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MTTM02 Degree Project in Engineering Logistics

Sustainable transportation and mapping of logistics activities

With the goal of having fossil-free transportation by 2030

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This master's thesis is conducted by two students from the *Faculty of Engineering* at Lund University in 2020 at the department of Industrial Management and Logistics. The authors are responsible for expressed opinions, conclusions, and results.

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Abstract

Heading of thesis Sustainable transportation and mapping of logistics activities - With the goal of having fossil-free transportation by 2030

Background Today's supply chains have become more global than ever before, which has brought out an enormous increase in environmental damage such as CO_2 emissions. In an initiative to become more environmentally friendly, Swedish Food Federation has launched a joint sustainability manifest. 41 food producers in Sweden have joined this initiative and The Company is one of them. The manifest consists of five commitments, where this thesis project is related to the first commitment. This commitment states that The Company needs to become fossil-free in their operations, including transportation, by 2030.

Purpose The purpose of the thesis is to develop a plan for The Company which helps them achieve the fossil-free transportation goal by 2030.

Method The research method of this master thesis is a single case study of sustainable transportation, where the unit of analysis is The Company's transportation operations. The case research allows the authors of this paper to investigate the phenomenon deeply and conduct semi-structured interviews with the stakeholders to develop a plan for the sustainability goal by 2030. The primary data is collected by qualitative semi-structured interviews with both internal and external stakeholders. Secondary data has been gathered through internet search and excel-files provided by the stakeholders. Furthermore, Swedish Transportation Agency's website has been used to gather data regarding different vehicles.

Recommendation The recommendations are made in two sections: KPIs and the roadmap. There are five KPIs recommended to The Company to measure in order to achieve the ultimate goal of becoming fossil-free in transportation by 2030. The roadmap aims to provide a plan to The Company to achieve the goal by 2030, by changing the leasing cars to 100% BEV, existing fossil-fueled forklifts with electric forklifts, purchasing 100% HVO fuel for the trucks by the LSPs, and lastly having fossil-free tractors either by using biofuels or electric tractors. The roadmap includes activities, market analysis and goals where the activities and market analysis are the steps to achieve the goals.

Keywords Logistics map, transportation, sustainability, fossil-free, food manufacturing, carbon emissions, biofuels, electric vehicles, KPIs

Abbreviations List

B2B: Business to business
BEV: Battery electric vehicle
CH_4: Methane
CO: Carbon monoxide
CO_2: Carbon dioxide
EOQ: Economic order quantity
EU: European Union
FG: Finished goods
FMCG: Fast-moving consumer goods
GDP: Gross domestic product
GHG: Greenhouse gas
HC: Hydrocarbon
HCV: High-capacity vehicle
HVO: Hydrogenated vegetable oil
IEA: International Energy Agency
ISO: International Organization for Standardization
JIT: Just-in-time
KPI: Key performance indicator
LDV: Light-duty vehicles
LPG: Liquefied petroleum gas
LSP: Logistics service provider
N_2O: Nitrous Oxide
NH_3: Ammonia
NMHC: Non-methane hydrocarbons
NO_x: Nitrogen oxides
OECD: Organization for Economic Co-operation and Development
PEV: Plug-in electric vehicle
PHEV: Plug-in hybrid electric vehicle
PM: Particulate matter
RM: Raw material
RME: Rapeseed oil methyl ester
SEK: Swedish krona
SFG: Semi-finished goods
SPBI: Swedish Petroleum & Biofuels Institute
THC: Total hydrocarbon
VAT: Value added tax
VMI: Vendor managed inventory
WAD: Warehouse for alcoholic drinks
WFF: Warehouse with freezing facility
WH: Warehouse
WTW: Well-to-wheel

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1. Introduction

This chapter provides an overview of the thesis topic and the background together with a description of the collaborating company. It also explains and formulates the problem which is the foundation of this master's thesis.

1.1. Background

Together with the technological developments in the last decades, supply chains have become more global than ever before. Even though this caused reductions in costs and improved product quality due to the possibility of reaching the best conditions in the world, it has also brought out an enormous increase in environmental damage such as carbon dioxide (CO_2) emissions. Especially in the last few years, customer priorities have changed, and customers have become more conscious about the environment and started demanding environmentally friendly solutions and products. Companies value customer demand to survive in the big global market and they try to satisfy the customers. Therefore, they have started taking action on becoming more environmentally friendly.

Since production has a massive effect on the environment, The Swedish Food Federation (Livsmedelsföretagen) has recently launched a joint sustainability manifest. This manifest consists of five commitments that a company should achieve by 2030, in order to make food production sustainable. The first commitments state that the industry should be fossil-free, which includes both production and transportation. The second commitment is to minimize food waste by half in the production. The third commitment is to only use packaging that is 100% recyclable. The fourth commitment is to have good terms for suppliers in each tier. Lastly, the fifth commitment is to have more effective water usage. 41 food producers in Sweden have already joined this manifest and The Company is one of them (Livsmedelsforetagen.se, 2019).

1.2. Company description

The collaborating company, which in this project will be referred to as The Company, based on their wish, is a family-owned Swedish company that is serving in the food and beverage industry. They have a long history of apple orchards, where the first apple tree was planted in 1888. The revenue of The Company is announced as 705M SEK and they have 208 employees in 2018. The main products of The Company are a large variety of juices, ciders, wines, and chutneys (The Company, 2020).

The Company only has production in Sweden, whereas its main production site is located in Kivik. Apart from production, they also have a majority of their apple and pear orchards here. The Company has a total of 52-hectare orchards in Kivik and Lund, which also is Sweden's biggest ecological orchard (The Company, 2020)

Except for the production plant in Kivik, they also have a production site in Stenhamra outside of Stockholm. The Company started using this plant for production in 2014 and they are producing all of The Company's PET products. Lastly, The Company has had a courtyard outside of Lund since 2015.

Here, they also have apple orchards and a store where customers can buy their products (The Company, 2020).

The Company has high product flexibility with over 350 different products in their assortment, where their most produced product is the beverages in the carton. The Company makes more than 50% of its sales through food retailing. Other sales channels are Systembolaget, service trades and B2B sales (The Company, 2020).

1.3. Problem description

The Company has recently signed the joint sustainability manifest, launched by The Swedish Food Federation, which means that they have a goal of having fossil-free activities by 2030. This goal is an initial step under the United Nations' global sustainable development goals. This means that both the manufacturing of the products and transportation should be fossil-free. The Company is continuously working to minimize fossil fuels in production. However, they have not managed to make a strategy on how their transportation is going to become fossil-free by 2030. The supply chain manager and the sustainability & product development manager are the main responsible people for this sustainability goal.

The Company has been maintaining many logistics operations both internally and externally. The Company has had some attempts to analyze logistics operations. However, it is required to deeply investigate eco-friendly fuels, vehicles, and transport modes.

Therefore, to address this problem, the focus of this project is to develop a plan to apply the first commitment of the sustainability manifest in terms of transportation.

1.4. Research purpose and questions

The purpose of the thesis is to develop a plan for The Company which helps them achieve the fossil-free transportation goal by 2030.

To approach the problem that is described in Chapter 1.3 in the correct way, and to fulfil the research purpose, the following research questions will be answered:

- RQ1: How does the current transportation map look at The Company and what is the environmental impact?

- RQ2: What are the alternative fuels and transportation modes to reach the sustainability goals?

- RQ3: How should the logistics activities be changed in order to reach the sustainability goals?

1.5. Focus and delimitations

The main focus of the master's thesis is to analyze the internal and external transportation at The Company and develop a plan for The Company which helps them achieve the fossil-free transportation goal by 2030. The strategy of the thesis is to reduce the environmental impact of transportation, while trying to investigate the financial impact with the available data.

The scope of the project includes internal and external transport vehicles that The Company owns. It covers the transportation of raw material (both bulk and dry goods) from Europe to Kivik (main production plant), Kristianstad (central warehouse) or Stenhamra (production plant). It also includes internal vehicles such as the cars that the employees use and the commercial vans, and the vehicles used in the plants such as forklifts and tractors. However, the project does not cover vehicles used for long distances e.g. work trips.

The aim of the project is not necessarily to propose a change in the supply chain actors, but to develop a plan on how to achieve the fossil-free transportation goals by 2030 with the existing supply chain.

1.6. Report structure

The second chapter describes what research approach this master's thesis has followed. It also describes in-depth what research method has been used together with data collection methods. Lastly, the chapter ends with a discussion regarding credibility of the used methodology.

The third chapter introduces a large variety of literature that has contributed to creating a wide knowledge about sustainability in many aspects, including the governmental regulations, sustainability manifest, alternative vehicles and fuels to become more sustainable, and many alternative methods for a sustainable industry. It also covers the significant effects of emissions on the environment and the main greenhouse gases that affect the world.

The fourth chapter provides the empirical findings gathered through the interviews. The chapter starts with explaining the current logistics activities, including the logistics map of The Company and the geographical locations of The Company's facilities and logistics service providers (LSPs). Furthermore, it presents the qualitative and quantitative data collected from the interviews and the internet search.

The fifth chapter provides an analysis of the empirical data presented in the previous chapter. The empirical data is firstly compared to existing literature, presented in Chapter 3. Furthermore, KPIs are discussed, and improvement areas are defined. Lastly, the analysis is completed with the development of a roadmap for fossil-free transportation by 2030.

The sixth chapter includes the recommendations of this project to The Company to become fossil-free in transportation operations by 2030. The recommendations are based on the analysis in Chapter 5 and presented in two parts: the KPIs and the roadmap.

The concluding chapter, Chapter 7, summarizes and explains how the research questions are answered based on the discussions and analysis stated in this report. Moreover, it provides insights for the future research and briefly explains how this report contributes to the theory.

2. Methodology

This chapter describes what research approach this master's thesis has followed. It also describes in-depth what research method has been used together with data collection methods. Lastly, the chapter ends with a discussion regarding credibility of the used methodology.

2.1. Research approach

In the previous chapter, the purpose and research questions of this master thesis were presented. These are the base for how the methodology is designed in this research. According to Golicic, Davis, and McCarthy (2005), there are two different approaches for research within logistics and supply chain management. These are inductive and deductive, as described in Figure 2.1.

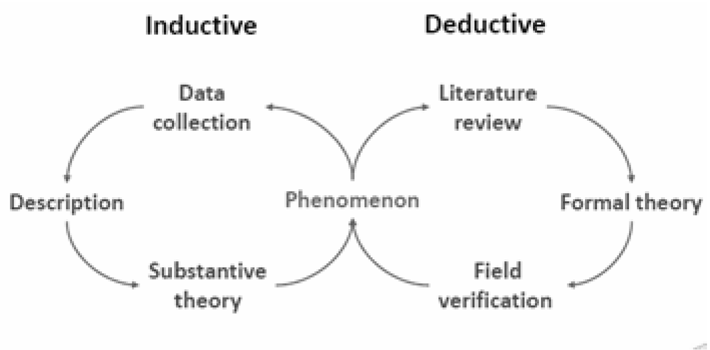

Figure 2.1: The two different research approaches (Woodruff, 2003, adapted by Olhager, 2019a)

Inductive is described as the qualitative path, and the aim is to *"understand the phenomenon in its own terms"* (Hirshman 1986, cited in Golicic, Davis and McCarthy 2005, p.20). The following steps should be followed for inductive research:

1. *Data collection* – Form an understanding of the phenomenon by observing it in its natural state
2. *Description* – Describe the phenomenon based on the collected data from the previous step
3. *Substantive Theory* – Build a substantive theory of the phenomenon, e.g. a process model describing relationships between variables

Apart from these steps, relevant literature is used throughout the approach in each step.

Deductive research is the most dominant approach in logistics and supply chain phenomena, and it is described as the quantitative path. The aim of deductive research is to *"add to the body of knowledge by building formal theory that explains, predicts and controls the phenomenon of interest"* (Golicic, Davis and McCarthy, 2005, p. 21). The following steps should be followed for deductive research:

1. *Literature review* – Develop a conceptual framework by reviewing literature related to the phenomenon. The aim is to understand the variables and relationships between them
2. *Formal Theory* – Form a general theory about the phenomenon
3. *Field Verification* – Collect data through carefully constructed instruments through surveys or experiments. The aim is to verify the theory stated in the previous step

A third research approach is also described by Golicic, Davis, and McCarthy (2005), called the balanced approach, also known as abductive research (Olhager, 2019a). Golicic, Davis, and McCarthy (2005) emphasize the importance of using deductive together with inductive research, to not delimit the scope and, thereby, increase the ability to add to the body of knowledge. Therefore, Golicic, Davis, and McCarthy (2005) describe the balanced approach as a way of utilizing the benefits of both approaches and create a more comprehensive theory.

The authors of this master thesis, therefore, use the abductive approach in this thesis in order to understand the phenomenon in its own terms, and then generate new theory as a sustainable transportation plan about the phenomenon.

2.2. Research methods

There are four research methods that are mainly used by researchers. This chapter briefly defines these methods.

Case study: Case studies aim to understand the phenomenon in its natural environment to develop expressive theory. The collected data is generally qualitative (Voss, Tsikritsis and Frohlich, 2002).

Survey research: Survey research aims to collect data to explore or explain the phenomenon by asking people for their knowledge and the collected data is generally quantitative and requires standardization (Forza, 2002).

Mathematical modeling and simulation: The quantitative methods aim to bring a solution to a real-life problem. Mathematical modeling requires proof; however, simulation is only a representation of reality (Bertrand and Fransoo, 2002).

Action research: Action research has two main purposes: bring up a solution to a real-life problem and to contribute to science. The research is conducted in real life (Gummesson, 2000).

2.3. Selected research method

The selected method in this master thesis is *case research*. The case research will allow the authors of this paper to investigate the phenomenon deeply and conduct semi-structured interviews with the stakeholders to develop a plan for the sustainability goal by 2030. The authors will have the chance of observing the phenomenon in its natural area and obtain the best results for academic and practical purposes. Therefore, the research method is a *case study* of sustainable transportation, where the unit of analysis is *The Company's transportation operations*.

Among the other methods, case studies have been particularly used in operations management when it comes to theory development (Lewis 1998, cited in Voss, Tsikritsis, and Frohlich, 2002). Case studies present the history of the phenomenon where the data about the phenomenon can be collected in many ways such as interviews and archives (Leonard-Barton 1990, cited in Voss, Tsikritsis and Frohlich, 2002). There are several benefits to conducting case research to investigate a phenomenon. Three main strengths of case research are defined as follows (Meredith 1998, cited in Voss, Tsikritsis and Frohlich, 2002).

1. Case research helps researchers investigate the phenomenon in its natural environment, and through the observations, it is possible to draw relevant conclusions.
2. It provides a full picture of the phenomenon and the questions of how, why, and what can be answered with a comprehensive understanding.
3. Case research can be conducted in the early stages of the phenomenon to explore the phenomenon and contribute to gain understanding.

Research purpose

Case research can be conducted for different reasons with different levels of knowledge about the phenomenon. There are four purposes of case research stated by Voss, Tsikriktsis and Frohlich (2002).

- *Exploration:* In this research type, there are not any specific research ideas and the researchers aim to investigate whether there are any interesting areas to research. These are unfocused and in-depth case studies.

- *Theory building:* The purpose of this type of research is to identify the key variables of the phenomenon and the linkages between them. These are few-focused and multi-site case studies.

- *Theory testing:* The purpose of the research is to test the theory that has been developed in previous research. In this stage, multiple case studies are conducted.

- *Theory refinement/extension:* This research type aims to generalize the theory and understand where it can be applied. The research structure includes experiments and case studies.

The purpose of the case research in this master thesis is to build theory by understanding the key variables and the linkages between them. This allows the authors of this thesis report to understand the phenomenon and develop a plan for sustainable transport for The Company.

Deciding on the number and types of cases

Voss, Tsikriktsis, and Frohlich (2002) define four ways to decide on the number and types of cases. First, the researchers might prefer to conduct a single case study. Even though this will provide them a great understanding of the phenomenon, it may restrict them due to the biased representatives and it is hard to generalize the results. The researchers, then, may choose multiple case studies where they will reduce the risk of biased results and obtain more generalizable data, but they will not have as in-depth data as in a single case study. As a research type, the researchers may conduct retrospective case studies. This allows researchers to collect historical data, however, it is hard to remember past events and it can be misleading to ask people's knowledge. Lastly, researchers might prefer longitudinal case studies where the implications of a past event will be analyzed in the future. However, it can be hard to conduct due to a long time between the events.

