an understanding of the stakeholders, the consumers and the competitors. These results should then be the foundation in the process of finding business opportunities for the Company. A business opportunity is hereby defined as an area where the Company can obtain a market share within Sustainable Chemistry and satisfy the customers' demands. This business opportunity should make it possible for the Company to compete with a Sustainable Chemistry product on the Sustainable Chemistry market.

1.5 Delimitations

1.5.1 Length of Master Thesis

The timeframe of the thesis is limited to 20 weeks full time work.

1.5.2 Geographical Limitation

This master thesis will focus on the Nordic region, hereby defined as Sweden, Denmark, Finland, and Norway. However, to get an understanding of Sustainable Chemistry, the European and American market will also be taken into account to identify macro trend and growth areas.

1.5.3 Business area for the Company

Only B2B commerce will be taken into account when evaluating business opportunities for the Company. The market mapping and business opportunity evaluation must also be related to the Company's business areas and commerce interests. Pharmaceutical and food processing chemical products will not be investigated.

1.5.4 Chemical knowledge limitation

Since the Sustainable Chemistry market demands extensive knowledge in chemistry, the discovered chemical methods and processes will only be briefly examined and the specifics are left to experts that are present within the Company.

1.5.5 Anonymization

Sensitive market information to the Company has been dismissed from the thesis. Since there are a limited number of global, chemical companies on the market, the competitors name has also been censured in the thesis in order to keep the Company anonymous.

1.6 Paper Outline

Chapter 1 – Introduction

In the Introduction, the reader will be presented with the scope and background for the master thesis. The introduction will begin with a general introduction to sustainability and the public and market attention the subject have been given the latest years. The reader will be introduced to the Company where the study has been performed and the purpose with the thesis is presented.

Chapter 2 – Methodology

The methodology will present different approaches and describe and motivate the chosen definition for the master thesis. The methods for collecting data will also be presented together with criticism of the chosen methods.

Chapter 3 – Theoretical Assessment

The reader will be introduced to the available theory used to define sustainability, map a market and assess business opportunities and growth strategies. These theories will be used and integrated in *The Sustainable Market Model*, which will be presented and explained in an in-depth manner in the second part of the chapter.

Chapter 4 – Empirical Data Collection

The collected empirical data will be presented according to the different phases of *The Sustainable Market Model*. The data is a combination of quantitative and qualitative sources and consists of statistical data, interviews and reviewed journals. The reader is advised to read the chapter in combination with "Chapter 5 – Analysis" since the presented material is collected accordingly to the processes in *The Sustainable Market Model*.

Chapter 5 – Analysis

The gathered empirical data will be analysed with the stated theoretical approaches used in *The Sustainable Market Model*. The reader is advised to read the chapter in combination with "Chapter 4 – Empirical Data Collection" in order to better understand the process.

Chapter 6 – Conclusion and Recommendation

A conclusion and recommendation will be stated both regarding the potential business opportunities within Sustainable Chemistry for the Company and regarding the usage and methodology of *The Sustainable Market Model*.

Chapter 7 – Discussion

The authors' thoughts and reflections will be presented and the results will be discussed. The chapter will also consist of recommendations for future research and discussion of the general contribution of the thesis.

Chapter 8 - References
In this section, the used sources that have been referred to throughout the paper are presented. The sources are alphabetically presented.

Chapter 9 – Appendix
Additional information supporting the analysis and conclusion is presented in the appendix. The material presented consists of calculations and scoring processes performed in the analysis as well as an example of an interview guide used for the qualitative data collection.

2 Methodology

This chapter presents different methodology approaches and describe how these have been applied in the master thesis. The chapter will start by stating the project classification and relation between theory and empirics. The type of methodology is stated before the data collection strategies are defined. Finally the validity of the methodology will be disclosed before reflections regarding the methodology criticism are discussed.

2.1 Project Classification

The methodology is closely linked to and dependent on the project and the research question. It is possible to describe the project purpose in several ways. A *descriptive* study has the overall purpose to describe how a specified task is executed or functions and can usually take the form of mapping an object. A *problem-solving* study is performed in order to find a solution to an identified problem. If an in-depth investigation is to be made to gain understanding of how something works, the study is defined as *exploratory*. In an *explanatory* study, causes and explanations are sought for a defined problem. It is also possible that a study consists of several segments, with different purposes and characteristics. (Höst, Regnell, & Runeson, 2006)

2.1.1 Project Classification in the thesis

The primary purpose, as stated, is to create a theoretical framework i.e. *The Sustainable Market Model* since there is a lack of a framework that emphasise sustainability. This is an identified problem and therefore the development of *The Sustainable Market Model* can be described as a *problem-solving* study. As previously stated, a major part of the secondary purpose is to map the Sustainable Chemistry market in order to understand the current trends, customer demand and the competitors. This purpose can therefore be described as a *descriptive study.*

2.2 The relation between theory and empirics

A reputable research study needs to be related to and answered by assistance of current available theory. The relationship between theory and executed research can be described in three different ways:

- *Deductive theory* is the most common way to interpret the relation between theory and conducted research. Based on current established theory, a hypothesis is made and then evaluated against observations made in reality (Bryman & Bell, 2011). The process is described in Figure 1

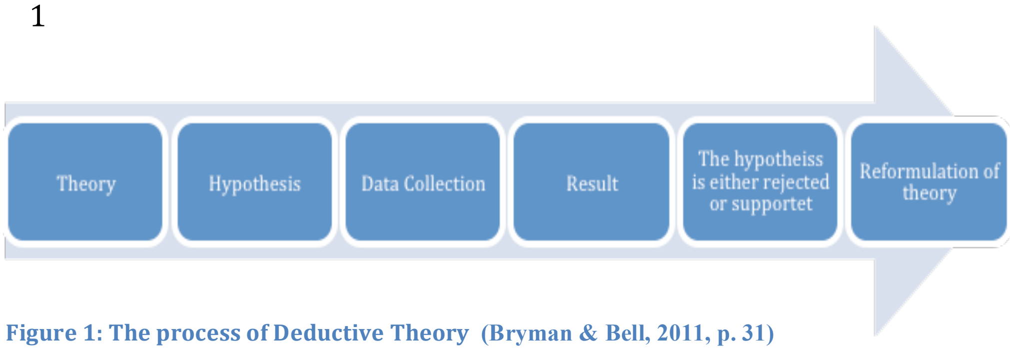

Figure 1: The process of Deductive Theory (Bryman & Bell, 2011, p. 31)

- *Inductive theory* process, the theory is a result of the collected research. The inductive theory is therefore the process of drawing conclusions and creating theory from performed observations. (Bryman & Bell, 2011)
- *Abducted theory* is a combination of *deductive*- and *inductive theory*. Using the abductive process it is possible to draw some conclusions from a current situation, which will build up a theoretical model. The theoretical model will then be tested against empirical obtained data. (Nilsson, 2015)

2.2.1 Relation of Theory and Empirics in the thesis

The research performed in this thesis, i.e. the created *Sustainable Market Model*, can be described with a *deductive theory* process. Conclusions were drawn from current stated theory, which were combined in order to develop the theoretical framework. The *Sustainable Market Model* was then used to discover and evaluate potential business opportunities for the Company.

2.3 Types of methodology

There are in general four different types of methodology that can be suitable for a master thesis. A methodology can either be fixed or flexible, where the former implies that the methodology is defined in advanced and the latter is iterative meaning the methodology can be changed as the research progress.

Survey is a recommended methodology if the aim with the research is to describe a current phenomenon or fact (Höst, Regnell, & Runeson, 2006). According to Groves et.al a survey is "a systematic method for gathering information from (a sample of) entities for the purpose of construction quantitative descriptors of the attributes of the larger population of which the entities are members." (Groves, Fowler, Couper, Lepkowski, Singer, & Tourangean, 2009). A survey has a fixed nature, since it is not possible to change or add questions once the survey population have been asked (Höst, Regnell, & Runeson, 2006).

Case Study is favourable when the research aims to describe a phenomenon in an in-depth manner (Höst, Regnell, & Runeson, 2006). A case study approach is preferred when the research is conducted to answer "how" or "why" questions (Yin, 2003). According to Höst et.al (2006), a case study can provide in-depth knowledge that is not possible to attain through a survey approach. A case study is of a flexible nature, since the obtained information will affect what type of information that will be of further interest. Case studies are often recommended and associated with an *exploratory approach,* however, Yin (2003) argues that a case study also is compatible with the others research purposes. The choice of using a case study approach should instead be based on the three following factors; if the research question is trying to answer a question that depends on operational links rather than incidents. Secondly, the control over behavioural events should be limited. Finally, the focus should lie on contemporary events. One of the strengths with case studies is that several techniques for gathering can be used; such as documents, artefacts, interviews and observations (Yin, 2003).

Experiment is a more controlled form of methodology, which is used when the objective is to explain the occurrence of different phenomena. In an experiment it is possible to analyse different factors impact on the research object by repeating the occurrence other different circumstances. The design of an experiment is fixed. (Höst, Regnell, & Runeson, 2006)

Action Research has the purpose to improve the research object while studying it. Action research is often described as a type of case study. The action research process begins by observations of a situation in order to define the research problem it aims to solve. This can often be made by either a survey or case study approach. The observation phase is followed by suggesting a solution to the defined problem, and implementing the discovered solution. The process is concluded with an evaluation of the solution. The action research is an iterative process where the evaluation determines the success or need or revision of the suggestion solution. (Höst, Regnell, & Runeson, 2006)

2.3.1 Methodology used in the thesis

The type of methodology suitable for this thesis is a *case study*. The nature of the research question can to a large extent be related to what Yin (2003) stated. The aim is to answer what current market trends will result in, which involves several factors that need in-depth analysis. The predefined influence of the study will be limited and the question is based on contemporary occurring events. Furthermore, to answer the research question in a satisfying manner, it is important to perform an in-depth study that will not be possible with a survey approach. The chosen methodology will also provide the possibility to use several different information collection tools, which is important to achieve satisfying results.

2.4 Data Collection Strategies

Before stating the methods and tools used to gather the necessary data, it is important to distinguish between *qualitative* and *quantitative* data. *Qualitative* data consist of descriptions of a phenomenon, where the collected data is rich on details. *Quantitative* data consist of countable material that can be analysed with statistical measures. (Höst, Regnell, & Runeson, 2006) Criticism regarding *quantitative* research is highly related to the possibility of neglecting possibilities for interpretation; the rather static method mirrors an objective reflection of the society. On the other hand, *qualitative* research methods can be criticised for being too subjective, since the research often can be build on the researcher's view of what is significant, leading to unwanted biases. (Bryman & Bell, 2011) Therefore, a combination of *quantitative* and *qualitative* can be favourable. (Höst, Regnell, & Runeson, 2006)

2.4.1 Data collection Strategy in the thesis

The data collection will consists of both *qualitative* and *quantitative* methods, where the used methods will play alternating importance throughout the process. Quantitative methods will be used to gather information of the current market and the competitive landscape. The quantitative methods will be complemented with qualitative methods, in order to receive an in-depth understanding of both the Company´s current business and external stakeholders projections of the future market.

2.5 Qualitative Assessment

Interviews are a *qualitative* research tool where a person is questioned in a more or less systematic way (Höst, Regnell, & Runeson, 2006). A qualitative interview can either be classified as *unstructured* or *semi-structured*. An *unstructured* interview is normally based on one overall theme, where the researcher allows the interview object to steer the conversation. A *semi-structured* interview is more specific, where the researcher often follows an interview guide in order to control the interview. The interview guide can be designed as a list over the areas covered in the interview, however, the most important is that the questions allows the researcher to gather the desired information while allowing flexibility. (Bryman & Bell, 2011)

It is seen as preferable to conduct an interview over a personal meeting since it is usually possible for the interviewer to react on personal events e.g. body language. (Lekvall & Wahlbin, 2007)

2.5.1 Qualitative Assessment in the thesis

Interviews are seen as an important and useful tool to gather information. The purpose with the interviews is to get a deeper knowledge and interpretation of the quantified collected data, which will strengthen validity and bring input to the collected data. The interviews will be performed in a *semi-structured* way in order to ensure that the desired areas will be addressed while providing interaction and flexibility to the interview. A example of a interview guide used can be seen in section 9.3 – "Example of Interview Guide" in the Appendix.

2.6 Quantitative Assessment

To gather information at first hand can both be time consuming and impracticable. It is therefore common to use second source data to obtain the information needed (Bryman & Bell, 2011). Second source data can be classified in the four following ways: (Höst, Regnell, & Runeson, 2006)

- *Processed material* is material that have been sourced with scientific measures and published in e.g. scientific journals and/or theses.
- *Statistics* consists of data that have been collected and sorted, but no conclusions have been drawn.
- *Registry Data* are data that have been collected for a specific purpose but has not been sorted or processed.
- *Archive data* information that not is systemized as data, e.g. meeting proceedings.

A researcher can use similar methods to process and analyse second source data as for primary data, however the material should be carefully validated (Höst, Regnell, & Runeson, 2006).

2.6.1 Quantitative Assessment in the thesis

The quantitative data is to a majority collected through secondary sources, due to the obstacles with both time resources and data availability. The quantitative data will mainly consist of *statistics* and *processed material*.

2.7 Credibility

Credibility is a process performed in order to verify the research result.
The validity of a flexible research should take the following areas into account. (Höst, Regnell, & Runeson, 2006);

- *Logging*: Documentation of the research process is an important factor to prove validity of the research process.
- *Feedback:* To confirm the interpretation of information, feedback should be gathered from the contributing sources.
- *Third-party auditing:* To reduce the risk of biases and subjective interpretation of the researches, a third-party can be consulted.
- *Triangulation:* By using several different methods in order to collect and analyse data allows for the research object to be studied in different perspectives, which is called triangulation.
- *Long-term studies:* There are both possible benefits and risks by performing long-term studies. Short studies might lead to a misinterpretation and neglecting of the complexity in the matter, while performing the study over a longer time period might lead to biases.

2.7.1 Credibility in the thesis

In order to prove validity of the research all of the cited examples are used, with the exception of long-term studies. Since the thesis has a pre-defined time frame, there is no possibility to perform the research over a longer time-period.

Feedback regarding validity is gathered by e.g. summary of the interview material, which is then sent back to the respondents in order to secure the result.

The supervisor at Lund University has functioned as a *third-part auditor* and has continuously reviewed the material and methods. As described earlier, both quantitative and qualitative methods have been used, which will ensure *triangulation*. Furthermore, weekly meetings were held with the Company to discuss the research progress where *feedback* was given. These meetings where based on documentation and *logging*.

2.8 Methodology Criticism

Approximately 20 interviews have been held with key persons both within the Company and with external stakeholders from e.g. business associations. A larger interview sample would have been superior, but due to the limited timeframe, 20 interviews is seen as satisfactory and provided the authors with the needed qualitative data.

The interviews were impossible to perform during a personal meeting since the interviewees have been positioned on several different geographical locations. The majority of the interviews were therefore conducted over telephone.

As mentioned, information has been collected from secondary sources. The material has been collected from reliable sources and databases, such as textbooks from university courses and from LUBSearch of Lund University Library. An evaluation of the origin of the author and character of the journal was performed in order ensure the quality of the gathered information. Regarding the qualitative sources i.e. the performed interviews, one should note that stakeholders, such as business associations, have a personal gain and interest in what information and impression they would like to spread and cannot therefore be seen as independent sources. However, since the gathered material and data was shown to several persons from different organisations and confirmed by several independent sources, the gathered qualitative data can be seen as valid.

3 Theoretical Assessment

This chapter presents the used theoretical tools and models, where each theoretical tool's and model's connection to "The Sustainable Market Model" is stated. Following, the theoretical framework "The Sustainable Market Model" is presented, described and explained.

3.1 Theoretical Presentation

As stated, the primary purpose of this master thesis is to develop a theoretical framework, which will be used in order to conduct a market mapping and find business opportunities within the defined Sustainable Chemistry market. To achieve this, market evaluation and investigation tools are needed in order to gain the needed in-depth understanding of the market. The identified potential business opportunities also need to be connected to the Company's business to ensure strategic fit. Moreover, the concept of sustainability has to be part of the entire process.

3.1.1 The Triple Bottom Line

The triple bottom line is a common way to make a company value its social, economic and environmental impact and not just focus on finances. These different impacts are the three parameters of sustainability and the triple bottom line is intended to infuse sustainability into business practises and goals. The triple bottom line is often stated as people, profit and planet, see figure 2.(Investopedia, 2015) (The Economist, 2009)

- **People -** fair and favourable business practices regarding labour and the community where the company conducts its business
- **Profit –** the economic value the company creates. Can also be seen as the economic benefit the company gives to its surrounding community and society

- **Planet –** the use of sustainable environmental practices and the reduction of environment impact

Figure 2: The Triple Bottom Line.

The triple bottom line's connection to The Sustainable Market Model

The triple bottom line will be used to define sustainability and therefore be used in phase 1, see section 3.2.1 "Phase 1 – Defining Sustainability". This definition will then follow through *The Sustainable Market Model* and is therefore seen as fundamental.

3.1.2 Ansoff's Matrix

Ansoff's matrix is a strategic tool that companies and organizations use to decide how growth can be obtained by assessing four basic alternatives for strategic development. The matrix focuses on a company's present product and market and tries to find growth by finding suitable, potential product portfolios and markets. To do so the matrix has four categories with corresponding strategies, see Figure 3:

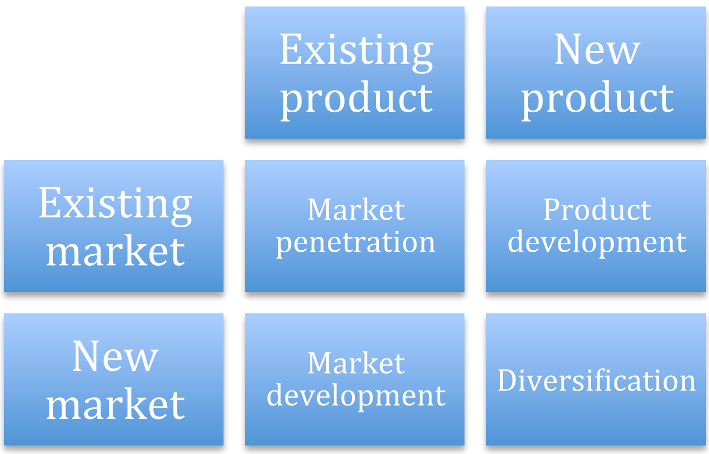

Figure 3: The Ansoff´s Matrix

For a company it is important to know the differences between the categories to make an appropriate strategic decision and each category will be presented below: (QuickMBA, 2010)

- **Market penetration –** is when a company stays on their current market with their current product portfolio, meaning the company aims to keep or increase its current market share. If the market is growing and there are possibilities for the company to keep or increase their market share, this strategy will result in growth. Market penetration is a low risk strategy and if the company has a strong competitive advantage such as more capacity than its competitors, this strategy is applicable. Important to note that this strategy gets more complicated in a saturated market and where there is a high competitive rivalry. (QuickMBA, 2010)
- **Market development –** is when a company starts doing business with its current product portfolio in a new market or market segment. This growth strategy associated with higher risk than market penetration, but if the company has a considerable competitive advantage that is applicable also in the new market, its potential to be successful. (QuickMBA, 2010)
- **Product development –** is when a company stays in the same market but develops its product portfolio. This strategy should be investigated if the company's competitive advantage is associated to the customer, meaning the customer is likely to choose the company rather than others due to e.g. branding, good reputation etc. This implies that a customer is expected to choose a certain company, even if this company release a new product. Product development is associated with risk since development often needs considerable investments. (QuickMBA, 2010)

  A new product can be defined in several different ways, from an entirely new product with new features and areas of usage or a development of an already existing product. There are three major reasons that drives product innovation: (Proctor, 2014)

  - Increased volatility in customer demand
  - Growing and more sophisticated competition on the market
  - Technological development

  Developing a new product is associated with high risk, since it is complex to calculate the investment needed, to create forecasts and there is a possibility that the predicted demand is inaccurate. Before developing a new product some crucial questions should be answered, e.g.: (Proctor, 2014)

  - Is the product compatible with present distribution channels?
  - Is the product complementary to current products?
  - Can it be priced alongside products of similar quality?

  - Will promotion of the product be easy?
  - Is the market likely to grow in size?

- **Diversification** – is when a company develops a new product and start doing business on a new market or market segment. This strategy carries the highest risk of the growth strategies, but the return for a company may be a new market with new customers. One can differentiate between two types of diversifications, where a "related" diversification has commonalities with the current business. Synergies and economics of scale can be reached based on the opportunity to synchronise the new opportunity with current knowledge. Both manufacturing skills and R&D skills are factors that can lead to new related diversification business opportunities. There exist potential risk areas with related diversification: (Proctor, 2014)

  - Similarities and potential synergies simply do not exist
  - Implementation problems provides barriers to the potential opportunity
  - The opportunity is over-valued

  On the other hand, unrelated diversification has no connections to the current business and are usually performed due to financial reasons, where the goal is to generate profit that might be either larger or more stable than from the current business. The largest risk with unrelated diversification is that the attention will be diverted from the core business. (Proctor, 2014)

Ansoff's connection to The Sustainable Market Model

This master thesis's purpose is to conduct a market mapping and find sustainable business opportunities within the defined Sustainable Chemistry market. Ansoff will especially be used in the final phase of *The Sustainable Market Model*, in order to position and analyse the most potential business opportunities the Model provides. Depending on what Ansoff category each business opportunity is placed in, this category's approach, risk, and strategy will be taken into account. To see the connection between Ansoff's matrix and *The Sustainable Market Model,* see section 3.2.8 - "Business Opportunity analysis".

3.1.3 PESTEL

PESTEL is a tool used to define and analyse an organization's macro environment in a structured way. Important to note is that PESTEL focus on the future impact that the different factors might have on the macro environment. PESTEL stands for: (PESTLEANALYSIS, 2015)

- **Political** – How e.g. a government can influence a market, an industry or a market segment. Political factors that can influence the market are, for an example, taxes, duties, subsidies, trade agreements and incentive programs
- **Economic** – How the macroeconomic situation affects a market, an industry or a market segment. Economic factors are e.g. inflation rates,

interest rates, growth patterns or fundamental pricing rules that affect competitiveness

- **Social** – Factors such as culture trends, demographics, population, specific regional needs and demand patterns
- **Technological** – Factors such as research, development and technological awareness that affect an industry, market or market segment
- **Environmental** – Factors that affect the surroundings of an industry, a market or a market segment. These surroundings often have a direct impact on an organization and automatically put the organization in a favourable or unfavourable position
- **Legal** – Laws that affect the industry, market or market segment. The legal aspect also covers e.g. policies that forces organizations to adapt

PESTEL's connection to The Sustainable Market Model

PESTEL will be used to structure the macro data influencing the market or market segment and how this macro data might influence the business opportunity potential for different product groups in the future. Since sustainability is a fundamental factor in *The Sustainable Market Model*, PESTEL will be modified to suit the special requirements of the model. How the PESTEL is used in *The Sustainable Market Model* will be further explained in section 3.2.6 "Phase 4 – Product Group Investigation".

3.1.4 Porter's Five Forces

Porter's five or six forces aim to characterise the key factors that have impact on a business opportunity, a defined market or a market segment. The purpose is to investigate how much rivalry that exists and hence the attractiveness and profitability potential. By using the model, it is possible to investigate if the unique situation caused by the correlation of the forces makes it possible for companies to be profitable or not. (Mind Tools (1), 2015) (Entreprenurial Insights, 2014)

The forces identified by Porter can be divided into: (Mind Tools (1), 2015) (Entreprenurial Insights, 2014)

- **Horizontal forces** – theses forces are characterised by: threat of substitutes, threat of new entrants and competitive rivalry
- **Vertical forces** – bargaining power of buyers and bargaining powers of substitutes

Competitive rivalry

Being able to quantify the competitive rivalry is the goal when using the model and this metric increase when: (Mind Tools (1), 2015) (Entreprenurial Insights, 2014)

- Similar sized companies operates in the same market
- Companies have similar strategies and are therefore alike in what they intend to do
- The companies offer similar product with similar features and customer values.

- There are high exit barriers and low entry barriers

Threat of new entrants

This metric investigates how easy it is for other companies to enter the same market as an existing company, meaning that if a company sees a market opportunity on another market than its own, how possible is it for the company to seize it. If a market or a market segment is profitable, especially in a long-term perspective, it will be attractive to new entrants. It is then important to investigate the barriers of entry of the market. These barriers may be: (Mind Tools (1), 2015) (Entreprenurial Insights, 2014)

- High investment cost
- Need to access special technology or infrastructure
- Patents and special knowledge
- Economies of scale or government driven obstacles
- High switching cost for customers from current supplier to a new
- Difficulties to access raw materials, create distribution channels and/or find suppliers

Threat of substitutes

Substitutes are products that are sold and affiliated to another market, but can satisfy the same need on the investigated market. This means that if it is easy to substitute a company's product on a market with another product from another market, the competitive environment is increased. The threat of substitutes is affected by: (Mind Tools (1), 2015) (Entreprenurial Insights, 2014)

- Brand loyalty
- Switching costs
- Relative prices
- Unique customer needs in the market or market segment

Bargaining power of buyers

It the buyers are big players and have the power to affect the prices on a market, they can influence the market attractiveness. Buyers have power when it is: (Mind Tools (1), 2015) (Entreprenurial Insights, 2014)

- Easy for them to switch suppliers
- The buyers are large companies with large purchasing volumes
- The buyers have a large market share
- The supplying company can't risk to loose its customer

Bargaining power of suppliers

If the suppliers to a market or segment have the power to dictate terms, set prices and affect the buying companies to their own advance, they have a high bargaining power. This may be if the suppliers: (Mind Tools (1), 2015) (Entreprenurial Insights, 2014)

- Are limited in terms of amount

- Switching cost from current suppliers is high
- The suppliers hold an important patent
- Buyers lack alternatives

The sixth factor: Government
When using Porter's five forces, one need consider what affects the overall market or market segment. Such factors can be e.g. governments, market trends and overall market lifecycle situation. Especially governments can directly affect a company's competitive situation by e.g. policies, legislations and incentive programs to create competitive capabilities for certain markets that they want to develop. (Entreprenurial Insights, 2014) (Mind Tools (1), 2015)

Porter's five forces connection to The Sustainable Market Model

Porter's five forces will be used in the final phase of *The Sustainable Market Model* to position the most potential business opportunities and connect them to the market, the company and the company's strategy, see section 3.2.8 – "Business Opportunity Analysis".

3.1.5 Market Attractiveness - GE Mckinsey Matrix

The GE Mckinsey matrix is a strategic tool designed to assist companies and organizations to determine where to invest when several alternatives exist. The tool provides a systematic, structured approach to investigate a company's business units (BU) and the industries the BUs are engaged in. The tools also states how each BU should be managed depending on its performance.

The GE Mckinsey matrix is divided into two parameters: **Industry attractiveness** and **Competitive strength of business unit or product**. (Strategic Management Insight, 2014) (McKinsey & Company, 2008)

Industry Attractiveness
The industry attractiveness parameter measures how complex it is to compete for a company within a defined market or industry. The Industry attractiveness' major measurement is profit, meaning the more profitable an industry or market is, the more attractive it becomes. When evaluating the industry attractiveness, a long-term perspective is recommended and factors to evaluate are: (Strategic Management Insight, 2014) (McKinsey & Company, 2008)

- Long term growth rate
- Industry, market or market segment size
- Industry profitability, often measured by using Porter's five forces described in section 3.1.4
- Trend of prices
- Product life cycle changes
- Macro environment factors, often stated by using PESTEL described in section 3.1.3

Competitive strength of business unit or product
The strength of BU measures how strong a product or business unit must be to be able to compete against others. The target is to achieve a sustainable

competitive advantage that will result in long-term profit. Factors to evaluate are: (Strategic Management Insight, 2014)

- Total market share
- Market share growth in comparison to competitors
- Brand strength
- Customer loyalty
- Ability for a company to meet Critical Success Factors
- Strength of value chain
- Profitability - meaning how can a BU be profitable in comparison with its competitors' BUs

How the GE Mckinsey Matrix is applied
A general methodology for how to use the tool is:

1. **Make a list of factors** – These are factors that affect the Industry Attractiveness. The list often contains common factors such as industry size, industry growth and pricing trends, but the list should be adapted to each industry's unique environment.
2. **Assign weights** – the weights declare how important each factor is for the industry's attractiveness. The weights can be in the range of (0-1) and the sum of the weights should be 1.
3. **Rate the factors** – rate the factors for each BU or market segment. This rating should be performed out of an industry perspective and answer how well a BU perform in relation to each factor previously stated.
4. **Calculate the total score** – multiply the assigned weights for the factors with the ratings of each factor. The product of this state how well a BU performs within the Industry Attractiveness parameter. This BU performance can then be compared with other BU's performance for the same factors.