The method of this research is a single case study where the authors obtain the information only through The Company and some main transportation stakeholders. Even though there is a risk of getting biased information, the authors prohibit this risk by working objectively and preparing fair interview guides. The reason for not using multiple case studies is the demand for fully understanding The Company's reality and developing a unique plan for it.

2.4. Data collection methods

Under this heading, data collection methods are explained. First, the literature review method is briefly described, and then the empirical data collection methods are explained under the headings of primary data collection and secondary data collection.

2.4.1. Literature review

The articles and books that are going to be studied in this master thesis are obtained through LubSearch and from the literature of the previous courses during the master study. The literature review is a critical phase of the research since it supports all the other research stages (Seuring and Gold, 2011). It will provide the findings of the phenomenon and will lead the authors to develop their plan for fossil-free transportation by 2030. The literature covers many areas of environmental sustainability from several journals and authors. Even though there is a lot of literature about sustainability, the authors have chosen the outstanding papers in their focus area. Together with the academic literature, the authors have also benefited from internet searches for finding more specific data to cover the gaps that the academic literature could not provide.

2.4.2. Primary data collection

The primary data is collected through interviews of different people both internally and externally. In order to understand the phenomenon in a broad perspective and obtain the participants' point of view, the interviews will be conducted in a semi-structured way. This will also give the participants and the interviewees the opportunity of elaborating on the content of the interview.

At The Company, the supply chain manager, the sustainability & product development manager, the orchards manager, the warehouse manager, and the technical manager from the production department are interviewed to form a comprehensive understanding of internal activities. Moreover, to understand the external activities, two of the external partners are interviewed. One of the partners is a third-party logistics company that is responsible for transportation of the liquid products in bulks and the other partner is the third-party logistics company which both transports dry goods and handles warehouse operations in Kristianstad for The Company. The interview guides are presented in Appendix A.

2.4.3. Secondary data collection

The secondary data is collected through internet searches and data provided by The Company and the LSPs. The secondary data collected for the project are excel files, one from the company regarding the information of leasing cars, commercial vans, tractors and forklifts, and another excel file from the LSPs regarding their transportations for The Company.

Moreover, the Swedish Transport Agency's website is used to complement the information on the excel files regarding the emissions of the leasing cars, tractors, and commercial vans. On the Swedish Transport Agency's website, it is possible to reach all the information on the vehicles regarding ownership, fuel consumption and emissions through the specific registration numbers. However, the information gathered through the website is limited to cars, commercial vans and one of the tractors because the website does not provide an equal level of information about each vehicle. For this project, it was not possible to reach the registration numbers of the trucks and the forklifts do not have registration numbers. Therefore, this specific information on these vehicles could not be gathered in this project.

2.5. Data analysis

The data that is gathered throughout this project is presented in Chapter 4, divided into qualitative and quantitative data, based on the interviews and the secondary data explained in Chapter 2.4.3.

Interviews are used to provide a broad understanding of the phenomenon in the supply chain of The Company. Therefore, the qualitative information gathered through these interviews is analyzed and compared with previous literature and research regarding the phenomenon, presented in Chapter 3. Later, the quantitative information is used to see the current situation in the supply chain regarding the vehicle and fuel preferences, and the emission scores of the vehicles, by comparing the empirical data with the literature review.

This project has the ultimate aim of providing a plan to The Company to become fossil-free by 2030 in the transportation operations. Therefore, the changes that are proposed in this project can be extreme for an immediate step but should be taken in steps in years to reduce the emissions by 100% by 2030.

This project considers the financial perspective of the plan as much as possible, with the available data. However, the goal of The Company requires firm investments both at The Company and the LSPs. Therefore, the costs have also been taken into account, where the data is available.

2.6. Credibility

To prepare a trustworthy thesis report to the university and provide a feasible plan to The Company, the authors have considered three points while making the investigation and writing the report. First, the measuring instruments should be reliable. For this specific report, the instrument will be well-prepared interview guides. Secondly, the measures should be valid, and the authors should focus on their research purpose, and aim to get the answers which help them answer the research questions. Lastly, the data collection and analysis should be done objectively where the information is separated from personal opinions (Olhager, 2019b). Then, the authors guarantee that the interview guides serve their primary purpose as obtaining the required data to understand the phenomenon and the data is collected and analyzed in a reliable, valid, and objective manner.

3. Literature review

This chapter introduces a large variety of literature that has contributed to creating a wide knowledge about sustainability in many aspects, including the governmental regulations, sustainability manifest, alternative vehicles, and fuels to become more sustainable, and many alternative methods for a sustainable industry. It also covers the significant effects of emissions on the environment and the main greenhouse gases that affect the world.

3.1. Supply chain mapping

Gardner and Cooper (2003) mainly discussed what the characteristics of a map are and how a map can help develop a firm together with its supply chain strategy. A map contains key information about the supply chain and helps understand and analyze the supply chain dynamics. The authors aimed to remark that there is no standard way of mapping the supply chain activities and therefore alternatives can be discussed. The supply chain map allows us to identify the inefficiencies in the system and redesign the required operations.

Supply chain maps can be created for two reasons, according to Gardner and Cooper (2003). Firstly, the map can be created to align supply chain activities to the strategy. Secondly, mapping can be done to analyze whether the activities are in line with the strategy. Apart from the benefits, supply chain mapping has some risks. Some risks discussed by Gardner and Cooper (2003) are the increased possibility of confidential information leakage, including more details than necessary and not utilizing the map to make strategic management decisions.

3.2. Environmental sustainability

3.2.1. Effects on the planet

Greenhouse gases (GHGs) cause climate change on the planet by trapping the heat in the atmosphere, and GHGs also have an effect on the diseases which are caused by air pollution. Together with this change in the climate, it has become harder to predict the weather conditions. Also, due to climate change and the increased temperatures, some species will become extinct and many others will need to migrate (National Geographic, 2019a).

GHGs increase the heat in the atmosphere. The main GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). CO_2 gas arises with burning fossil fuels, solid waste, biological materials, and some chemical activities. Burning fossil fuels is the reason that CO_2 is the biggest contributor to climate change (US EPA, n.d; David Suzuki Foundation, n.d.). According to Hoen et al. (2014), the relationship between fossil fuel consumption in transportation and CO_2 emissions is linear. Therefore, with an increase in the consumption of fossil fuel, there is the same increase in CO_2 emissions. CH_4 is produced through the manufacturing and transport of oil, natural gases, and coal. Nitrous oxide is emitted through chemical fertilizing activities and burning fossil fuels (US EPA, n.d; David Suzuki Foundation, n.d.).

Fossil fuels are obtained from the remaining dead plants and animals and contain high levels of carbon (NRDC, 2018). Some of the fossil fuels are oil, coal, and natural gases and these produce around 80%

of the world's energy. The CO_2 and GHG are released when these fuels are burnt and this causes heat in the atmosphere, hence these are important contributors to climate change and global warming (National Geographic, 2019b).

3.2.2. Action plan for sustainability in supply chains

Dey, LaGuardia, and Srinivasan (2011) concluded their research about sustainability in global supply chains, by recommending short- and long-term actions a company can use to become sustainable in their global supply chain. The short-term recommendations are:

- Start taking initiatives towards sustainability today
- Start off with simple things by picking the low hanging fruits. It could be activities that do not involve big investments. Start by studying the organization's facilities and learn where they are most inefficient
- The top management must be committed since sustainability needs resources that top management can provide
- A visual representation of the organization's global supply chain could help to make tactical decisions
- Benchmark each area of the supply chain to other organizations

Dey, LaGuardia, and Srinivasan (2011) presented the following long-term recommendations:

- Management must always be updated about government regulations that might be affecting the operations
- Set specific KPIs to measure the CO_2 emissions of your company and state goals in order to reduce the CO_2 emissions

3.2.3. Sustainability in the food industry

The food industry has been taking special attention to the environmental impacts of the activities along the supply chain since the customers, policymakers, and organizations can see the effects of the operations. Working in an environmentally friendly way is not only good for the ecological benefits for the companies but it also brings a competitive advantage in the market. Fast-moving consumer goods (FMCG) companies prefer using LSPs or managing their distribution operations. The main factor is normally the profit maximization whilst not sacrificing quality, reliability, and time. If sustainability can be considered as a decision point, companies may choose LSP which provides fewer emissions and better ecological solutions (Kellner and Igl, 2015).

3.3. Environmental requirements

3.3.1. Sustainability manifest

The manifest aims to ensure a sustainable and viable environment for the food industry in Sweden. The manifest is prepared by the light of the United Nation's future climate plans by 2030, and the Paris Agreement (Livsmedelsforetagen.se, 2019).

The manifest includes five goals on how the food companies apply and follow the sustainability requirements (Livsmedelsforetagen.se, 2019). The goals are briefly explained as follows:

1. A fossil-free industry

About 80% of Sweden's emissions that are affecting the climate comes from fossil fuels, and heating and transportation have an important impact on CO_2 emissions due to fossil fuels. In order to reduce this impact and stabilize the effects of these activities on the earth, a transition to fossil-free energy is needed in the industry. For this reason, it is aimed to use fossil-free energy sources in production and transportation by 2030 (Livsmedelsforetagen.se, 2019).

2. Reduce food waste by half

Around 30% of the food produced globally is wasted. Reducing this proportion is the responsibility of everybody from the producers to the consumers. It is aimed to reduce the food waste by half by 2030 in the production, handling, and consuming stages (Livsmedelsforetagen.se, 2019).

3. Recyclable packaging material

Food packaging is crucial for retaining the content and ensuring the quality and safety of the food to reduce food waste. However, material waste is also important for the environment. The correct design of the package can still protect the food and reduce packaging waste. The aim by 2030 is to change to 100% recyclable packaging material and to have a better rate of recycling material for packaging (Livsmedelsforetagen.se, 2019).

4. Good terms in supplier stage

The working conditions, the rights of the workers and the ethical working environment are critical for the employees in the food companies and as well as for their suppliers. For this reason, a code of conduct will be prepared by 2020 for the suppliers' working conditions and be followed up, every year (Livsmedelsforetagen.se, 2019).

5. Efficient water usage

Sweden has a high consumption of water but good access to water, as well. Together with climate change, there is a risk of water scarcity. Therefore, the efficient consumption of water is critical. The surveys are conducted in 2019 and they promise it to have established efficiency targets for 2020 (Livsmedelsforetagen.se, 2019).

3.3.2. Performance measurements for sustainability

Lee and Wu (2014) concluded in their research that performance measurements that are sustainability-oriented can help an organization to identify trade-offs between economic sustainability and the environmental impacts of CO_2 emissions. Therefore, it is of the great importance of having integrated performance measures of environmental sustainability whilst focusing on green logistics and transportation. However, Lee and Wu (2014) also mention that performance measurement of sustainability in logistics and supply chains are not that well investigated yet since it is a rather new area of focus. Hence, there is a lack of approaches and tools to help organizations find measurements that integrate environmental and economic performance within transportation and logistics. In order to find eco-efficient solutions, there must be an efficient way of measuring environmental sustainability.

Roth and Kåberger (2002) state that transport buyers have decent motivations to prefer the following indicators: CO_2/ton and CO_2/m^3. These indicators exclude the transport work but emphasize the volume and weight. This way, they can pay attention to a possible reduction in the distance of transportation and choose the suppliers close to the market.

One point with specifying the indicators is to decide who takes the responsibility of which activity in the supply chain. Each stakeholder should be liable for the emission impacts of their own activities. ISO recommends stating the activities in which one actor has a major impact and a major influence. However, in this case, some environmental impacts can be included twice. To address this problem, one can consider the supply chain rather than focusing on one company and analyze the impacts of the activities for the entire supply chain. This will also solve the responsibility conflict (Roth and Kåberger, 2002).

3.4. Sustainable transportation

3.4.1. Regulations from the EU and Sweden

The energy consumption in the transportation sector has been a major topic in the last few years. The consumption of fossil fuels has been an important factor to measure the environmental impact of activities and moderate environmental risks. Governments and the EU have been developing policies to reduce the consumption of fossil fuels and become more environmentally sustainable by 2020 (Börjesson et al., 2014).

Transportation is usually seen as the most visible aspect of logistics and it is also the activity that contributes to the most CO_2 emissions within logistics management (Lee and Wu, 2014). The transportation sector is responsible for one-fourth of the total GHG emission in the EU, and only road transport produces 20% of the EU's CO_2 emissions, according to Kellner and Igl (2015). However, in Sweden, the transport sector generates around one-third of Sweden's GHG emissions, according to the Swedish Environmental Protection Agency (Robèrt, Borén and Broman, 2017). The transportation sector, unlike the other industries, has an increasing trend in producing emissions. Since 1990, the emissions due to the transportation sector have increased by 36% in the EU (Kellner and Igl, 2015).

The Swedish Government announced two goals to solve the emission problem: by 2030, all the vehicles in Sweden must be fossil-free and by 2050, the country should be GHG neutral (Ministry of the Environment, 2011, cited in Robèrt, Borén, and Broman, 2017).

3.4.2. LSPs' perspective on sustainability

Challenges for LSPs

Many large companies have started working on code of conduct and corporate social responsibility which shows that these companies are paying attention to the environmental impact of their actions. However, these are mainly big and global LSPs. Small or medium LSPs still do not put the environmental impact on top of the agenda (Nilsson, Sternberg, and Klaas-Wissing, 2017).

Nilsson, Sternberg, and Klaas-Wissing (2017) pointed out several challenges for LSPs to become more environmentally friendly. These can be summarized as complexity in diagnosis and measurement of the environmental impacts of the activities, operationalization difficulty in logistics, and uncertain policies and regulations about the sustainability requirements and also customer demands. Another challenge for LSPs is also not being able to have full control of the subcontracted haulers but they still have to take the responsibility of their actions (Nilsson, Sternberg and Klaas-Wissing, 2017).

The most significant challenge for LSPs is the cost impact. According to the study performed by Nilsson, Sternberg, and Klaas-Wissing (2017), customers are still prioritizing cost before sustainability. Also, as long as LSPs cannot guarantee long-term relationships, the customers are not willing to take the risk in investment. Similarly, Von der Gracht and Darkow (2016) state that it is not expected that the customers will accept the changes in the prices without resisting.

Considerations of LSPs

The experts expect that the LSPs will need to measure and document not only any kind of emissions but also the noise in terms of environmental impact. Moreover, they also expect more strict rules and regulations on sustainability. There will be a need to change the driving habits and patterns in the supply chains and the LSPs will be required to prefer green vehicles. The LSPs also need to measure and control the CO_2 emissions in real-time which will be an upcoming qualifier for LSPs (Von der Gracht and Darkow, 2016).

The experts do not foresee an extreme increase in the oil barrel prices by 2030 but it is not clear about the future of the fossil fuels in terms of prices and resources, therefore it is considered to search for alternative fuels. Some experts believe that even though there is a significant increase in fossil fuel prices or regulations regarding sustainability which makes the energy consumption more expensive, the primary concern will still be efficient and quick. Some others think that sustainability attempts will diminish energy consumption. Therefore, LSPs should work on balancing efficiency both in terms of the speed and energy in the supply chain (Von der Gracht and Darkow, 2016).

In order to avoid long transports, LSPs can consider focusing on localization and establishing in regions. Even though this can be an environmentally friendly alternative, it is not expected that the local transport will be enough to satisfy customer demands unless the customer behavior changes, especially in the developing countries which are highly dependent on imports. (Von der Gracht and Darkow, 2016).

3.5. Impacts of vehicles and emissions

3.5.1. Transportation

The transport sector is the fastest-growing sector in terms of GHG emissions. The main gasses cause the emission is CO_2, nitrogen oxides (NO_x) and carbon monoxide (CO) (Mariano et al., 2017). According to the studies, 37% of the Organization for Economic Co-operation and Development (OECD) countries and 10% of the low gross domestic product (GDP) countries demand more eco-friendly solutions. The outstanding solutions to emission problems are traffic reducing alternatives and transport planning, choice of eco-friendly transport modes, financial applications such as economic measures and taxes, improving consumer behavior and regulation to improve vehicle efficiency (Rodt et al., 2010 cited in Mariano et al. 2017).

Lumsden (2007) describes that there are several parameters to consider when describing the environmental impact of transportation, not only connected to fuel. Firstly, the energy consumption, i.e. how much fossil CO_2 is discharged during the activities. Secondly, other particles need to be considered, as well. These are, for example, NO_x, hydrocarbons (HC), and sulfur. Lastly, noise, soil use and effects on barriers need to be considered.

Considering the reduction in emissions is not solely enough for the logistics perspective. There are some other measures that should be taken into account as well, such as economic activity and value density. Moreover, reducing transportation intensity with decentralization and more local operations, reducing traffic intensity with utilizing capacities better and increasing vehicle efficiencies, reducing energy intensity with eco-driving, and reducing CO_2 emissions intensity with policies and regulations should be considered (Mariano et al., 2017).

The study carried out by Mariano et al. (2017) shows that mainly the developed countries are working on reducing the environmental impact of transport operations. However, there are some examples of low GDP countries that perform much better in this sense that the developed countries.

Since sustainability issues got raised and started becoming a topic on the agenda, diesel vehicles were starting to be used instead of gasoline. Diesel fuel generated lower CO_2 emissions. However, it was also seen that diesel-generated more air pollution than conventional cars using gasoline (Velazquez et al., 2015).

3.5.2. Agricultural tractors

There are some main gases that cause pollution because of agricultural operations such as methane (CH_4), ammonia (NH_3), carbon dioxide (CO_2), nitrogen oxides (NO_x), hydrocarbons (HC), and particulate matter (PM). In recent years, there are more attempts to limit the emissions of NO_x, CO, HC, and PM from the engines. Therefore, there are some technological adaptations to reduce emissions such as exhaust gas recirculation, selective catalytic reduction, diesel catalyst, and diesel particulate filtration (Lovarelli and Bacenetti, 2019). Total hydrocarbons (THC) and non-methane hydrocarbons (NMHC) are two ways to measure HC. It is also possible to combine HC + NO_x rather than using two individual measures (Dieselnet.com, n.d.).

The analysis provided by Lovarelli and Bacenetti (2019) shows that the production of exhaust gases and the selected biofuel blend used are causally related to the field conditions. Some investigation regarding the biodiesel effects on exhaust gas emissions shows that the use of pure biodiesel or a blend of biodiesel and fossil diesel worsen the emissions, increases fuel consumption, and reduces engine power. On the other hand, this is not true for all the studies and the effects might change with other biomasses.

The studies show that biodiesel reduces CO, HC and PM emissions but increases CO_2 and NO_x emissions. The authors state that fuel consumption, engine efficiency, and exhaust gas emissions are severely affected by extreme engine loads. They also conclude that decent environmental and engine performance can be achieved with a low proportion of biofuels with fossil fuels. However, a high proportion of biofuel blends will negatively affect fuel consumption, exhaust gas emissions, and engine performance (Lovarelli and Bacenetti, 2019).

3.5.3. Forklifts

Boenzi et al. (2017) state that the inbound and outbound logistics operations have become important to investigate with the increasing demand for sustainability, especially when it comes to carbon footprints. Johnson (2008) defined carbon footprint as the GHG emissions produced by a human, product, or company. There are many alternatives to reduce the carbon footprint and the energy consumption of the warehousing activities such as optimization of forklift routes, applying storage plans which leads to a minimum material handling using forklifts which consume less energy (Boenzi et al., 2017).

For energy consumption, it is possible to choose between three different forklift engines: diesel, liquefied petroleum gas (LPG) and electric (Boenzi et al., 2017; Johnson, 2008). The analysis carried out by Boenzi et al. (2017) to compare LPG and electric forklifts under the same conditions showed that electric forklifts are always better in terms of ecological aspect and energy costs according to the assumed figures. Unlike Boenzi et al. (2017), Johnson (2008) concluded that in principle the carbon footprints of both alternatives are equal, however, in practice, LPG forklifts have a smaller footprint than the electric forklifts.

There is a conflict in the literature about which engine type is more environmentally friendly, and there are cases supporting different engines. There are also comments that the impact should be considered on a case-by-case basis. Nevertheless, electric forklifts are preferable in a general first result (Boenzi et al., 2017).

3.6. Alternative solutions

3.6.1. Alternative fuels

Fossil fuels made it possible to have adaptable and fast transportation since it has high availability, great combustion properties, and energy density. Also, compared to many other available fuels, it has had a low price and is still seen as a cost-effective option (Figueroa et al., 2014). However, since it has a high impact on the environment with GHG, fossil fuels should be replaced in vehicles. Four examples that Figueroa et al. (2014) present are natural gas, biofuels, electricity, and hydrogen.

Natural gas

Many countries are today increasing the usage of natural gas for transportation. Today, natural gas is used to a great extent in India for taxi fleets, also for busses e.g. in Iran and China. The authors also explain that natural gas is more commonly used for delivery transportation and long-haul trucks in the U.S. (Figueroa et al., 2014).

Compressed natural gas, which consists primarily of CH_4, and LPG, primarily propane and butane, can be used instead of fuels in engines driven gasoline. Only a small modification to the fuel and control system is needed (Figueroa et al., 2014). Thanks to new technology, the price for natural gas has reduced drastically in the U.S. Unfortunately, the market share for natural gas is still rather small for trucks and cars in the U.S. However, since the price of natural gas remains low, the authors conclude that the market share will increase, and natural gas will be more commonly used (Figueroa et al., 2014).

The benefit of natural gas is regarding particulate emissions. However, one disadvantage is the CH_4 emissions, which could cause more GHG impact than what diesel fuels have today. Therefore, the probability that natural gas will be a future fuel for decarbonized transportation in the future is rather low (Figueroa et al., 2014).

Biofuels

Biofuels are typically liquid or gas, and it comes from biomass. In 2013, a majority of biofuels were ethanol (from sugarcane or corn) or biodiesel (from soy or rapeseed). Ethanol from sugarcane is already a commercial fuel, whereas Brazil is the dominant producer of it. It is also one of the few fuel alternatives which are cost-competitive with gasoline (Figueroa et al., 2014). However, Figueroa et al. (2014) state that biofuels from food crops have been quite controversial since studies have shown that the reduction in GHG is rather low.

In 2013, the year before this article was published, biofuels had a market share of 3% globally and is probably the non-petroleum transportation fuel that has been most successful (Figueroa et al., 2014). According to Swedish Petroleum & Biofuels Institute (SPBI), the use of biofuels increased with more than 5% during the year 2017, and according to International Energy Agency's (IEA) forecast, the usage of biofuels will continue to increase with 5% per year to 2025, and 3,5% per year from 2025 to 2040. (Spbi.se, 2019)

Since biofuels have a reduced amount of CO_2 emissions, it can also be blended with other fuels as an approach to reduce the overall CO_2 emissions (Shell.com, n.d). For this reason, biofuels are also seen as a potential fuel to replace fossil fuels, since it reduces GHG emissions and CO_2 emissions drastically (Velazquez et al., 2015).

One alternative to fossil fuels is hydrotreated vegetable oil (HVO), which is one kind of biofuel. HVO is produced from vegetable oil and fat. The difference of HVO from the other biofuels is that HVO uses hydrogen as a catalyst in the generation procedure rather than CH_4 (Crown Oil UK, n.d.).

Rapeseed oil methyl ester (RME) is one biodiesel used in Sweden which is produced by rapeseed oil. RME was produced in a minor scale until 2006, and nowadays the usage area is expanding. B100 which consists of 100% RME biodiesel is mainly used in heavy vehicles such as buses and trucks. In Sweden, RME is blended with other fuels by 5% (biodiesel - Uppslagsverk - NE.se, n.d.). The maximum RME mixture of a vehicle is 7%. In order to increase the mix percentage, one should ensure that the engine can handle it or should get an approval from the manufacturer of the vehicle (Vegetabiliska oljor (RME) - TRB, n.d.).

As of the 1st of July 2018, the Swedish parliament decided on a regulation regarding biofuels, called reduction duty (reduktionsplikt). This regulation means that the suppliers of fuels have to mix fossil fuels with a certain percentage of biofuels, in an attempt to decrease the GHG emissions. How much biofuels should be added is based on what kind of fossil fuel that is used and the percentage of biofuels is calculated with the purpose of reducing the fossil CO_2 emissions, compared to only using fossil fuels (Spbi.se, 2019).

Electric vehicle

The only option that potentially can give a zero CO_2 emission is carriers run on electricity and hydrogen. However, their energy also needs to be produced without any CO_2 emissions, such as through wind or solar power. Therefore, depending on what country you operate in, it could mean that electric vehicles are better in some countries. For example, in Norway where electrical systems are dominated by renewable sources, electrical vehicles are better than conventional vehicles. However, in countries like India or Poland, where energy production is mainly dominated by coal, it is likely that electric vehicles can cause more CO_2 emissions than conventional vehicles (Figueroa et al., 2014). In 2016, 54% of Sweden's energy was produced from renewable sources. Sweden's aim by 2040 is to reach 100% of renewable electricity production (sweden.se, 2019).

Plug-in electric vehicles (PEVs) have had an increase in demand in recent years, this includes both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). PHEV combines an electric motor with a combustion engine (Figueroa et al., 2014).

Velazquez et al. (2015) describe that a hybrid electric vehicle is a better choice since it can reduce CO_2 emissions in both the transportation sector and the energy sector by enhancing cheap and clean electricity. However, Figueroa et al. (2014) explain that it will be hard to find applications for electricity in vehicles beyond personal vehicles and light-duty vehicles (LDV) since long-haul trucks and ships are in need of long-range travel with higher capacity. There is also a need for long-term commitment when choosing electricity.

Renault ZOE is the most bought BEV in Sweden, where a total of 5420 cars have been sold (Elbilsstatistik.se, n.d). The car has a charging time of 6h (using 16 amperes) and a driving range of 390 km. When buying a new Renault ZOE (from the year 2020) it has a market price of a minimum of 286 990 SEK (including VAT) (Miljofordon.se, 2020a).

Volkswagen Passat GTE is the most bought PHEV in Sweden and according to statistics, a total of 12 969 cars has been sold (Elbilsstatistik.se, 2020). The primary fuel for this car is electricity and the secondary fuel is gasoline. The charging time is however smaller than for the Renault Zoe and is only 5 h. The driving range is 970 km on hybrid mode and 70 km on battery. The market price of a new Volkswagen Passat GTE (from the year 2020) starts from 454 900 SEK (including VAT) (Miljofordon.se, 2020b).

The environmental effects of Volkswagen Passat GTE are presented in Table 3.1 together with the environmental impacts of the Renault ZOE.

Table 3.1: Environmental impacts of the Renault ZOE and Volkswagen Passat GTE (Miljofordon.se, 2020a; Miljofordon.se, 2020b)

	BEV: Renault ZOE	**PHEV: Volkswagen Passat GTE**
Fuel	Electricity	Primary: Electricity Secondary: Gasoline
CO_2Tailpipe[1]	0 g/km	34 g/km
CO_2ekv. WTW[2]	2 g/km	46 g/km
NO_x	0 g/km	0 g/km when using electric
Particles	0 g/km	0g/km when using electric

[1] Total amount of CO_2 per 100 driven km

[2] Well to Wheel (WTW) which means the fuel's total life cycle, from raw material to combustion of the fuel in the vehicle.

Hydrogen

As stated earlier, hydrogen, together with electricity, could potentially be the only option for having a total reduction of CO_2 in transportation. However, there is also a need for long-term commitment when deciding to change to hydrogen. There is not going to be any significant impact in transforming the energy use in transportation in the short term (Figueroa et al., 2014). In 2014, when Figueroa et al. (2014) performed their study, hydrogen had two to three times longer driving range than BEV had.

In order to use hydrogen as an energy source, it has to be produced since it only exists in chemically bound form. Today, there are a number of ways of producing hydrogen (Shell.com, 2017). However, most of the production processes use fossil energy sources, as shown in Figure 3.1. Only 5% of global hydrogen is produced using electricity. However, the authors that performed this study are assuming an increase in using electricity in the near future. The production process of hydrogen is described in Figure 3.2 (Shell.com, 2017).

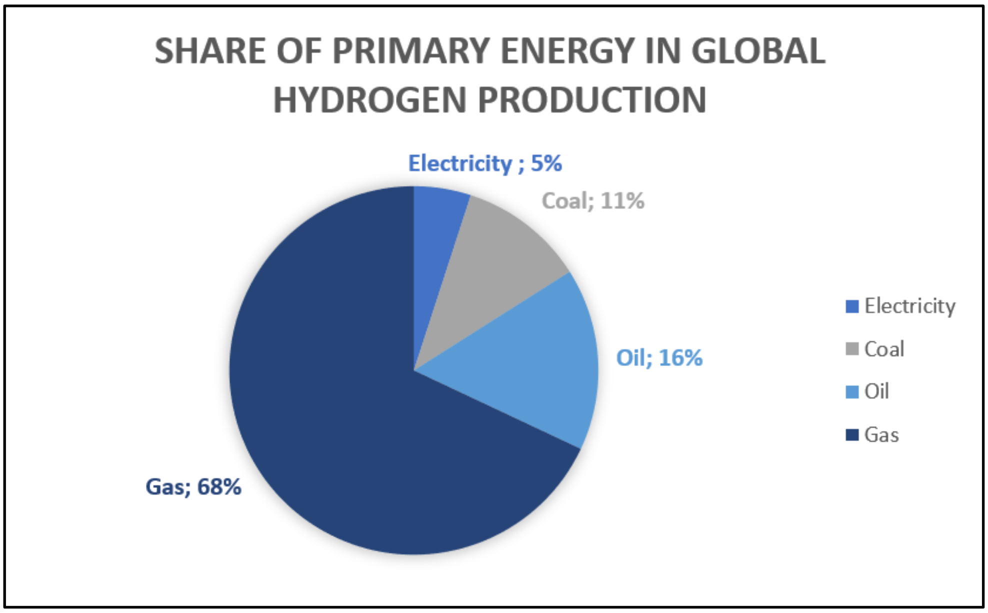

Figure 3.1: Share of primary energy source in the production of hydrogen (Source: Shell.com, 2017)

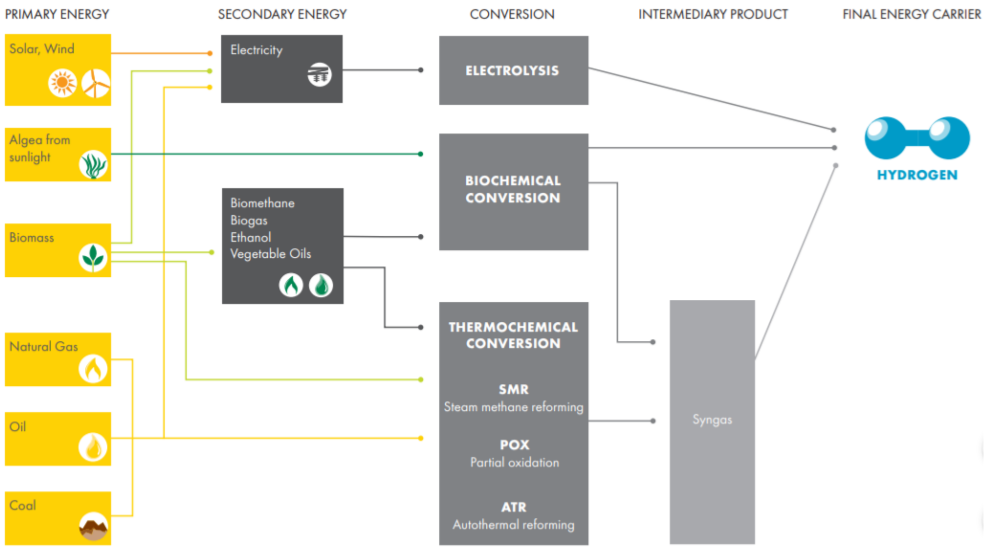

Figure 3.2: Production process of hydrogen (Source: Shell.com, 2017, p.12)

3.6.2. Alternative vehicles: High-capacity vehicles

Unlike many other European countries, it is allowed in Sweden to drive longer and heavier vehicles on the roads and the limit is so far up to 64 tons and 25.25 meters. Even though this is way higher than the other countries' limits (40t and 18.75m), the Swedish government is planning to implement much longer and heavier vehicles, high-capacity vehicles (HCV), soon (Pålsson et al., 2017).