The "Competitive strength of business unit or product" is calculated using the same methodology, however, now are the factors, weights and ratings from the BU's perspective. When both the **Industry Attractiveness** and **Competitive Strength of BU** are calculated for each BU it is possible to plot the result in a matrix, called the GE Mckinsey matrix. This matrix puts the analysed BUs in relation according to their performance in Industry Attractiveness and the Competitive Strength of each business unit. An example of such a matrix can be seen in Figure 4. (Strategic Management Insight, 2014)

Analysis of each business unit
When each BU is investigated, the results can be used to decide how to allocate a company's resources in a strategic way. If the Industry Attractiveness and Competitive Strength of BU parameters both are high, the company is recommended to invest in the to seize the business opportunity. If both parameters are low, the allocation of resources should just be enough to keep the business unit operating, as long as the BU is expected to be profitable. If the BU is not profitable, it should be harvested, see Figure 4. (McKinsey & Company, 2008)

Market Attractiveness \ Business Unit Strength	High	Medium	Low
High	Grow	Grow	Hold
Medium	Grow	Hold	Harvest
Low	Hold	Harvest	Harvest

Figure 4: The GE Matrix. When the BU Competitive Strength and Industry attractiveness parameters are high, the GE Mckinsey Matrix suggest that a company should invest in that BU, in this table stated as "Grow". The "Hold" sections depicts that the company should invest to keep its market share. If the BU is positioned in the "Harvest" sections the company is recommended to liquidate that BU or change it. (Marketing91, 2014)

GE Mckinsey Matrix's connection to The Sustainable Market Model

The GE Mckinsey matrix will be fundamental when analysing the discovered market segments and product groups. The GE Mckinsey matrix therefore takes *The Sustainable Market Model* from being a mapping tool of the defined market to finding and analysing business opportunities within the defined market. The GE Mckinsey Matrix will, after being modified, help to create factors, weights and ratings that makes it possible to rate and compare different market segments and product groups from market mapping in order to see display their performance to be a business opportunity for a company.

As mentioned, the GE Mckinsey Matrix will be modified when applied in *The Sustainable Market Model.* Instead of using a matrix, the ratings will be displayed as a table where especially **Industry Attractiveness** factors are emphasized. How the list of factors, weights and ratings are conducted in *The Sustainable Market Model* will be explained in section 3.2.5 - "Selection Process of Phase 3", and section 3.2.7 "Selection Process of Phase 4".

3.1.6 SWOT

SWOT stands for strengths, weaknesses, opportunities and threats and is a tool to structure what a company or organization can or cannot do related to its environment. The tool is widely used in the industry since it allows the user to structure data and it is also relatively easy to understand, manage and communicate. The tool can be used as a:

- Management tool for strategic issues
- An exploration tool to find new growth opportunities
- To evaluate and prepare for business or organizational change
- Analysis tool to find your company's competitive advantages
- Analysis tool to understand the competitive landscape

The first step is to define the scope of the analysis in order to understand the purpose when using the tool. When the scope is understood, the second step is to divide the SWOT tool's components into internal and external factors. The internal factors are represented by strengths & weaknesses and are factors that come from within the company. (University of Kansas, 2014) The external factors are represented by threats & opportunities: (Mind Tools (2), 2015)

- **Strengths** – the strengths are related to a company's resources and capabilities. These factors answer why a company, organization, product, service etc. is better, cheaper, more efficient, provides competitive advantages.
- **Weaknesses** – are opposite characteristics to strengths. Areas of weakness in a company or for a product etc. should be the answer to: what can be improved, what is not performing satisfactory and what is likely to be perceived as a weakness for others?
- **Opportunities** - are market opportunities that the company should react in order to create e.g. revenue or competitive advantages. Opportunities can be a new customer demand, trends, technological leap etc.
- **Threats** – are related to risks that can be derived from competitors, customers, the market, governmental laws and policies. The threats are factors that a company needs to adapt to if it wants to uphold a competitive advantage and take into account when making a decision.

An example of a SWOT matrix can be seen in Figure 5

Figure 5: the SWOT analysis. Strengths and weaknesses are internal factors, threats and opportunities are external factors

SWOT's connection to The Sustainable Market Model

SWOT will be used to evaluate the most potential business opportunities that the theoretical framework will provide. The tools will therefore be used in the final phase of *The Sustainable Market Model* and together with Porter's five forces and

Ansoff's matrix, connect the business opportunities to the market, the company and the company's strategy. See section 3.2.8 – "Business Opportunity Analysis"

3.2 The Sustainable Market Model

The Sustainable Market Model is intended to be a mapping tool that helps companies to find, investigate and evaluate business opportunities in a defined market, where sustainability in emphasised throughout the whole process. *The Sustainable Market Model* is intended to be applicable on any given market or market segment, for any company or organization. In this master thesis the Sustainable Chemistry market will be the targeted market, which is mapped and evaluated using *The Sustainable Market Model* for the Company. The model is developed through a iterative process, where it has been modified throughout the working progress in order to integrate obtained data and validate the functionality of the model.

A visualisation of *The Sustainable Market Model* is displayed in Figure 6. The model´s first step is to define the market's core values and characteristics to draft the exterior market requirements. Following, the defined market is analysed out of a macro perspective and each found market segment is investigated. This market segment investigation ends in a selection process where the market segments with the largest potential to contain a business opportunity are further investigated on a product group level. The product group level investigation ends in a selection process where the product groups that are most likely to be a business opportunity are further analysed. The last analysis connects the business opportunities to the market, the company and the company's business using known strategic tools. *The Sustainable Market Model is* divided into five phases, each will be explained in the following sections.

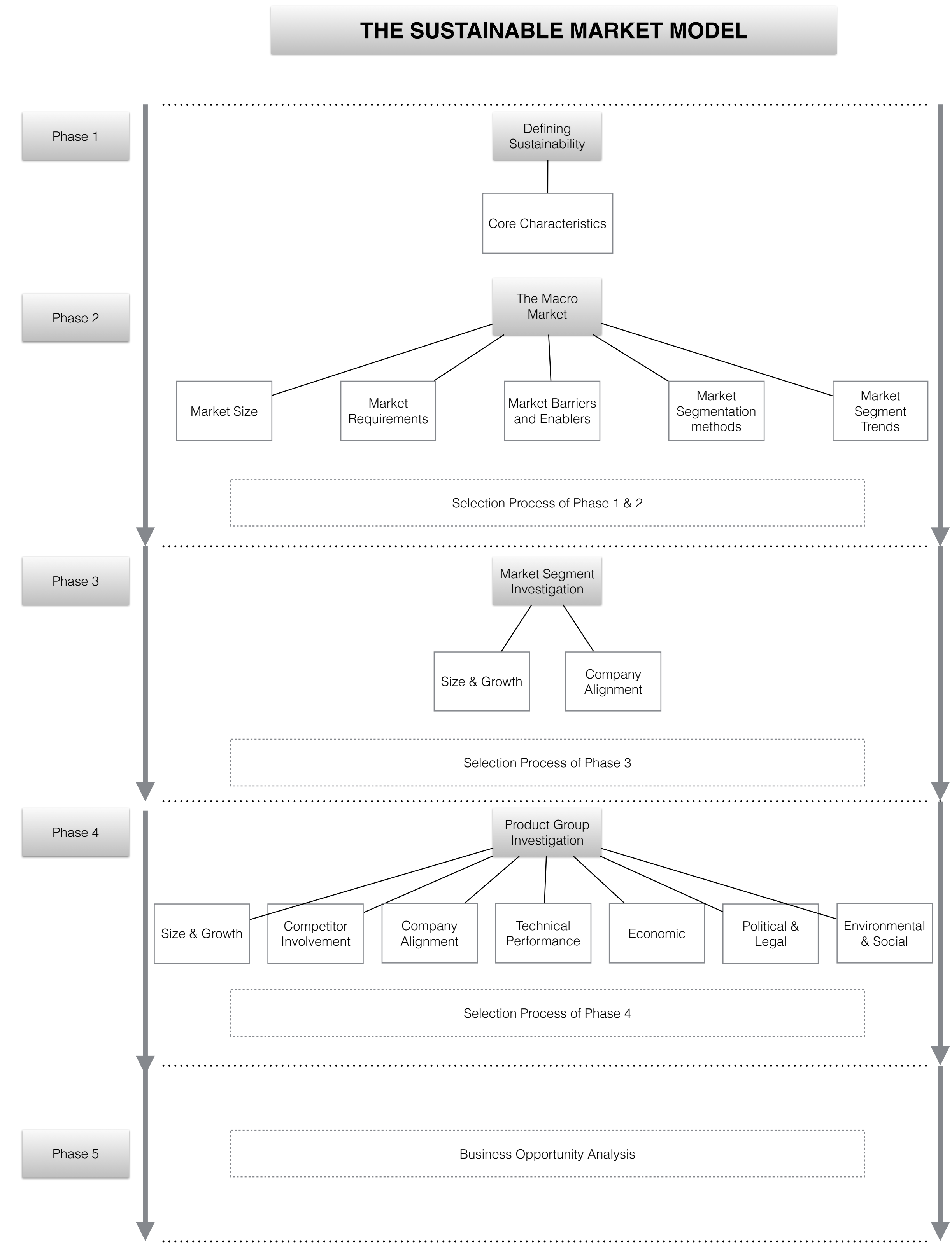

Figure 6: ***The Sustainable Market Model.*** **Each Phase is described in the following sections. Each "Selection Process of (..) " and the "Business Opportunity Analysis" are also described.**

3.2.1 Phase 1 – Defining Sustainability

Before it is possible to map the market, it is crucial to define sustainability and the core characteristics of the market. The previously presented Triple Bottom Line is used to do this. The first phase will gather relevant market definitions and influences that will be fundamental in the following process of *The Sustainable Market Model*.

In this master thesis this phase answers what Sustainability and Sustainable Chemistry is.

3.2.2 Phase 2 – The Macro Market

The second Phase - The Macro Market consists of a general mapping of the market, where the general market size, market requirements and market barriers and enablers will be investigated. Furthermore, it is also stated how the market can be segmented. The available segments of the Market are valued in terms of size and growth and each of the factors stated in the visualisation of *The Sustainable Model* are investigated, see figure 6.

In this master thesis this phase maps the general Sustainable Chemistry market and states how the Sustainable Chemistry market can be segmented. The Sustainable Chemistry Segments are valued in terms of size and growth and each of the factors of The Macro Market are investigated.

3.2.3 Selection Process of Phase 1 & 2

In this section, the obtained data from phase 1 & 2 is analysed in order to select which segments that will be further analysed in *The Sustainable Market Model*. The selection will be based on analysis and screening of the different segmentation methods and on the size & growth of the stated segments. The selected segments will fulfil the requirements stated by e.g. the Triple Bottom Line. The Company´s strategy will also be used as input for the selection process, in order to liquidate segments that will not be of interest for the company or not at all affiliated with the company’s business.

The output from the process will be an outside-in understanding of the Sustainable Chemistry market and which market segments that will further analysed.

3.2.4 Phase 3 – Market Segment Investigation

In Phase 3, the market segments selected for further analysis in the previous step will be investigated further. Data will be collected regarding the market segments’ “Size & Growth” and their alignment to the company´s current business and area of expertise, referred to as “Company Alignment”. For each market segment, the size and growth of the specific sustainable market will be stated as well as for the general, overall market.

The presented data consists of both quantitative data, in form of market statistics, and qualitative data collected from the performed interviews.

3.2.5 Selection Process of Phase 3

In this selection process, the data obtained in phase 3 – "Market Segment Investigation" is analysed and evaluated in order to rank the different market segments after their potential to contain business opportunities for the Company. The market segments are analysed using the GE Mckinsey matrix methodology, starting by stating a list of factors that will be used to rate the different segments against each other. As stated, the GE Mckinsey Matrix will be modified and focus on "Industry Attractiveness", and will be divided into two major areas. The first is referred to as **Size & Growth** and has the following list of factors:

- **Sustainable segment growth rate** – measured as expected growth per year from today until 2020. The numbers are in some occasions differing in terms of starting and finishing year.
- **Sustainable segment market size** – measuring how large the market is per year in terms of tons.
- **Market growth rate** – measured as overall market growth per year in the same time frame as sustainable segment growth rate. The overall market for e.g. bio-based plastics is plastics.
- **Market size** – the overall market size, measured in tons per year

To connect to the Company's own business, the following **Company Alignment** evaluation factors will be used:

- **Compatibility with current business** - How much aligned the sustainable market segment is with the company's own business. Meaning that e.g. the company is involved in the conventional market and have the competence to produce the sustainable chemistry product.
- **Company ambition** – the company's stated ambition to engage in the sustainable market segment.

These factors will be assigned weights to declare how important each factor is for the market segments to contain a potential business opportunity for the company. These weights are distributed between 0-1 and the sum of all factors' weights is 1.

Each segment will then be rated after their performance related to each stated factor. Each rating is distributed between 0-10 where 10 equals highest performance. Depending on the nature of each factor, the rating will be quantitative or a qualitative. The quantitative factors are factors that can be quantified in terms of market volume and growth and in *The Sustainable Market Model* these are placed under "Size & Growth". The qualitative factors are less static and more subjective and "unique". These factors should therefore be rated in cooperation with technical and market experts and are in *The Sustainable Market Model* placed under "Company Alignment".

The score is thereafter calculated by multiplying the weight and rate for each market segment, for each factor. The scores are the summarized for each market segment and will be used to determine each market segment's potential to contain business opportunities. How the weights and rates are determined in this thesis is presented in section 5.2.3 – “Weight” and section 5.2.4 – “Rate”.

The market segments that receive the highest score will qualify for further investigation.

3.2.6 Phase 4 – Product Group Investigation

In Phase 4 the qualified market segments from “Selection Process of Phase 3” are investigated on a product group level. The investigation is therefore deepened and performed on a more detailed level. The collected data is presented in a structure that makes it possible to analyse and compare the product groups against each other. The structure will follow the modified PESTEL, where the factors are:

- **Technical Performance**
- **Economic**
- **Political & Legal**
- **Environmental & Social**

In addition to the factors above, which are described in section 3.2.3 – “PESTEL” one additional factor will be added, namely “Competitor Involvement”. This factor will be used to investigate how the competitors are engaged in the same market segment. So, the added factor to the modified PESTEL is:

- **Competitor involvement**

The GE Mckinsey Model will also be used to structure the data, where the factors are:

- **Size & Growth**
- **Company Alignment**

3.2.7 Selection Process of Phase 4

In this selection process, the data obtained in phase 4 – “Product Group Investigation” is analysed and evaluated in order to rank the different product groups after their potential to be a business opportunity for the company.

The product groups are analysed using the GE Mckinsey matrix methodology, starting by stating a list of factors that will be used to rate the different product groups against each other. The list of factors will follow the same structure as in section 3.2.6 “Phase 4 – Product Group Investigation”. The list of factors is therefore the following:

- **Size & Growth**
- **Competitor Involvement**
- **Company Alignment**
- **Technical Performance**
- **Economic**
- **Political & Legal**
- **Environmental & Social**

Each of these factors will be assigned weights to declare how important each factor is for the Product Groups to contain a potential business opportunity for the company. These weights are distributed between 0-1 and the sum of all factors' weights is 1.

To achieve the in-depth analysis, each factor will be divided into subfactors. Each subfactor will be weighted according to how important the subfactor is for its superior factor. The sum of all the subfactor's weights belonging to the same superior factor will be 1. The subfactors are described in Table 1, which were decided upon in collaboration with the Company.

Superior Factors with their ulterior Subfactors	Description of Subfactors
Size & Growth	
Product group growth (%)	The CAGR to 2020
Current market size (tons/year)	Current size of the product segment
Nordic product growth	The expected production growth in the Nordic region
Nordic market size (production)	Expected size of the production in the Nordic region
Competitors	
Status (commercial/ramp-up)	The status of the commercialization of the product group
Number of competitors	Number of competitors that are investing/selling the product group
Engaged in the Nordic region	Presence of competitors in the Nordic region
Company Alignment	
Available competence	Competence within the Company to produce the product group
Previous research in area	Have the Company investigated the product group before
Produce fossil based equivalent or substitute	Is the Company producing products that can be substituted with the product group
Technical Performance	
Drop in or Functional Equivalent	Technical definition of the product group
Similar performance	Performance and quality of the product group
Research status	Based on existing or developing technology
Economic	
Price competitiveness	Can the product group be produced to a price competitive level compared to conventional alternatives
Predicted cost improvement	Projection of how much the production cost will improve
Political & Legal	
Favorable incentives and policies	Occurrence of labels, classifications and governmental polices
Favorable laws	Presence of laws and regulations favoring the product group

Environmental & Social	
Sustainability degree	Degree of sustainability compared to conventional product
WTP	The willingness to pay for the product on the market
Public interest	Interest on the market from a public perspective
Collaboration projects	Incentives and joint ventures in place for the product group in order to make the product group commercial/increase market share

Table 1: Each superior factor with its belonging subfactors.

Each product group is rated according to their performance in each subfactor. Depending on the nature of each subfactor, the rating will be quantitative or qualitative. The quantitative factors are the factors that can be quantified in terms of market volume and growth, in *The Sustainable Market Model* these are placed under the superior factor "Size & Growth". The qualitative factors are less static and more subjective and "unique". These factors should therefore be rated in cooperation with technical and market experts and are in *The Sustainable Market Model* placed under "Competitor Involvement", "Company Alignment", "Technical Performance", "Economic", "Political & Legal" and "Environmental & Social"

The product groups' ratings are multiplied with their corresponding weights for each subfactor, which result in each product group's score for each of the subfactors. When the product group's score for each subfactor belonging to the same superior factor is summarized, this score becomes the rating for the product group in that superior factor. This rating is then multiplied with the superior factor's weight, which equals the score for the product group in that superior factor. When this procedure is done for all product groups, for all factors, it is possible to compare the product groups' performance for each superior factor. The final score is obtained by summarizing the score for all superior factors for each product group.

The output from this selection process is three product groups that will be further analysed in *The Sustainable Market Model*. How the weights and rates are distributed in this master thesis will be explained in section 5.3.3 – "Weight" and section 5.3.4 – "Score".

Example of the weight and rate process

The reader is recommended to study Table 2 and Table 3, which is an example to display the methodology mentioned in this section 3.2.7 – "Selection Process of Phase 4". The product group, the weights, and the product group's ratings are hypothetical.

As seen in Table 2 the superior factor "Environmental & Social" has four subfactors, with an individual weight that represent their relatively importance to their superior factor. Each product group is rated from 0-10 for each subfactor. In this example, the hypothetical product group received the rate 5,5,8,5 respectively for each subfactor. By multiplying each subfactor weight with the corresponding product group ratings, the product group's score for each subfactor is calculated. The total score is determined by summarizing the scores for all subfactors belonging to the same superior factor, which ads up to 5,9 in this example.

Environmental & Social, subfactors	Weight	Rate	Score
Sustainability Degree	0,3	5	1,5
WTP	0,3	5	1,5
Public interest	0,3	8	2,4
Collaboration projects	0,1	5	0,5
Total	*1*		*5,9*

Table 2: The superior factor "Environmental & Social" and the weights for the subfactors. The product group receive a rate for each subfactor and a score is calculated by multiplying the weight with the rate.

The calculated score, 5,9, is transferred to the second weighting scheme, and used as rate for the product group in the belonging superior factor, as seen in Table 3. The different superior factors receive a weight depending on their relative importance for the product groups to be a business opportunity and the final score is calculated by multiplying the weights with the rates. The total final score for each product group is obtained by summarizing the product group's score for all superior factors.

Superior Factor	Weight	Rate	Score
Size & Growth	0,12	-	-
Competitor Involvment	0,10	-	-
Company Alignment	0,16	-	-
Technical Performance	0,16	-	-
Economic	0,17	-	-
Political & Legal	0,09	-	-
Environmental & Social	0,20	5,9	1,18
Total	*1*		*1,18*

Table 3: Each subfactor weight multiplied with each product group's score results in the overall score for the superior factor. In this example 0,3*5+0,3*5+0,3*8+0,1*5 from Table 2 equals 5,9. The superior factor is weighted to relate how important it is compared with the other superior factors. 0,2*5,9 equals 1,18, which is the total Score for the product group in the superior factor "Environmental & Social".

3.2.8 Phase 5- Business Opportunity analysis

No data will be added in the empiric data assessment for this phase. The purpose of the phase is to investigate, validate and connect the found business opportunities. The product groups that receive the highest score in the selection process of phase 4 in *The Sustainable Market Model* are regarded as actual business opportunities. To validate and investigate these product groups these well renowned tools will be used: the SWOT framework, Porter's five forces and Ansoff's matrix.

4 Empirical Data Collection

The empirical data collection will provide and display the gathered data and information relevant for this thesis. The data will be presented accordingly to the phases stated in The Sustainable Market Model. Relevant data will be provided to give the reader an understanding of the made conclusions. The reader is advised to study section 3.2 - "The Sustainable Market Model" and chapter 5 - "Analysis" in parallel with this chapter in order to obtain a better understanding of the presented material.

4.1 Phase 1 – Defining Sustainability

4.1.1 Introduction

Sustainability is a concept constructed by three ingoing parameters: Social factors, Economic factors and Environmental factors where the goal is to find a balance along the factors (EPA - Environmental Protection Agency). A concept closely related to sustainability is sustainable development, which is a development that meets the needs of today without compromising future generation's ability to meet their needs (International Institute of Sustainable Development, 2013).

4.1.2 Core Characteristics for Sustainable Chemistry

Chemistry has been associated with toxicity and danger in the past and this reputation still remains to some extent today. In order to improve this reputation was Green Chemistry introduced, that aims to reduce the hazards of chemistry throughout the whole life cycle. To achieve this, the twelve principles of Green Chemistry where stated (Anasteas & Eghbali, 2010):

1. **Prevention** – It is better to prevent waste than to treat or clean up waste afterwards.
2. **Atom Economy** – Synthetic methods should be designed to maximize the incorporation of material used in the process into the final product.
3. **Less Hazardous Chemical Synthesis** – When applicable, synthetic methodologies should be designed to use and generate substances that pose little or no toxicity to humans and environment.
4. **Designing Safer Chemicals** - Chemical products should be designed to affect their desired function while minimizing their toxicity.
5. **Safer Solvents and Auxiliaries** - Should be made unnecessary wherever possible and innocuous when used.
6. **Design for Energy Efficiency** - Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at natural temperature and pressure.
7. **Use of Renewable Feedstock** - A raw material or feedstock should be renewable rather than fossil based and depleting whenever technically and economically practicable.
8. **Reduce Derivatives** - Unnecessary derivatisation, e.g. temporary modification of physical/chemical processes, should be minimized or

avoided, because such steps require additional reagents and can generate waste.

9. **Catalysis** - Catalytic reagents are superior to stoichiometric reagents.
10. **Design for Degradation** - Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. **Real-time analysis for Pollution Prevention** -Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. **Inherently Safer Chemistry for Accident Prevention** -Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions and fires.

Green Chemistry is an important part of Sustainable Chemistry, but Sustainable Chemistry also consist of a broader concept which includes the earlier stated parameters of sustainable development; People, Planet and Profit. The ultimate target with Sustainable Chemistry is to encourage a bio-economy, an economy where chemistry, biochemistry and biotechnology seamlessly create sustainable business opportunities. (Townsend, 2012)

The concept Sustainable Chemistry should emphasise all principles of Green Chemistry, but a survey issued by Mckinsey states that four characteristics are more important in the concept Sustainable Chemistry than others. In Europe the four most important characteristics are the following, see Figure 7:

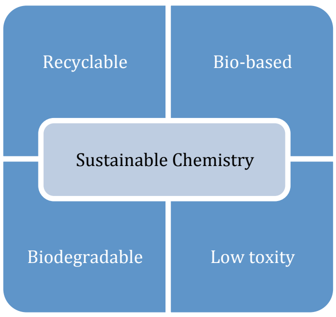

Figure 7: The four most important principles of Sustainable Chemistry.

Furthermore, the report also states that the sustainable attributes are more important close to the end-life stage of a product than in the origin. (Kaiser, Miremadi, Musso, & Weihe, 2012)

4.2 Phase 2 - The Macro Market of Sustainable Chemistry

4.2.1 Introduction

This section will state factors and data that affect the whole Sustainable Chemistry market. These factors are therefore fundamental in order to understand the market and also to understand the trends and potential business opportunities companies can find within sustainable chemistry. Such factors are e.g. global trends, market barriers, legislations and customer demands.

4.2.2 Market Size

In 2011, the global chemistry market value was 4000 billion USD and it is expected to reach 5300 billion USD by 2020. The Sustainable Chemistry market is in relation to the overall market very small, see figure 8, but the growth rate is considerably higher. The Sustainable Chemistry market was valued to 2,8 billion USD in 2011 and is expected to grow to 98,5 billion USD by 2020. This represents a growth of approx. 3400%.

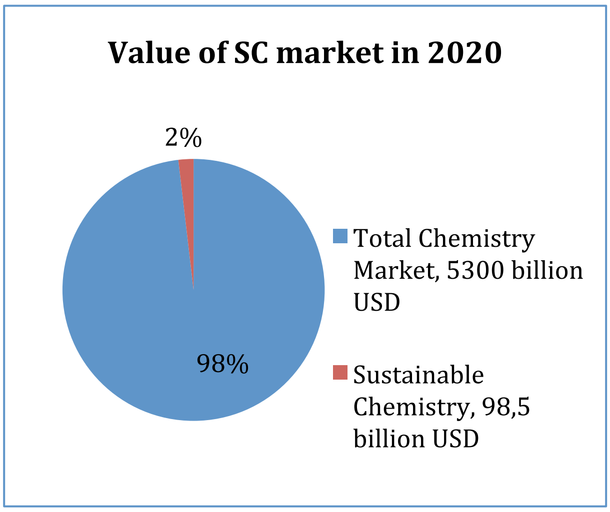

Figure 8: The sustainable segment market year 2020 in relation to the total 2020 chemistry market.

Western Europe, Asia and North America will be the largest growth regions for Sustainable Chemistry and the Sustainable Chemistry industry is forecasted to save the general industry 65,5 billion USD by e.g. less toxic chemical handling, improved processes and improved product life cycles. (Pike Research, 2011)

4.2.3 Market Requirements

Fundamental Customer Requirements for Sustainable Chemistry products

It is of utter importance that the SC product has at least the same performance as the conventional product that it is intended to complement or substitute. If the performance is lesser, no Willingness to Pay (WTP) exists for the product in question. (McKinsey & Company, 2012) Furthermore, the Sustainable Chemistry product should be competitive out of a life cycle perspective, where a cradle-to-cradle measurement is applied (Gustafsson, BASF on Sustainable Chemistry, 2015)

A second requirement for SC products to be competitive is that the benefit of using a SC product rather than a conventional product is possible to communicate or show. This means that customers are more likely to have an increased WTP if they can see or understand the benefits or if e.g. known environmental labels guarantee the product's sustainability performance. (BE, 2015) (GM, 2015)

Willingness to pay

In order for the Sustainable Chemistry market to be competitive, there has to be a WTP for the SC products that can complement or substitute conventional chemical products. This WTP is not evenly distributed throughout the value chains and are dependent on industry.