It is agreed that HCVs can provide better transport efficiency and reduce resource consumption in terms of per ton and per ton kilometer, therefore reduced transportation costs. Even though the results can change by the different conditions in the countries, this paper considers Sweden, and it was seen that the increase in weight limit on trucks caused a 20% cost reduction per ton-km in Sweden. The cost reduction only occurs in road transport while rail and sea freight costs remain the same (Pålsson et al., 2017).

The transport mode shifts are not foreseen in the future. The common transport modes in the regions depend on the geographical features, infrastructure, and historical development of the area. It is not easy to make big investments to create energy-efficient infrastructure, and it is mostly preferred to make small modifications in the existing ones. Road transport seems like it will continue to be the most common transport mode, in the future (Von der Gracht and Darkow, 2016).

There have been drastic weight reforms in Sweden in the last 90 years and in 1990, the weight limit was increased to 56t (previously 51.4 since 1974) which caused a modal shift from rail to road. Road transport gained a cost advance on long-distance with increased weight limits which was the strength of railways, before (Pålsson et al., 2017).

When it comes to environmental impact, even though individual HCVs produce more fuel consumption and energy with a greater cost per vehicle kilometer than the traditional trucks, the improved loading capacity has decreased the number of trucks needed on the road. This leads to a reduction in energy consumption and emissions. However, when it is assumed that the trucks will consume fossil-free fuels in the future, the modal shift from sea and rail to road, improved transport volumes and vehicle efficiency will not directly affect the CO_2 emissions (Pålsson et al., 2017).

One consideration about the HCVs is the capacity of the road infrastructure since the roads and bridges are not always able to comply with the weight restrictions. On the other hand, the need for fewer vehicles will lead to less traffic flow and then, the investments for road and rail capacities might be kept on hold (Pålsson et al., 2017).

The analysis shows that longer and heavier vehicles will lead to a reduction in vehicle-kilometers since the same number of products can be carried by a fewer number of trucks. It also leads to a reduction in operation cost per ton-km and this shifts the demand for road transport (Pålsson et al., 2017). According to der Gracht and Darkow (2016), larger transport vehicles can be used against the increasing transport prices and benefit the economies of scale. However, the concern is the infrastructure since the developing countries do not have as advanced ways as the developed countries.

3.6.3. Alternative methods: Lean processes

Some of the consumer goods supply chains generate up to 15% of the total GHG emissions due to transportation during its entire life cycle. Lean processes aim to reduce any kind of waste in the operations in a supply chain (Ugarte, Golden, and Dooley, 2016). Connected to this aim, Ugarte, Golden, and Dooley (2016) investigated the environmental impacts of the lean logistics processes in the supply chain.

There are three lean logistics processes analyzed by Ugarte, Golden, and Dooley (2016) in terms of CO_2 emissions: just-in-time (JIT), product postponement and vendor managed inventory (VMI). The JIT concept aims to pull the products from the upstream to the downstream only in the required quantity, at the required time and place. Product postponement aims to postpone all the product customization activities as much as possible to the downstream to satisfy the high customization requirements. Lastly, VMI is where the suppliers manage the customers' inventory to maintain the inventory levels that satisfy the customer demand (Ugarte, Golden, and Dooley, 2016).

The research shows that JIT inventory is led to produce higher GHG emissions than economic order quantity (EOQ) inventory management, and product postponement and VMI are led to produce lower GHG emissions than EOQ inventory management demand (Ugarte, Golden, and Dooley, 2016).

4. Empirical findings

This chapter provides the empirical findings gathered through the interviews. The chapter starts with explaining the current logistics activities, including the logistics map of The Company and the geographical locations of The Company's facilities and LSPs. Furthermore, it presents the qualitative and quantitative data collected from the interviews and the internet search.

4.1. Current logistics map

The logistics map is investigated and designed together with the supply chain manager and the sustainability & product development manager, see Figure 4.1. All the information provided in this chapter is based on the data obtained from these two managers during the project. The symbols are further explained in Appendix B.

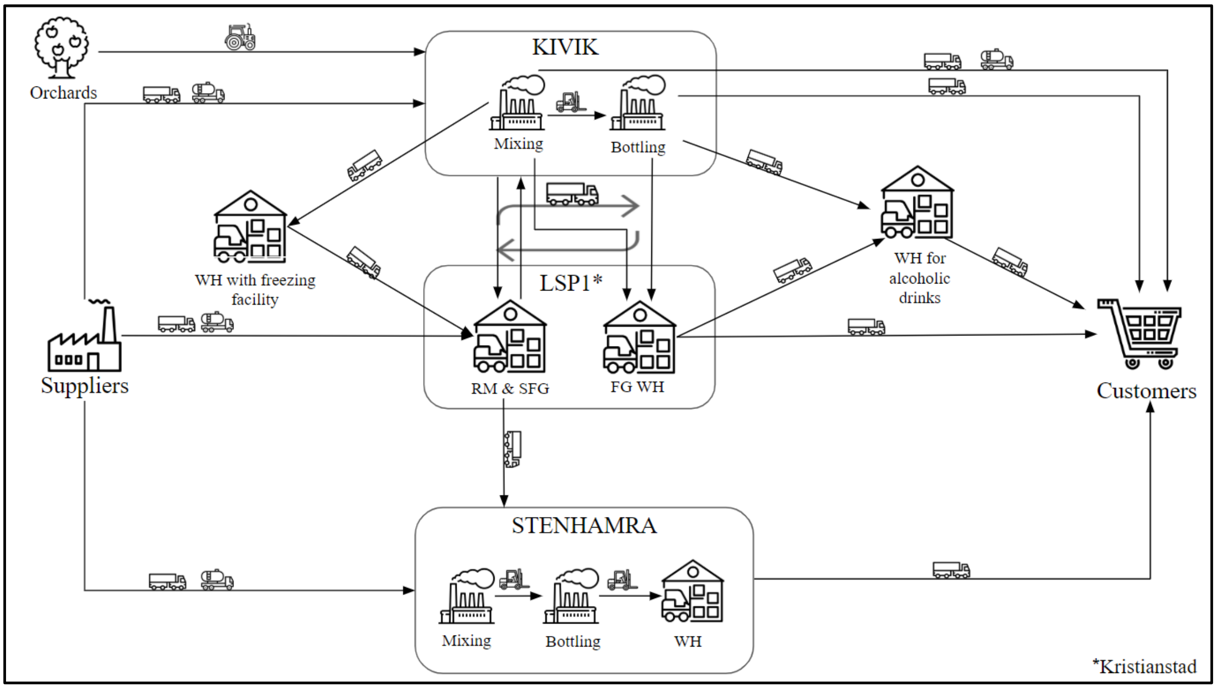

Figure 4.1: Logistics map of The Company

The Company has three facilities, two production plants in Kivik and Stenhamra, and one facility in Lund. There are in total 52-hectares of orchards both in Lund and Kivik which are almost equally distributed between two cities. There are no orchards in Stenhamra. The orchards in Lund mostly harvest and sell apples directly to customers in the south part of Sweden, whilst some is used for production. The fruits that are harvested in Kivik are used to manufacture The Company's products in the production plant in Kivik and Stenhamra. Both in Lund and in Kivik, tractors are used in the orchards to transport the fruits to each facility.

The Company's suppliers are providing other raw materials, such as sugar, juice concentrate, berries, additives, and packaging material for the production. These materials are brought to The Company's central warehouse located in Kristianstad. This central warehouse is handled by a third-party logistics company, LSP1. The transportation is done through trucks (LSP1) or bulk trucks (LSP2) according to the characteristics of the material, i.e. pallets or liquids.

The geographical locations of the facilities and the warehouses are shown in Figure 4.2. The red points show the facilities that belong to The Company, and the black points are the logistics partners.

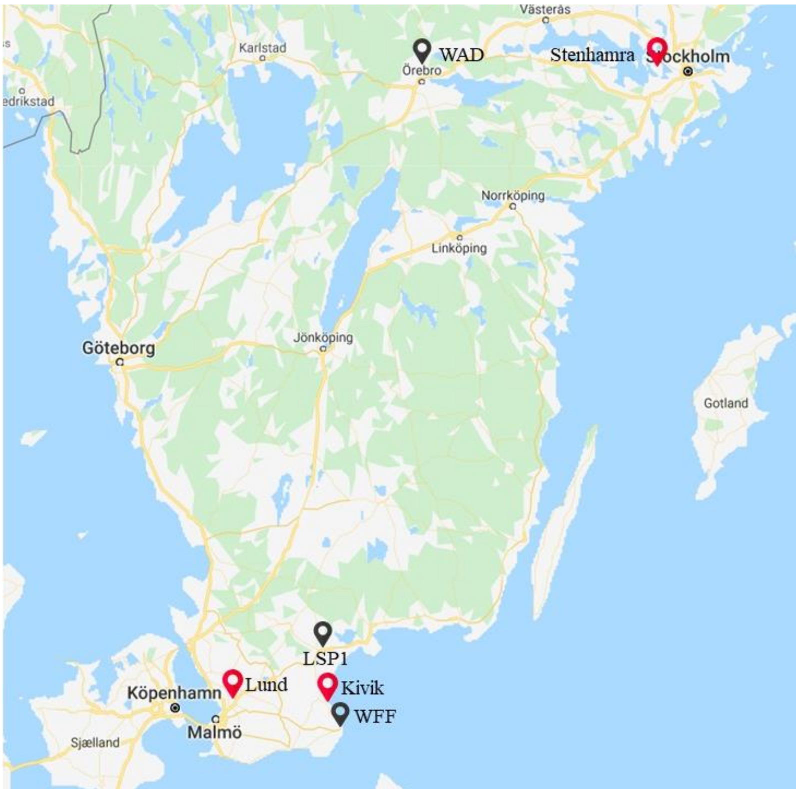

Figure 4.2: Geographical location of The Company's facilities and logistics partners

The production facility in Stenhamra was bought in 2014 and there are only PET and pail products manufactured, whereas all the other products are manufactured in Kivik. The Stenhamra facility has mixing, bottling and warehouse areas where all the transportation between the areas is done by forklifts. The warehouse in Stenhamra is used to store finished products that are directly delivered to the customers by regular trucks. On the other hand, LSP1 still delivers raw materials to Stenhamra from the central warehouse in Kristianstad. One initiative applied in Stenhamra to make the logistics operations more environmentally friendly is to receive the pet bottles flat and then blow out the bottles during the bottling operation.

On the other hand, the facility in Kivik only has mixing and bottling areas. The facility in Kivik only has small warehousing areas for raw material and finished goods, where the material and finished goods are stored only for a short period of time, except for bulk tank. The Company uses its central warehouse in Kristianstad for storing both raw material and finished goods, where the raw materials are transported to Kivik when it is needed, and the finished goods are transported to Kristianstad as soon as they are produced. Therefore, the storing areas in Kivik are small and temporary. All the transportation between the areas in Kivik is done by forklifts and conveyor belts.

For the freshly pressed apple juice, another warehouse with the freezing facility (WFF) is used. This warehouse is located close to Kivik, where the products are delivered by trucks after mixing to get frozen.

The products manufactured in Kivik are usually sent to the central warehouse handled by LSP1 in Kristianstad to be stored, and thereafter the products are delivered to the customers. There are always two trucks shuttling between the warehouse of LSP1 and Kivik in four rounds in a day. In a few cases, the products are delivered directly to the customer from Kivik by LSP1 or LSP2 according to the product characteristics. Then, the products are directly delivered either from mixing or bottling to the customer.

The company also produces alcoholic drinks. These are not allowed to be stored in a regular warehouse, therefore a warehouse for alcoholic drinks (WAD) in Örebro is used to distribute to customers from there by trucks. It is possible to see in the logistics maps that the alcoholic products are also transported to LSP1 (FG WH), before it is transported to WAD. This is sometimes done when there are not full truckloads from Kivik to WAD, to minimize the less than truckload transportation. It is worth mentioning that these alcoholic products are not stored in the FG WH, but only placed in a staging area for an upcoming truck-loading.

All the finished products apart from the ones sent to the customers after mixing in Kivik are delivered to the customers by trucks of LSP1 from Kivik bottling, the warehouse for the alcoholic drinks, the warehouse of LSP1 or Stenhamra warehouse. LSP1 is transporting a total of 30 000 ton per year for The Company, excluding the shuttle operation. These trucks can be loaded with a minimum of one pallet up to 37-39 tons, which is a full truckload.

4.2. Qualitative data

4.2.1. Sustainability perspective of The Company

The Company is located in Kivik, in the southeast of Sweden. The sustainability & product development manager and the supply chain manager state that The Company prioritizes environment and sustainability because of the nature that they are surrounded by in Kivik. For this reason, they have started taking sustainability at the top of the agenda even before it was a trend in the industry.

The Company has started many initiatives regarding environmental sustainability, where one is signing the sustainability manifest that is described in Chapter 3.3.1. in April 2019. They follow all the stages in the manifest and have already completed many of the goals and have a sufficient level of KPIs. In terms of transportation and logistics, the managers describe the efficient packaging methods that they have been using in order to minimize air transportation. Another consideration of The Company is demanding the usage of HVO trucks from the LSPs and suppliers.

The orchards manager at The Company states that they perform activities primarily to be more efficient in the operations in the orchards. For instance, the paths in the orchards are designed to reduce and optimize the driving in the orchards, and this resulted in a decrease in the consumption of diesel in tractors. The orchards manager also stated that the food producers do not earn as much as the downstream actors in the supply chain. Therefore, it is harder for food producers to invest in new vehicles and machines financially.

4.2.2. Initiatives about sustainability in the logistics chain

The Company has been working with LSP1 and LSP2 for the transportation operations for 10-15 years. Further, The Company has been using the central warehouse of LSP1 in Kristianstad for two years. The contracts for the transportations will be renegotiated in the beginning of 2021 with both of the LSPs and they will renew it once in every year or every second year. The supply chain manager at The Company stated that it is not unusual to change the LSPs if they cannot offer the demanded services with a reasonable price or environmental requirements.

The Company has made an agreement with LSP1 specifically to decrease the truck traffic in Kivik and have more convenient routes for the trucks. For this reason, they have been working with LSP1 of which the warehouse is located in Kristianstad. Therefore, many customers can easily pick up their products from the central warehouse since the highway E22 goes through the city. Moreover, LSP1 is also storing the raw materials and the finished goods in the same warehouse, which means that the trucks are always full either with raw materials or finished goods and can shuttle between Kivik and Kristianstad. Through this, they avoid empty trucks and air transfer. These deliveries are referred to as the shuttle and the trucks are driven on 100% HVO.

Currently, LSP1 does not offer The Company 100% fossil-free deliveries. Even though the shuttle uses 100% HVO, the direct deliveries to customers are consuming a mixture of regular diesel and HVO, which is called environmental diesel. The key account manager also states that it is not possible to offer 100% HVO in Sweden right now, since the current production of HVO is not sufficient enough to supply that demand. LSP1 is working on becoming fossil-free as much as possible. However, due to the stated reason, both LSP1 and the other transportations companies in Sweden do not offer 100% HVO to the customers, but only use it for the fixed flows, e.g. the shuttle that drives the same route every day.

LSP1 is working according to the customer preferences and is offering deliveries with that fuel that the customer demands. However, the orders of The Company are not always full truckloads, which requires that different customers’ orders be loaded in the same truck. In this case, the customer preferences of the fuel must be the same, otherwise it is a conflict of who takes the responsibility for the extra cost that for example, HVO causes.