However, sustainability is not considered by industry experts to be a fad, and SC plays an important role in the development of a sustainable community since chemistry is part of almost every existing value chain. In a survey, issued by Mckinsey, focusing on chemicals used in consumer goods, packaging, automotive, medical devices, electronics and construction states that 38% of the survey respondents in Europe require or consistently emphasize green, sustainable features when purchasing. The respondents of the survey where executives with a possibility to influence the selection and use of chemicals in their organization. Organisations and consumers are willing to pay a premium price, where the amplitude of the premium varies dependent on business segment, for sustainable features as long as overall performance is not sacrificed, Figure 9, Figure 10 and Figure 11 display the respondents' answers: (McKinsey & Company, 2012)

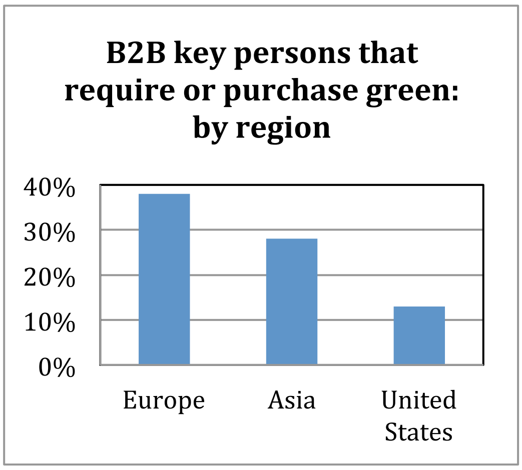

Figure 9: Key persons that consistently require or purchase green. The chart states that sustainable products are especially bought in the European region. (McKinsey & Company, 2012)

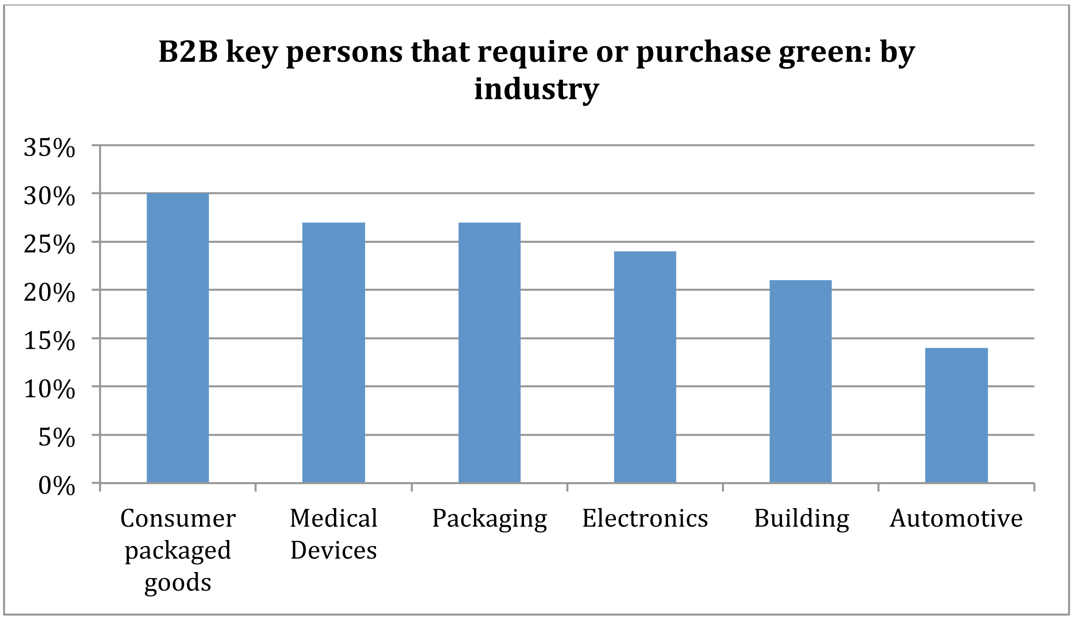

Figure 10: B2B persons that require or purchase products with sustainable characteristics by different industries. (McKinsey & Company, 2012)

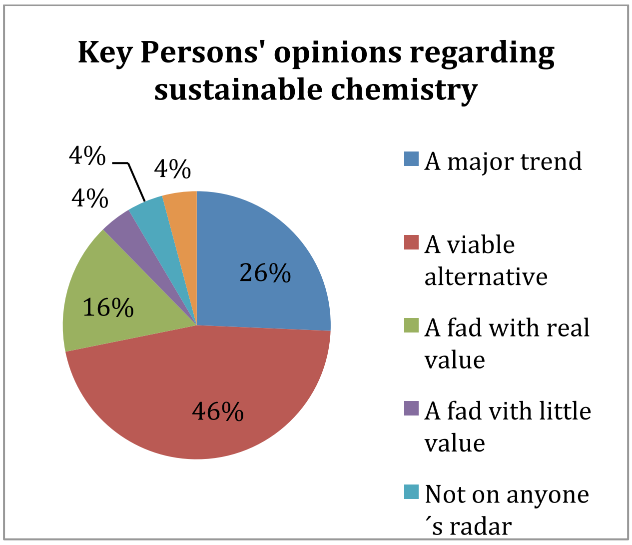

Figure 11: Key person's opinions of the Sustainable Chemistry market. (McKinsey & Company, 2012)

The highest premium that consumers are willing to pay is situated in the intermediate stage of a product's supply chain where the cost easily can be transferred to the end costumer. An example of such a situation is in packaging where the packaging material stands for a fraction of the product cost, but the packaging material is valued for having sustainable features such as bio-based, biodegradable. Figure 12 displays how the WTP premium is distributed across different industries and how the WTP declines when the premium increase. (McKinsey & Company, 2012)

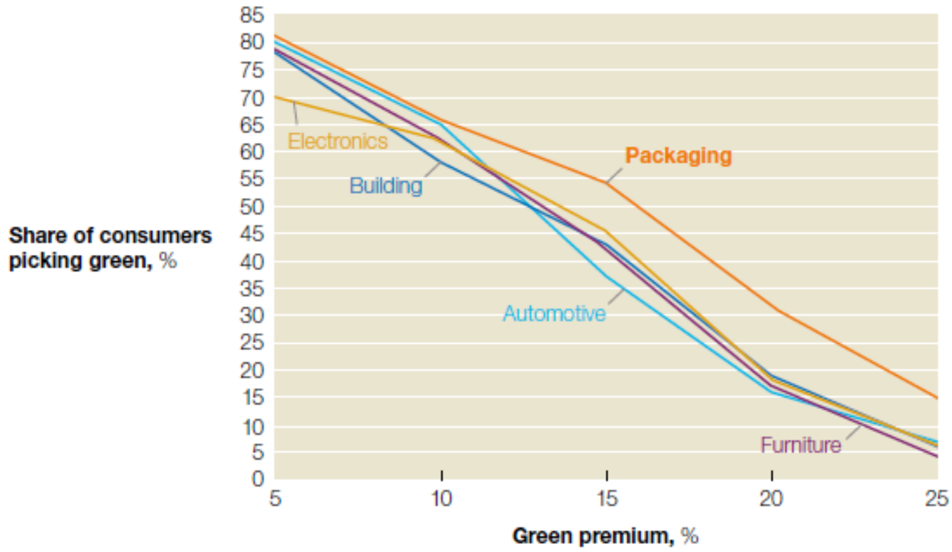

Figure 12: Share of consumers picking green by premium rate, it can be seen that the highest WTP can be found in packaging. (McKinsey & Company, 2012)

4.2.4 Market Barriers and Enablers

Even though there has been a decrease in the production cost of SC products due to technical advances and process improvements, SC products are not, and will not in the nearest future, be price competitive with petrochemical based products. The development of SC is therefore dependent on e.g. WTP to pay a premium from customers, regulations and political policy instruments, such as tax reliefs, tolls etc. (Wallberg, 2015)

There do not exist any global rules for Sustainable Chemistry such as global trading agreements, chemical trading legislations, barriers or global policies. Such global cooperation could make the sustainable chemistry industry more competitive and increase the development. The lack of a global system have lead to that each region has different systems to aid the SC industry. (Gustafsson, 2015)

Europe

The European Commission has a large influence of the SC market development in the EU and there are several incentives that stimulate the sustainable innovation climate. A stated goal, among others, is for example that 20% of the chemicals and materials produced in Europe will be bio-based by 2020. The European Commission have invested 3,12 billion USD in R&D- and flagship programs in order to achieve this goal. (Bio-based Industries Consortium, 2013)

However, even if there exist policy measures and subsidies there is a lack of concrete, long-term policies. Industry experts therefore witness a hesitance to invest from business executives, due to the lack of clear and direct incentives from the EU and governments. Developing and producing Sustainable Chemistry products often require an economy of scale to make SC products competitive which often requires considerable initial investments. The lack of clear incentives and regulations make it hard for companies to assess the risk of such an investment and understand how the economic landscape will be in the future. (Wallberg, 2015) (Josefsson, 2015)

Another issue in the EU is that if an overall commercial scale production of SC is achieved, there are problems to obtain the needed feedstock such as crop residues and forestry waste since the availability of resources are fragmented in comparison to e.g. fossil sources. Due to toll systems, the needed feedstock to produce SC products is expensive in comparison with conventional fossil based feedstock. Sugar is an example of feedstock that is restricted due to EU´s protectionist agricultural policies. (American Chemical Society, 2013) But following the de-regulation based on a new EU common agricultural policy, the production and import quota for sugars and iso-glucose will be lifted in the EU year 2017, providing a potential cheaper and more accessible feedstock in the EU, especially Western Europe (Deloitte Touche Tohmatsu Limited, 2014). Sugar is a convenient feedstock for producing ethanol, which is one of the primary building blocks in Sustainable Chemistry. However, even if the sugar production quotas are lifted, the tolls for ethanol and sugar will remain, resulting in a disadvantaged position for the bio-based Sustainable Chemistry industry in Europe. This disadvantageous regulation can be seen in smaller growth in SC production capacity in Europe in comparison with e.g. Asia and the U.S and the regulation is pushed to change by lobbying organizations and industries across Europe. (Alwarsdotter, 2015) (Wallberg, 2015)

Europe has in general a highly developed research platform to discover new ways to process and produce SC products. However, the region lacks investment policies, regulations and incentive subsidies, making investments to be made elsewhere (Norlin, 2015)

REACH

REACH stands for Registration, Evaluation, and Authorisation of Chemicals and was first introduced year 2007. REACH is a regulation that aims to protect human health and environment from the risks that can occur when using chemicals. REACH also aims to enhance the competitiveness of the EU chemical industry.

REACH forces EU companies to identify and manage the risks associated to the chemicals they use and sell in the EU and the companies are entitled to prove that they handle the chemicals in a safe way. If the companies fail to do so, REACH authorities can restrict the use of the problematic chemicals or even force companies to substitute them with safer alternatives.

Since chemicals are used in a wide range of industries and part of almost all value chains, REACH is designed to have an impact across many sectors. For manufacturers of chemicals, REACH regulates how and which chemicals that can be produced, for importers REACH regulate what kind of chemicals that can be imported. For producers that indirect use chemicals in their value chain, REACH require the producers to follow REACH's policies and understand how they are responsible to handle their products in any safe way. An issue with REACH is that it is a not global policy, meaning companies established outside the EU are not bound to REACH regulations. These companies are still able to export their products to the EU and it is then up to the importer to fulfil REACH requirements. (European Chemicals Agency, 2015)

Another stated issue with REACH is the bureaucracy, meaning the REACH authorization process is time consuming and prevents the agile growth and development of the chemical industry in Europe. (Hannerz, 2015)

Global

The U.S use incentive systems and policies that reduce the risk for especially the sugar and ethanol production investments in the country, resulting in growth and an increased production capacity. These incentive systems also increase the competitive ability for SC products within the country, making it possible to take production of SC products from demonstration to commercial scale. Another advantage the U.S policies hold is a more efficient bureaucracy making decision processes for e.g. investments, labelling more efficient. (Gustafsson, 2015)

The shale gas revolution

The decreasing crude oil price has prevented the development of SC products derived from a natural feedstock. The current oil price is approximately 51 USD per barrel, which can be compared with year 2008's price of approximately 150 USD per barrel (Anderson, 2014). The decrease of crude oil prices can be related to the shale gas development in the US. The shale gas revolution has resulted in a cheaper petrochemical feedstock due to an intensified price war between fossil producers, and has also made the U.S more or less independent of crude oil produced in the Middle East (Emanuelsson & Nilsson Orviste, 2014). This availability on the US market results in decreasing oil prices, making the production of SC products less cost competitive. In broad terms, the oil price should reach a price of 200 USD per barrel in order for SC feedstock to be cost competitive. (Wallberg, 2015) (BJ & AN, 2015)

Food vs. Fuel debate

There exist ethical issues that create barriers for the SC market development, one of the major issues is the food VS fuel debate. The debate considers the moral dilemma and discusses the question if it is correct to use land mass and bio-based feedstock to produce chemical products that could be used for food. There have been several studies in the subject where, for example, the Food and Agricultural Organization of the UN state that SC products, more specifically biofuels, have provoked a rise in food commodity prices (Committee on World Food Security, 2013). Even though biofuels stand for a small portion of the total demand of fuels, the feedstock needed have an impact on food crop availability (Searchinger & Heimlich, 2015). A way to solve the problem is to use material that are bio-based but does not compete with food production, such as residues from crop and forest (Searchinger & Heimlich, 2015). This type of feedstock is used in second-generation bio refineries. (Naik, Vaibhav, Prasant, & Ajay, 2010)

Drop-in vs. Functional Sustainable Chemistry Product

Sustainable Chemistry products can be divided into drop-in products and functional equivalents. The drop-in products are products that instantly can substitute existing products in a value chain without forcing the following or prior value chain to adapt. In Sustainable Chemistry, this generally means that a sustainable drop-in product is used in an existing petrochemical value chain to substitute a fossil derived component. (Bosch, Schers, & Pera, 2014) This substitution can be implemented throughout the entire value chain. Drop-in SC products are expected to grow faster in a short-term perspective since they are easier to integrate into existing value chains and fulfil existing market needs. (Bosch, Schers, & Pera, 2014)

The functional equivalents are product that can solve the same market need, but the value chain is different and often undeveloped since the molecular structure of the product is different in comparison to the conventional product. The functional equivalent may also have unique characteristics that affect its application area, and therefore opens up new, potential markets. Such characteristics can be bio-degradability and low weight. In a long-term perspective, functional SC products are forecasted to grow as well, and functional products are expected to be a high margin market with increased value in comparison with drop-in SC products. (Bosch, Schers, & Pera, 2014)

4.2.5 Market Segmentation Methods

Introduction

The concept Sustainable Chemistry is a wide area that covers which feedstock the product derives from, how the product is manufactured, the life cycle of the product and what happens when it expires. There has been a rigorous amount of research focusing on different parts of Sustainable Chemistry and in order to have a structured approach, a segmentation of sustainable chemistry is required. Following will different segmentation methods be stated.

Mapping the Green Chemistry Community - Segmentation

Following section 4.1.2 – "Core Characteristics of Sustainable Chemistry", most research within GC has been conducted in order to solve the following issues: (Epicoco, Oltra, & Maider, 2013)

- **Alternative or renewable feedstock** –is the area where researchers aim to replace fossil-based feedstock and petrochemicals with renewable feedstock such as biomass, cellulosic materials, agricultural waste etc. The main drivers for this research area is the goal to reduce environmental impact, reduce society's dependency on fossil-based chemicals and the expected depletion of fossil-based fuels.
- **Alternative solvents** – is the area where researchers try to find more sustainable and less hazardous ways to process chemical reactions. Today, solvents are often a waste issue and moreover are the solvents often toxic, corrosive, flammable etc. Research tries to find biodegradable and renewable solvents, create solvent free reactions or solvents that are more environmentally benign.
- **Alternative synthetic pathways** - highlight the search for sustainable catalysts. An interesting area that is growing is the use of catalysts based on organic materials, such as modified enzymes. Often, these catalysts are also intended to be used in natural temperatures, normal pressure and with water as a solvent.

- **Chemical Engineering** – is the research are that investigate the use of greener industrial processes

Deloitte Segmentation

When investigating the SC market, Deloitte states that the highest growing and most relevant segments within bio-based SC are: (Deloitte Touche Tohmatsu Limited, 2014)

- **Biofuels** – fuels that can be used for transport and energy just as conventional fuels.
- **Bio-based polymers** – polymers that derive from bio-based feedstock e.g. sugar.
- **Industrial Enzymes** – Microorganisms with diverse application areas such as food, feed and to process bio-based feedstock by e.g. fermentation.
- **Organic Acids** – Acids containing carbon atoms.
- **Solvents –** a substance that dissolve, very diverse application areas such as chemical industry, pharmaceutical etc.
- **Amino Acids –** Acids containing a carboxylic acid, diverse application areas such as food, feed, cosmetics and chemical industry.
- **Vitamins –** Organic compound used especially in the food and feed insdustry
- **Antibiotics –** Anti bacterial compounds, used in the food-, feed- and pharmaceutical- industy
- **Biogas –** gas that derives from bio-based feedstock. Methane and Carbon dioxide are two common biogases.

Drop-in versus Functional Segmentation

A third way to segment SC is to examine the building blocks used to create a sustainable product and investigate what characteristics they have and what the blocks are especially used for. Using this segmentation, the characteristics for each segment are: (U.S Department of Energy, 2004)

- **Direct product replacement** – Building blocks that compete directly against existing products and chemicals derived from petroleum. An example of such a product is Acrylic Acid that derives from bio-based feedstock, which can substitute conventional fossil-derived Acrylic Acid.
- **Novel Products** – Building blocks that possesses new and improved properties for replacement of existing functionality or new applications. An example is Polylactic Acid that derives from Lactic Acid, which is bio-based and biodegradable.
- **Building Block Intermediates** – Building blocks that provide basis of a diverse portfolio of products from a single intermediate. An example is Succinic Acid, a potential sustainable platform chemical. The building block intermediates can be seen as bulk products that are needed to create large-scale production and risk reduction since they can be used in both the “drop-in” and “functional” segment.

4.2.6 Market Segment Trends

Market trends of growing areas in Sustainable Chemistry

Following Deloitte's segmentation earlier stated in this report, some SC segments are expected to grow more than others. The expected growth for each area can be seen in Figure 13. Important to note is that the most growing segments are still small in terms of volume and value. (Deloitte Touche Tohmatsu Limited, 2014)

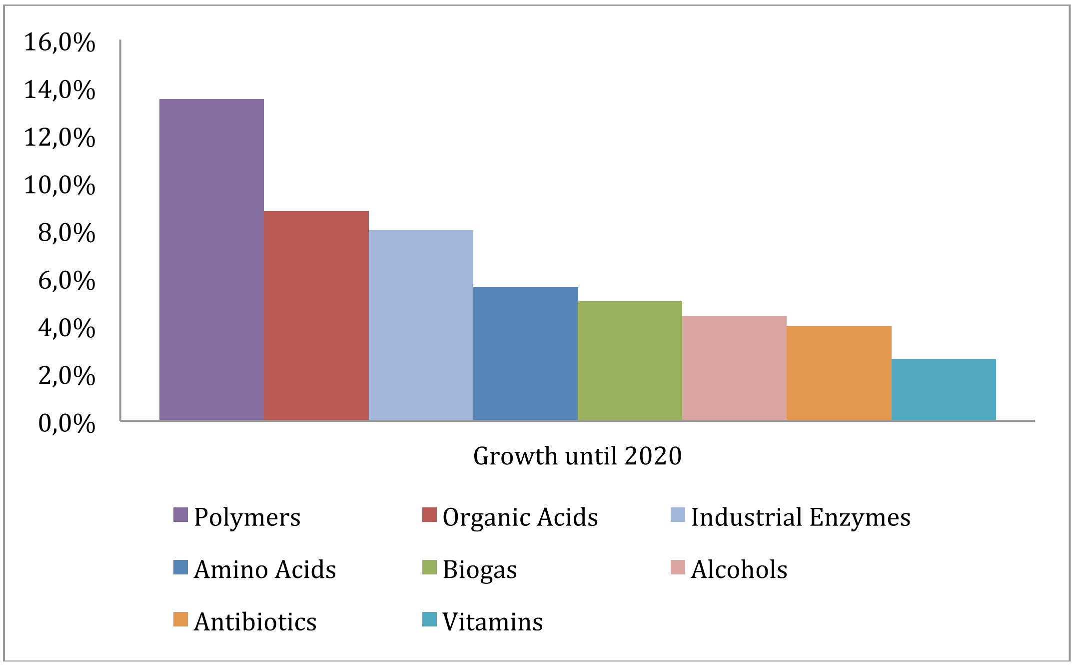

Figure 13: SC growth segments.

Additional Sustainable Chemistry growing areas

Sustainable solvents and sustainable lubricants are two areas that are expected to grow until 2020. Today, a lot of research is conducted to find solvents that can be used in SC products, where less quantity is needed and the solvent is not toxic or hazardous. There is a market demand for these solvents and possibly a WTP for these types of products.

Within SC, there also is a demand for sustainable lubricants that especially are biodegradable. This area is also expected to grow on the market and research is conducted that can result in increased market growth. (SM, 2015)

Before continuing to section 4.3 "Phase 3 – Market Segment Investigation", the reader is recommended to study the analysis for phase 1 & 2, which can be found in section 5.1 "Selection Process of Phase 1 & 2". The output of this analysis is the Market Segments that are investigated in the following section.

4.3 Phase 3 – Market Segment Investigation

4.3.1 Bio-based plastics

Introduction

Bio-based plastics can be divided into a wide range of different types, which have different characteristics, features and production processes. What they have in common and the factor that defines them is that they are a material that is either bio-based, biodegradable or features both properties (European Bioplastics, 2011). A bio-based plastic can be classified as a "drop-in" or as a "functional equivalent". The used feedstock to produce a bio-based plastic varies from type to type. It is also possible to create a specific type of bio-based plastic from several different types of feedstock.

Size & Growth

The global plastic market is estimated to a volume of 233,75 million tons in 2013 with an expected CAGR of 5,3% to 334,83 million tons by 2020 (Grand View Research (1), 2014). The current bio-based plastic market is experience a large growth and is growing with a CAGR of 20%. The current global production capacity and future volumes can be seen in, Figure 14 (Dammer, Carus, Raschka, & Scholz, 2013):

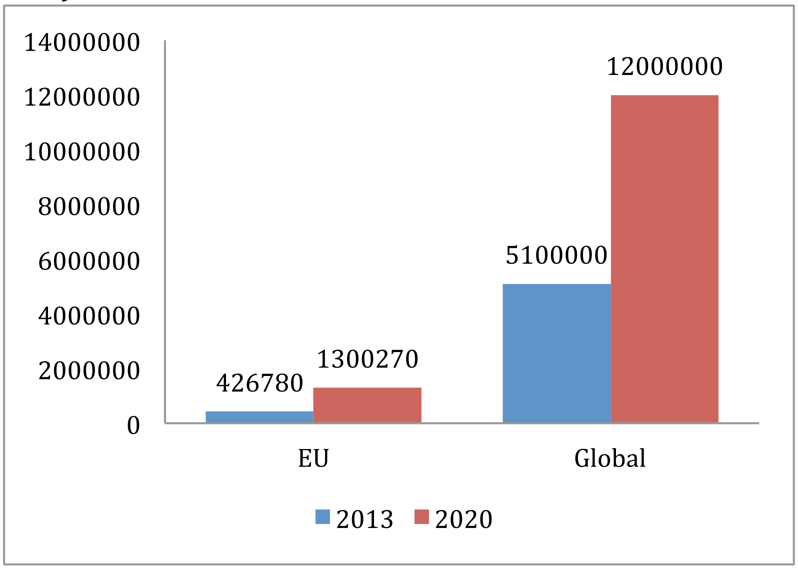

Figure 14: The bio-based polymer production capacity year 2013 and the predicted capacity year 2020. The volumes are in tons.

Company Alignment

The Company are currently producing a variety of conventional plastics and is one of the leading producers on the global market. The Company´s plastic business unit has a high profitability and is a business area that is growing. The Company has shown interest in the bio-plastic market and has been investigating the area, but is currently not producing any type of bio-based plastic. The reason for this is that the Company states there are other areas and markets where the Company can have a bigger impact and create more growth and profit. (BJ & AN, 2015)

4.3.2 Bio-Fuels

Introduction

Biofuels are liquid or gaseous transports fuels, such as biodiesel or bioethanol, which derive from biomass. One can distinguish between two types of biofuels, namely first- and second generations of fuels (International Energy Agency, 2010):

- First-generation biofuels are the commercialized form of biofuels that exist on the current market to a wide extent. First generation biofuels are generated from feedstock that, in most cases, also can be used as for food or feed. The feedstock normally consists of sugar, starch, oil-bearing crops or animal fats.
- Second-generation biofuels are not yet fully commercialized, however, large resources have been invested to develop the production and make it competitive on the market. Second generation biofuels are generated from feedstock that does not compete with material that can be used as food or feed, such as cellulose.

Size & Growth

The global demand for biofuels are expected to grow with more than 300% by 2040, from 50 million tons per year to approximately 200 million tons per year. This volume stands for 4,4% of the total expected global fuel demand. In 2013 the total global transport fuel demand was valued to approximately 4,2 billion tons per year and is expected to grow o 4,6 billion tons per year in 2020. (International Energy Agency, 2010). A market research performed in 2011 estimates that the value of the biofuels will increase by 124% from 82.7 billion USD to 185,3 billion US dollars by 2021 (Pike Research, 2011)

The production and use of biofuels have increased significantly over the last two decades. In 1990 the usage of biofuels was non-existent in comparison to the current consumption of circa 14 400 k TOE (Tonnes of Oil Equivalents) in the EU. As seen in Figure 15 the consumption of biofuels had the highest growth rate between 2003-2010. (European Union, 2014)

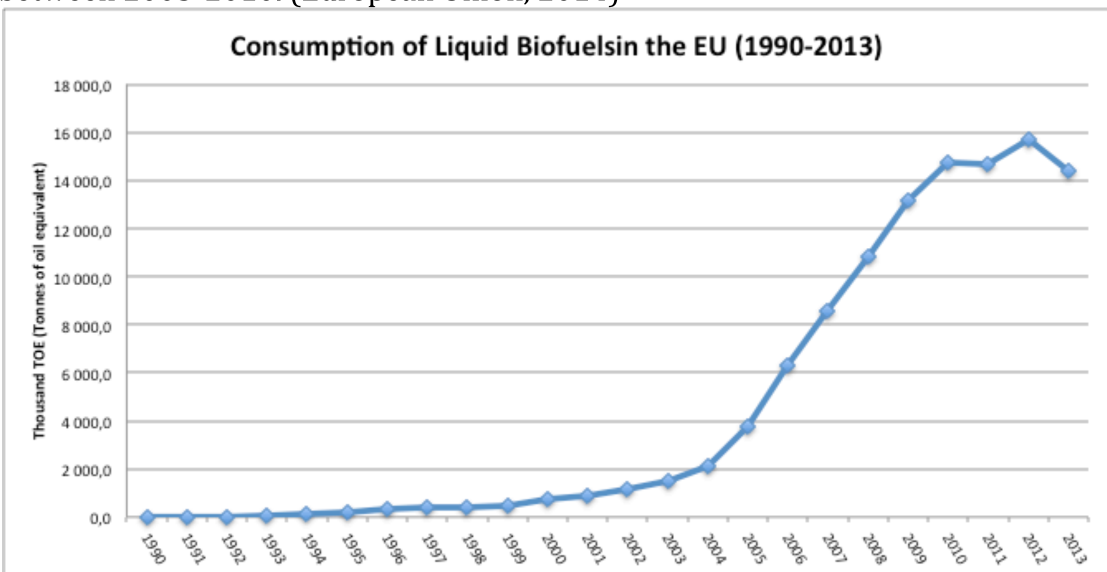

Figure 15: The consumption of liquid biofuels in the EU from 1990 to 2013. Important to note is the decline the latest years.

Company Alignment

The company is currently not producing any type of fuel, and there is no plan to be involved in this business area since it is too far from the current core business and it is a competitive market. However, the possibility to be involved in the side streams and bi-products opportunities that will be a surplus from the biofuel production is of interest. (BJ & AN, 2015)

4.3.3 Sustainable Solvents

Introduction

Solvents have a wide application spectrum but are mainly used in chemical processes to facilitate separations and purifications. Solvents are also often a primary component in adhesives and cleaning agents. Several of the different types of solvents are toxic and classified as VOC materials (Volatile Organic Compound) and therefore there is a large interest of finding sustainable solvents. (Kerton & Marriott, 2013). Regulations stated by REACH, EPA (Environmental Protection Agency) and DEFRA (Department of Environment, Food & Rural Affarirs) are also influencing the shift towards more sustainable solvents (Grand View Research, 2015).

Size & Growth

The solvent industry is a growing market with an annual CAGR of 2,3 % with a global consumption in 2012 of 28 million tons (IHS Chemical, 2013). If the less environmental solvents are excluded, the annual growth is 4% implying that more sustainable alternatives are experiencing a higher growth and are replacing the lesser alternatives (Kerton & Marriott, 2013). The global market was valued to 22,8 billion dollars in 2012 and are expected to grow to 29,3 billion dollars by 2018. The largest growth can be directly related to Asia Pacific, which also stands for 40% of the global consumption. The European market is expecting a slow growth, since the market is mature. (Transparency Market Research , 2013).

In a market research report executed in 2015, the global bio solvent market demand was estimated to approximately 2,4 million tons in 2012, where solvents used as adhesives and sealants are expected to witness the highest growth rate until 2020. (Grand View Research, 2015)

Company Alignment

The Company is a large player in the solvent market and stands for a large market share. The major strength that the Company has in comparison with their competitors is a wide product portfolio of different solvents. The Company´s largest business segment for solvents is coatings, however the cleaning market and inks are also large sectors. The bio-based solvents are not seen as a threat today, and according to B.E, Technical Service Manager for solvents at the Company, there is not really any viable bio-solvent on the market that can compete with conventional solvents. The research of solvent-free processes is something that has gained attention, and it has gained some market momentum – especially for paints. However, this is not a large market and not an overall transition that will happen for many years and is not seen as a threat to the Company´s current business. (BE, 2015)

The Company does not have any bio-bases solvents on the market today, however they have two products in the portfolio that can be sold as sustainable solvents. If customers show interest and willingness to pay a premium, the feedstock could be changed from conventional to renewable. (BE, 2015)

4.3.4 Platform Chemicals

Introduction

Platform Chemicals is a group of different chemicals that are used as building blocks when creating other, specific chemical products. These are the cornerstone in the refined chemical production and the possibility to use bio-based alternatives have gained a large market interest.

Size & Growth

The global platform chemical market is difficult to quantify, due to its size and wide application area. The bio-based platform chemical market is and previously mentioned a growing sector, and the production will be boosted by e.g. the demand for bio-based plastics, since the platform chemicals is the building block when producing these end type materials. (Bio-based economy, 2013)

Company Alignment

The Company is currently producing several types of platform chemicals that could potentially be substituted with bio-based alternatives. Bio-based alternatives are therefore highly consistent with the company´s business and an interesting area. (BD, 2015)

4.3.5 Industrial Enzymes

Introduction

Enzymes are protein that which initiates, speed up or regulate a biological process. Enzymes are widely used in the industry, in different sectors such as production of biofuels, washing detergents, food and feed production. (Novozymes, 2015)

The industrial enzymes can be divided in four different usage groups; (Novozymes, 2015)

- **Detergents –** Enzymes can e.g. provide special features of detergents.
- **Technical** – Enzymes used in e.g. chemical processes to improve efficiency.
- **Food** – Enzymes can e.g. be used as a preservative.
- **Feed** – Enzymes can e.g. be used as a preservative.

Size & Growth

When analyzing the market development, one can determine that all previously stated usage groups are expecting a positive growth in EMEA (Europe Middle East Africa). The fastest growing is the detergent sector with a CAGR of 11,5%, which represent a value on 673,9 million US dollars in 2018. The sector with the largest value is industrial enzymes used for feed, which is expected to grow with

9,8% CAGR. This represents a value of 1027,5 million US dollars in 2018.The EMEA stands for approximately 40% of the global enzyme market. (BCC Research, 2014)

Company Alignment
The Company is currently not involved in the enzyme business segment and has neither plan nor interest in entering the market. (BJ & AN, 2015)

4.3.6 Lubricants

Introduction
Lubricants are an important substance in a wide range of industries. The main purpose of an industrial lubricant is to decrease the fraction between to moving surfaces. A large amount of lubricants is used in the manufacturing industry in e.g. machinery and smaller amounts are used in gearboxes and engines in common vehicles. An industrial lubricant normally consists of three main components; base oil, thickener and an additive. The base oil stands for around 75-90% of the total volume of the lubricant and is usually based on either a mineral oil or synthetic oil, where a mineral derives from regular cracking of crude oil and synthetic oil is regarded as a more specialized, qualitative oil that can derive from different kinds of sources. . The base oil can also be replaced by a sustainable alternative, such as a vegetable oil. (Shankar, 2014)

Size & Growth
The global industrial lubricant demand was 37,11 million tons in 2013 and is expected to reach 44,22 million tons by 2020, where Asia Pacific stands for the largest market share. Both Europe and the US are considered as mature markets. The value of the global industrial lubricant market is projected to reach 70,32 billion USD until year 2020. (Grand View Research (2), 2014)

The demand for bio-based lubricants was approximately 500 thousand tons in 2011 with an expected growth to 785 thousand tons in 2018. The global bio-based lubricant market account for approximately 1% of the total lubricant market. (Nasdaq GlobeNewswire, 2015)

In the EU, Germany stands for the largest bio-based lubricant market where approximately 4% of the used lubricants are derived from a bio-based feedstock. The Nordic market stands for a fraction of the global lubricant demand. (GM, 2015)

Company Alignment
The Company is a rather small actor on the lubricant market, with a market share of less than 1%. However, the Company is the leading supplier of a specific, synthetic oil based, lubricant. The company is currently not producing or selling any bio-based products but it is possible to change the current synthetic feedstock used in their market-leading product to a entirely or partially bio-based alternative. (GM, 2015)

Before continuing to section 4.4 "Phase 4 – Product Group Investigation", the reader is recommended to study the analysis for phase 3, which can be found in *section 5.2 - "Selection Process of Phase 3". The output of this analysis is the Product Groups that are investigated in the following section.*

4.4 Phase 4 – Product Group Investigation

4.4.1 Bio-based plastics

Introduction

A description of the different types of bio-based plastics and their production routes can be viewed in Figure 16. The bio-based plastics are found in the outer ring.

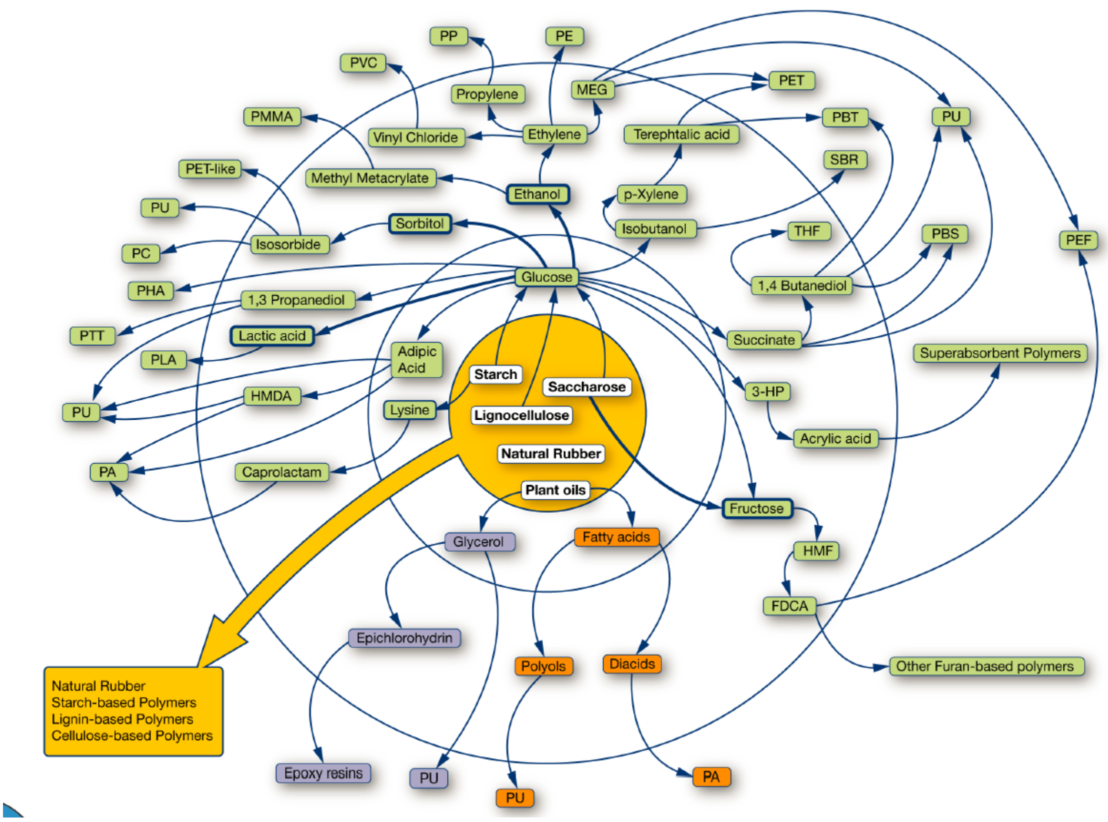

Figure 16: By using Starch, sugar, lignocelluloses, vegetable oil and natural rubber can the following bio-based polymers be made. The bio-based polymers are situated outside the outer ring. The middle ring contains platform chemicals. (Nova Institute, 2015)

Some of these plastics are more relevant than others out of a Size & Growth perspective, and will now be presented further:

- **Bio-PET 30** – PET stands for Polyethylene Terephthalate and was first commercialized year 1940. The polymer is generally fossil-based or partially bio based and is a thermoplastic in the polyester family. Bio-PET is a drop-in plastic for regular PET, is not biodegradable and mainly used in the packaging industry. Today, the Bio-PET consists of 30% bio based material. (Shen, Haufe, & Patel, 2009) The Coca-Cola Company, Ford Motor Company, H.J. Heinz Company, Nike Inc and Procter & Gamble formed year 2012 the Plant PET technology collaborative to develop a 100% bio-based PET. (Carus, Ravenstjiin, Baltus, Carrez, Kaeb, & Zepnik, 2013)
- **Bio-PE** stands for bio-based Polyethylene, which is a part of the Polyolefin family. Bio-based polyethylene is generally derived from

ethanol, which can produced from e.g. sugar cane, starch or sugar beets. Polyethylene can be divided into HDPE (High-Density Polyethylene), LDPE (Low-Density Polyethylene) and LLDPE (Linear Low-Density polyethylene. Bio-PE is a drop-in plastic that can substitute fossil based PE. (Shen, Haufe, & Patel, 2009)

- **PLA** stands for Polylactic Acid, which is a part of the Polyester family. PLA is made by fermentation of bio-based feedstock into Lactic Acid, which is then polymerized. PLA is especially used in the packaging and textile industry and is today on of the leading bio-based plastics (Shen, Haufe, & Patel, 2009). PLA can substitute conventional plastics such as PE and PET. (Carus, Ravenstjiin, Baltus, Carrez, Kaeb, & Zepnik, 2013)
- **Bio-PA** stands for bio-based Polyamide and is often called Nylon. There are many different types of polyamides, where some derives from fully or partially bio-based feedstock. Bio-based polyamide can be produced in many different ways with different feedstock. An important production route is to ferment sugar into adipic acid, which is then polymerized into Nylon 66. Bio-based polyamides are drop-in polymers that can substitute their fossil based equivalents. (Shen, Haufe, & Patel, 2009)
- **PHA** stands for Polyhydroxyalkanoates and is a biodegradable, bio-based polyester. Polyhydroxyalkanoates are produced by bacterial fermentation where e.g. corn or sugar beets can be used as feedstock. PHA can substitute conventional plastics such as PE and PET. (Shen, Haufe, & Patel, 2009)
- **Biodegradable polyesters** are a group of different polymers with the similarity that they are bio degradable and in the polyester family. The most common ones are PBAT (Polybutylene Adipate Terphthalate) PBS(Polybutylene Succinate and PCL (Polycaprolactone) (Carus, Ravenstjiin, Baltus, Carrez, Kaeb, & Zepnik, 2013) (Shen, Haufe, & Patel, 2009)
- **Starch blends** are complex blends of different components such as PCL (Polycaprolactone), PLA (Polylactic Acid), PBAT (Polybutyrate) and PBS (Polybutylene succinate). The different components are blended in order to give the product special features specialized for unique purposes. (Carus, Ravenstjiin, Baltus, Carrez, Kaeb, & Zepnik, 2013) The starch blends are bio based and more or less biodegradable. However, starch blends can be mixed with fossil based polymers as well. Starch blends are especially used in the packaging industry, but the agricultural industry is important as well. (Shen, Haufe, & Patel, 2009)

Size & Growth

In the bio-based plastic sector there are some types that are predicted to grow more than others, displayed in Figure 17 below. These are predicted to grow due to the market pull, available technology and feedstock availability. (Institute for bioplastics and biocomposites, 2015) (Carus, Ravenstjiin, Baltus, Carrez, Kaeb, & Zepnik, 2013)

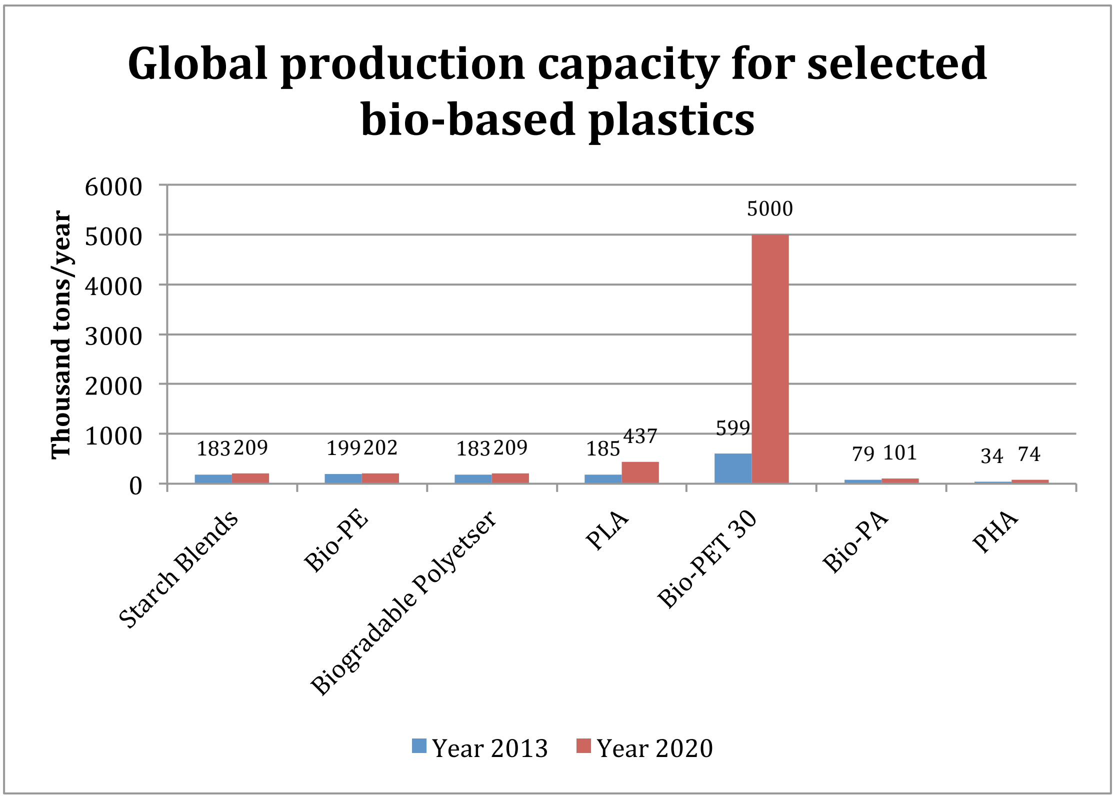

Figure 17: Global production capacity for selected bio-based plastics. As the figure displays, the highest growth will be for Bio-PET 30.

Competitor Involvement

Several of the largest competitors to the Company are present within the bio-based plastic segment, where a summarization of the produced and sold bio-plastics can be seen in

Name	Type	Specific Product	Status
Company A	Polyester	PLA	Commercial
Company A	Polytetrahydro	Bio-THF	Commercial
Company B	Polyurethanes	PDI	Ramp up
Company C	Thermoplastic	Bio-PE	Commercial
Comapny D	Thermoplastic	Bio-PTT	Commercial
Company D	Elastomer	Bio-TPC	Commercial
Company D	Polyamide	PA	Commercial
Dompany D	Polyols	Polytrimethylene diol	Commercial
Company D	Polymer	Soy polymer	Commercial
Company E	Polyamide	PA	Commercial
Company E	Polyester	Polyester Polyol	Commercial
Company F	Thermoplastic	Bio-PBT	-
Company F	-	EPDM	Commercial
Company G	Thermoplastic	Bio-PC	Commercial
Company G	Polyester	PLA	Commercial
Company H	Thermoplastic	Bio-PE	Commercial
Company H	Polyolefins	Bio-PP	Commercial
Company I	Polyamide	Bio-PPA	Commercial
Company I	Polysaccharide	Cellulose Plastic	Commercial

Table 4: Summary of competitors' involvement in the bio-plastic market

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Name	Type	Specific Product	Status
Company A	Polyester	PLA	Commercial
Company A	Polytetrahydro	Bio-THF	Commercial
Company B	Polyurethanes	PDI	Ramp up
Company C	Thermoplastic	Bio-PE	Commercial
Comapny D	Thermoplastic	Bio-PTT	Commercial
Company D	Elastomer	Bio-TPC	Commercial
Company D	Polyamide	PA	Commercial
Dompany D	Polyols	Polytrimethylene diol	Commercial
Company D	Polymer	Soy polymer	Commercial
Company E	Polyamide	PA	Commercial
Company E	Polyester	Polyester Polyol	Commercial
Company F	Thermoplastic	Bio-PBT	-
Company F	-	EPDM	Commercial
Company G	Thermoplastic	Bio-PC	Commercial
Company G	Polyester	PLA	Commercial
Company H	Thermoplastic	Bio-PE	Commercial
Company H	Polyolefins	Bio-PP	Commercial
Company I	Polyamide	Bio-PPA	Commercial
Company I	Polysaccharide	Cellulose Plastic	Commercial

Table 4: Summary of competitors' involvement in the bio-plastic market

There is currently no large-scale production of bio-based plastics in the Nordic region, however a research project called "Närodlad plast" is investigating the potential of initiating bio-based plastic production in Sweden. The project is founded by the institution SP Processum, which is governmentally founded, and co-founded by the involved parties. Involved stakeholders are, among others: IKEM, SEKAB, Tetra Pak, Holmen, Södra, Sveaskog, Trioplast and Borealis. The goal is to investigate the possibility and potential for producing bio-PE in the Nordic region. The decision to focus on bio-based plastics is based on the fact there it exists a demand and a willingness to pay for these products. The produced bio-PE would primarily derive from imported bio-ethanol but the long-term goal is to supply the feedstock from the Nordic forestry industry. The goal is to produce 100 000 tons of bio-PE in the future. (Alwarsdotter, 2015)

Company Alignment

As previously mentioned, the Company is a large producer of conventional plastics whereas PE and PU (Polyurethanes) stand for the largest volume, which could in theory be substituted with bio-based equivalents. The Company has also been in involved in a joint venture to produce PLA, which they subtracted from before the product was ramped up. Furthermore, The Company also initiated a project to start producing bio-PE, however the project was liquidated due to financial instabilities. (AN, BJ, & SM, 2015)

Technical Performance

The stated bio-based plastics have different technical properties, in Table below the plastics are sorted after their drop-in or functional properties, previously defined in section 4.2.4 – "Market Barriers and Enablers".

Name	Drop-in	Functional
Bio-PET	X	
Bio-PE	X	
PLA		X
Bio-PA	X	
PHA		X
Biodegradable Polyesters	X	
Starch Blends		X

Table 5: Technical characteristics of bio-based plastics

Several bio-based plastics can be produced on a large scale and have similar performance as the conventional plastics. In a technical perspective, 82% of the currently used plastics could be substituted with bio-plastics (Dammer, Carus, Raschka, & Scholz, 2013). There exist no known patents for producing bio-based plastics.

Economic

To produce bio-based plastics is currently not as cost efficient as conventional plastics, especially in Europe. Presently, the demand for bio-based plastics is large in Europe, but the production is mainly performed in other regions. This is due to the fact that the production within Europe is not as cost-efficient as in other regions, which is largely due to high feedstock prices. A majority of the produced bio-plastics are derived from sugar, a feedstock that has a much higher price in Europe than in other regions. (Alwarsdotter, 2015)

Why the feedstock cost for sugar is higher within Europe will be further discussed under "Political & Legal".

Political & Legal

One barrier to the project is the toll for imported ethanol and trade agreements within the EU. Currently, the entire market for products based on bio-ethanol is growing outside of the EU – even though there is a large, growing demand within the region. This is largely due to the resistance from European farmers to sell sugar to bio-ethanol production, since that would imply a decrease in price for them. The farmers are not forced to lower their prices to market level due to the toll systems that protects the farming industry in Europe. As discussed in section 4.2.4 – "Market Barriers & Enablers", the Swedish government is pushing for a change in the toll agreements, which would make it possible to import sugar to competitive prices. There is a demand for sugar produced in Europe, which would boost the European chemistry production, but the feedstock needs to be cost competitive with world market sugar prices. (Alwarsdotter, 2015)

Environmental & Social

The production of bio-based plastics will not compete with land-use in a extensive way, the projection of production of bio-based plastics in 2018 will imply a need of 0,02% of the total global agricultural area. Bio-based plastics are favourable in an environmental perspective since they can reduce GHG (Greenhouse Gas) emissions or even be carbon neutral. (European Bioplastics, 2014)

A market study that "Närodlad plast" has conducted confirms several opportunities and possibilities. The feedstock from the forestry industry is available and the needed amount for "Närodlad plast" will not compete with the current use for pulp production. Furthermore, there are several pulp plants and other factories that recently have been forced to liquidate their production which have led to an availability of production sites and to some extent equipment for the project. There is also a developed infrastructure and potential to create new jobs. Furthermore, there exists a willingness to pay for bio-based plastics since the cost can be easily transferred to the end consumer. (Alwarsdotter, 2015)

4.4.2 Biofuels

Introduction

As previously stated, biofuels can be divided into first- and second- generation biofuels. First generation biofuels are generated from bio-based materials that can be used for food or feed, second generation biofuels are generated from bio-based materials that cannot be used for food or feed. (International Energy Agency, 2010) Following, the three major types; ethanol, biodiesel and cellulosic ethanol, will be presented:

- **Ethanol** is a first generation biofuel that generally derives from corn, whey, sugar cane or sugar beets and can be consumed directly or be refined and processed into other chemical products. Ethanol has been produced for a long time and was before the primary source for producing ethylene, a platform chemical from which many polymers derive. (Renewable Fuels Association, 2015)

  Ethanol is defined by its purity level and in general lower purity ethanol is used for fuel and higher purity ethanol is used for chemicals. E.g. to produce pure ethylene a high degree of purity is required for the ethanol. The major part of all produced ethanol is used for fuels and is therefore a lower purity ethanol. (Bozell & Petersen, 2010)
- **Biodiesel** is mainly derived from first generation feedstock, but can also derive from second-generation sources such as pine trees. When it derives from first generation feedstock, it is mainly corn, vegetable oils or soyboeans that is processed. (Biodiesel - America´s Advanced Biofuel, 2015) In Sweden, rapeseed is most common used feedstock (Haaker, 2008)
- **Cellulosic ethanol** has the exact same properties as regular ethanol and can be used for the same applications, such as fuels or platform chemical depending on its purity level. The difference is that cellulosic ethanol derives from second-generation feedstock such as agricultural residue or other lignocellustic feedstock. (Wyman, 2007)

Size & Growth

The global market size of bioethanol was approximately 83,1 million tons in 2012 (UNCTAD, 2014) and is expected to grow with a CAGR of 8,1% until 2020, to 155 million tons (OECD-FAO, 2011). Brazil and the US are the largest producers of bioethanol, Europe stands for approximately 8% of the global production volume (ePure European Renewable Ethanol, 2014). The demand in

Europe is expected to more than double by 2020, and only half of the expected demand can be met by local production (Hart Energy, 2011).

The global market size of biodiesel is smaller than the bioethanol market, in 2012 the production volume was 22,5 million tons (UNCTAD, 2014). The production is expected to grow with a CAGR of 8,11% to a volume of 42 million tons by 2020 (OECD-FAO, 2011). Europe is the world's largest biodiesel producer and produces 40% of the total market (OECD-FAO, 2013).

The production volume of Cellulosic Ethanol is currently rather small but the growth is projected at a CAGR of 52,2% between 2013-2020, which is the fastest growth rate for any second generation biofuel. It is possible that cellulosic ethanol can surpass the production of biodiesel in the future. (Allied Market Research, 2013)

Competitor involvement

In Table an overview of the global competitors presence within biofuels can be seen.

Name	Type	Specific Product	Status
Company A	Cellulosic Ethanol	Cellulosic Ethanol	Pilot Plant
Company B	Cellulosic Ethanol	Cellulosic Ethanol	Commercial
Company C	Bio-ETBE	Bio-ETBE	Commercial
Compnay D	Bio-ETBE	Bio-ETBE	Commercial
Compnay E	1st gen. Bioethanol	Sugarcane bioethanol	Commercial
Company F	1st gen. Bioethanol	Bioethanol	Commercial
Company G	Hydrogen	Fuelcells	Commercial
Company H	2nd gen. Biodiesel	Straw, plant residue	Research/Pilot plant

Table 6: Summary of the competitors' involvement on the biofuel market

As seen in the table, several of the largest competitors are investing in the production of second-generation biofuels. ETBE stands for Ethyl Tert-Butyl Ether and is usually blended with conventional gasoline in order to improve the air quality (European Biofuels Technology Platform, 2015).

When analysing the Nordic market, several companies are investigating the potential of using the forestry industry as feedstock for fuel production. A governmental project initiated by BioInnovation is investigating the possibility of using lignin, a residue from the pulp- and paper production, as feedstock for biodiesel production. Preem is one of the involved stakeholders in the project. Beside the lignin-project, Preem is also Sweden's largest producer of biodiesel derived from pine oil. (Håkansson, 2015)

Several researches and stakeholders are currently investigating new projects in order to make the bio fuel competitive on the market, which confirms the interest in second-generation biofuel. These projects can both be related to the use of forestry biomass as well as algae as potential feedstock. (Josefsson, 2015)

Company Alignment

As previously mentioned, the Company is currently not producing any type of fuel, and there is no plan to be involved in this business area since it is too far from the current core business and it is a competitive market. However, the possibility to be involved in the side streams and bi-products opportunities that will be a surplus from the biofuel production is of interest. (BJ & AN, 2015)

Technical Performance

The production of bioethanol and biodiesel by a fermentation process is well known and highly developed (Wallberg, 2015)

A large volume of the produced bioethanol is used as an additive in conventional gasoline. An issue with bioethanol is the fact that a conventional vehicle engine cannot run entirely on bioethanol fuel and therefore special designed engines are needed. These bioethanol-cars can however both run on bioethanol and on conventional gasoline. There has been negative publicity around bioethanol, stating that the engines get a shorter life span when only driven on bioethanol. (SvD Näringsliv, 2014)

Biodiesel on the other hand can be used directly in conventional diesel engines, since it has equally or even enhanced technical performance. Another technical benefit for the producer is that the production can be made in existing facilities and using the same infrastructure. (Håkansson, 2015)

The production of cellulosic ethanol is in its early stages, and extensive research is conducted in order to increase the yield and efficiency of the process. Cellulose is a more complex feedstock to refine in comparison to e.g. sugar, which complicates the refining process. (Wallberg, 2015)

Economic

The production of biofuels is more expensive than fuels derived from a fossil based feedstock, such as crude oil, and biofuels will not be cost competitive in the nearest future. The low oil price is a factor that interferes with the competiveness of biofuels, and subsides and governmental policies and regulations are needed in order for biofuels to be attractive on the market. (Wallberg, 2015)
Due to the complexity and novelty in the technical process of refining cellulose, cellulosic ethanol is more expensive to produce than other biofuels. However, in line as the technical aspects develops the cost decreases and cellulosic ethanol is predicted to be cost competitive in the future. With the current technology, cellulosic ethanol would be cost competitive with conventional gasoline when the crude oil price is at 100 USD per barrel. In 2030, the corresponding crude oil price would be $75. (Clixoo, 2014)

Another option for increasing the cost competiveness of biofuel is to increase the usage and extract of the side-streams that occur in the bio refinery process. Investors are dependent on a product that can be produced in large scale, in order to reap the benefits from economics of scale. When a functionally bulk production process is in place, side streams can be used to produce fine chemicals and other chemical applications. (Wallberg, 2015)

Political & Legal

The high growth of production and usage of biofuels in Europe can to an extent be directly related to the European Commission's Renewable Energy Directive where one specific directive stated that 10% of the used fuels in the EU should derive from renewable sources. (European Academics Science Advisory Council, 2012). In October 2012, this policy was amended to take the food vs. fuel debate into account and therefore 5% of the biofuels should be derived from feedstock that do not compete with current land use and potential food production. This new amended reversed version will strengthen the incentives for second-generation biofuels (European Comission, 2012). However, how these targets will be renewed after year 2020 is still unclear.

The EU commission states that the transport development should be based on sustainable fuels, but no new targets have been defined. (European Comission, 2014). At the same time there is an overall goal to reduce the carbon dioxide emissions derived from the transport sector by 20% until 2030, compared with the levels of 2008 (European Comission, 2011).

Environmental & Social

There exist several contradicting opinions on how sustainable biofuels actually are, where the source of the disagreement to a large extent can be related to the food vs. fuel debate, introduced in section 4.2.4 – "Market Barriers and Enablers". According to a study performed by Ecofys, the production of biofuels is not competing with food production nor a major factor for driving up food prices. The analysis showed that the 2010 crop production was enough to feed 12 billion people, the major problem of food shortage can be related to lack of infrastructure, lacking techniques to preserve food and waste. (Ecofys, 2013)

However, the debate is still infected and several businesses do not want to be associated with the refinement of food feedstock for fuel production. Therefore, the usage of second-generation feedstock to produce biofuels is of great interest and the potential of using and refine the Nordic forest has gained international attention (Hannerz, 2015). In some situations, the potential to use the forest as a feedstock for fuel production have gained resistance from a European perspective, mostly due to ignorance and lack of knowledge of the availability of forestry feedstock in the Nordics. Those who lack knowledge of the available resources in the Nordics argues that the forest is growing too slowly and fear that production of biofuels from this feedstock would imply devastation and a high negative impact on nature. (Håkansson, 2015)

When looking at the actual GHG reduction that biofuels can contribute with, the potential reduction is highly dependent on the used feedstock, production process and technique. The GHG reduction from ethanol derived from wheat can vary between 7 to 77% in comparison with conventional fuel whereas ethanol derived from sugarcane can reduce GHG with up to 90%. (Environmental Audit Committee, 2008)

Even though biofuels are close to the end consumer, there is a lack of willingness to pay a premium for the product. An interest can however be seen from freight forwarders and other companies that are active in the transport sector. The interest is due to the possibility to perform large procurement volumes and get a better price and to make sustainability and the use of biofuels a branding competitive advantage towards the end user who buys the transport services. (Håkansson, 2015)

4.4.3 Platform Chemicals

Introduction

Platform chemicals are referred to as basic chemicals that can be directly used, or processed into other high volume or value-adding chemicals, such as plastics. These platform chemicals have traditionally derived from petrochemical sources, but recently the bio-based platform chemicals have gained market shares again since the biotechnical production routes have evolved (Biebl & Zeng, 2002). In Figure 18, various platform chemicals are displayed as the two inner rings inside the bio-based plastics previously described. Following, the most relevant platforms: Organic Acids, 1.4 Butanediol, 1.3 Propanediol and Lignin will be described.