LSP2 has started their own method called The Environmental Steps in 2009, and when they first look at whether they can coordinate transport, optimize route planning, increase fuel efficiency, and finally ensure the usage of as much environmentally friendly fuel as possible. A detail that saves both fuel and money is that they use nitrogen in their tires. As of 2019, LSP2 is affiliated with the Fossil-Free Sweden initiative. Therefore, LSP2 always tries to encourage their customers to choose fossil-free transportation.

As the quality and sustainability manager stated, in early 2019, LSP2 took the initiative to offer customers fossil-free transport. As long as the HVO fuel cost as much as diesel, it was easy to choose fossil-free transportation. LSP2’s fleet consists of vehicles which can run on HVO and in some cases also RME. Following the parliament's decision, described more in 3.6.1. on a reduction obligation for fuel suppliers, demand, and the price of HVO have increased. With today's pressed transport prices, there are no margins for more expensive fuel. However, the manager states that if they share the extra cost with the customer, they both take part in the burden and they can both show that they want to contribute to a better climate.

The price for HVO fuel is 4-6% higher than the regular diesel. Therefore, customers do not prefer this option. In 2019, LSP2 tried to encourage customers to use HVO. However, the customers were not interested since it was going to cause an increase of 1-1,5% in total transportation costs. Anyways, LSP2 aims to have 75% HVO transportation by the end of 2022.

LSP2 has different KPIs to measure environmental sustainability for transport such as fuel consumption, fuel mix X% diesel and X% fossil-free fuel, driving behavior, and energy consumption. They also have chosen to offset their CO_2 emissions for offices, workshops, and counters.

The quality and sustainability manager of LSP2 states that the drivers have been doing eco-driving for a long time and today they are measuring each driver's driving behavior and consumption. The driving behavior is measured using a system that gives a score for each driver's behavior. It gives scores according to how many panic breaks are detected per 100 km, and the percentage distance that the driver is coasting.

Both LSPs stated that it is sometimes possible to drive a truck with 100% RME. However, the engine capabilities and the performance of the trucks decrease when driving on RME, and it requires four times as often maintenance. Therefore, it is not a common alternative even though it is a cheaper biofuel, see Figure 4.9.

4.3. Quantitative data

4.3.1. Leasing cars

Emissions of cars

Today, there are in total 31 leasing personal cars and two commercial vans dedicated to The Company. Out of 31, only two cars are PHEVs, one car consumes gasoline and the other cars consume diesel. The two commercial vans also consume diesel. The following figures show the distribution of CO_2, CO, NO_x, THC, particles and NMHC emissions of the personal cars, respectively (See Figure 4.3, Figure 4.4, Figure 4.5Figure 4.6, Figure 4.7Figure 4.8). This data is gathered through the Swedish Transport Agency (Transportstyrelsen), where the information can be collected through each car's registration number.

It is worth mentioning that the information given on the Swedish Transport Agency is limited, which means that the same information is not presented for all the vehicles. Some data are missing, and therefore not presented in the following graphs.

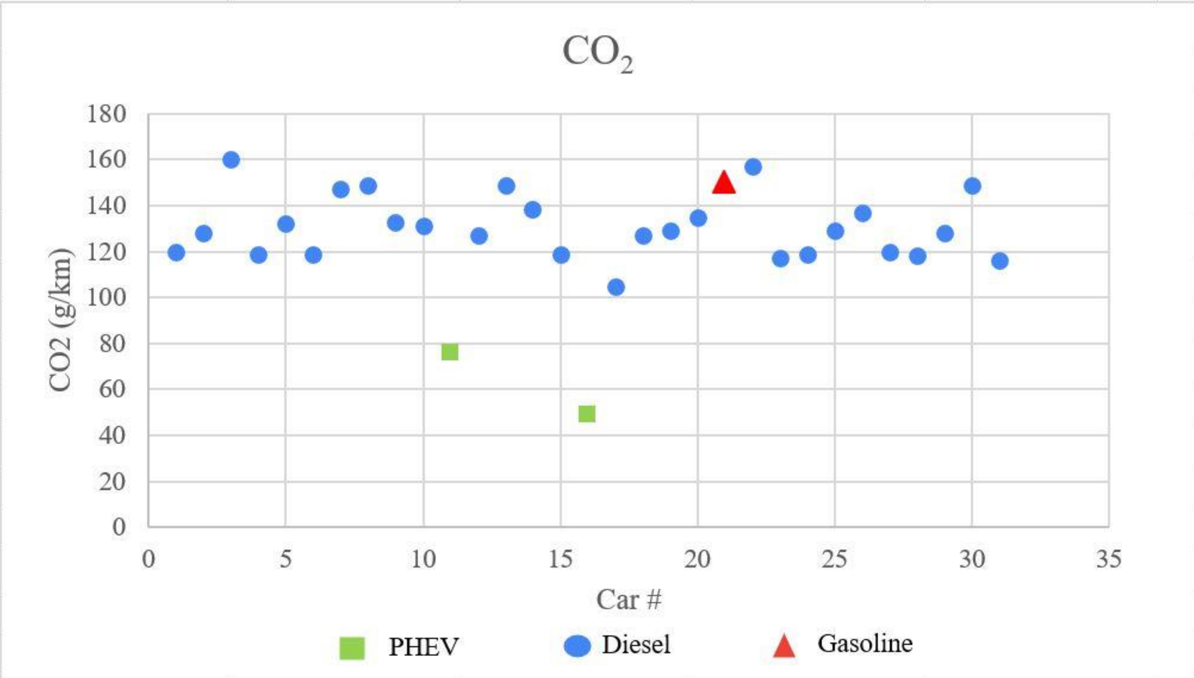

Figure 4.3: CO_2 emissions of leasing personal cars

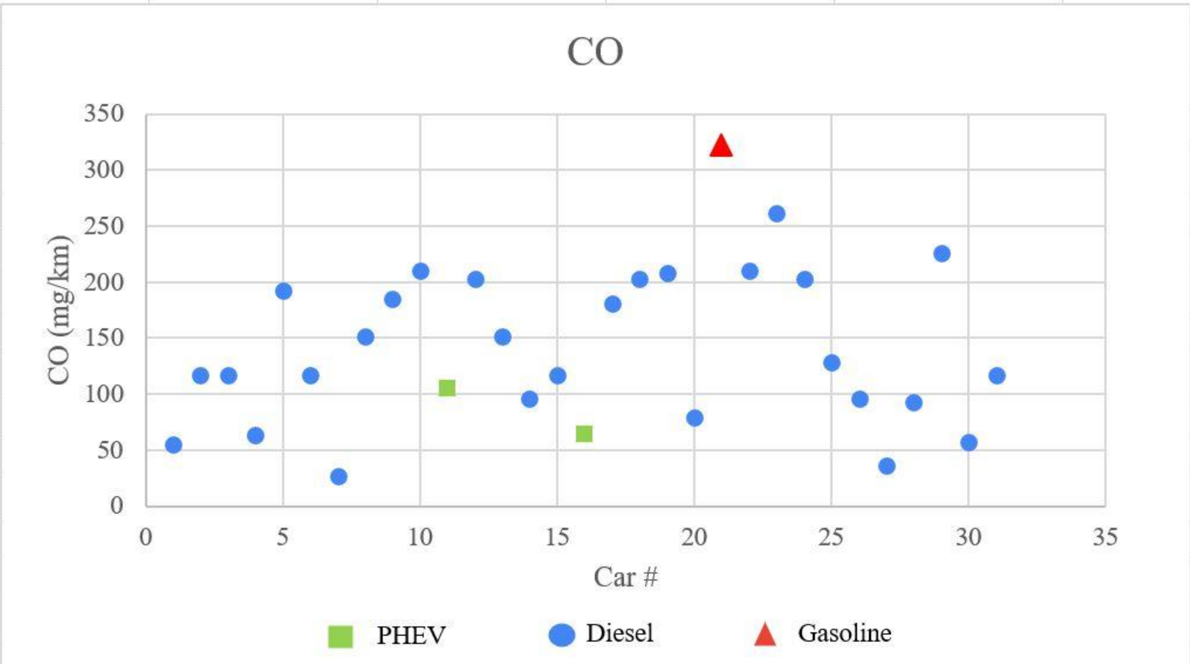

Figure 4.4: CO emissions of leasing personal cars

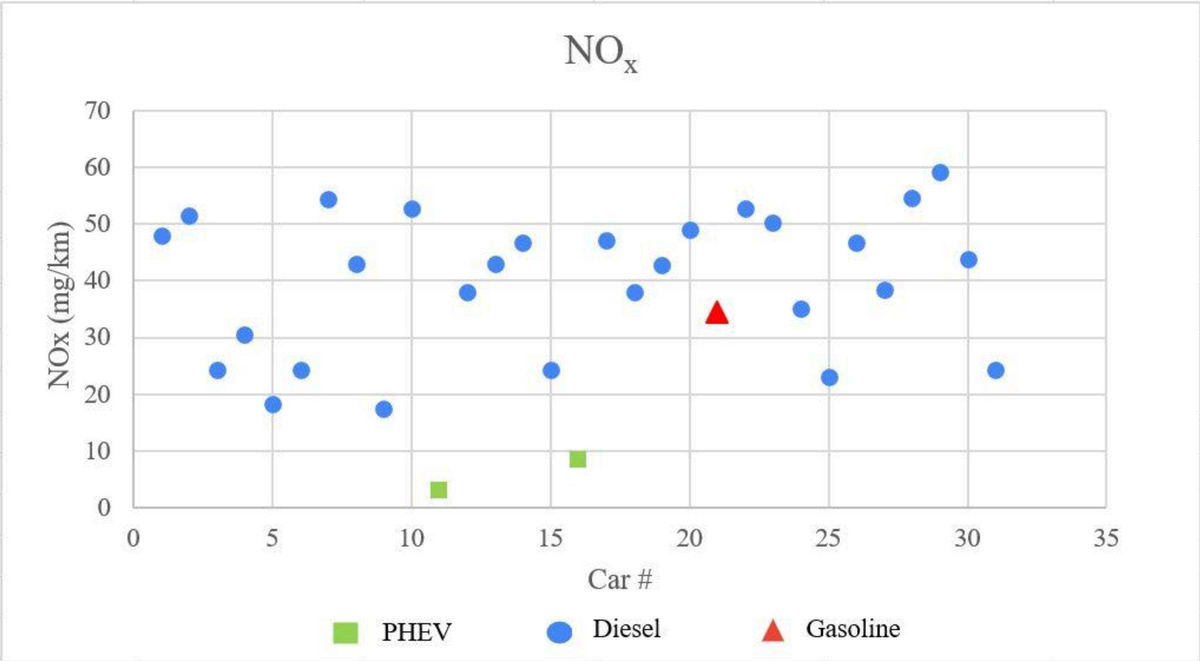

Figure 4.5: NO_x emissions of leasing personal cars

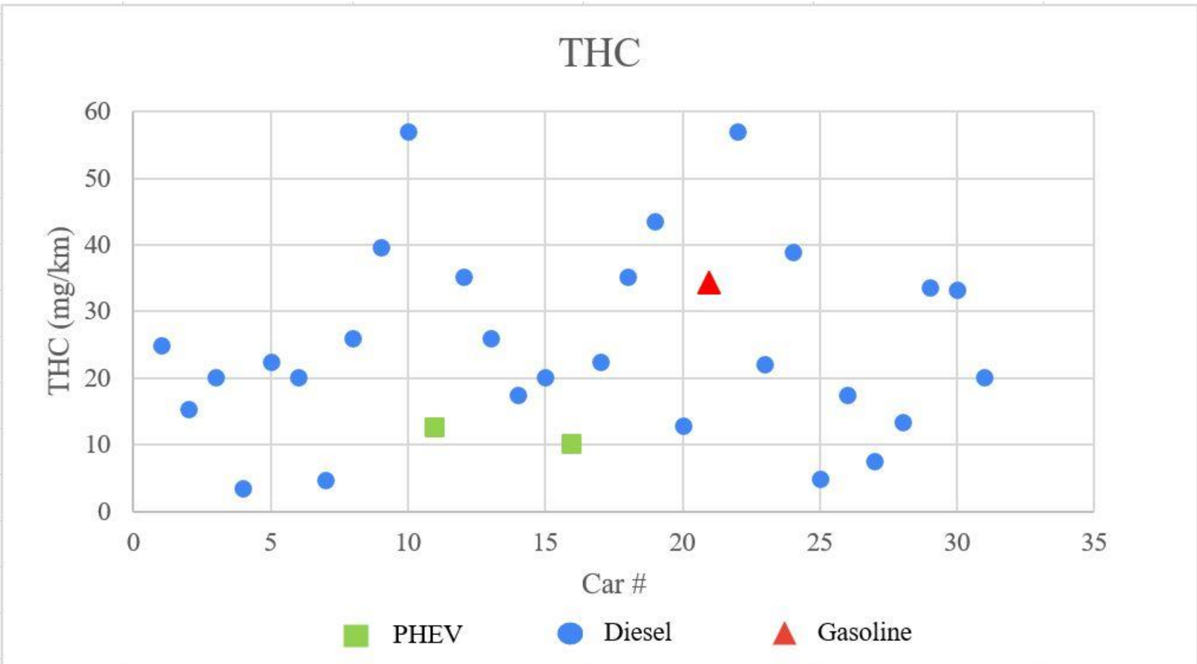

Figure 4.6: THC emissions of leasing personal cars

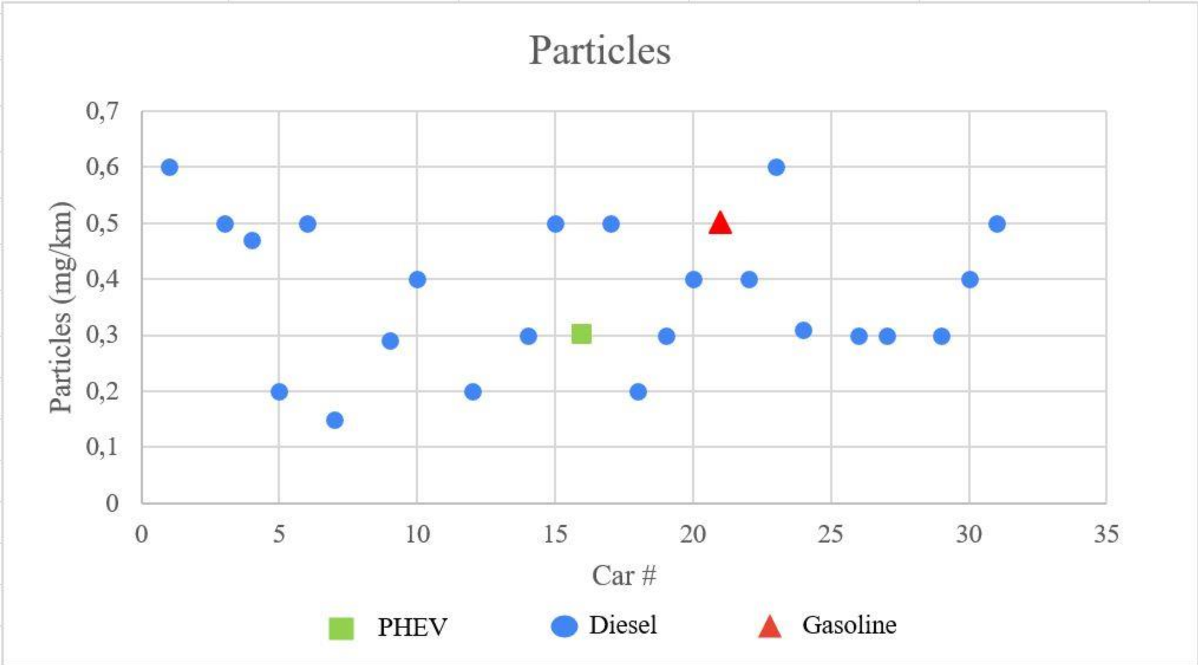

Figure 4.7: Particle emissions of leasing personal cars

As seen in Figure 4.8, NMHC emissions are only presented for the gasoline and electric hybrid cars which consume gasoline as the secondary fuel.