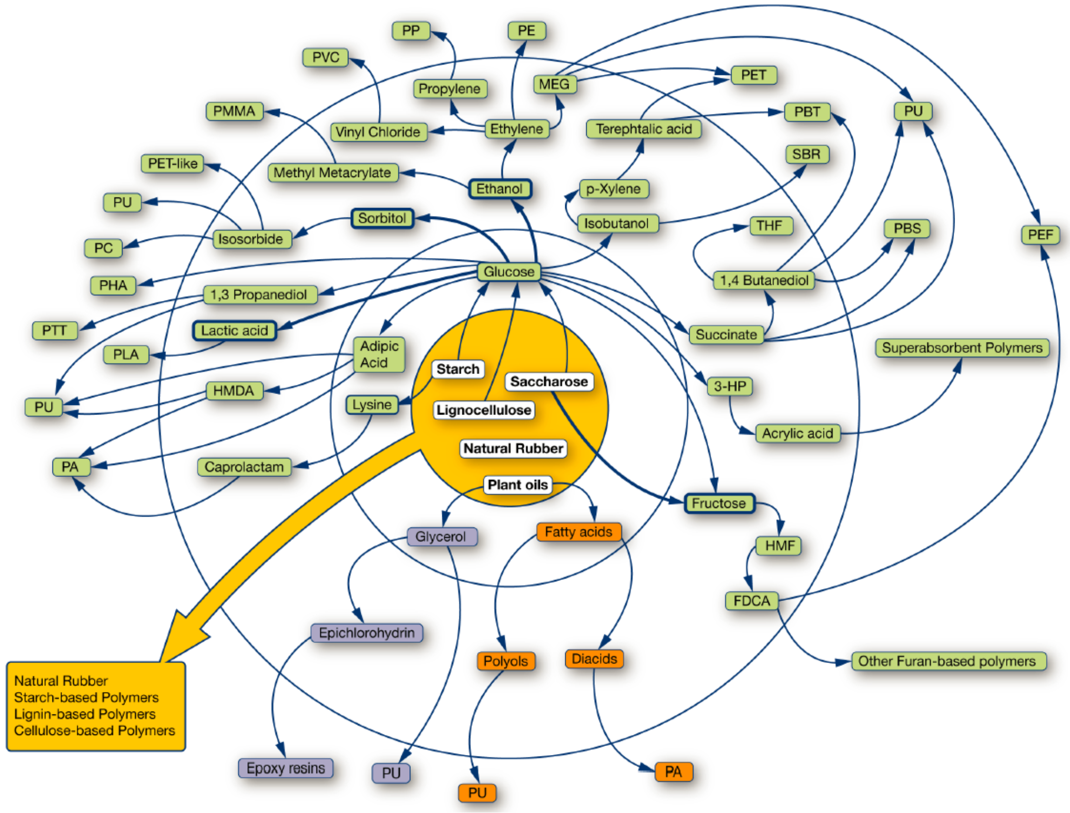

Figure 18 : The platform chemicals in this figure are placed the middle ring where e.g. "polyols", "HMDA" and "Fructose" can be found. (Nova Institute, 2015)

Organic Acids

Within platform chemicals, one of the fastest growing segments is organic acids. Organic acids is a platform chemicals product group that have been used in nature and by humans for a very long time. Before, fermentation and bio-based feedstock where the most common way to produce organic acids, but when the petrochemical industry evolved and gained market shares, organic acid production from fossil-derived feedstock followed. Today, sustainable Organic

Acids derived from renewable sources and produced by biotechnical methods have gained market share again. (Carole, Pellegrino, & Paster, 2004)
There exists a wide range of organic acids and therefore will only the most common be described below:

- **Lactic acid** is one of the most important organic acids and is used in a range of industrial and biotechnical applications, where the most common one is within Polylactic acid (PLA) mentioned earlier in section 4.4.1 – "Bio-based plastics". Bio-based lactic acid is produced through fermentation using bacteria or fungi. The feedstock for the production of bio-based lactic acids varies, but cellulosic material and sugar cane molasses are common (Ghaffar, et al., 2015).
- **Succinic acid** production is today mostly derived from fossil based feedstock. Succinic acid is widely used in the industry and can substitute other chemical platform chemicals such as Adipic acid in e.g. production of polyurethanes (Erickson, Nelson, & Winters, 2012). Succinic acid can also be used to create 1.4 Butanediol, which is an important platform chemical when producing many polymers such as PBS, PU and PBT (Dammer, Carus, Raschka, & Scholz, 2013). Succinic Acid can be used to produce coatings, detergents, green solvents and surfactants. The most common feedstock for producing succinic acid is glucose, obtained by e.g. starch, sugar cane and whey (Cheng, Zhai, Zeng, & Zhang, 2012).
- **Acetic Acid** occurs naturally in vinegar, which traditionally is produced by fermentation of wine. However, the most common way to produce acetic acid is by synthetic routes from fossil feedstock. The fermentation route where bacteria and microorganisms produce acetic acid is still of interest since it's more environmental than the synthetic routes. Acetic acid is especially used for the production of vinyl acetate, which is polymerized to polyvinyl acetate (PVA) and acetic anhydride. (Le Berre, Serp, Kalck, & Torrence, 2013)
- **Acrylic acid** is a colourless liquid that is used in the manufacturing of plastics, coatings, paints and as a chemical intermediate (EPA, 2013). Acrylic acid is normally derived from petrochemicals, where propene is used as feedstock. It is possible to produce acrylic acid by a fermentation process of sugar (Straathof, Sie, Franco, & van der Wielen, 2005). It is also possible to genetically modify yeast in order to produce acrylic acid, where the feedstock could be found in the pulp- and paper industry. (Chalmers Tekniska Högskola, 2013)

1.3 Propanediol and 1.4 Butanediol

1.3 Propanediol is a platform chemical used to produce e.g. bio based polymers, resins, coatings and adhesives. This chemical has traditionally been produced by synthetic process routes derived from fossil fuels, but today, bio based production routes have gained market shares due to e.g. environmental, market and business factors. (Ferreira, Ribeiro, Ribeiro, Freire, & Coelho, 2012)

1.3 Propanediol is a colourless, odourless liquid and the bio-based 1.3 Propanediol generally is derived from sugar or corn, which is processed using engineered microorganisms and bacteria. (Kurian, 2005)

1.4 Butanediol is an important commodity chemical with a wide application area in the chemical industry. 1.4 Butanediol is mostly used as an intermediate in chemical processes and in the production of various plastics (Austrial Governmnet Department of Helath, 2013). Conventional 1.4 Butanediol is exclusively produced from a petrochemical route where natural gas or crude oil is refined. Bio-based 1.4 Butanediol can be produced by a fermentation process with sugar as feedstock. (Khandurina, Tremblay, & Duczak, 2013)

Lignin

Another platform chemical that is gaining interest both globally and especially in the Nordic region is lignin, which derives from lignocellulose. Cellulose can be divided into lignin, cellulose and hemicelluloses where cellulose and hemicelluloses are the two major components used in Sweden to create pulp for paper and packaging products. Some lignin is also mixed into the pulp, but mostly it is burned to provide energy to the pulp production process. As the pulp and paper production process has become more efficient, and the paper market is saturated, stakeholders are looking for ways to use lignin for production of chemical products. (Wallberg, 2015) The lignin can therefore play a significant role as a second-generation feedstock and a variety of chemicals and products can be derived from lignin, see Figure 19. (IEA Bioenergy, 2012)

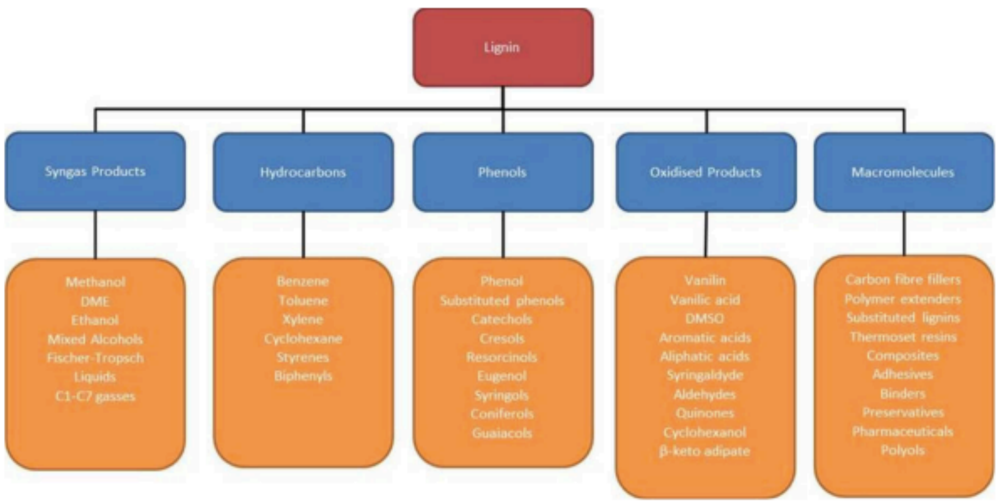

Figure 19: Lignin as a bio-based feedstock can produce a variety of platform chemicals and products. (IEA Bioenergy, 2012)

Size & growth

Organic Acids

The global bio-based succinic acid market was estimated to 50 000 tons in 2013 and is estimated to grow to 600 000 tons by 2020 (Grand View Research (3), 2014), whereas the total global succinic acid market is expected to reach 711 000 tons. Important to note is that Europe is the largest market for bio-based succinic acid with a global market share of 49% year 2013 and an estimated CAGR of 23,6% until 2020 (Grand View Research (3), 2014).

The global lactic acid was estimated to 500 000 tons in 2012 and is estimated to reach a volume of 1,96 million tons by 2020, which represents a CAGR of 15,5%.

The growth of the lactic acid market is directly related to the growing demand of the earlier mentioned PLA market. (Grand View Research (4), 2014)

The global demand for acetic acid was estimated to 10,5 million tons in 2013 and is expected to grow with a CAGR of 5,1% to 2020, reaching a volume of 14,9 million tons (Research, 2014). Since the production of bio-based acetic acid is in its early stages, there exist no available data on current size and possible growth.

The global acrylic acid market was estimated to 5,57 million tons in 2014 and is expected to grow to 6,94 million tons by 2019, which represents a CAGR of 4,6%. Since the production of bio-based acrylic acid still is in the early stages of development, there exists no available data on current size and possible growth. (MarketsandMarkets, 2014)

1.3 Propanediol & 1.4 Butanediol

The global 1.3 Propanediol, both bio-based and conventional, is expected to grow with a CAGR of 10,4% from 2014 to 2021. The major driver for this growth is the increased usage of bio-based plastics, especially PTT (Polytrimethylene terephthalate), but also new application areas such as cosmetics, personal care and cleaning. Due to a patent issued by one of the competitors to the Company, the number of players on the market is limited today. The bio-based production route is dominant in comparison to the conventional production route, and the total market is expected to grow to a value of $621,2 million by 2021. (MarketsandMarkets, 2015). The global produced volume for bio-based 1.3 Propanediol was 78 000 tons year 2013 and is expected to be 120 000 tons year 2020. (Dammer, Carus, Raschka, & Scholz, 2013)

The global 1.4 Butanediol market was estimated to 1,95 million tons in 2012 and expected to grow to 2,55 million tons in 2017 which represents a CAGR of 5,5% (RnR Market Research, 2012) The production of bio-based 1.4 Butanediol is in its early stages, in 2013 there was no global production of bio-based 1.4 Butanediol, but the production is expected to grow to approximately 216 thousand tons by 2020 (Dammer, Carus, Raschka, & Scholz, 2013).

Lignin

1 million tons of lignin is currently used each year for non-fuel applications, which represent less than 2% of the total available volume (Glasser & Lora, 2002). In Sweden there is an availability of approximately 2 million tons of lignin annually, where approximately 8% is suitable for production of chemicals. As the pulp and paper industry becomes saturated, the forestry companies are putting increased effort to find new value derived from their feedstock, the forest. Lignin is one of those possibilities and therefore is the use of lignin for chemicals expected to increase. (Wallberg, 2015).

Competitor Involvement

Several of the Company´s global competitors are present within the bio-based platform chemical segment, see Table .

Name	Type	Specific Product	Status
Company A	Succinic Acid	Succinic Acid	Commercial
Company B	Succinic Acid	Succinic Acid	Ramp up
Company B	Acrylic Acid	Acrylic Acid	Research project
Company B	Butanediol	1,4-Butanediol	Commercial
Comapny C	Propanediol	1,3-Propandiol	Commercial
Company D	Succinic Acid	Succinic Acid	Commercial
Company D	Butanediol	1,4-Butanediol	Commercial
Company D	Succinate	Disodium Succinate	Commercial
Company E	Butanediol	1,4-Butanediol	Pilot Plant

Table 7: Summary of competitors' involvement in the bio-based platform chemical market

In the Nordic region, several companies are investigating the possibility to use lignin as a platform chemical. As previously mentioned in section 4.4.2 – "Biofuels", a project called "Bioinnovation" is researching the potential usage areas of lignin. E.g. the fuel company Preem would like to use the lignin to produce biofuels and is expected to mix a small percentage of lignin into their refineries. To increase value, the goal is also to create side streams from the biorefineries where lignin can be used to produce special chemicals for various applications. (Håkansson, 2015)

There also exists a Norwegian company that is the largest producers of products derived from lignin, such as vanillin. They have successfully implemented a side-stream utilization of excess feedstock from the forestry industry. (Josefsson, 2015)

Company Alignment

Organic Acids

The Company is a large producer of conventional acrylic acid and it is an important product in the portfolio (BJ & AN, 2015). The Company have explored the possibility to produce acrylic acid from a bio-based route, however the project was shut down due to the fact that bio-based acrylic acid was inferior in a life-cycle perspective in comparison to conventional acrylic acid production. The Company does not have any current production of the previously stated organic acids and there is currently no interest in extending the product portfolio or take interest in these products. However, some of the organic acids are used to manufacture the Company's product portfolio. (BD, 2015)

1.3 Propanediol & 1.4 Butanediol

The Company has not produced bio-based 1.3 Propanediol and has no intention to do so. However, the needed knowledge exists within the Company and they can therefore produce it. The Company also use conventional 1.3 Propanediol in their business to produce other chemicals products. (BD, 2015)

The Company is not producing 1.4 Butanediol and is not using the product in their manufacturing, they have no plans to invest in this particular area. (BD, 2015)

Lignin

The Company has not produced lignin-derived products and has no intentions to do so. However, if the technical difficulties to produce lignin and separate different types of lignin are overcome, the Company should investigate the lignin market. The Company could also provide process chemicals that are needed to produce, purify and process the lignin into other platform chemicals and chemical products. (BJ & AN, 2015)

Technical Performance

Organic Acids

The bio-based organic acids previously stated have identical technical performance as their conventional fossil-based equivalent, which according to the previously stated classifications defines them as drop-ins. (BD, 2015)

The technical development of succinic acid production has progressed the recent years, leading to that the acid can be produced in large scale with satisfying quality (Bechthold, Bretz, Kabasci, Kopitzky, & Springer, 2008). Lactic acid can be produced both from a synthetic route and a fermentation route, whereas the synthetic route was associated with several limitations. Several of the technical barriers have been overcome (Datta & Henry, 2006). Other organic acids is still in such an early stage that several technical processes is still being developed (BD, 2015).

Lignin

A problem with lignin is that it is not a homogenous chemical structure and therefore demands that the processes where lignin should be used as a feedstock to be robust. Another problem is that the product group lignin consists of different types of lignin and many applications require a specific type of to function satisfactory. Since it is hard to separate the different types, many application areas are hard to achieve. (Wallberg, 2015) Furthermore, lignin is evolved to be rigid and strong to e.g. make trees grow tall. Therefore, it is difficult to break down the lignin in an efficient way. Another problem is that lignin often contains other substances that need to be removed, such a substance is e.g. sulphur. (Glasser & Lora, 2002)

If the obstacles to produce a pure lignin product in an economic way are achieved, lignin can be used in many application areas where its chemical structure is outperforming several conventional chemicals. Since lignin-derived chemicals and products have a different production route, lignin is classified as a functional equivalent. (Glasser & Lora, 2002)

1.3 Propanediol & 1.4 Butanediol

Bio-based 1.3 Propanediol has the same performance and often a higher purity level than the conventional product, there are therefore no technical performance issues to produce bio-based 1.3 Propanediol. However, as with many other biotechnology routes, the yield is lower than conventional production and the process route is costly. (Kaur, Srivastava, & Chand, 2012)

Bio-based 1.4 Butanediol has the same technical performance as the conventional 1.4 Butanediol and is therefore classified as a drop-in product. (BD, 2015)

Economic

Organic Acids

Of the most promising bio-based organic acids, succinic acid is currently more cost-effective to produce than conventional petroleum derived (Jang, et al., 2012). The other previously stated, acetic acid and lactic acid are however more expensive to produce than the conventional product (Erickson, Nelson, & Winters, 2012) (Harmsen & Hackmann, 2013).

According to a study performed in 2015, the production of bio-based acrylic acid can be cost competitive with conventional methods at an crude oil price of $90 per barrel (Metabolix, 2015). Which is approximately 30% higher than the current crude oil price (Bloomberg Buisness, 2015).

1.3 Propanediol & 1.4 Butanediol

Bio-based 1.3 Propanediol is unfortunately not economically competitive today in many aspects. Two reasons are the low crude oil price that makes fossil derived chemicals more cost competitive and a patent protection issued by a competitors to the Company, which protects their bio-based production route (MarketsandMarkets, 2015). Another reason is that the feedstock for bio-based 1.3 Propanediol is expensive. One opportunity is that 1.3 Propanediol can be produced from glycerol, which is a bi-product when producing biodiesel. The production of biodiesel can therefore result in a cheaper feedstock for bio-based 1.3 Propanediol. (Kaur, Srivastava, & Chand, 2012)

The technical development for producing bio-based 1.4 Butanediol is progressing rapidly, which also leads to a decrease of production cost. A study from 2006 states that there was currently no viable economic production process for bio-based 1.4 Butanediol, however the production status have developed extensively since then. (DG Research, 2006)

Lignin

"You can make everything from lignin but money" is a famous quote that is widely known in the forestry industry. Lignin has an impressive chemical structure that is hard to change into platform chemicals and building blocks. What researches try to achieve is to speed up the natural decomposition of cellulosic structures into hybrocarbons chains such as fossil fuels. The natural process route takes thousands of years and is therefore hard to speed up enough without increasing the cost too much as well. Lignin is therefore hard to be competitive against fossil fuels. However, in specialized application areas, lignin is competitive, and some companies are engaged and profitable in these areas. (Wallberg, 2015)

Political & Legal

There are currently no regulations or political incentives that encourage the production of bio-based platform chemicals, however there is an indirect policy for some of the platforms since they are used in products, which are regulated. This mostly occurs for platform chemicals that also can be used to produce biofuels. (BD, 2015)

Environmental & Social

Since the platform chemicals are positioned in the early stages of the value chain, it is more difficult for the end consumer to see the potential environmental value of the product. In B2B situations, the margins are usually smaller and there is less WTP. Bio-based feedstock is still interesting in those cases where the end-product is used by an end consumer, meaning that the cost can be transferred to the end consumer,e.g. bio-based platform chemicals used to produce bio-based plastics that are used by the end consumer. (BD, 2015)

Organic Acids

As previously mentioned, for some organic acids i.e. acrylic acid the environmental impact is greater for the bio-based process route than for a conventional fossil based. (BD, 2015)

1.3 Propanediol & 1.4 Butanediol

Bio-based 1.3 Propanediol is better out of an environmental perspective in comparison with its petrochemical counterpart since it e.g. reduces greenhouse gas emissions (Hermann, Blok, & Patel, 2007) and releases no toxic by-products (Kaur, Srivastava, & Chand, 2012).

There is no available data regarding “Environmental & Social” for 1.4-Butanediol.

Lignin

Lignin has been regarded as a waste product whose best usage area was to be used for energy. Today, research tries to commercialize lignin-derived chemical products and increase value by finding new application areas. This is regarded as a more sustainable usage area than energy, there is therefore a social and environmental interest on the market, especially in the Nordic region. (Wallberg, 2015) (Josefsson, 2015)

The reader is now recommended to study the analysis for phase 4, which can be found in section 5.3- “Selection Process of Phase 4”. The output of this analysis is the Product Groups that will analyse in section 5.4 - “Business Opportunity Analysis”.

5 Analysis

Following The Sustainable Market Model, the analysis and empirical data collection have been conducted in an iterative process where the gathered data from Phase 1 and 2 is input for the "Selection Process of Phase 1 & 2" and so forth. The following chapter will display the analysis that was performed for "Selection Process of Phase 1 & 2" "Selection Process of Phase 3" "Selection Process of Phase 4" and "Business Opportunity Analysis" The reader is advised to read this chapter in parallel with chapter 4 – "Empirical Data Collection" in order to obtain a better understanding of the presented analysis. The reader is also recommended to keep section 3.2- "The Sustainable Market Model" in mind.

5.1 Selection Process of Phase 1 & 2

5.1.1 Introduction

This analysis is based on section 4.1 "Phase 1 – Defining Sustainability" and section 4.2 "Phase 2 – The Macro Market of Sustainable Chemistry". The majority of data stated in these sections is intended to give the reader an insight in the concept of sustainability and Sustainable Chemistry. Parts of the data stated in previously stated empiric sections will not be analysed directly, but rather work as a foundation for the whole analysis to make the reader understand the Sustainable Chemistry market.

To summarize from section 4.1 "Phase 1 – Defining Sustainability" and section 4.2 "Phase 2 – The Macro Market of Sustainable Chemistry" the most important information is:

- Sustainable chemistry products must have the same or improved performance in comparison with conventional products
- Bio-based, biodegradable, low toxicity and recyclable are the four most valued characteristics of a SC product
- It is important to be able to show or communicate the improved performance or characteristics of a SC product to the buyers in order to achieve a WTP
- WTP especially exists close to end-customer and where the SC cost is a fraction of the total cost, as in e.g. packaging. Europe is a major market for SC
- Legislations, policies, tolls and oil price are important factors for the SC industry
- Second generation derived SC products are superior to first generation to avoid the food vs. fuel debate.

5.1.2 Analysis

Segmentation methods

In section 4.2.5 – "Market Segmentation Methods" several ways to segment the Sustainable Chemistry were presented, however not all of these will be further investigated.

In “Mapping the Green Chemistry Community – Segmentation” the three first issues: **Alternative or renewable feedstock**, **Alternative solvents**, **Alternative synthetic pathways** will be used since these issues are in line with the four most valued Sustainable Chemistry characteristics. **Chemical Engineering**, is an area where significant research is being conducted. However, this area will be disregarded since the area does not fulfil the stated criteria for Sustainable Chemistry e.g. it does not concern the bio-based origin nor the biodegradability aspect. Chemical Engineering is only concerned with the goal to improve processes in order to reduce waste.

The “Deloitte segmentation” sorts SC into smaller areas that are comprehensible and possible to further divide into sub-groups. Such segmentation is seen as a good basis for further investigation and will therefore be the foundation of what segments to further investigate in the following phases. Moreover, Deloitte conducts its segmentation searching for business opportunities, which is partially aligned to the secondary purpose of this master thesis.

Parts of the “Drop-in versus Functional Segmentation” will also be emphasized since there is a higher predicted initial growth for drop-in products. Therefore, when looking for business opportunities **Direct product replacement** and **Building Block Intermediates** will have an advantage over **Novel Products**. In the Novel Products, the market and value chain often has to be developed in order to make it possible for the new product’s unique characteristics to satisfy a new demand.

Selection

Following the “Deloitte segmentation” and based on the trends stated in section 4.2.6 “Market Segment Trends”, the following segments where investigated:

Antibiotics, Vitamins and Amino Acids, which were stated by Deloitte to have a significant growth and future importance in the bio-based society, will be omitted. The decision is made since these segments are especially used for products in the pharmaceutical- and food processing industry, which is outside this master thesis’s scope.

Bio-based plastics will be further analysed, since several sources have stated the importance and future potential of this segment. Bio-based polymers are stated as a high growth area by Deloitte, which is confirmed by qualitative data, e.g. interviews with stakeholders. Biofuels will also be further investigated based on the same input, which also is aligned with the Deloitte report since biogas is defined as a type of biofuel.

As stated, extensive research is being conducted within GC to find an alternative feedstock and to find new building block intermediates. The feedstock would function as the building blocks for other products. Organic Acids and Alcohols are segments that are included in this area, and the segment will therefore be further investigated, here forth addressed as **Platform Chemicals.**

Lubricants is not considered as a potential interesting segment when scanning the macro market, however, the segment was added due to the Company´s wishes and special interest in the area. Enzymes and Solvents, have gained interest in both the GC community and seen as growth segments according to Deloitte. These segments will also be further analysed.

5.1.3 Output of Selection Process of Phase 1 & 2

Based on the different Sustainable Chemistry areas stated in section 4.2.6 - "Market Segment Trends" and with input from whole section 4.1 - "Phase 1 – Defining Sustainability" and section 4.2 - "Phase 2 – The Macro Market of Sustainable Chemistry" the following segments will be further analysed using *The Sustainable Market Model:*

- Bio-based Polymers
- Biofuels
- Platform Chemicals
- Industrial Enzymes
- Bio-based Solvents
- Bio-based Lubricants

All these segments fulfil the stated definition of Sustainable Chemistry and are major growing segments in the Sustainable Chemistry market. The segments are also potentially aligned with the company's business.

5.2 Selection Process of Phase 3

5.2.1 Introduction

This analysis is based on section 4.3 - "Phase 3 – Market Segment Investigation" in the empirical data assessment. The reader is therefore recommended to study this section before continuing to the following section in order to obtain an understanding of the analysed material. The reader is also to recommended to keep the developed theoretical framework in mind, stated in section 3.2 - "The Sustainable Market Model"

The purpose of this selection process is to analyse the Sustainable Chemistry segments that where the output of section 5.1 - "Selection process of phase 1 & 2" and find what Product Groups that can be further analysed using *The Sustainable Market Model.*

5.2.2 List of Factors

As previously stated in section 3.2.5 "Selection Process of Phase 3", the list of factors that each segment will be rated according to is the following:

Size & growth:

- Sustainable segment growth rate
- Sustainable segment size
- Market growth rate
- Market size.

Company Alignment:

- Compatibility current business
- Company ambition

5.2.3 Weight

As previously mentioned in section 3.2.5 – "Selection Process of Phase 3" the stated evaluation factors are weighted based on their relative importance for the segment to contain a potential business opportunity for the Company. The weights for the list of factors are displayed in Table .

Size & Growth	Weight
Sustainable segment growth rate (%)	0,3
Sustainable segment size (tons)	0,2
Market Growth rate /year (%)	0,05
Market size (tons)	0,05
Company Alignmnet	
Compatibility current business	0,25
Company ambition	0,15
Total	*1*

Table 8: Weight distribution to display the relative importance of each factor. The sum of the weights is 1.

The "Sustainable Segment Growth Rate" is decided to be of highest importance since growth increases the possibility for the company to gain market share in this new market segment. It also reduces the competitive rivalry for the specific market segment. The "Compatibility Current Business" is chosen to be second most important since it affect the Company's ability to be able to compete within the new segment and satisfy the segments' customer needs. The "Sustainable Segment Size" is also of importance since it will increase the possibility for the Company to achieve an economy of scale, which is of importance to reduce production cost and pay back investments that will be needed to enter the new market segment. The remaining parameters are decided to be of less importance, a decision made in accordance with the Company.

5.2.4 Rate

Each investigated market segments receive a rate from 0-10 for every factor, where 10 is the highest rate, based on their performance for that specific factor. The factors are as mentioned divided into quantitative and qualitative data, each will be explained below. To see a summary of the actual numbers from the empiric data, the reader is encouraged to study section 9.1.1 – "Rate distribution, Selection Process of Phase 3" in the Appendix.

Quantitative Data Distribution

The quantitative data are the factors that are quantifiable and the rate can therefore be distributed in relation to the segments' s growth rates and volumes for each factor. How the limits have been decided will be described in the section below.

Growth Rate

When considering the growth rate, both from the "Sustainable Segment Growth" and "Market Growth" perspective one can determine that the growth rates are fairly evenly distributed. In the "Sustainable Segment Growth" factor the growth rates differ between 4% and over 20% and since the growth implies there is a growing customer demand, the higher the growth the higher the rate.

The "Market Growth" factor is more complex. In one hand, a low growth rate for the general market in combination with a high sustainable segment growth implies that the sustainable alternative is gaining market share on the price of the conventional alternatives. The cannibalization trend confirms that the sustainable segment is a more attractive market and therefore, a low "Market Growth" should receive a high rating. On the other hand, a low "Market Growth" could also imply that the general market is mature and loosing market share due to a decrease in demand, which suggests a low attractiveness and therefore, a low "Market growth" should receive a low rating. It was decided that a high growth would get a high rating regardless if the growth were in "market growth" or "sustainable segment growth", this decision was made in accordance with the Company.

The rate distribution for the "Sustainable Segment Growth" and the "Market Growth" factors is summarized in Table. The reader is recommended to study Figure 24 and Figure 25 in section 9.1.1 – "Rate distribution, Selection Process of Phase 3" in the Appendix to fully grasp the rate distribution.

RATE	GROWTH
10	>25%
9	23%
8	20%
7	18%
6	15%
5	13%
4	10%
3	8%
2	5%
1	3%
0	0%

Table 9: Rate distribution for the growth of the sustainable product segment

Market Size

The relative size of the market segments where taken into account when deciding the rating limits for each stated factor. Both the "Sustainable Segment Size" and the "Market Size" factors have a large variety for the different market segments, where biofuels stand for the largest volume by far in both factors. To get a more even rating, the biofuels market segment was given highest score in both the "Sustainable Segment Size" and the "Market Size" factors and the biofuel volume was then disregarded. The reader is advised to study figure 26 to 31 section 9.1.1 – "Rate distribution, Selection Process of Phase 3" in the appendix to understand how the product segment volumes are related.

What is to be considered to be a large size is subjective and highly dependent on the company in question and their current size and market coverage. The limits for the rating can be seen in Table and Table for the “Market Size” and “Sustainable Segment Size” respectively. The reader is recommended to study Figure 26 to Figure 31 in section 9.1.1 – “ Rate distribution, Selection Process of Phase 3” in the Appendix to fully grasp the rate distribution.

RATE	SIZE
10	> 500 000 000
9	450 000 000
8	400 000000
7	350 000 000
6	300 000000
5	250 000 000
4	200 000 000
3	150 000 000
2	100 000 000
1	50 000 000
0	0

Table 10: Rate distribution for the factor "Market Size"

RATE	SIZE
10	>10 000 000
9	9 000 000
8	8 000 000
7	7 000 000
6	6 000 000
5	5 000 000
4	4 000 000
3	3 000 000
2	2 000 000
1	1 000 000
0	0

Table 11: Rate distribution for the factor "Sustainable Segment Size"

Qualitative Data Distribution

The rating of the “Company Alignment” factors is less static compared to the previously stated, quantitative factors, and also subjective and dependent on the company in question. The rating limits were therefore made in collaboration with technical and business experts within the Company, and the decided limits can be seen in Figure 20.

Rate Section	RATE
3-Step	
Strong	8
Moderate	6
Low	4
4-Step	
Positive	8
Moderate	6
Low	4
Not Positive	0

Figure 20: Rating for the qualitative data. Each qualitative factor where given a suitable distribution and each segment's performance was rated according to these distributions. The distributions and ratings where determined along with the Company.

Rating for Market Segments

Based on the analysis conducted in section 5.2.4 - "Rate" the following rates are determined to display each market segment's performance in relation to each factor, see Table . To see the actual numbers, the reader is recommended to study section 9.2.1 – "Segment Investigation" in the Appendix.

	Bioplastics	Platform chemicals	Biofuels	Enzymes	Lubricants	Solvents
Size & Growth						
Sustainable segment growth rate (%)	8	9	3	3	3	1
Sustainable segment size (tons)	5	6	10	3	1	3
Market Growth rate /year (%)	2	3	1	3	1	1
Market size (tons)	5	6	10	1	1	1
Company Alignment						
Compatibility current business	10	10	1	0	5	5
Company ambition	8	8	2	1	6	4

Table 12: Rating for each segment where 10 is highest. The ratings are decided using the previously stated rating distribution charts. Platform chemicals and bioplastics are the two most growing sustainable market segments and therefore get a high rating. Fuels/Biofuels are the largest markets in terms of volume for both the overall market and the sustainable market and therefore get a high rating.

5.2.5 Score

When the weights for each factor and the rates for each market segment's performance in relation to that factor where multiplied, a total weighted score was calculated, which determined the ranking of the market segments. It was determined in collaboration with the company that a final score over 4 would qualify the market segment for the next phase in *The Sustainable Market Model*. Three of the market segments received a score of 4 or higher and was therefore selected for further analysis. The score and the ranking of the market segments can be seen in Table , the final score can be found under the label "Sum Score".

	Sustainable segment growth rate (%)		Sustainable segment size (tons)	
	Rate	Score	Rate	Score
Bioplastics	8	2,4	5	1
Platform chemicals	9	2,7	6	1,2
Biofuels	3	0,9	10	2
Enzymes	3	0,9	3	0,6
Lubricants	3	0,9	1	0,2
Solvents	1	0,3	3	0,6
	Market Growth rate (%)		**Market size (tons)**	
	Rate	Score	Rate	Score
Bioplastics	2	0,1	5	0,25
Platform chemicals	3	0,15	6	0,3
Biofuels	1	0,05	10	0,5
Enzymes	3	0,15	1	0,05
Lubricants	1	0,05	1	0,05
Solvents	1	0,05	1	0,05

	Compatibility current business		Company ambition		SUM SCORE
	Rate	Score	Rate	Score	
Bioplastics	8	2	8	1,2	6,95
Platform chemicals	8	2	8	1,2	7,55
Biofuels	4	1	0	0	4,45
Enzymes	4	1	0	0	2,7
Lubricants	6	1,5	6	0,9	3,6
Solvents	6	1,5	4	0,6	3,1

Table 13: Score for each market segment in relation to each factor. The weighted score is the product of the rate multiplied with the weight, stated in table 8. It can be seen that Bioplastics, Platform Chemicals and Biofuels are the three best performing market segments.

5.2.6 Output of Selection Process of Phase 3

The three best performing market segments of the analysis of phase 3, with a total weighted score over 4 are the following:

- Bioplastics with a weighted score of 6.95
- Platform chemicals with a weighted score of 7,55
- Biofuels with a weighted score of 4,45

These three market segments will continue for further analysis in *The Sustainable Market Model*.

5.3 Selection Process of Phase 4

5.3.1 Introduction

This analysis is based on section 4.4 - "Phase 4 – Product Group Investigation" in the empirical data assessment. The reader therefore recommended to study this section before continuing to the following section in order to obtain an understanding of the analysed material. The reader is also advised to keep the developed theoretical framework in mind, stated in section 3.2 - "The Sustainable Market Model", especially section 3.2.6 -"Phase 4 – Product Group Investigation" and section 3.2.7 -"Selection Process of Phase 4".

The purpose of this selection process is to further analyse the Sustainable Chemistry market segments that where the output of section 5.2- "Selection process of phase 3" on a product group level. The goal is to find the product groups within these market segments that have the highest potential to be a business opportunity for the Company. These products groups will also be further analysed using *The Sustainable Market Model*.

5.3.2 List of factors

As stated in section 3.2.7- "Selection Process of Phase 4" the list of superior factors that each segment will be rated after are the following:

- **Size & Growth**
- **Competitor Involvement**
- **Company Alignment**
- **Technical Performance**
- **Economic**
- **Political & Legal**
- **Environmental & Social**

Each of these superior are divided into subfactors, which also where presented in section 3.2.7- "Selection Process of Phase 4".

5.3.3 Weight

It was decided in collaboration with the Company that the weights should emphasise "Company Alignment", "Technical Performance", "Economic" and "Environmental & Social", and therefore these factors received the highest weight. The weights for the superior factors and subfactors are presented in Table and Table.

Superior Factors	Weight
Size & Growth	0,12
Competitor Involvement	0,1
Company Alignment	0,16
Technical Performance	0,16
Economic	0,17
Political & Legal	0,09
Environmental & Social	0,2

Table 14: Decided weights for superior factors, the sum of the weights equals 1.

Subfactors	Weight
Size & Growth	
Product group growth (%)	0,2
Current market size (tons)	0,4
Nordic product growth	0,2
Nordic market size (production)	0,2
Competitor Involvement	
Status (commercial/ramp-up)	0,3
Number of competitors	0,3
Engaged in the nordic region	0,4
Company Alignment	
Available competence	0,4
Previous reserach in area	0,3
Produce fossil based equivalent or substitute	0,3
Technical Performance	
Drop in or Functional Equvivalent	0,4
Similar performance	0,5
Research status	0,1
Economic	
Price competitiveness	0,6
Predicted cost improvement	0,4
Political & Legal	
Favourable incentives and policies	0,5
Favourable laws	0,5
Environmental & Social	
Sustainability Degree	0,3
WTP	0,3
Public interest	0,3
Collaboration projects	0,1

Table 15: Decided weights for subfactors. The sum for each group of subfactor belonging to a specific superior factor equals 1. The subfactor weights where decided in accordance with the Company.

5.3.4 Rate

The product group could receive a rate from 0-10 in each subfactor, where 10 is the highest score. The subfactors are as mentioned divided into quantitative and qualitative data. To see a summary of the actual numbers from the empiric data, the reader is encouraged to study section 9.2.2 – "Product Group Investigation" in the Appendix.

Quantitative Data Distribution

The rate distribution for the quantitative data was based on the relative size of the product group. The market size for the analysed products was fairly evenly distributed, with the exception of the markets sizes for ethanol (1st gen) and biodiesel (1st gen), which are significantly larger. Ethanol (1st gen) and biodiesel (1st gen) were therefore given the highest rate in the in the "Current market size (tons)" subfactor and was then excluded to provide a more even distribution for the remaining product groups. The remaining product groups' rating limits is stated in table 17. To understand the calculation of the limits stated in table 17, the reader is recommended to study the appendix, section 9.1.2 – "Rate Distribution, phase 4 selection process", figure 34, 35 and 36.

The growth rate was evenly distributed and there was therefore no need to adjust or exclude any product group to get a suitable distribution and the rate-growth limits are stated in table 16. To understand the calculation of the stated limits the reader is recommended to study the appendix, section 9.1.2 – "Rate Distribution, phase 4 selection process", figure 32 and 33.

RATE	GROWTH
10	>53%
9	48%
8	42%
7	37%
6	32%
5	27%
4	21%
3	16%
2	11%
1	5%
0	0%

Table 16: The relation between the rate and growth rate for the product groups.

RATE	SIZE (tons)
10	> 599400
9	539 460
8	479 520
7	419 580
6	359 640
5	299 700
4	239 760
3	179 820
2	119 880
1	59 940
0	-

Table 17: Rate limits related to market volumes for the product groups.

Qualitative Data Distribution

The factors that are not possible to quantify are more subjective and complex to rate. The rate distribution followed different approaches based on the characteristics of the subfactor. The following rating limits where decided in a workshop with technical- and market experts from the Company, see Table 1.

Rate section	RATE
2-step	
Yes	5
No	0
3-Step 1(4)	
Commercial	8
Ramp-up	6
Pilot	4
3-Step 2(4)	
Yes	5
Moderate	3
No	0
3-Step 3(4)	
Few	8
Moderate	6
Multiple	4
3-Step 4(4)	
High	5
Moderate	3
Low	0
4-Step	
High	8
Moderate	6
Low	4
No	0

Table 18: Different rates for qualitative criteria, to see how each rating section is applied, see appendix section 9.2.2 – "Product Group Investigation".

Rating for Product Segments

Based on the analysis conducted in section 5.3.4 - "Rate" the following rates are determined to display each product group's performance in relation to each subfactor, see Table 19. To see the actual numbers, the reader is recommended to study section 9.2.2 – "Product Group Investigation" in the Appendix.

RECIEVED RATE FOR EACH SUB FACTOR	Bio-PET 30	BIO-PE	PLA	Bio-PA	PHA	Biodegradable polyesters	Starch blends	Ethanol (1st gen)
Size & Growth								
Product group growth (%)	10	1	3	2	3	3	1	1
Current market size (tons)	9	3	3	2	1	2	3	10
Nordic product growth	0	3	0	0	0	0	0	1
Nordic market size (production)	0	1	0	0	0	0	0	3
Competitors								
Status (commercial/ramp-up)	8	8	8	8	6	8	8	8
Number of competitors	4	8	4	4	8	4	4	4
Engaged in the Nordic region	0	5	0	0	0	0	0	0
Company Alignment								
Available competence	0	5	5	5	5	5	5	0
Previous reserach in area	0	5	5	0	0	0	0	0
Produce fossil based equivalent or substitute	0	5	3	5	3	5	3	0
Technical Performance								
Drop in or Functional Equivalent	5	5	0	5	0	5	0	0
Similar performance	5	5	3	5	3	5	3	3
Research status	8	4	0	8	8	8	6	0
Economic								
Price competitiveness	6	0	8	0	6	0	0	0
Predicted cost improvement	0	0	0	3	3	3	0	0
Political & Legal								
Favourable incentives and policies	5	0	0	0	0	5	0	5
Favourable laws	0	0	0	0	0	0	0	5
Environmental & Social								
Sustainability Degree	5	5	5	5	5	5	5	5
WTP	5	5	5	5	5	5	5	0
Public interest	8	8	0	0	0	0	0	0
Collaboration projects	5	5	5	0	0	0	0	0

RECIEVED RATE FOR EACH SUB FACTOR	Biodiesel (1st gen)	Cellulosic Ethanol (2nd gen)	Lactic Acid	Succinic Acid	Acetic Acid	Acrylic Acid	1,3 Propanediol	1,4 Butanediol	Lignin
Size & Growth									
Product group growth (%)	1	10	3	8	3	4	2	6	5
Current market size (tons)	10	2	8	1	1	1	2	3	2
Nordic product growth	3	5	0	0	0	0	0	0	3
Nordic market size (production)	6	2	0	0	0	0	0	0	4
Competitors									
Status (commercial/ramp-up)	8	6	8	8	4	6	8	8	4
Number of competitors	4	8	8	4	8	8	8	6	8
Engaged in the Nordic region	0	5	0	0	5	0	0	0	5
Company Alignment									
Available competence	0	0	0	0	0	5	0	0	5
Previous reserach in area	0	0	0	0	0	5	0	0	0
Produce fossil based equivalent or substitute	0	0	0	0	5	5	0	3	5
Technical Performance									
Drop in or Functional Equivalent	5	5	5	5	5	5	5	5	0
Similar performance	5	3	5	5	5	5	5	5	3
Research status	6	8	4	8	4	8	8	8	8
Economic									
Price competitiveness	0	0	0	8	0	0	0	0	0
Predicted cost improvement	0	5	0	5	0	3	5	5	3
Political & Legal									
Favourable incentives and policies	5	5	0	0	0	0	0	0	0
Favourable laws	5	0	0	0	0	0	0	0	0
Environmental & Social									
Sustainability Degree	5	5	0	5	0	0	5	5	5
WTP	0	0	0	0	0	0	0	0	0
Public interest	8	6	0	0	0	0	4	4	6
Collaboration projects	0	5	3	5	0	3	5	5	5

Table 19: The determined rates for the product groups' performance according to each subfactor

Each of the determined rates was multiplied with the corresponding weights for the subfactors, stated in table 15, in order to determine the score for the subfactors. The rate and corresponding score for each product group according to each subfactors is stated in table 20. When summarizing each product group's score for all subfactors belonging to the same superior factor, the total score is obtained, which is also displayed in table 20.

RECIEVED SCORE FOR EACH SUBFACTOR	Bio-PET 30		BIO-PE		PLA		Bio-PA		PHA		Biodegradable polyesters	
	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE
Size & Growth												
Product group growth (%)	10	2	1	0,2	3	0,6	2	0,4	3	0,6	3	0,6
Current market size (tons)	9	3,6	3	1,2	3	1,2	2	0,8	1	0,4	2	0,8
Nordic product growth	0	0	3	0,6	0	0	0	0	0	0	0	0
Nordic market size (production)	0	0	1	0,2	0	0	0	0	0	0	0	0
SUM		5,6		2,2		1,8		1,2		1		1,4
Competitor Involvement												
Status (commercial/ramp-up)	8	2,4	8	2,4	8	2,4	8	2,4	6	1,8	8	2,4
Number of competitors	4	1,2	8	2,4	4	1,2	4	1,2	8	2,4	4	1,2
Engaged in the Nordic region	0	0	5	2	0	0	0	0	0	0	0	0
SUM		3,6		6,8		3,6		3,6		4,2		3,6
Company Alignment												
Available competence	0	0	5	2	5	2	5	2	5	2	5	2
Previous reserach in area	0	0	5	1,5	5	1,5	0	0	0	0	0	0
Produce fossil based equivalent or substitute	0	0	5	1,5	3	0,9	5	1,5	3	0,9	5	1,5
SUM		0		5		4,4		3,5		2,9		3,5
Technical Performance												
Drop in or Functional Equivalent	5	2	5	2	0	0	5	2	0	0	5	2
Similar performance	5	2,5	5	2,5	3	1,5	5	2,5	3	1,5	5	2,5
Research status	8	0,8	4	0,4	0	0	8	0,8	8	0,8	8	0,8
SUM		5,3		4,9		1,5		5,3		2,3		5,3
Economic												
Price competitiveness	6	3,6	0	0	8	4,8	0	0	6	3,6	0	0
Predicted cost improvement	0	0	0	0	0	0	3	1,2	3	1,2	3	1,2
SUM		3,6		0		4,8		1,2		4,8		1,2
Political & Legal												
Favourable incentives and policies	5	2,5	0	0	0	0	0	0	0	0	5	2,5
Favourable laws	0	0	0	0	0	0	0	0	0	0	0	0
SUM		2,5		0		0		0		0		2,5
Environmental & Social												
Sustainability Degree	5	1,5	5	1,5	5	1,5	5	1,5	5	1,5	5	1,5
WTP	5	1,5	5	1,5	5	1,5	5	1,5	5	1,5	5	1,5
Public interest	8	2,4	8	2,4	0	0	0	0	0	0	0	0
Collaboration projects	5	0,5	5	0,5	5	0,5	0	0	0	0	0	0
SUM		5,9		5,9		3,5		3		3		3

RECIEVED SCORE FOR EACH SUBFACTOR	Starch blends		Ethanol (1st gen)		Biodiesel (1st gen)		Cellulosic Ethanol (2nd gen)		Lactic Acid		Succinic Acid	
	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE
Size & Growth												
Product group growth (%)	1	0,2	1	0,2	1	0,2	10	2	3	0,6	8	1,6
Current market size (tons)	3	1,2	10	4	10	4	2	0,8	8	3,2	1	0,4
Nordic product growth	0	0	1	0,2	3	0,6	5	1	0	0	0	0
Nordic market size (production)	0	0	3	0,6	6	1,2	2	0,4	0	0	0	0
SUM		1,4		5		6		4,2		3,8		2
Competitor Involvement												
Status (commercial/ramp-up)	8	2,4	8	2,4	8	2,4	6	1,8	8	2,4	8	2,4
Number of competitors	4	1,2	4	1,2	4	1,2	8	2,4	8	2,4	4	1,2
Engaged in the Nordic region	0	0	0	0	0	0	5	2	0	0	0	0
SUM		3,6		3,6		3,6		6,2		4,8		3,6
Company Alignment												
Available competence	5	2	0	0	0	0	0	0	0	0	0	0
Previous reserach in area	0	0	0	0	0	0	0	0	0	0	0	0
Produce fossil based equivalent or substitute	3	0,9	0	0	0	0	0	0	0	0	0	0
SUM		2,9		0		0		0		0		0
Technical Performance												
Drop in or Functional Equivalent	0	0	0	0	5	2	5	2	5	2	5	2
Similar performance	3	1,5	3	1,5	5	2,5	3	1,5	5	2,5	5	2,5
Research status	6	0,6	0	0	6	0,6	8	0,8	4	0,4	8	0,8
SUM		2,1		1,5		5,1		4,3		4,9		5,3
Economic												
Price competitiveness	0	0	0	0	0	0	0	0	0	0	8	4,8
Predicted cost improvement	0	0	0	0	0	0	5	2	0	0	5	2
SUM		0		0		0		2		0		6,8
Political & Legal												
Favourable incentives and policies	0	0	5	2,5	5	2,5	5	2,5	0	0	0	0
Favourable laws	0	0	5	2,5	5	2,5	0	0	0	0	0	0
SUM		0		5		5		2,5		0		0
Environmental & Social												
Sustainability Degree	5	1,5	5	1,5	5	1,5	5	1,5	0	0	5	1,5
WTP	5	1,5	0	0	0	0	0	0	0	0	0	0
Public interest	0	0	0	0	8	2,4	6	1,8	0	0	0	0
Collaboration projects	0	0	0	0	0	0	5	0,5	3	0,3	5	0,5
SUM		3		1,5		3,9		3,8		0,3		2

RECIEVED SCORE FOR EACH SUBFACTOR	Acetic Acid		Acrylic Acid		1,3 Propanediol		1,4 Butanediol		Lignin	
	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE
Size & Growth										
Product group growth (%)	3	0,6	4	0,8	2	0,4	6	1,2	5	1
Current market size (tons)	1	0,4	1	0,4	2	0,8	3	1,2	2	0,8
Nordic product growth	0	0	0	0	0	0	0	0	3	0,6
Nordic market size (production)	0	0	0	0	0	0	0	0	4	0,8
SUM		1		1,2		1,2		2,4		3,2
Competitor Involvement										
Status (commercial/ramp-up)	4	1,2	6	1,8	8	2,4	8	2,4	4	1,2
Number of competitors	8	2,4	8	2,4	8	2,4	6	1,8	8	2,4
Engaged in the Nordic region	5	2	0	0	0	0	0	0	5	2
SUM		5,6		4,2		4,8		4,2		5,6
Company Alignment										
Available competence	0	0	5	2	0	0	0	0	5	2
Previous reserach in area	0	0	5	1,5	0	0	0	0	0	0
Produce fossil based equivalent or substitute	5	1,5	5	1,5	0	0	3	0,9	5	1,5
SUM		1,5		5		0		0,9		3,5
Technical Performance										
Drop in or Functional Equivalent	5	2	5	2	5	2	5	2	0	0
Similar performance	5	2,5	5	2,5	5	2,5	5	2,5	3	1,5
Research status	4	0,4	8	0,8	8	0,8	8	0,8	8	0,8
SUM		4,9		5,3		5,3		5,3		2,3
Economic										
Price competitiveness	0	0	0	0	0	0	0	0	0	0
Predicted cost improvement	0	0	3	1,2	5	2	5	2	3	1,2
SUM		0		1,2		2		2		1,2
Political & Legal										
Favourable incentives and policies	0	0	0	0	0	0	0	0	0	0
Favourable laws	0	0	0	0	0	0	0	0	0	0
SUM		0		0		0		0		0
Environmental & Social										
Sustainability Degree	0	0	0	0	5	1,5	5	1,5	5	1,5
WTP	0	0	0	0	0	0	0	0	0	0
Public interest	0	0	0	0	4	1,2	4	1,2	6	1,8
Collaboration projects	0	0	3	0,3	5	0,5	5	0,5	5	0,5
SUM		0		0,3		3,2		3,2		3,8

Table 20: Each product group's rate for each subfactor is multiplied with its corresponding weight to obtain the score. When summarizing the product group's score for all subfactors belonging to the same superior factor, the overall score is obtained.

As earlier stated, the summarized score of the subfactors belonging to a specific superior factor becomes the rate for the superior factor in the final weighting scheme. The rate for the superior factors can be seen in table 21.

Rate for the Superior Factors	Bio-PET 30	BIO-PE	PLA	Bio-PA	PHA	Biodegradable polyesters	Starch blends	Ethanol (1st gen)	Biodiesel (1st gen)	Cellulosic Ethanol (2nd gen)	Lactic Acid	Succinic Acid	Acetic Acid	Acrylic Acid	1,3 Propanediol	1,4 Butanediol	Lignin
Size & Growth	5,6	2,2	1,8	1,2	1	1,4	1,4	5	6	4,2	3,8	2	1	1,2	1,2	2,4	3,2
Competitor Involvement	3,6	6,8	3,6	3,6	4,2	3,6	3,6	3,6	3,6	6,2	4,8	3,6	5,6	4,2	4,8	4,2	5,6
Company Alignment	0	5	4,4	3,5	2,9	3,5	2,9	0	0	0	0	0	1,5	5	0	0,9	3,5
Technical Performance	5,3	4,9	1,5	5,3	2,3	5,3	2,1	1,5	5,1	4,3	4,9	5,3	4,9	5,3	5,3	5,3	2,3
Economic	*3,6*	*0*	*4,8*	*1,2*	*4,8*	*1,2*	*0*	*0*	*0*	*2*	*0*	*6,8*	*0*	*1,2*	*2*	*2*	*1,2*
Political & Legal	2,5	0	0	0	0	2,5	0	5	5	2,5	0	0	0	0	0	0	0
Environmental & Social	5,9	5,9	3,5	3	3	3	3	1,5	3,9	3,8	0,3	2	0	0,3	3,6	3,2	3,8

Table 21: Rate for each product group according to the superior factors.

5.3.5 Score

The superior factors were weighted according to the distribution stated in Table and multiplied with each product group's corresponding rate stated in table 21. The final summarized weighted score determined the ranking of the product groups. It was decided in collaboration with the Company that the top three product groups would be selected for the final analysis in phase 5. The entire final ranking can be seen in Table 22.

Superior Factors	Size & Growth		Competitor Involvement		Company Alignment		Technical Performance	
	RATE	SCORE	RATE	SCORE	RATE	SCORE	RATE	SCORE
Bio-PET 30	5,6	0,672	3,6	0,36	0	0	5,3	0,848
BIO-PE	2,2	0,264	6,8	0,68	5	0,8	4,9	0,784
PLA	1,8	0,216	3,6	0,36	4,4	0,704	1,5	0,24
Bio-PA	1,2	0,144	3,6	0,36	3,5	0,56	5,3	0,848
PHA	1	0,12	4,2	0,42	2,9	0,464	2,3	0,368
Biodegradable polyesters	1,4	0,168	3,6	0,36	3,5	0,56	5,3	0,848
Starch blends	1,4	0,168	3,6	0,36	2,9	0,464	2,1	0,336
Ethanol (1st gen)	5	0,6	3,6	0,36	0	0	1,5	0,24
Biodiesel (1st gen)	6	0,72	3,6	0,36	0	0	5,1	0,816
Cellulosic Ethanol (2nd gen)	4,2	0,504	6,2	0,62	0	0	4,3	0,688
Lactic Acid	3,8	0,456	4,8	0,48	0	0	4,9	0,784
Succinic Acid	2	0,24	3,6	0,36	0	0	5,3	0,848
Acetic Acid	1	0,12	5,6	0,56	1,5	0,24	4,9	0,784
Acrylic Acid	1,2	0,144	4,2	0,42	5	0,8	5,3	0,848
1,3 Propanediol	1,2	0,144	4,8	0,48	0	0	5,3	0,848
1,4 Butanediol	2,4	0,288	4,2	0,42	0,9	0,144	5,3	0,848
Lignin	3,2	0,384	5,6	0,56	3,5	0,56	2,3	0,368

Superior Factors	Economic		Political & Legal		Environmental & Social		SUM SCORE
	RATE	SCORE	RATE	SCORE	RATE	SCORE	
Bio-PET 30	3,6	0,612	2,5	0,225	5,9	1,18	3,897
BIO-PE	0	0	0	0	5,9	1,18	3,708
PLA	4,8	0,816	0	0	3,5	0,7	3,036
Bio-PA	1,2	0,204	0	0	3	0,6	2,716
PHA	4,8	0,816	0	0	3	0,6	2,788
Biodegradable polyesters	1,2	0,204	2,5	0,225	3	0,6	2,965
Starch blends	0	0	0	0	3	0,6	1,928
Ethanol (1st gen)	0	0	5	0,45	1,5	0,3	1,95
Biodiesel (1st gen)	0	0	5	0,45	3,9	0,78	3,126
Cellulosic Ethanol (2nd gen)	2	0,34	2,5	0,225	3,8	0,76	3,137
Lactic Acid	0	0	0	0	0,3	0,06	1,78
Succinic Acid	6,8	1,156	0	0	2	0,4	3,004
Acetic Acid	0	0	0	0	0	0	1,704
Acrylic Acid	1,2	0,204	0	0	0,3	0,06	2,476
1,3 Propanediol	2	0,34	0	0	3,2	0,64	2,452
1,4 Butanediol	2	0,34	0	0	3,2	0,64	2,68
Lignin	1,2	0,204	0	0	3,8	0,76	2,836

Table 22: Summary of final score for all product groups. Each rate for each product group is multiplied with the corresponding superior factor weight, displayed in table 14.

5.3.6 Output of Selection Process of Phase 4

The three best performing product groups of the selection process of phase 4 are:

- Bio PET with a weighted score of 3,897
- Bio-PE with a weighted score of 3,708
- Cellulosic Ethanol (2nd gen) with a weighted score of 3,137

These three product groups will continue to the final phase in *The Sustainable Market Model*.

5.4 Business Opportunity Analysis

5.4.1 Introduction

Followed by the Phase 4 in *The Sustainable Market Model* the three best product groups will be analysed in Phase 5. The goal with this final analysis is to investigate and validate the three potential business opportunities that are found within Sustainable Chemistry for the Company. The analysis will be conducted by applying the earlier stated tools: Ansoff´s Matrix, Porter´s Five Forces and the SWOT analysis on the obtained data and earlier findings. The reader is recommended to study each tool in section 3.1.2 - "Ansoff's Matrix, section 3.1.4 - "Porter's Five Forces and section 3.1.6 - "SWOT". The reader is also to recommended to keep the developed theoretical framework in mind, stated in section 3.2 - "The Sustainable Market Model".

The top three product groups will be analysed individually.

5.4.2 Bio-PET – Business Opportunity

Ansoff´s Matrix

Since bio-PET can be seen as a development of an already existing product that would be sold to current customers, bio-PET can be associated with the "Product Development" category according to Ansoff´s Matrix. The market for bio-PET is expected to have a high growth and the production can be compatible with present distribution channels at the Company, which is in favour for developing bio-PET. However, the fact that bio-PET cannot be priced alongside with the conventional PET since it is more expensive to produce today increases the risk for the Company to invest in bio-PET according to Ansoff. Moreover, it is uncertain if the Company will be able to promote the new product in an efficient way, partly because bio-PET to some extent lacks classifications and labels, which further increase the risk.

Porter´s Five Forces

Competitive Rivalry

Bio-PET is currently produced by smaller companies that are not competing on the same level as the Company. However, these companies have already developed a value chain and sell to the large customers demanding bio-PET such as Coca-Cola. The Company therefore need to investigate how these smaller companies operate in order to keep their position on the market.

Threat of new entrants

Since the bio-PET market is expected to have a high growth, one can determine that there exists an interest from competitors on the market to grasp this business opportunity. If the competitors also have experience of the plastic market, there exists a developed production process and supply chain that will reduce the investment cost and barrier for new entrants on the market. There exist no known switching cost for the customers to change supplier and no known production patens on the market. These competitors may be large chemical companies and may have similar competitive advantages as the Company.