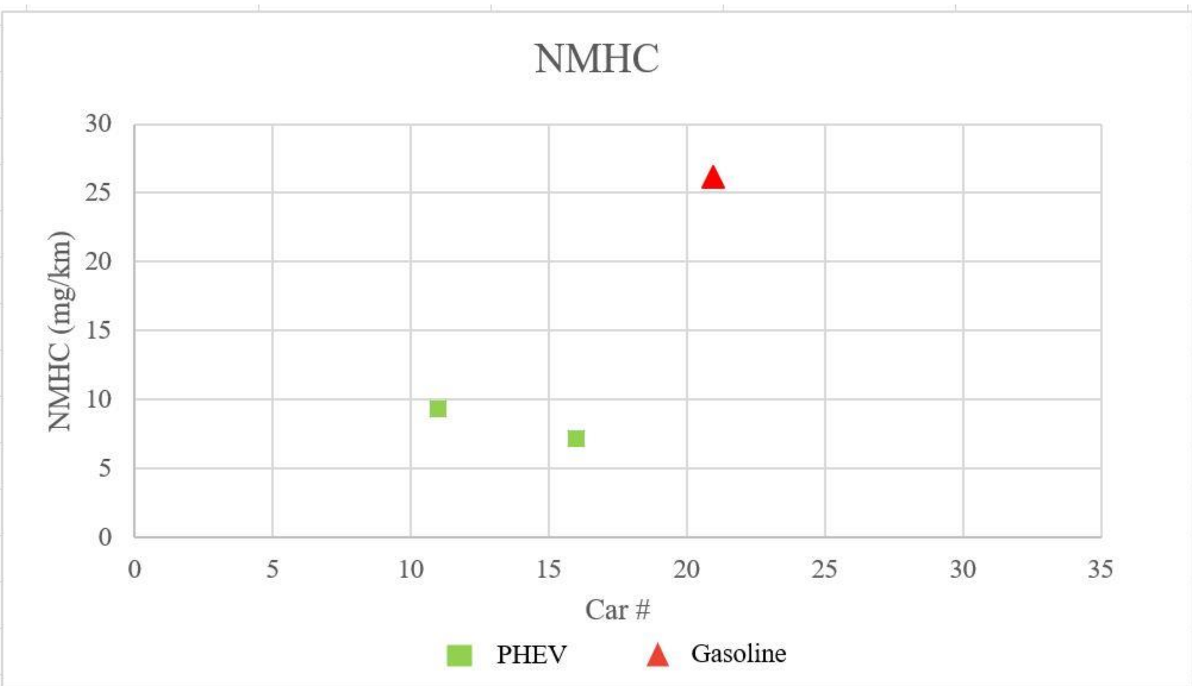

Figure 4.8: NMHC emissions of leasing personal cars

Other than the personal cars, there are two commercial vans used in Lund and Kivik. The emission scores of the vans are shown on Table 4.1.

Table 4.1: Emission scores of the commercial vans

Car type	Fuel	Fuel consumption (l/100km)	CO_2 (g/km)	CO (mg/km)	NO_x (mg/km)	THC (mg/km)	Particles (mg/km)
Commercial van 1	Diesel	7,6	199	261,5	205,3	33,9	0,9
Commercial van 2	Diesel	4,5	118	199,9	193,2	18,2	0,3

Cost for leasing cars

Total cost of the leasing cars was 1 904 371 SEK in 2019. It is thus interest + depreciation. The average costs per car is then calculated by dividing the total cost with the total number of leased cars. However, the total number of leased cars is different throughout the year. and this number could become misleading as some cars were only paid a few months in 2019. Therefore, an average of how many cars have been leased is presented as 35 for 2019. However, the emissions presented above include 31 cars which was the current number of cars when data was collected for this project (March 2020). Then the cost was calculated as 54 411 SEK per month and 4 534 SEK per car and month. The costs are presented in Table 4.2.

Table 4.2: Costs for leasing cars in SEK

	Current cost (SEK)
Total cost for leasing cars	1 904 371
Average cost/car	54 411
Average cost/car/month	4 534

4.3.2. Tractors

There are in total eight diesel tractors in Lund and Kivik, as presented in Table 4.3. However, one of the tractors in Kivik, that is marked as *Out of use* in Table 4.3 is only used for commercial reasons as a part of presenting visitors the company history and is therefore never used in the orchards.

Table 4.3: Tractors in Kivik and Lund

Tractor	Fuel	Manufacturing year
Lund 1	Diesel	1996
Lund 2	Diesel	2012
Lund 3	Diesel	2005
Lund 4	Diesel	1988
Kivik 1	Diesel	2009
Kivik 2	Diesel *(Out of use)*	1960
Kivik 3	Diesel	1978
Kivik 4	Diesel	2017

During the study, it was not possible to reach the emission scores of all the tractors. However, the authors have obtained the data for one of the tractors and based on this data, the assumption is made that the data can be generalized for all the tractors since they are used for the same purpose and are performing similarly. The emission scores that is presented in Table 4.4, are obtained from the Swedish Transportation Agency's website using the tractor's registration number.

Table 4.4: Emission scores of tractors

	CO (g/kWh)	NO_x (g/kWh)	HC/THC (g/kWh)	Particles (g/kWh)
Tractor	0,786	3,013	0,128	0,0159

4.3.3. Forklifts

There are in total 22 forklifts in Kivik, 15 in Stenhamra and 4 in Lund, as presented in Table 4.5. Out of 22 forklifts in Kivik only one forklift consumes diesel and it is used outdoors, and out of 15 forklifts in Stenhamra only one is an LPG forklift. All the other forklifts used in the three facilities are run by electricity.

Table 4.5: Forklifts in Kivik, Stenhamra and Lund

Location/Fuel	Kivik	Stenhamra	Lund
Diesel	1		
LPG		1	
Electric	21	14	4

The warehouse manager stated during the interview that the diesel forklift in Kivik is used outdoors and it is not preferred to use an electric forklift because the diesel forklift performs better and it can handle uphill in the facility, differently from the electric forklifts. The LPG forklift in Stenhamra is also used outdoors, and the authors of this paper assume that the reason for using an LPG forklift rather than electric forklift is again the better performance of the LPG forklift.

4.3.4. Trucks

LSP2 uses diesel, HVO and RME for their transportations. In the first half of 2018, they used 100% HVO within Sweden, and for international transportations, they used 7% RME and 93% diesel fuel. In the second half of the year, they converted to 42% biofuels (5% RME and 37% HVO) and 58% diesel within Sweden. The change in fuel blending in Sweden was due to a change in government-decision that it is not allowed to use 100% HVO. For international deliveries, they kept a 7% RME mixture. Similarly, as stated in 4.2.2, LSP1 also offers biofuel mixture in transportations, but always uses 100% HVO for the shuttle trucks between Kristianstad and Kivik.

There are emission standards for heavy vehicles defined by the European Union, and the emission values are obtained from both LSP1 and LSP2 as stated in Table 4.6 and Table 4.7. The standards are presented in two separate tables, since the values are different due to the different units of measurement used by the LSPs. However, there is no specific mathematical connection between the measurement units in Table 4.6 and Table 4.7. The fleets of LSP1 and LSP2 only consist of Euro5 and Euro6 class of vehicles.

Table 4.6: Emission standards for heavy vehicles, obtained from LSP1

Euro type	NO_x (g/kWh)	CO (g/kWh)	HC (g/kWh)	PM (g/kWh)
Euro1	8	4,5	1,1	0,36
Euro2	7	4	1,1	0,15
Euro3	5	2,1	0,66	0,1
Euro4	3,5	1,5	0,46	0,02
Euro5	2	1,5	0,46	0,02
Euro6	0,4	1,5	0,13	0,01

Table 4.7: Emission standards for heavy vehicles, obtained from LSP2

Euro type	NO_x (g/l)	CO (g/l)	HC (g/l)	PM (g/l)
Euro1	26	3	1,4	0,5
Euro2	22	2,6	0,9	0,3
Euro3	17	2,3	0,8	0,2
Euro4	13	1	0,04	0,1
Euro5	27	1,2	0,00	0,1
Euro6	0,9	0,13	0,06	0,01

Table 4.8 presents the CO_2ekv emissions of LSP1 which means both $CO_2$and the other GHG included in the total amount of the emissions. The total emissions are for all deliveries that LSP1 is performing, excluding the shuttle transportation.

Table 4.8: Total amount of CO_2ekv per ton and km, gathered from LSP1

	Total	WTW (kg CO_2ekv)
Total emissions		167 294
Fossil kg CO_2ekv per ton	33 449 ton	5,00
Fossil kg CO_2ekv per km	971 510 km	0,17

The fuel consumption for a truck is gathered from LSP2, where the fuel consumption is 0,34 liter/kilometer for international deliveries and 0,36 liter/kilometer for deliveries within Scandinavia. Therefore, the average fuel consumption is 0,35 liter/kilometer. This is also assumed to be equal for LSP1's trucks.

The costs for diesel, HVO and B100 (RME) fuels are presented in Figure 4.9. The costs are an average of the market prices per month gathered from Circle K, starting from March 2019 to February 2020.

The prices are presented in Swedish pennies (öre). However, since these are the market prices, LSPs get a 5% discount on these prices.

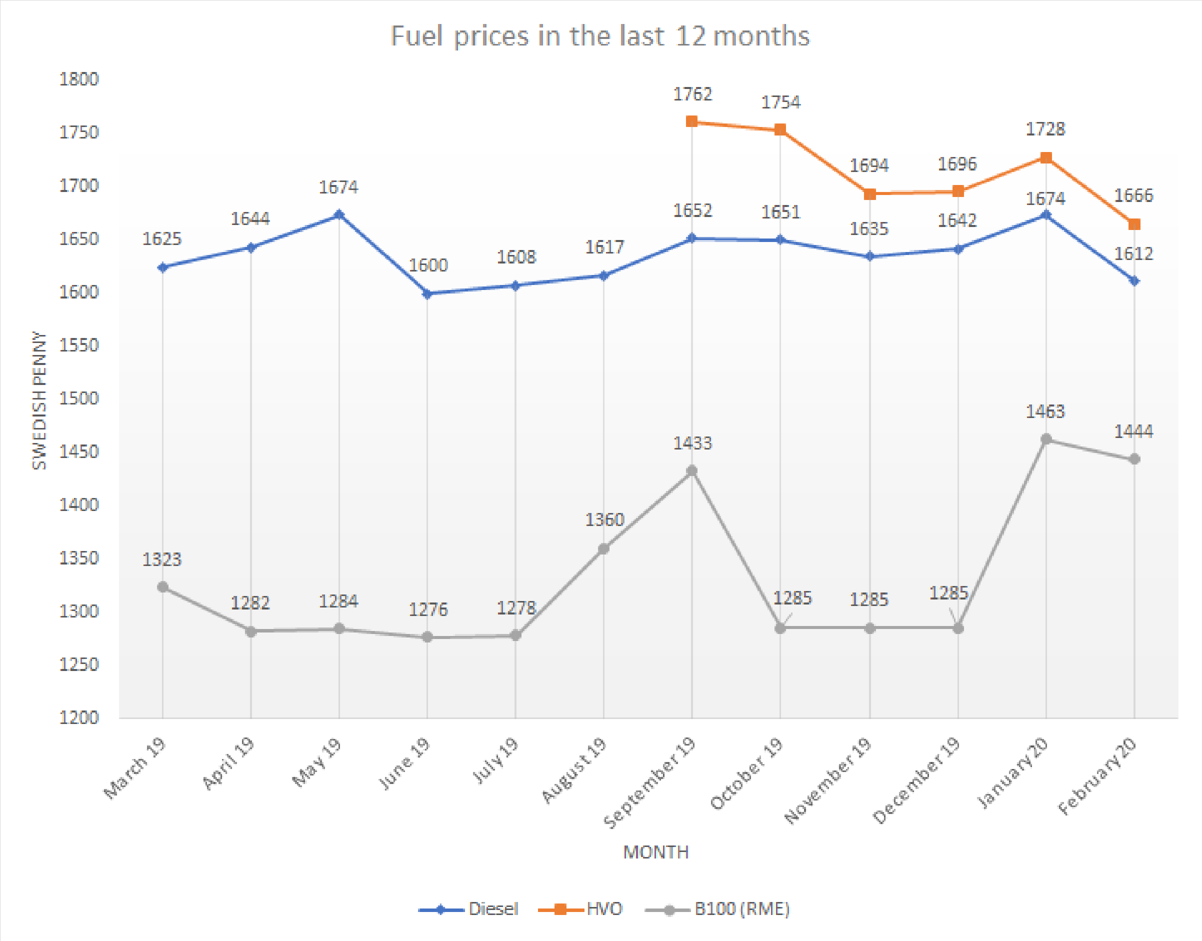

Figure 4.9: Market prices of diesel, HVO100 and B100 (RME)

5. Analysis

This chapter provides an analysis of the empirical data presented in the previous chapter. The empirical data is firstly compared to existing literature, presented in Chapter 3. Furthermore, KPIs are discussed, and improvement areas are defined. Lastly, the analysis is completed with the development of a roadmap for fossil-free transportation by 2030.

5.1. Comparison of literature and empirical data

5.1.1. Supply chain perspective

As Gardner and Cooper (2003) discussed, a supply chain map is useful for deciding the supply chain strategy and if the supply chain actors are aligned with this strategy. Through the logistics map, that is presented in Figure 4.1, it is possible to see the supply chain of the company and how each actor is contributing to the sustainability strategy that they are trying to work with.

In order to become sustainable in a supply chain, companies need to take initiatives other than changing the vehicles and fuels. As discussed in Chapter 3.2.2., there are both short- and long-term initiatives that The Company need to apply in their daily operations. Some of the short-term recommendations that Dey, LaGuardia and Srinivasan (2011) discussed have already been applied by The Company, such as start taking initiatives towards sustainability and analyzing small inefficiencies to improve the operations in terms of sustainability. When it comes to long-term recommendations, The Company has been following the governmental regulations closely. However, there is a lack of KPIs connected to environmentally sustainable logistics operations.

5.1.2. The Company's perspective

The interviewed managers of The Company stated that sustainability has been on top of the agenda even before it was the attention of the industry. It provided them a competitive advantage in the market through being known as an environmentally friendly company, as discussed in Chapter 3.2.3.

The Company has had a focus on sustainability in production, but the transportation operations are a fairly new area of investigation for them. Therefore, there are not any standardized performance measurements defined by The Company for different operations within logistics. As Lee and Wu (2014) argued in Chapter 3.3.2., it is fair not to have well developed environmental KPIs connected to logistics activities since it has been a recent focus of the industry. In order for The Company to become more environmentally sustainable, they need to find efficient KPIs to measure the performance.

As described by Lumsden (2007) in Chapter 3.5.1., CO_2, particles, NO_x, and HC are the main parameters that need to be considered for environmental sustainability in transportation. For this reason, the empirical data provides the GHG emissions of trucks, personal cars, and tractors.

The Company uses different solutions in different operations in transportation and logistics. They mainly use electric forklifts and a few electric-hybrid cars, but they still have diesel or gasoline solutions for the other parts of the operations. One reason for this is that the electric vehicles (trucks and tractors) are not so common in the industry and the technology is not well developed for electric tractors and trucks. This will be analyzed further below.

Using hydrogen as a fossil-free alternative is not further discussed in detailed in this paper since the production of hydrogen is still highly dependent on fossil fuels, as described in Chapter 3.6.1. Also, it is not a common alternative as a fossil-free fuel in today's industry.

Leasing cars

It is important to understand the background of reality while considering changing to electric vehicles. Converting to electric vehicles to become fossil-free is not enough since the entire life cycle of the fuel needs to be considered. As discussed in Chapter 3.6.1., it is also critical how electricity is produced in the country. Figueroa et al. (2014) stated in the related chapter that Sweden has the aim of producing electricity through 100% renewable energy by 2040. Therefore, the electric consumption in vehicles can only be fossil-free by then.

Tractors

The empirical data shows the emissions of average tractors used at The Company. Today, electric tractors are not used in the industry, and it is not possible to drive tractors by 100% biofuels due to the performance issues. As the orchards manager stated in Chapter 4.2.1, the food manufacturers do not earn as much, and it is still a big investment for The Company to change to more environmentally friendly tractors that consume less fuels and discharge less GHG emissions. In case of such an investment in the future, The Company should also ensure the performance of the tractors.