Threat of substitutes

Bio-PET will always compete with the conventional PET alternative, and it is easy for the customers to switch between the two. The relative price is also in favour for conventional PET and Bio-PET can also be substituted by other bio-based alternatives. However, the fact that bio-PET is a drop-in product is favourable.

Bargaining power of buyers

There is a large supply of plastic on the overall market and the buyer is in a power position. As previously mentioned, there is no switching cost associated with changing supplier, which works in favour for the buyer.

Bargaining power of suppliers

There exist several supplies on the market and there is no cost associated in switching supplier, which stands in favour for the Company. There are no known patents in place and there exist several alternatives for the buyer on the market.

The sixth factor: Government

Government has a large impact on the attractiveness for the specific market. As earlier stated, the toll system and market regulations in Europe make it difficult to use sugar as feedstock for production of bio-PET. However, even though there is a focus on using the forestry feedstock for producing bio-PE in the Nordic region, if the project is successful it is possible use the same feedstock for producing bio-PET.

Even though there does not exist any clear regulations or policies today, there exists an governmental ambition e.g. the goal that all material and chemical products produced in Europe should be 20% bio-based by 2020. Statements as this revile that the sustainability factor is seen as important and will probably have a larger momentum in the future.

5.4.2.1 SWOT

Strengths

One of the major strengths with bio-PET is the drop-in classification leading to that the product easily can be introduced in current production processes and value streams, e.g. recycled bio-PET can be recycled along with conventional PET. As earlier mentioned, the Company has been involved in the plastic market for a considerable time and have great knowledge and competence within market.

Weaknesses
A considerable weakness with bio-PET is that the Company is currently not producing the conventional PET, leading to that an entirely new business unit needs to be built up, with new customer and production units. As for bio-PE, a weakness is also the internal business culture at the Company might prevent a movement into the bio-PET market.

Opportunities
Bio-PET is experiencing an extensive market growth, with a large increase in demand. The large volume proves that there is a market pull and a market attractiveness for bio-PET. Several large market leaders have stated their ambition to use bio-PET in their products, such as Coca-Cola. The plant-bottle incentive initiated by Coca-Cola have created a market attention and spread throughout the industry, leading to that companies further up the value chain adapt to provide more sustainable alternatives and other companies such as P&G, Pepsi and have made similar sustainable statements. The large momentum that bio-PET is experiencing can also be explained by the closeness to the end-consumer, and there exists a willingness to pay for the product. Since bio-PET is especially used as for packaging, the increased cost for having a sustainable packaging is only a small increase when looking at the product cost as a whole.

The fact that the bio-PET currently only contains 30% bio-based material can also be seen as an opportunity, since it makes the product not as affected by crude oil prices, e.g. a low oil price lowers the cost to produce the remaining 70% of the product.

Threats
There is lack of presence on the Nordic market, both in terms of producers and in customers, where especially the latter is a considerable threat. Since sugar is the most common used feedstock for the bio-PET production, the toll policies and market regulations in the EU will make it difficult to import sugar to a cost competitive price. As for bio-PE, the absence of classification and labels could also affect the bio-PET production in a negative way.

A summary of the SWOT analysis is displayed in Figure 21.

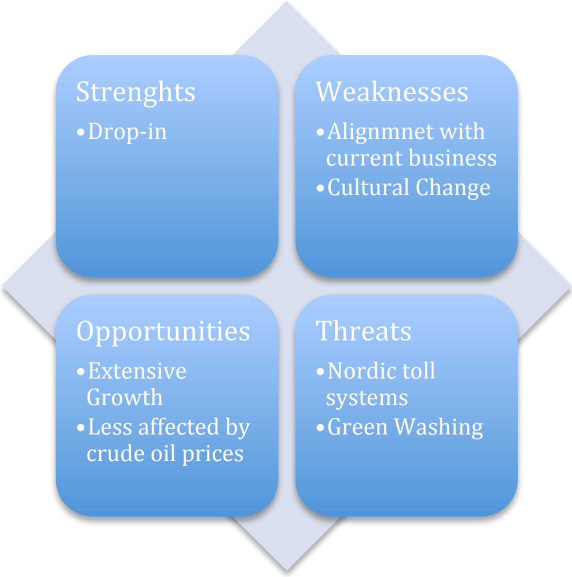

Figure 21: Summary of SWOT analysis for bio-PET

5.4.3 Bio-PE – Business Opportunity

Ansoff´s Matrix

Since bio-PE can be seen as a development of an already existing product that would be sold to current customers, bio-PE falls under the "Product Development" category according to Ansoff. Bio-PE is compatible with current distribution channels and complementary to current products, especially since the Company is producing conventional PE. The market is also expected to grow, even though to a moderate extent. However, bio-PE cannot be priced alongside conventional PE and it is uncertain if the promotion of bio-PE will be simple due to the lack of classifications and labels.

Porter´s Five Forces

Competitive Rivalry

There are a few competitors to the Company involved in the bio-PE market, where one major chemical company can be seen as the by far largest competitor. They are similar to the Company in terms of both size and strategy, and this competing company is supplying a majority of the global bio-PE volume today. An entry on the market would probably result in a high rivalry on the market, where the competing company would try to protect its market share.

Threat of new entrants

There are several competitors that are supplying conventional PE. Since they have similar expertise and developed supply chain as the Company, they have the same preconditions to broaden their product portfolio by offering bio-PE.

Threat of substitutes

Bio-PE will always compete with conventional PE. When the crude oil price is as low as it is today, it is difficult for bio-PE to be price competitive. For some applications, it is possible to substitute bio-PE with other bio-based materials such as PLA. However, bio-PE still has the advantage of being a drop-in product compared to PLA and therefore the threat of substitution from PLA would be rather small. There does not really exist any brand loyalty on the market or a switching cost, which increase the threat of substitutes.

Bargaining power of buyers

There is a large supply of plastic on the overall market and the buyer is in a power position. As previously mentioned, there is no switching cost associated with changing supplier which works in favour for the buyer.

Bargaining power of suppliers

There exist several supplies on the market and there is no cost associated in switching supplier, which stands in favour for the Company. There are no patents in place and there exist several alternatives for the buyer on the market

The sixth factor: Government

Governments have a large impact on the attractiveness for the specific market. As earlier stated, the toll systems and market regulations in Europe make it difficult to use sugar as feedstock for production of bio-PE. However, this can provide an opportunity for alternative feedstock derived from the forestry industry in the Nordic region.

Even though there does not exist any clear regulations or policies today, there exists an governmental ambition e.g. the goal that all material and chemical products produced in Europe should be 20% bio-based by 2020. Statements as this reveal that the sustainability factor is seen as important and will probably have a larger momentum in the future.

SWOT

Strengths

One of the considered largest strengths with Bio-PE is that the product group is closely linked to the Company´s current business. The Company is a large producer of conventional PE and it is considered to be one of their most important products within the Company´s plastic product portfolio. The Company has a long experience of producing the material and have an established supply chain with production routes and customers. The fact that bio-PE is defined as a drop-in material is also one of the product groups strengths, since a conversion to bio-PE would not affect the current use or involve any change for the customer, instead the product can be adopted easily.

Weaknesses

A weakness with bio-PE is that the possibility of producing the product have already been investigated and decided as a non-attractive business investment, there can exist a redundancy in the Company to re-evaluate the possibility. As previously mentioned, the Company´s strategy focus is large-scale production, which might not be consistent with investing in a smaller production segment such as for bio-PE. For the product group to be accepted there has to be a change in the Company's business culture, which can be be very difficult.

Opportunity

Bio-PE is expected to grow in volume, implying a business opportunity for the Company. There is also an interest in the Nordic region, where major potential bio-PE customers – such as Tetra Pak, are investigating the possibility to use bio-PE derived from cellulosic feedstock in their products. The trend is considerable in the Nordic region and the fact that market leaders are investigating bio-PE can reflect in an international trend. The potential of using the Nordic regions forestry feedstock is also an opportunity since that there is a high demand of bio-based plastics in Europe, but the current toll system and market regulations are making it difficult to produce bio-PE from the most common used bio-based feedstock i.e. sugar. By producing from forestry feedstock, the food versus fuel debate is also avoided.

Threat

As for the entire bio-based chemical market, the crude oil price has a high impact on the price competiveness for the sustainable products. A low crude oil price and availability of shale gas is proving it difficult for products based on an alternative feedstock to be cost competitive. Another threat is the absence of regulations and classifications. As previously stated, it is of greatest importance that the sustainability factor is visible to the end-consumer and that the information is easy to take in. The absence of labels can provide an opportunity for "green washing" i.e. stating sustainability attributes to a product without any real substance, leading to that the term sustainability could be associated with a negative and unserious recognition. In this hypothetical scenario, the willingness to pay for sustainable attributes would most likely decline.

Another threat related to the opportunity to derive bio-PE from a cellulosic feedstock is that the technology is in its early stages and it is uncertain if the feedstock can be cost-competitive with conventional bio feedstock.

A summary of the SWOT analysis is displayed in Figure 22.

Figure 22: Summary of SWOT analysis regarding bio-PE

5.4.4 Cellulosic Ethanol – Business Opportunity

Ansoff´s Matrix

Since cellulosic ethanol is a new product for the Company that would be supplied to a new market, cellulosic ethanol falls under the category "product diversification" according to Ansoff. Since there is a possibility to integrate the production of cellulosic ethanol, and especially the side-streams, in the Company's current core-business the opportunity is defined as a related diversification. If the Company were to produce cellulosic ethanol, economics of scale could be achieved and the Company could use their advance knowledge in large-scale production.

Since cellulosic ethanol is in its early stages, it is uncertain if an investment would be valuable or not and there might be that the technique for producing cellulosic ethanol is so different from other large-scale production so the potential similarities are non-existent.

5.4.4.1 Porter´s Five Forces

Competitive Rivalry

The global fuel market consists of a rather small group of companies that supply a large share of the total market volume. When focusing on cellulosic ethanol, there exist only a few competitors that are investigating/producing the product. These competitors have similar size as the Company and have similar strategies and market intentions.

Threat of new entrants

Since cellulosic ethanol is a rather new product on the market and is a complicated feedstock to refine there is a need of special technical competence to produce the product, which creates a barrier for new entrants. The production is also associated with high investments cost and there is a need to create new distributions channels between the forestry companies and the refinery.

Threat of substitutes

Cellulosic ethanol can be substituted with several other fuels on the market, whereas conventional gasoline and diesel are the most commonly used today. When focusing on biofuels, bioethanol derived from sugar is the most commonly used and is currently more cost competitive compare to cellulosic ethanol. As earlier mentioned there is a need for the end-consumer to invest in a vehicle with a engine that can run entirely on bioethanol which implies that there is a switching cost associated with using bioethanol.

Bargaining power of buyers

If one sees the end consumers as the buyer, there exist a large number of buyers which all purchase a low volume of fuel. The bulk of the produced bioethanol today is mixed with conventional gasoline and the buyer has very little power to deselect the bioethanol. If one sees the fuel companies as the buyer, the opposite bargaining power exists, where there are a limited number of buyers, which purchase large volumes. These customers are very important to the supplier and loosing one of those costumers will have a large impact on the company in question.

Bargaining power of suppliers

There exist a limited number of suppliers on the forestry market and they have a large power over supply. However, since the pulp- and paper industry is experiencing a decline in their market demand, they are pushing for another use of their feedstock e.g. ethanol and chemical products.

The sixth factor: Government

Governmental policies have a high influence on the market. There exist several goals to 2020 that are favouring biofuels, and promoting second-generation biofuels. There is an uncertainty on the market since these goals are not be renewed after 2020, but as earlier mentioned, there exist an political ambition where sustainability is highly valued which will probably influence the market even more in the future.

SWOT

Strengths

A strength with Cellulosic Ethanol is that the Company could both be involved in the production of the biofuel as well as using the side-streams that occurs in the production process and integrate these in their existing production. These side-streams could provide a great feedstock for producing sustainable speciality chemicals.

Weaknesses

A considerable weakness with Cellulosic Ethanol is that the Company is currently not producing any type of fuel and extensive investments are needed to gain the competence needed to enter this completely new business area.

Opportunities

Cellulosic Ethanol has high growth expectancy and is anticipated to play a significant role on the biofuels market. Both volume and value of the market are seen as very attractive. The use of the Nordic feedstock provides a great opportunity to make use of an available feedstock an increase the presence in northern Europe. Another opportunity is the presence of laws and regulations that works in favour for second-generation feedstock and the EU policies that subsides biofuels.

Threats

As previously mentioned, there is an absence of long-term governmental policies and it is uncertain if biofuels will have the same subsides as it has today. If these policies where not to be renewed, cellulosic ethanol will be very affected by the current crude oil prices. The production of cellulosic ethanol is in its early stages and it is uncertain if the production can be cost-competitive with conventional fuels.

A summary of the SWOT analysis can be seen in Figure 23.

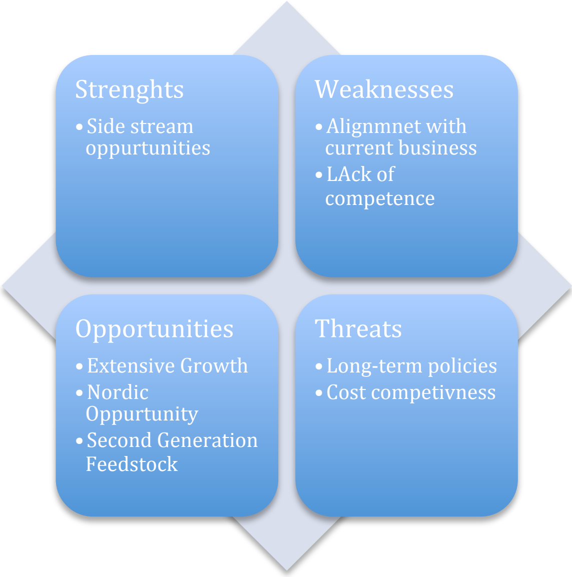

Figure 23: Summary of SWOT analysis regarding cellulosic ethanol.

6 Conclusions and Recommendations

The primary purpose of this thesis is, as described in "Chapter 1 – Introduction", to create a theoretical framework: The Sustainable Market Model - that emphasizes sustainability when mapping and evaluating a market and looking for business opportunities for a company. The secondary purpose is to perform a market mapping regarding Sustainable Chemistry. The results were to be used in finding business opportunities for the Company. This chapter will present the conclusions and recommendations for this thesis regarding these purposes.

6.1 The Sustainable Market Model

The primary purpose of the master thesis is to create a theoretical framework – *The Sustainable Market Model,* which emphasise sustainability. The conclusion of the created framework will be presented below.

6.1.1 Phase 1 & 2 – Define Sustainability and Define Macro Market

These first phases are of utter importance since they lay the foundation for the successive investigation and evaluation. In order to find a potential business opportunity it is of greatest importance to define what sustainability is and which characteristics of features that are valuable for the end consumer. The definition should be founded in well-stated known general theory, such as the triple bottom line and also be consistent with the specific business industry, such as the Green Chemistry principles for this particular case. If the model were to be used by a company operative in another industry, the definition should be revised to reflect on the most important factors concerning that industry. The general market data, regarding e.g. governmental policies and trends, gives important input of which enablers and barriers that exist on the market. This knowledge is important and will affect the future mapping and evaluation.

6.1.2 Selection Process of Phase 1 & 2

The goal with the first selection process is to narrow down the found market segments, where the ones with largest development trends while providing some connection to the current business of the Company is chosen. The selection is subjective and the user should carefully consider the decision to avoid biases.

6.1.3 Phase 3 – Market Segment Investigation

By investigating the different market segments from the "Size & Growth" and "Company Alignment" perspective, a broad view over the market segments are received. This information of the market is necessary and fundamental for determining the attractiveness of the market segments. The stated factors are general and able to be used independent of business industry. The weights used has not been analysed from a sensitivity perspective, meaning that there has not been investigated how a different selection of weights would affect the final result. The model would have benefitted from such a analysis since it would have provided the model with more validility.

6.1.4 Selection Process of Phase 3

To use a weighted ranking process is a simple and effective way to determine the market attractiveness for the market segments. The used factors gives a broad view over the business opportunity potential and are seen as necessary and fundamental. One should note that the rating process and weight is highly subjective, and this should be taken into account to avoid biases. Since the authors to this thesis are external to the Company and the purpose with the master thesis was to investigate a new market, biases were reduced and avoided.

6.1.5 Phase 4 – Product Group Investigation

The fourth phase of *The Sustainable Market Model* provides the user with a systematic way to structure the collected data. The different factors that the modified PESTEL and GE Mckinsey Matrix provides, make it possible to achieve the in-depth information level of the different product groups that are necessary to determine the business opportunity potential of the product groups. By collecting data both regarding the current- and future state in every investigation factor, a more valid view can be received of the business opportunity potential of the product groups. The stated perspective the factors provide are general and able to be used for companies engaged in other business industries.

6.1.6 Selection Process of Phase 4

To use a weighted ranking process is a simple and effective way to determine the market and business opportunity potential for the product groups. The used factors gives an in-depth view over each product groups performance and displays their business opportunity potential. This weighted ranking process is therefore seen as necessary and fundamental. By using a double weighting scheme, first for the relatively importance of the sub-factors and secondly for the superior factors, provides the user with a more accurate result and make it possible to understand the importance of all the ingoing factors. One should note that the rating process and weight process is subjective, and this should be taken into account to avoid biases. Since the authors to this thesis are external to the Company and the purpose with the master thesis was to investigate a new market, biases were reduced and avoided. As previously mentioned, no sensitivity analysis was performed to investigate the implication of a different weight distribution would have on the final result. Such as analysis would have been beneficial to the model.

6.1.7 Phase 5 – Business Opportunity Analysis

Using known methods such as SWOT, Ansoff and Five Forces is an effective way to analyse gathered material and put it in relation to each other and provides the investigation with a qualitative analysis that complements the weighting scheme used in the previously selection phases. The used methods in phase 5 are also common in the industry and therefore easy to communicate and connect to a company's strategy. The usage of the methods in phase 5 is therefore concluded to be effective.

6.1.8 Recommendation

The Sustainable Market Model is recommended to be used when a company or organization is mapping a market and investigating and evaluating potential business opportunities where sustainability is to be emphasised. The model is especially effective when exploring a new market or new segment and the company or organization wants to investigate it as a whole to be able to understand it.

It is difficult to determine the validity of the model since it is impossible to perform a long-term investigation, where the recommendations provided by using the Sustainable Market Model could have been studied to ensure the accuracy of the model. However, since the Sustainable Market Model has been used in the case study, a face validity have been performed meaning that the model is subjectively viewed as fulfilling its purpose.

6.2 Mapping the Sustainable Chemistry market and finding Business Opportunities for the Company

Sustainable Chemistry is defined as chemical materials and products that are recyclable, bio-based, biodegradable and/or have a low toxicity. When examining the defined market, it can be concluded that SC is a growing market trend, even though still small in comparison with the current chemical industry. In order to find a viable sustainable business opportunity, some preconditions needs to be fulfilled. First, a sustainable product must have similar or improved performance compared to the conventional alternative. Secondly, the sustainability factors should be visible and close to the end consumer to make a willingness to pay occur. Due to the current market situation, where crude oil price is low and have a high availability, it is difficult for Sustainable Chemistry products to compete on the market from a price perspective. Governmental policies and regulations will therefore have a large impact on the economically feasibility for sustainable chemistry products.

Following the developed structure and methodology of *The Sustainable Market Model*, six product segments were selected to potentially contain business opportunities for the Company. Among these segments, three segments where decided to be more attractive and within these, three product groups where decided to have the highest attractiveness namely: Bio-PET, Bio-PE and Cellulosic Ethanol.

These three product groups have different strengths and weaknesses and there is no product group that has a clear advantage compared to the others. Bio-PET and Bio-PE has the advantage that they are classified as a "Product Development" growth strategy in the Ansoff´s Matrix. The advantage can be related to the fact that there is less risk associated with this type of growth compared to "Differentiation" i.e. Cellulosic Ethanol. Since the market for Cellulosic Ethanol is in its early stages, the risk is even greater due to the fact that the Company would need to invest in technology and resources for an undeveloped market.

Bio-PET and Bio-PE are similar in terms of the influence of the competitive landscape, as described using the Porter´s Five Forces. There exist several competitors that are similar to the Company, in terms of size and strategic market interest. Since there is no known patents or other technical restrictions for entering the market it is easy for competitors to enter the market. In this case, Bio-PE is seen as superior due to the connection to the Company´s core competences and the fact that the Company is a large producer of conventional PE, which is also one of the key take away from the SWOT-analysis. To conclude, Bio-PE can be seen as superior compared to the other product groups, due to the following reasons:

- There is a clear connection to the Company's current business
- There exists knowledge and a developed supply chain within the Company
- There is a clear connection to the Nordic region and potential to use a alternative feedstock
- There exists a customer demand which is predicted to increase
- Final product is close to end consumer and cost can be transferred to the consumer
- It is easy and convenient for the customer to adapt to the new product

As previously mentioned, the Company´s strategy focus on high growth, and therefore a resistance to more uncertain product areas can occur. To produce bio-PE is a relatively small step from the current core competence and is therefore predicted to face less resistance than the other product groups.

6.2.1 Recommendation

The Company is recommended to involve themselves in the Sustainable Chemistry market, since it is a growing market, which can help the Company position themselves better related to their competitors. The Company is also recommended to further investigate bio-PE. The Company should investigate the possibility to create a joint venture with the forestry industry in the Nordic and/or a large close-to-consumer company that can use bio-PE in e.g. their packaging. It should also be investigate how the production should be implemented and the value chain developed.

The Company is also recommended to investigate the chemical side streams of value added products that will be possible to produce when using a bio-based feedstock derived from e.g. forestry. These side streams will help increase the margins for the Sustainable Chemistry products, where bio-PE can be a bulk product.

7 Discussion

This section will display of the authors' thoughts and reflections that have occurred throughout the performed master thesis. This section will also provide areas that are suggested for future research.

7.1 Critical Issues and insights regarding Sustainable Chemistry

After several performed interviews with key persons from the Company, both from the technical- and market- side, a rather pessimistic impression of sustainability and bio-based materials was not uncommon among the interviewees. Several people argued that it is more important to have a system thinking approach towards sustainability than to priorities the origin of the feedstock. Meaning that there is a general view that the Company can contribute more and have a larger positive sustainability impact by making their processes more effective, using less water and energy, and contributing to resource effectiveness for other businesses. An example is that the chemical industry stands for a small percentage of the total volume crude oil that are consumed, but this consumption can makes other, larger industries such as transportation and energy, more efficient by providing better products. E.g. insulation is made by the chemical industry and mostly derives from fossil sources, but this insulation makes the energy and heating industry more efficient and therefore consumes less fossil derived-feedstock in total.

On the other hand, others at the Company stated that the pessimistic view towards bio-based materials is founded in an unwillingness to change, since the Company and the chemical industry has a more or less infinite supply of fossil based feedstock. One can state there are currently no right or wrong way when defining sustainability and how the largest positive impact will be received, however, the authors believe that bio-based materials will have an impact on the future market and that the fact that competitors to the Company are investigating and investing in the area should be taken as an important sign. Which approach that would result in a greater positive environmental impact is left for future research.

The possibility and need of using side-streams when using a bio based feedstock to produce e.g. bio-fuels or chemicals is an argument that have been used in favour of Sustainable Chemistry by several stakeholder. A possible risk with relying on several processes and products to be connected to each other is that you create a system that is fragile and sensitive. The more products and interests that are involved in the same value chain the greater impact if one where, by example, experiencing a decrease in demand. The impact and possibility for this scenario could affect the stated business opportunities and is suggested for future research.

To conclude, the authors firmly believe that the Sustainable Chemistry market will grow and new value chains will be developed. There is a market pull towards sustainability and companies close to consumers are already experiencing this. As this market pull develops, it will affect the chemistry industry and force it to adapt and chemical companies that aren't ready for this, will loose market shares. The authors believe that in the future, chemical companies will not compete only with technical and economic attributes, they will compete with social and environmental attributes as well.

7.2 The Importance of Collaboration

After scanning and analysing the general market and the competitors, it was discovered that in most situations where a sustainable product was either investigated or released on the market, a joint venture or collaboration in some form was behind the product. It exists several reasons for creating a joint venture, such as shared investment cost, shared risk and joined forces in marketing and with expert competence. The competitors to the Company have both created collaborations with each other and with smaller, innovative companies. To actively search for innovative companies and potential business partners within Sustainable Chemistry is therefore stated as important to be competitive on this market and how these collaborations can be made is an area that should be further investigated.

7.3 Will Sustainable Chemistry Ever Be Cost Competitive?

The cost competiveness of Sustainable Chemistry is a factor that has been mentioned several times throughout the master thesis and is an important factor for any business to invest in a new product development/market. As earlier mentioned, the crude oil prices have decreased severely for the past years, mainly due to the increased availability of shale gas that changed the competitive market for energy and fuels. These macro affects on the market makes it difficult for any other feedstock to be cost competitive. The crude oil is not however an infinite resource and as availability declines, the price will increase, which will lead to that other feedstock will yet again get more attention on the market. Until that occurs, the future of Sustainable Chemistry is highly dependent on legislations and governmental policies. As previously mentioned, there exist an ambition by e.g. the European Commission to focus on sustainability but a lack of knowledge of how to define sustainability and resistance from other industries, which will be negatively affected by a change, is slowing down the development. It is reasonable that new policies and laws should be well anchored in theory and have a holistic view. They should also be put in context and aligned with the climate changes we are experiencing right now, and its is arguable if these governmental influences should be working faster to make a change, or slower to find the perfect solution.

It is also important to state that the fossil derived industries have a considerable know-how and experience in comparison with this new bio-based industry. The more this new bio-based industry evolves and develops, the more cost competitive it may be.

7.4 Improvement areas for The Sustainable Market Model

The authors realised under the process that a life cycle analysis (LCA) would have been appropriate to add to the investigation of the different product groups. However, even if the realisation would have occurred in an earlier stage, the integration of an LCA might have been impossible due to the lack of chemical expertise. The absence of knowledge of basic chemistry was a delimiting factor throughout the master thesis, and it would have been of interest to integrate a more chemicals expertise knowledge from the beginning.

It is the authors' viewpoint that *The Sustainable Market Model* can be applied in other market segments and industries and therefore will contribute to academia. However, since the model was developed in collaboration with a large, global company one should investigate the applicability with smaller, more local companies and organizations. As earlier mentioned, the definition of sustainability should also be redefined and costumed to the business or market in question. It is also recommended for future research to analyse the used factors and weights to find improvement areas that might result in an even better result.

As seen in the final score in section 5.3.5 – "Score", there were several product groups that had a final score very close to the three superior alternatives. Due to the limited timeframe for the master thesis, it was impossible to evaluate these alternatives as well in phase 5. Therefore, it is also recommended for future research to evaluate these product groups as well. Furthermore, several market where excluded early in the process to be able to achieve a conclusion and a result. These markets may contain business opportunities on a product group level, and if the time frame or investigation capacity is increased, these areas should be further investigated.

As previously mentioned, no analysis has been made regarding the sensitivity of the given weights and how different distribution weight would affect the final result. It is therefore recommended for future research or for potential users of the model to perform such an analysis.

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8.1 Conducted Interviews

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9 Appendix

9.1 Calculation of rate distribution

9.1.1 Rate Distribution, Selection Process of Phase 3

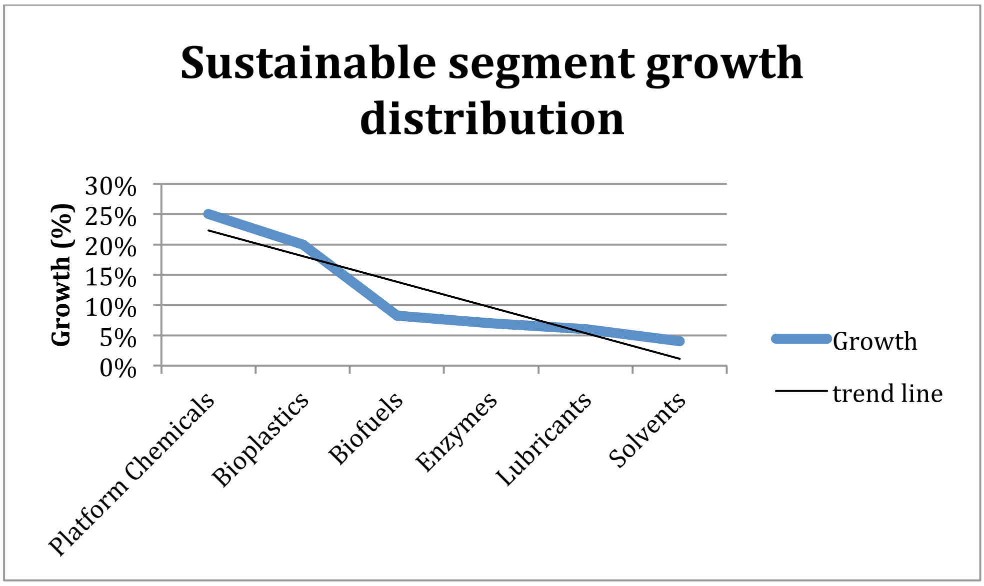

Figure 24: A high growth results in a high rate. This chart displays how the growths for the sustainable segment are distributed. The trend line is used to decide how the rating limits should be distributed.

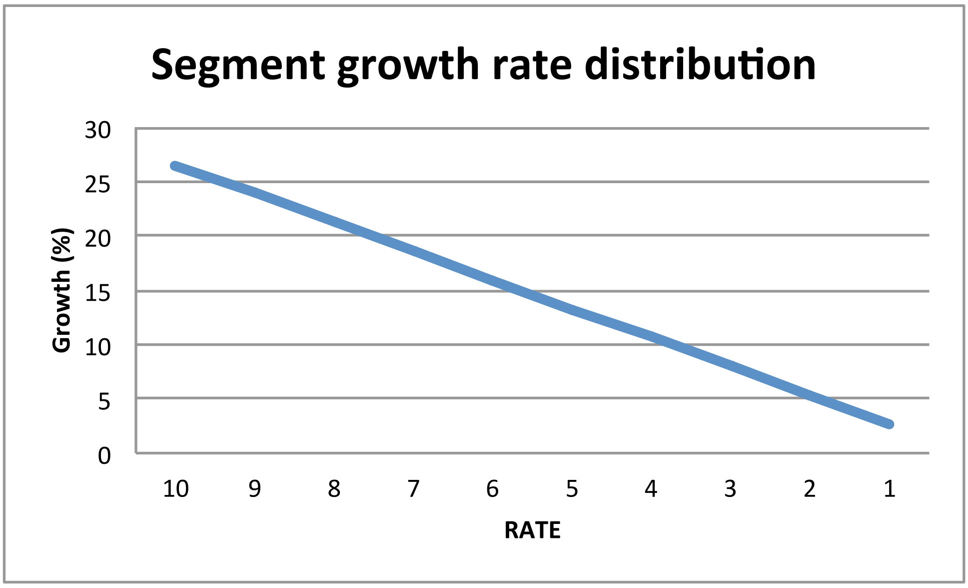

Figure 25: Displays how the ratings are distributed in relation to the factor Segment Growth rate. Both for the sustainable segment and the overall market.

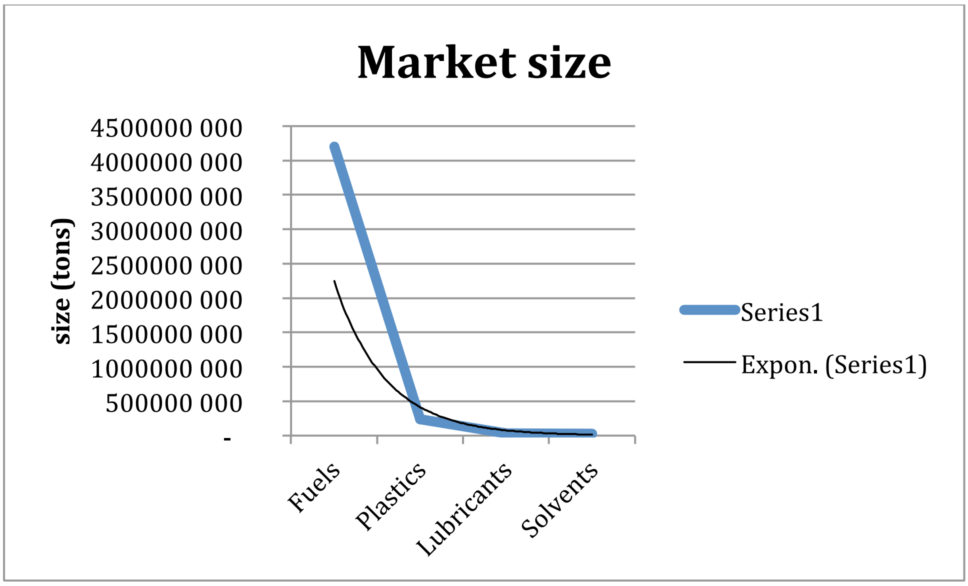

Figure 26: Market size in tons for investigated market segments. Fuels is by far the largest market in terms of volume and will therefore be given the highest rate. The trend line is exponential to get a more even distribution.

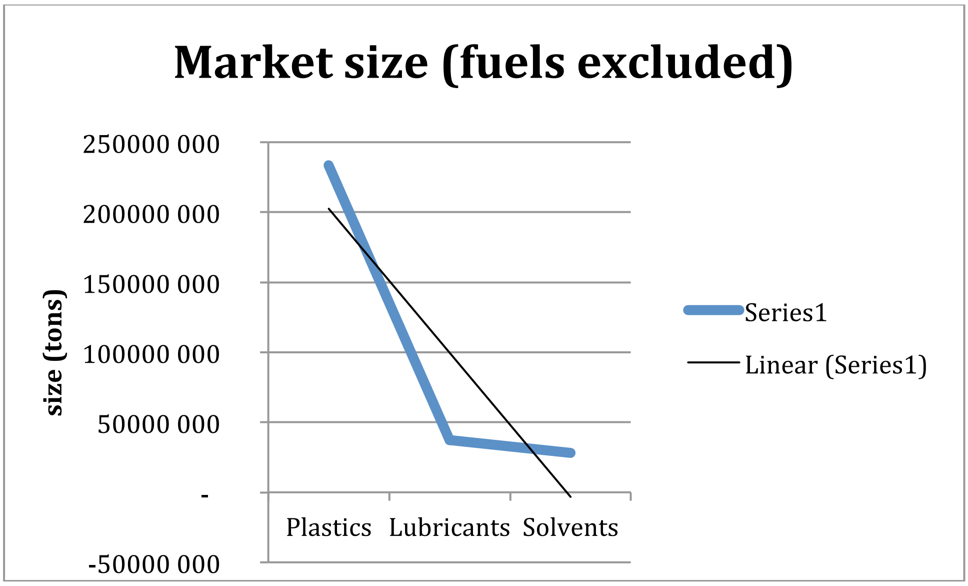

Figure 27: Market size when fuels are excluded. This chart is the foundation for the rating limits for all market segments except fuels

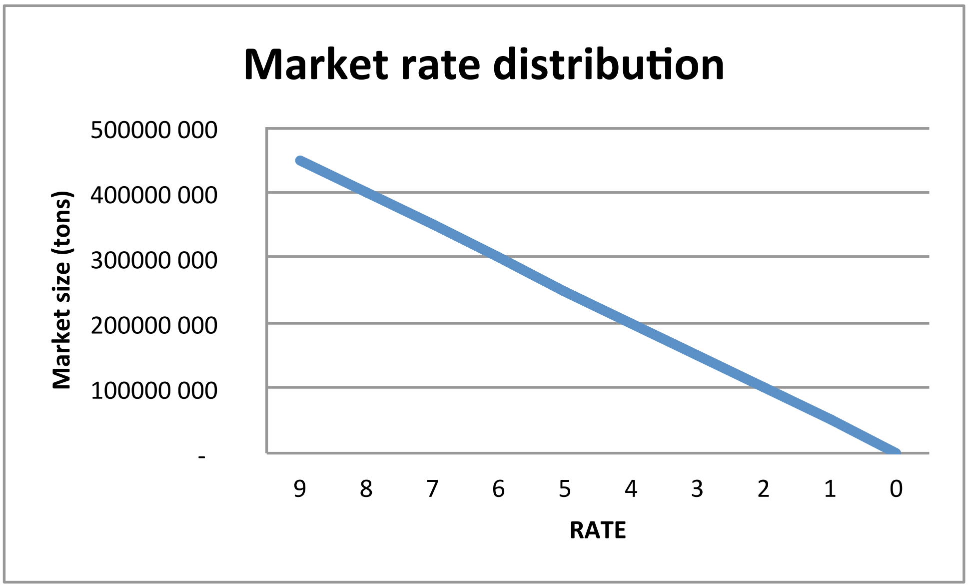

Figure 28: Fuels are excluded, this chart displays the rating distribution for the remaining market segments.

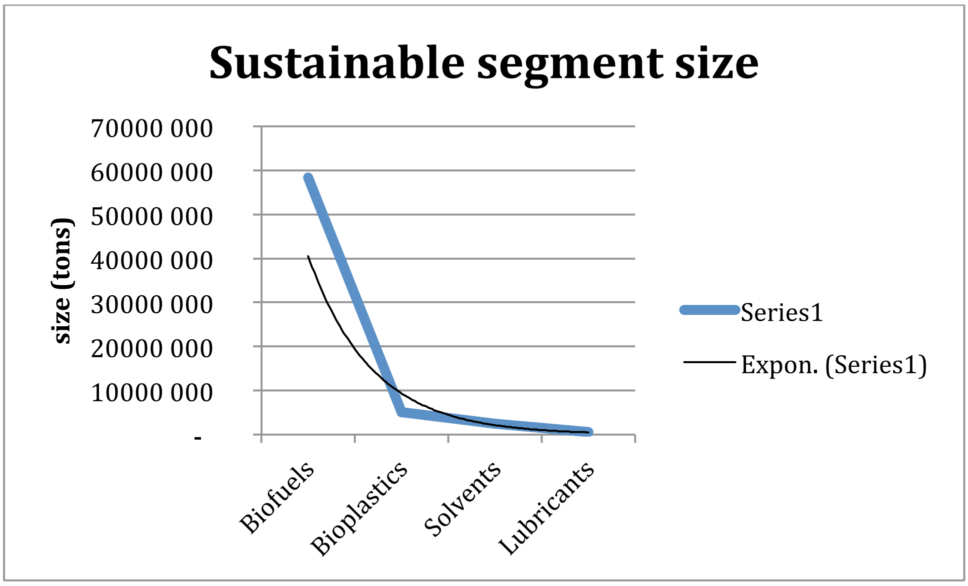

Figure 29: Sustainable segment size, biofuels is by far the largest market in terms of volume and is therefore given highest rate.

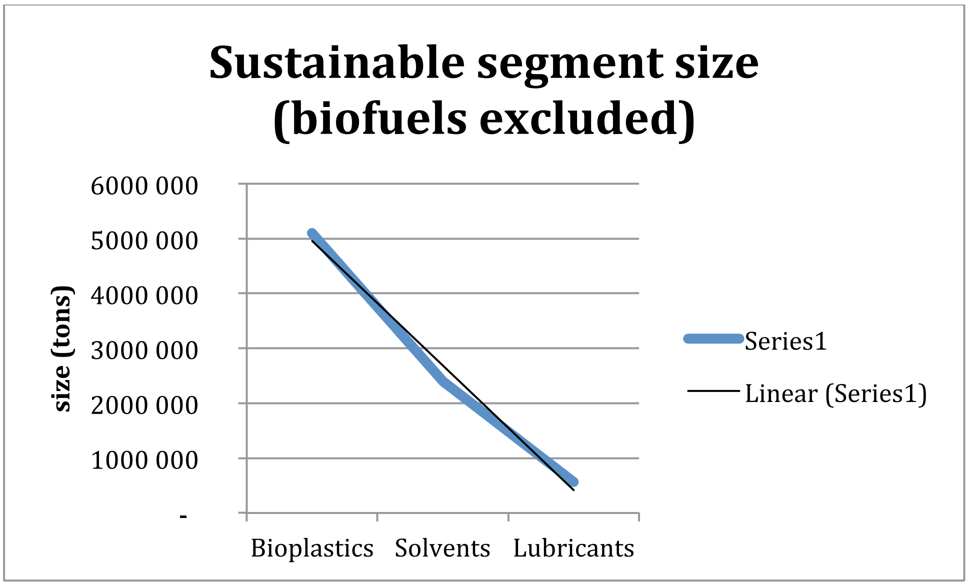

Figure 30: Sustainable segment size when biofuels is excluded. This chart is the foundation for the rating limits for the remaining market segments.

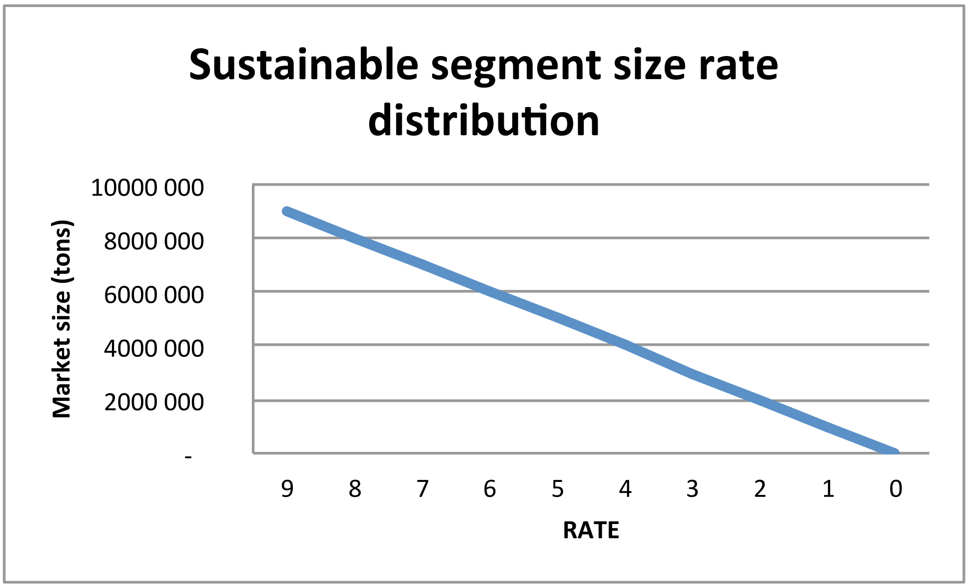

Figure 31: Rating distribution for the market segments. The rate is related to the volumes for each segment.

9.1.2 Rate Distribution. Selection Process of Phase 4

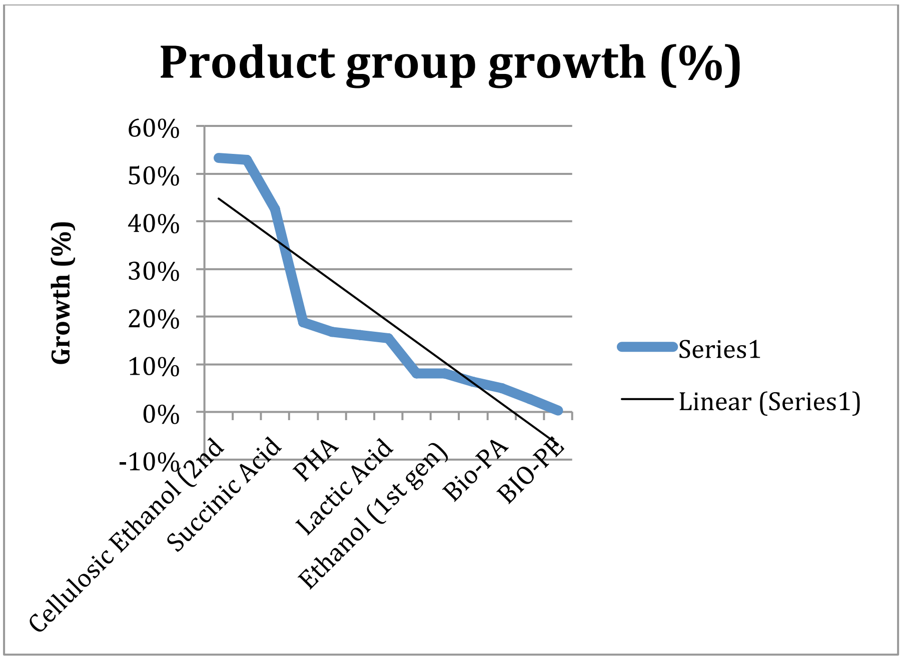

Figure 32: Product group growth for different product groups. The Trend line is used to determine the rating limits.

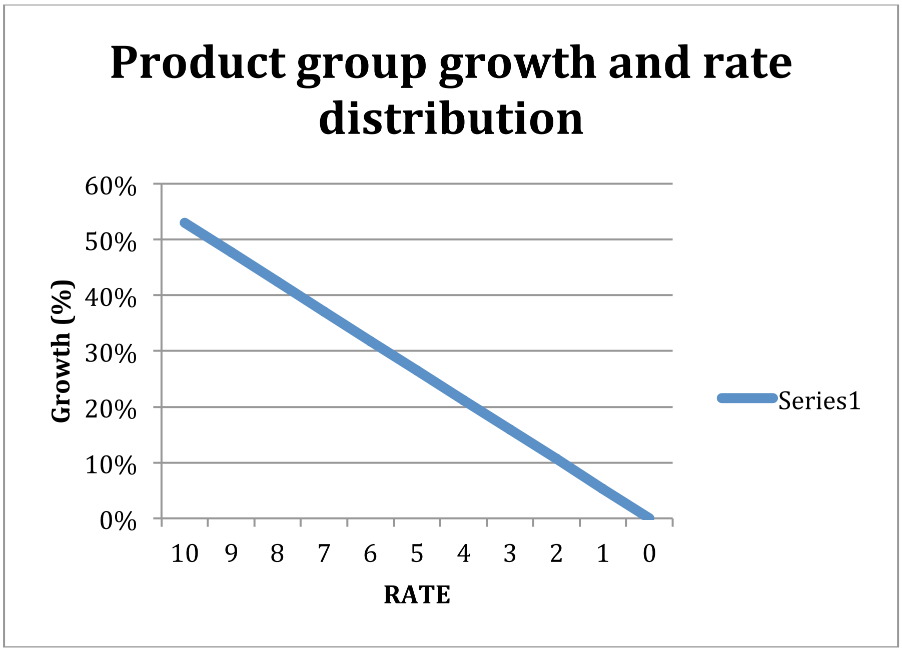

Figure 33: Product group rate distribution in relation to growth.

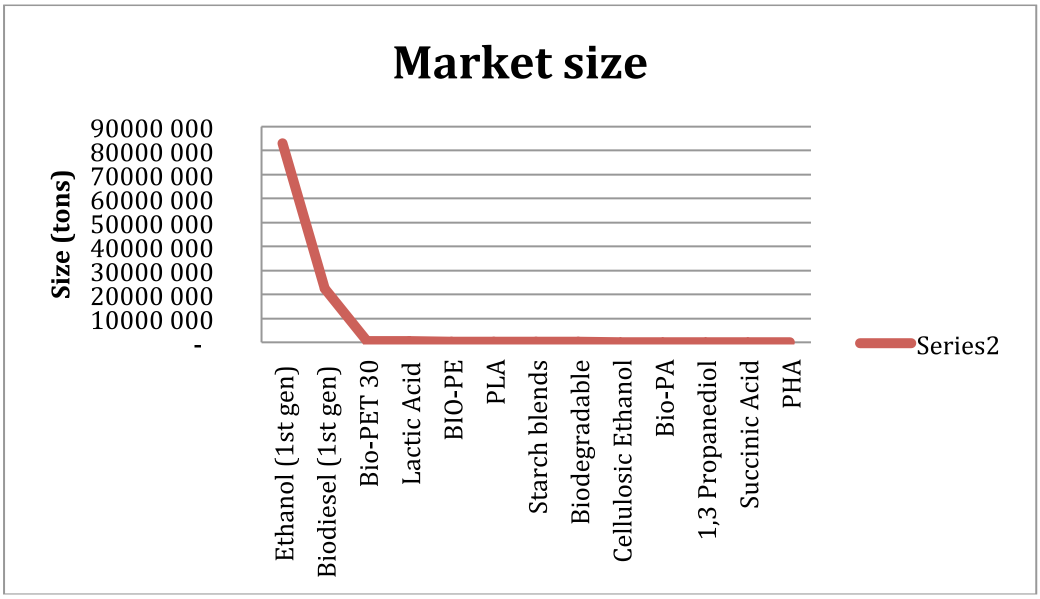

Figure 34: Market size in tons per year for the different product groups. The two by far largest groups are ethanol and biodiesel. These are excluded when determining the rating limits related to market size.

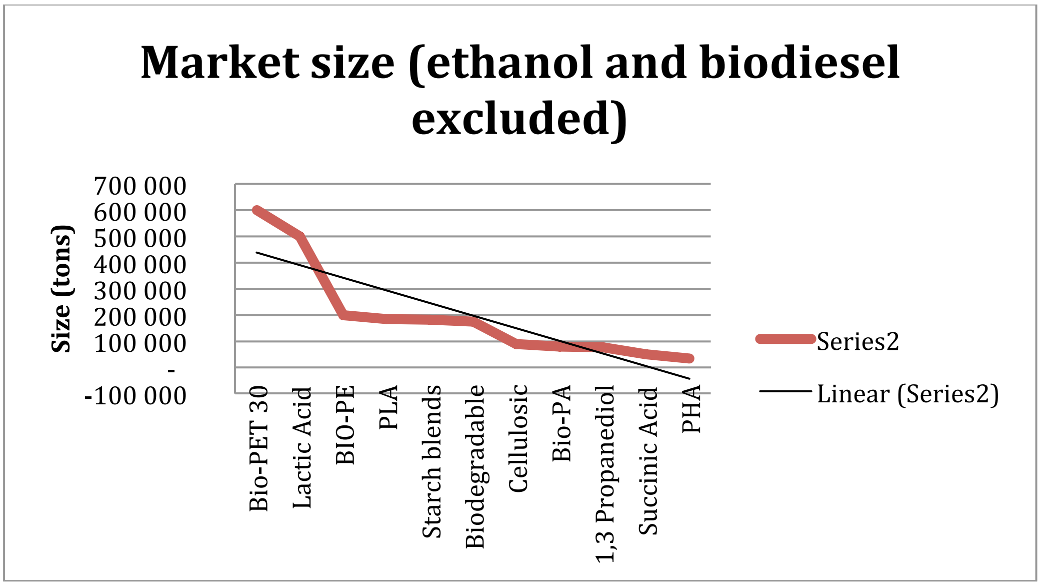

Figure 35: Market size for different product groups. The Trend line is used to determine the rate distribution related to product group size.

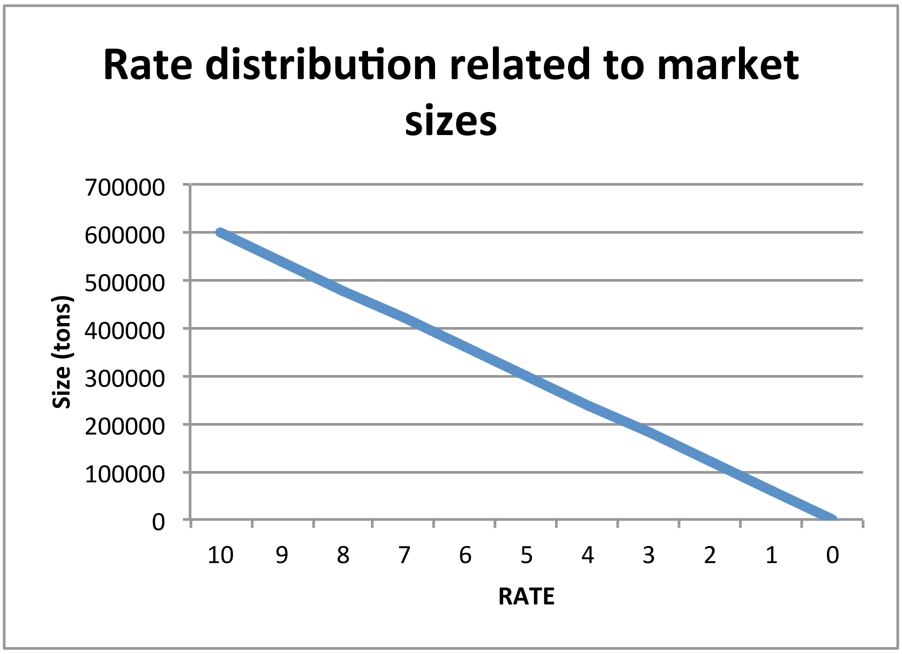

Figure 36: Rate limits related to market volumes for the product groups.

9.2 Summarized data for Phase 3 – Market Segment investigation and Phase 4 – Product group investigation

9.2.1 Market Segment investigation

	Bioplastics	Platform Chemicals	Biofuels	Enzymes	Lubricants	Solvents
Size & Growth						
Sustainable segment growth rate (%)	20%	>20%	8%	growing	6%	4%
Sustainable segment size (tons)	5 100 000	large	58 320 000	moderate	560 000	2 400 000
Market Growth rate /year (%)	5%	-	1%	-	2%	2%
Market size (tons)	233 750 000	-	4 200 000 000	-	37 110 000	28 000 000
Company Alignment						
Compatibility current business	Strong, especially for drop in	Strong	Low	Low	Moderate	Moderate
Company ambition	Positive	Positive	Not positive	Not positive	Moderate	Low

Table 23: Qualitative and quantitative data summarized for Phase 3 – Market Segment investigation and Phase 4 – Product group investigation.

9.2.2 Product group investigation

Figure 37: Size & Growth factor with corresponding sub factors. The data is gathered from the empiric data collection section or provided by the Company.

Figure 38: Competitors and Company alignment factor with corresponding subfactors The data is gathered from the empiric data collection or provided by the Company.

	Size & Growth			
	Product group growth (%)	**Current market size (tons)**	**Nordic product growth**	**Nordic market size (production)**
Bio-PET 30	0,528471791	599400	-	-
BIO-PE	0,002635872	199260	expected to grow	expected to grow
PLA	0,188233277	184680	-	-
Bio-PA	0,049250164	79380	-	-
PHA	0,168247037	34020	-	-
Biodegradable polyesters	0,161683435	174960	-	-
Starch blends	0,026925739	183000	-	-
Ethanol (1st gen)	0,081038931	83100000	-	small
Biodiesel (1st gen)	0,081143512	22500000	-	large
Cellulosic Ethanol (2nd gen)	0,533	90000	Expected to grow	small
Lactic Acid	0,155	500000	-	-
Succinic Acid	0,426161635	50000	-	-
Acetic Acid	-	-	-	-
Acrylic Acid	-	-	-	-
1,3 Propanediol	0,063473478	78000	-	-
1,4 Butanediol	Large	-	-	-
Lignin	large	-	Large	small

	Status (commercial/ramp-up)	Nbr of competitors	Engaged in the nordic region	Available competence	Previous reserach in area	Produce fossil based equivalent or substitute
0	commercial	multiple	No	No	No	No
	commercial	few	Yes	Yes	Yes	Yes
	commercial	multiple	No	Yes	Yes	Moderate
	commercial	multiple	No	Yes	-	Yes
	ramp-up	few	No	Yes	-	Moderate
dable poly	commercial	multiple	No	Yes	-	Yes
ends	commercial	multiple	No	Yes	-	Moderate
1st gen)	Commercial	multiple	No	No	No	No
(1st gen)	Commercial	multiple	No	No	No	No
Ethanol (2	Ramp Up	few	Yes	No	No	No
d	Commercial	few	No	No	No	No
Acid	Commercial	multiple	No	No	No	No
id	Pilot	few	Yes	No	No	Yes
cid	Research	few	No	Yes	Yes	Yes
nediol	Commercial	few	No	No	No	No
ediol	Commercial	moderate	No	No	No	Moderate
	Research	few	Yes	Yes	No	Yes

Figure 39: Political & legal and Technical performance factors with corresponding sub factors. The data is gathered from the empiric data collection or provided by the Company

Figure 40: Environmental & Social factor with corresponding sub factors. The data is collected from the empiric data collection or provided from the Company.

	Environmental & Social			
	More sustainable than conventional product	WTP	Public interest	Collaboration to make product group commercial / gain market share
Bio-PET 30	Yes	Yes	Yes	Yes
BIO-PE	Yes	Yes	Yes	Yes
PLA	Yes	Yes	-	Yes
Bio-PA	Yes	Yes	-	-
PHA	Yes	Yes	-	-
Biodegradable polyester	Yes	Yes	-	-
Starch blends	Yes	Yes	-	-
Ethanol (1st gen)	Yes	No	-	-
Biodiesel (1st gen)	Yes	No	Yes	-
Cellulosic Ethanol (2nd g	Yes	No	Moderate	Yes
Lactic Acid	-	No	-	Moderate
Succinic Acid	Yes	No	-	Yes
Acetic Acid	-	No	-	No
Acrylic Acid	No	No	-	Moderate
1,3 Propanediol	Yes	No	Low	Yes
1,4 Butanediol	Yes	No	Low	Yes
Lignin	Yes	No	Moderate	Yes

9.3 Example of Interview Guide

In prior to an interview, an individual interview guide was constructed. As mentioned in the Chapter 2 – "Methodology" the interview guide was semi-structured in order to insure that the desired areas were covered at the same time as flexibility was seen as important. The interviews followed the subsequent general approach:

Presentation of the interviewers and the master thesis

The interviews always began with an introduction of the authors and an overview of the master thesis. It was emphasised that the master thesis was performed at the Lund University, the scope of the thesis and the key deliverables.

General Questions

- What is your position within the Company?
- What is your area of expertise?

Current situation

- How large is the Company´s market share of product X?
- How does the production process function?
- What is the general trends on the market?
- Is bio-based production of product X seen as an alternative?
- Have any investigations in the bio-based market been made?

Future Scenario

- What is your opinion of the future for bio-based product X?
- Is the development seen as a threat to the Company's current business?
- Does it exist a perceived market pull for sustainable products?

Connection to the Nordic Region

- How important is the Nordic region for product X?
- Can local feedstock be used to produce product X?

Asking if it exist any available material on the subject that the interviewee could share concluded the interview.