Forklifts

As stated in Chapter 3.5.3., the discussion of whether LPG or electric forklifts is better from the environmental perspective is still not finalized. There are two contradicting results presented in the stated chapter. However, the authors of this paper believe that the most recent research presents a more credible and updated result. Therefore, it is assumed that electric forklifts are performing better in terms of carbon footprint.

The Company has 41 forklifts in total, of which 39 are electric, one is LPG and one is diesel. The literature does not cover the performance of the diesel or LPG forklift. However, the warehouse manager at The Company stated that the diesel and LPG forklifts are driven outdoors and the reason for using these forklifts is that they perform better than the electric forklifts. This does not change the fact that the forklifts still need to be changed to electric ones in order to become fossil-free in the warehousing operations. Therefore, the only change that needs to be done in the warehouse and production facility is changing these two forklifts to electric forklifts. However, the performance of the electric forklifts is not sufficient to be driven outside. This means that there is no motivation for investing in electric forklifts for outside usage at the moment. This is rather an investment for the future when the performance for electric forklifts is adequate to be used outside.

5.1.3. LSPs' perspective

Fuels

The total cost of transportation increases in the case of using eco-friendly fuels such as HVO. The literature provided in Chapter 3.4.2. supports the information gathered from the quality and sustainability manager at LSP2 with his point of customer preferring fossil fuels since it is more cost-efficient. Even though customers demand eco-friendly options, it is still not the priority of the customers, at the moment.

One initiative that LSP2 is offering is sharing the extra costs of fossil-free fuel in order to encourage the customers to choose fossil-free alternatives. This can be a way of guaranteeing long-term relationships between The Company and LSP2 as discussed in Chapter 3.4.2. Unlike LSP2, the key account manager of LSP1 stated that they have not discussed sharing responsibility for the extra cost. Nevertheless, since LSP2 managed to have this as an initiative, LSP1 should also consider this to encourage the customers to choose fossil-free options.

LSP1 uses diesel blended together with biofuel for regular transportation due to the increasing prices of biofuels in the market. On the other hand, The Company prefers 100% HVO for the shuttle operations between Kristianstad and Kivik as stated in Chapter 4.2.2., since this is a more environmentally friendly option.

LSP2 provided 100% HVO to The Company in the first half of 2018 for the transportations within Sweden. However, after the parliament regulation mentioned in Chapter 3.6.1., The Company started using a mixture of diesel and biofuels to balance the cost of transportation since the price of HVO has increased after the regulation of reduction duty.

Weight restrictions
As stated in Chapter 3.6.2., Sweden has different weight limits than the rest of Europe, and it is possible to load a truck up to 64 tons. However, as it is understood from the interview with the key account manager at LSP1, this is not a common application in the country, and LSP1 has still maximum weight limits as 37-39 tons per truck. Since utilizing higher truck capacities will allow companies to reduce the number of trucks on the road, it is an opportunity to decrease the total emissions. Therefore, this application in Sweden can be considered to be implemented by LSP1. However, it must also be considered that there are cases that LSP1 is transporting less than truckloads for The Company, as well. Moreover, the weight restriction is not considered for LSP2 since it transfers liquid and bulk products.

5.2. Identification and suggestions for improvement areas for fossil-free transportation

5.2.1. Leasing cars

The Company must aim to have a fleet of 100% BEVs by 2030. However, by then, it might be possible to change to PHEVs first in order to reduce the environmental impact of the personal cars, before changing to BEVs. The reason is that the energy sources for producing electricity are not totally renewable today, therefore PHEVs are better in terms of driving performance i.e. driving distance.

Currently, The Company has cars with fossil fuels and PHEVs. It is seen in Figure 5.1 and Figure 5.2 that the PHEVs perform better in terms of fuel consumption and GHG emissions, compared to fossil-fueled cars. Therefore, The Company should replace the fossil-fueled cars with the PHEVs to reduce the GHG drastically. Even though this provides an important reduction in the emission, it is still not fossil-free. Therefore, The Company should keep track of the development of the performance of BEVs.

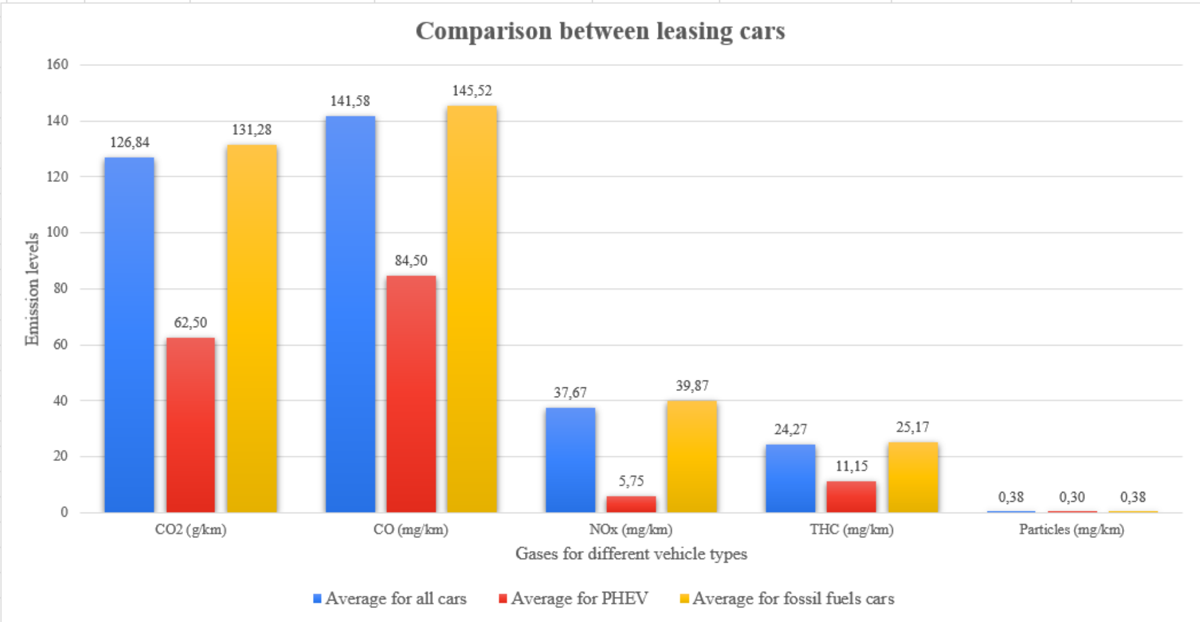

Figure 5.1: GHG emissions of different types of leasing cars

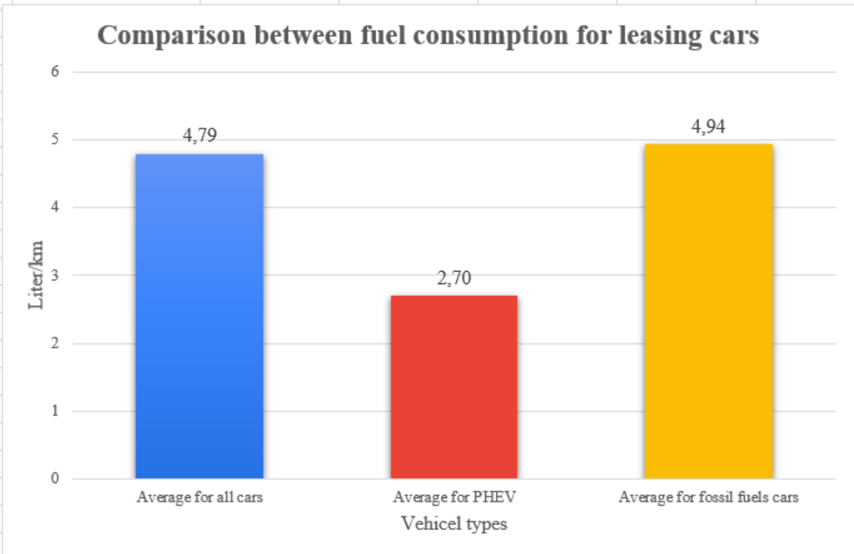

Figure 5.2: Average fuel consumptions of different types of leasing cars

Apart from the fuel consumptions of different types of cars, the leasing costs of the cars are also compared and shown in Table 5.1. The comparison includes the current leasing cars of The Company, which currently is based on 35 cars. The current leasing cars are compared to the most purchased BEV in Sweden today (Renault Zoe), and a PHEV (Toyota Corolla) that one employee at The Company uses today. These two cars are in the same price range, where the Renault Zoe has a market price of 286 990 SEK, and the Toyota Corolla has a market price of 264 900 SEK (Toyota Sverige, 2020). Therefore, it is fair to use these in the analysis, instead of the Volkswagen Passat GTE that was presented in Chapter 3.6.1. which is the most bought PHEV, but also in a higher price class of 454 900 SEK .

The conditions for the leasing of PHEV and BEV are kept as the same in the comparison in Table 5.1. Therefore, the leasing period is 36 months, and based on the assumption that the driving range is 15 000 km per year and including winter tires, for both of the options. The total costs later are calculated in the same way with the current total cost which is based on 35 cars. It is worth mentioning that the comparison is based on the private leasing prices for the PHEV and BEV, and it is assumed that there is a discount in corporate leasing.

The average cost/car/month is obtained from each car's manufacturer's website as 3 648 SEK for Toyota Corolla (PHEV), and 3 976 SEK for Renault Zoe (BEV) (Toyota Sverige, 2020; Renault, 2020). Later, the average cost/car is calculated by multiplying the monthly cost by 12, and the total cost is calculated by multiplying the annual cost by 35 which is assumed as the number of leasing cars.

Table 5.1: Cost comparison for different types of personal cars

Car type	PHEV	BEV	Current
Total cost for leasing cars (SEK)	1 532 160	1 669 920	1 904 371
Average cost/car (SEK)	43 776	47 712	54 411
Average cost/car/month (SEK)	3 648	3 976	4 534

As seen in Table 5.1, both PHEV and BEV are economically better options than the current spending on the personal cars. By leasing PHEVs, The Company can save almost 20%, and by leasing BEVs, the savings will be around 12% compared to the current leasing prices.

5.2.2. Trucks

The Company does not buy 100% biofuel transportation from either of the LSPs even though both can provide this service. According to the data provided by LSP2, described in Chapter 4.2.2., transportation with 100% biofuel is 1-1.5% higher cost. Since this is based on the fuel market facts, it is assumed that the price will be in the same level for LSP1, as well. It is assumed that The Company does not purchase 100% biofuel transportation from LSP2 because of the higher cost. However, this is not the only reason for LSP1. As the key account manager of LSP1 explained, the deliveries of the different customers are loaded in the same truck, and this causes a conflict of the liability of the fuel price in case The Company demands 100% biofuel.

LSP2 also has an aim of becoming fossil-free. Therefore, they consider offering to share the extra cost of the transportation for having 100% HVO. The Company and LSP2 should consider collaborating for the extra cost of the transportation which can also create a good partnership and long-term relationship between the companies.

LSP1 should offer 100% biofuel for the full truckloads to The Company's customers. However, it will be harder for the less than truckload deliveries, that are loaded together with other company's products. However, since more companies are demanding fossil-free deliveries today, it is likely that LSP1's other customers will start demanding transportations that is not using fossil fuel in the near future. Then, it will be possible to start using HVO for trucks that are loaded together with the orders of different customers.

As stated in Chapter 4.2.2, The Company is going to renew the contract with the LSPs in the beginning of 2021. Then, they will have a chance to negotiate the fuels and cost increases for changing to transportations with fossil-free fuel. Since both LSP1 and LSP2 stated that they can offer fossil-free transportation, they have the competence to satisfy the demand, and it is not a new area of investigation for them. However, if the LSPs cannot satisfy the demand of offering fossil-free deliveries, The Company should consider changing the LSPs in the future. Supported by Kellner and Igl (2015), when sustainability is the primary focus of The Company, LSPs can be chosen according to their performance on emissions and ecological solutions.

5.2.3. Forklifts

As discussed earlier, electric forklifts do not perform as well as forklifts driven on diesel and LPG. Therefore, The Company has these two forklifts to be able to transport products outside in the facility, since these can handle the uphill in the plant. Despite that, The Company still needs to replace these with electric forklifts, to be able to fulfil their goal of becoming fossil-free by 2030. Until the technology is advanced enough to change to electric forklifts, it is crucial for The Company to keep track of the optimized routes for the diesel and LPG forklifts, and thereby minimize the GHG emissions.

An analysis considering costs for forklifts is not covered in this chapter, since there are no available alternatives for electric forklifts to be handled outside.

5.2.4. Tractors

As discussed in previous chapters, there are no available electric tractors on the market, yet. On the other hand, another future alternative fuel could be to use 100% biofuels for the tractors. However, the information regarding how the biofuels affect the engine performance for the current tractors is limited. Therefore, this can only be a recommendation for the future. Another alternative for now can be blending biofuels in diesel to reduce the environmental impact of the agricultural activities. However, it is assumed that not all the engines of the current tractors at The Company can handle a mixture since the average age of the tractors are 19 years. Thereby, this needs to be investigated by The Company before any investment or change in the application.

Changing the tractor fleet is a big investment for a company, especially for a food manufacturer company, based on the interview with the orchard manager, described in Chapter 4.2.1. Consequently, it is not possible for The Company to invest in a new tractor fleet that is more environmentally friendly, as soon as a better tractor is launched on the market.

For The Company to reach their goal of having fossil-free transportations, they still need to have tractors driven on electricity or 100% biofuels. For this reason, it is still important to follow the development of electric tractors and tractors that can be driven on 100% biofuels, and continuously being updated about the new technology.

It is worth mentioning that this paper does not propose a route optimization for orchards The Company since it was already stated by the orchards manager in Chapter 4.2.1, that the tractor paths in the orchards are designed to minimize the driving distance.

This chapter does not provide a discussion about the costs of the tractors since there is currently no alternative vehicle for tractors available on the market.

5.3. Identifying environmental KPIs

There are different areas under investigation of this project at The Company. The KPIs that are analyzed in this chapter are related to the warehousing operations, orchard activities and the leasing cars and the commercial vans. When it comes to the LSPs, LSP2 has already set some KPIs and shared it for this project. These KPIs are used as a starting point to determine the KPIs for the LSPs. This chapter also includes a discussion about the further performance measurements for the LSPs.

The aim for the KPIs is to help The Company to become fossil-free in transportation operations by 2030. In today's circumstance, it is not possible to be 100% fossil-free in transportation. However, with KPIs, The Company and the LSPs can assess their current level of environmental sustainability and further investigate how to improve it. Therefore, these KPIs that are stated in this chapter should have a target of 100% fossil-free transportation by 2030 by assuming that the technology will satisfy the conditions by then.

5.3.1. The Company

Leasing cars and commercial vans

The Company must change to electric vehicles by 2030 since this is the only option that is fossil-free. The Company must monitor the change from having fossil-fueled vehicles to electric vehicles both for leasing cars and commercial vans. The KPI is set as *the percentage of electric vehicles in the fleet per year*. The goal is to have 100% electric vehicles by 2030. The KPI is calculated as the following:

$$The\ percentage\ of\ electric\ vehicles\ in\ the\ fleet\ per\ year = \frac{Total\ number\ of\ electric\ vehicles}{Total\ number\ of\ vehicles}$$

Moreover, The Company should assess the total carbon emissions of the vehicles. However, this is not easy for The Company to measure since the leasing cars are used as personal vehicles for the employees. Therefore, The Company should continuously work on reducing the carbon emission of the leasing cars by preferring lower carbon emission cars while leasing new cars in the future. By gathering the CO_2 information from the Swedish Transportation Agency's website for each car that The Company is leasing, an average measurement of CO_2 can be calculated and monitored to ensure that the CO_2 emission is continuously decreased. This KPI is set as the *average carbon emission of the leased vehicles per year*, and be calculated as the following:

$$Average\ carbon\ emission\ of\ the\ leased\ vechicles\ per\ year = \frac{\sum CO2\ emissions\ for\ the\ leased\ vehicles\ per\ year}{Total\ number\ of\ leased\ vehicles}$$

Tractors and forklifts

Both in the orchards and the warehouses, the main KPI that The Company should measure is the *fuel consumption* of the vehicles. With today's technology, it is not possible to change to electric tractors or tractors driven on 100% biofuels, since these are not yet well developed on the market. However, The Company can still keep track of the fuel consumption to ensure that they are not increasing the fuel consumption and continuously working on decreasing the negative effects of diesel fuel. The Company should measure the average fuel consumption per month. However, since it is difficult to measure how many kilometers one tractor is driving per month, the average is calculated through the total purchased diesel per year, using a moving average of 12 months. By doing this, it also eliminates the peaks during the harvesting season, when the tractors are used more often. The calculation method of the KPI is stated below.

$$Average\ purchased\ diesel\ per\ month\ for\ the\ tractors = \frac{\sum Purchased\ diesel\ over\ the\ last\ 12\ months}{12\ months}$$

The Company should also investigate whether the engines of the existing tractors can handle a certain percentage of biofuels blended with diesel. In case it is possible, they should also measure the fossil-free fuel percentage to further decrease the effects of the fossil fuels for the total number of tractors. The calculation method of the KPI is stated below.

$$Annual\ fossil\ free\ fuel\ percentage = \left(\frac{Total\ fossil\ free\ fuel\ in\ liter}{Total\ fuel\ in\ liter}\right)^{*}$$

** Used for the entire fleet per year*

When it comes to warehousing operations, the electric forklifts are not performing as well as the diesel forklifts uphill, as stated before. Therefore, it is important for The Company to ensure that they are not increasing the fuel consumption and continuously working on decreasing the negative effects of fossil fuels, as for tractors. It is assumed that there are peaks in warehousing operations, even though they do not fluctuate as much as for agricultural operations. However, to avoid the peaks, the KPI is set on an average value and is calculated using a moving average of 12 months. The KPI is calculated as follows:

$$Average\ purchased\ fossil\ fuel\ per\ month\ for\ forklifts = \left(\frac{\sum Purchased\ fossil\ fuel\ over\ the\ last\ 12\ months}{12\ months}\right)^{*}$$

**To be separately calculated for LPG and diesel*

The KPI discussed for leasing cars regarding the total carbon emissions should also be used for forklifts and tractors to assess their average carbon emissions. However, it is not possible to obtain the data regarding the carbon emissions of all the tractors and forklifts since the data are not provided on the Swedish Transportation Agency's website or by the producers. For this reason, no KPI of average carbon emissions for forklifts or tractors are determined in this paper.

5.3.2. Logistics service providers

As described in Chapter 4.2.2., LSP2 has different KPIs to measure environmental sustainability for transport, such as:

- Fuel mix of X% diesel and X% fossil-free fuel
- Fuel consumption
- Driving behavior

The information regarding the KPIs for sustainability has not been covered during the interview with the key account manager at LSP1. Therefore, the stated KPIs above are discussed for both of the LSPs.

The mentioned KPIs are divided into two groups as primary and secondary, according to the relevance of the purpose of the project. The primary KPI is the fuel mix X% diesel and X% fossil-free fuel which is directly linked to the goal of fossil-free transportation. Whereas the secondary KPIs help with assessing the current sustainability, but not supporting the ultimate goal of becoming fossil-free by 2030.

Today, LSP2 measures the fuel mixture per truck. However, it is believed that it is more important to measure based on overall transportation to understand the fuel consumption for the deliveries of The Company. Thereby, it is possible to get an overview of how much fossil-free fuel is used compared to diesel. The *fossil-free fuel percentage* can be measured as follows, and the target for this KPI is to achieve 100% by 2030.

$$Annual\ fossil\ free\ fuel\ percentage = \left(\frac{Total\ fossil\ free\ fuel\ in\ liter}{Total\ fuel\ used\ in\ liter}\right)^{*}$$

** Used for the entire fleet per year*

The secondary KPIs focus on reducing the environmental impact by efficient fuel consumption and driving behavior rather than serving the purpose of becoming fossil-free. These two KPIs can be measured to keep track of the improvement and ensure that these are continuously improved. Both KPIs are important to measure while using diesel and HVO for different reasons. When diesel is used, it is significant to keep track of the fuel consumption and driving behavior from an environmental point of view. The driving behavior and the fuel consumption are highly connected since poor driving behavior causes an increase in fuel consumption as well as in GHG emission.

On the other hand, when HVO is used, these two KPIs are important from an economical perspective. Because HVO is more expensive than diesel as shown in Figure 4.9, and poor driving behavior again causes inefficient consumption of fuel and this will increase the total transportation cost. However, these two KPIs are not further analyzed since they are not the primary focus.

Lastly, both of the LSPs are assessing the *total carbon footprint* by measuring the CO_2 emissions of their transportation per km and ton. The results of the carbon footprint of LSP1 is provided in Table 4.8. It is known that LSP2 also keeps track of the data, but it is not provided for this project. The carbon footprint will decrease with the usage of HVO rather than diesel. Table 5.2 summarizes the KPIs discussed in this chapter.

Table 5.2: Summary of the discussed KPIs

	Vehicle	KPI	KPI calculation
The Company	Leasing vehicles	Percentage of electric vehicles in the fleet per year	$\frac{Total\ number\ of\ electric\ vehicles}{Total\ number\ of\ vehicles}$
	Leasing vehicles	Average carbon emission of the leased vehicles per year	$\frac{\sum CO2\ emissions\ for\ the\ leased\ cars\ per\ year}{Total\ number\ of\ leased\ cars}$
	Tractors	Average purchased diesel per month	$\frac{\sum Purchased\ diesel\ over\ the\ last\ 12\ months}{12\ months}$
	Tractors	Annual fossil-free fuel percentage	$\left(\frac{Total\ fossil\ free\ fuel\ in\ liter}{Total\ fuel\ in\ liter}\right)^{*}$ **Used for the entire fleet per year*
	Forklifts	Average purchased fossil fuel per month per forklift	$\left(\frac{\sum Purchased\ fossil\ fuel\ over\ the\ last\ 12\ months}{12\ months}\right)^{*}$ **To be separately calculated for LPG and diesel*
Logistics service providers	Trucks	Annual fossil - free fuel percentage	$\left(\frac{Total\ fossil\ free\ fuel\ in\ liter}{Total\ fuel\ used\ in\ liter}\right)^{*}$ ** Used for the entire fleet per year*
	Trucks	Fuel mix of X% diesel and X% fossil-free fuel	
	Trucks	Fuel consumption	
	Trucks	Driving behavior	
	Trucks	Total carbon footprint per ton	
	Trucks	Total carbon footprint per km	

5.4. Development of a roadmap for fossil-free transportation

To help The Company reach their goal of becoming fossil-free in transportation operations by 2030, a roadmap is developed based on the empirical data and the analysis. The roadmap covers the necessary activities, goals, and market analysis. The roadmap includes proposals about leasing vehicles, trucks, forklifts, and tractors for a time period of 10 years from 2020 to 2030. The roadmap will be the recommended tool for The Company with the purpose of reaching the goal and obeying the sustainability manifest. The milestones are spread over 10 years to not have all the investments and activities towards the end of the period and to be able to make the financial plans in a predictable manner.

First of all, The Company needs to kick off the change project to involve both the internal and the external stakeholders and ensure that everyone is ready for the development that is about to be executed. This needs to be done immediately in 2020 to plan ahead. The Company should start the change process by doing an as-is analysis, with the recommended KPIs to monitor the improvements in the future.

The first area of development is the leasing cars which are now mostly diesel. The Company should have 100% BEVs by 2030 in order to become fossil-free. Currently, the leasing period is 36 months and even though the leasing periods of the cars do not end at the same time, it is practical and reasonable to assume the latest leasing date for the project. Therefore, it is fair to make this change in stages and spread the change in 9 years. The first milestone is in 2023 to have 100% PHEVs since the analysis showed that PHEVs are performing better than BEVs, at the moment. Moreover, the electricity production in Sweden will be based on more renewable sources in 2030.

The next milestone is in 2026 where The Company starts monitoring the performance of BEVs in the market and to consider changing to BEVs if the performance is adequate. In this stage, The Company can still lease PHEVs for another time period of 36 months, if needed. The last milestone for the leasing cars is in 2029 where all the personal cars should be BEVs in order to reach the goal.

When it comes to LSPs and transportations by trucks, The Company should start discussing the terms regarding biofuels and cost sharing with the LSPs for the contract that they are going to renew in the beginning of 2021. Therefore, the discussion must be done already at the end of 2020. The Company has had a long-term relationship with both of the LSPs for over 10 years. Therefore, they should be able to have an open discussion about collaborating in terms of how to become fossil-free and how to share the financial liabilities. It is not urgent to make bigger changes for the contract of 2021. However, it is important to initiate the collaboration with the LSPs.

The Company should start assessing the performance of the LSPs in mid-2021 for the demands regarding environmental sustainability. If the LSPs cannot guarantee fossil-free transportation by 2030, The Company should consider changing the LSPs starting 2022, to ensure that the demands are satisfied. Even though The Company has had a long-term relationship with both of the LSPs, it is important to obey the sustainability manifest and have an LSP that can provide the demanded services.

Once The Company decides upon the LSPs, they need to measure the current situation of the fossil fuels and fossil-free fuel consumption and the GHG emissions through the stated KPIs in Chapter 5.3. The goal for LSPs is to have at least 50% fossil-free fuels by 2026 and thereby, to halve the GHG emissions. The ultimate goal of LSPs is to use 100% fossil-free fuels and eliminate GHG emissions by 2030. The reason for keeping four years between the goals is to provide some buffer time both to The Company and the LSPs to analyze and solve potential problems and improve the situation. According to the need in the future, The Company and the LSPs can set more milestones and divide the development in more detailed steps.

In 2021, The Company should start working on improving the performance of forklifts operations by optimizing the routes to reduce the fuel consumption. This is specifically needed to be done for the forklifts used outside, since these are driven on LPG and diesel.

The Company should continuously monitor the market for better performing electric forklifts for outside use from 2024. The reason why this has not been suggested earlier in the roadmap is that there is no such technology at the moment. Assuming that the technology will be developed enough by 2027, The Company should complete the investment plan and start investing on electric forklifts. The ultimate goal is to replace the current two forklifts driven with LPG and diesel, and only use electric forklifts by 2030.

When it comes to tractors, The Company should start analyzing the current performance and engine capabilities of the existing tractors and investigate whether they can mix biofuels with diesel in the tractors in 2022. Moreover, The Company should keep track of the industry for electric tractors or the tractors that can be driven on 100% biofuels. Since this is a market analysis, the time period of this is the same with the forklifts. Therefore, the first market analysis should start in 2024 and the investment plans should be completed by 2027 with an ultimate aim of becoming fossil-free in agricultural transportation operations by 2030.

The recommended roadmap that has been developed is presented in Figure 5.3. The activities are presented with green squares, the goals are presented with red circles and the market analysis are presented with blue triangles. The market analysis and activities help The Company achieve the goals.

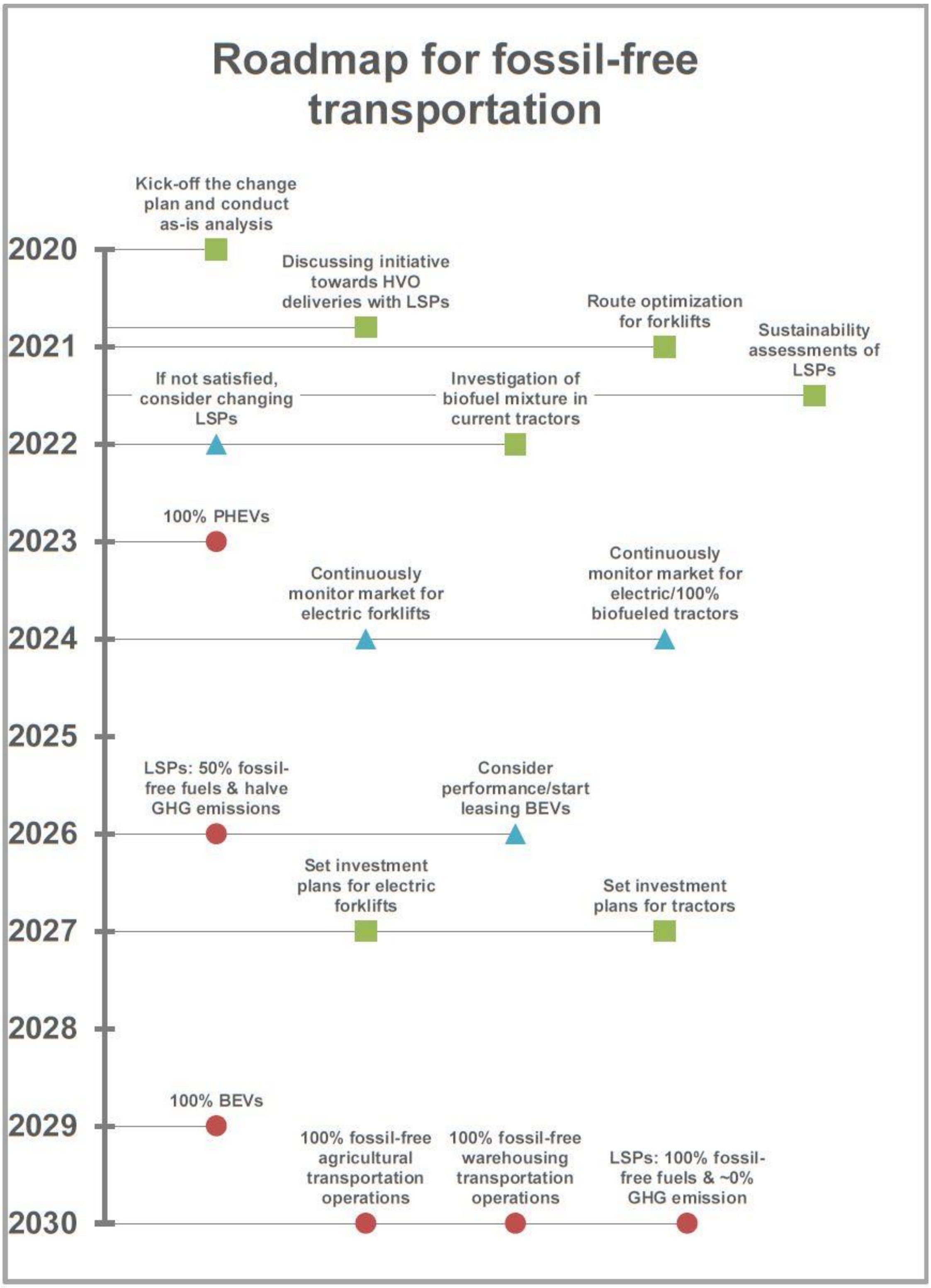

Figure 5.3: The developed roadmap for fossil-free transportation

6. Recommendations

This chapter includes the recommendations of this project to The Company to become fossil-free in transportation operations by 2030. The recommendations are based on the analysis in Chapter 5 and presented in two parts: the KPIs and the roadmap.

6.1. The recommended KPIs

Chapter 5.3. presented a detailed analysis of the KPIs including both the potential KPIs that The Company and the LSPs should use, and some of the existing KPIs that are related to transportation operations. After the analysis, the KPIs that serve to the primary focus of this project are recommended to The Company.

There are five KPIs determined in total for the internal and external transportation operations with an ultimate aim of becoming fossil-free and minimizing CO_2 emission to the greatest extent by 2030. Currently, forklifts and tractors do not have a fossil-free alternative. Therefore, the KPIs related to these vehicles aim to monitor fossil fuel consumption to provide an opportunity to analyze the ways of reducing the consumption, in the future. The recommended KPIs are presented in Table 6.1.

The only alternative that can provide a fossil-free transportation fleet for the leasing vehicles is to only have electric vehicles. Therefore, it is important for The Company to measure the *percentage of electric vehicles in the fleet,* where the target is to have 100% electric vehicles by 2030. The KPI should be assessed once a year to monitor the improvement.

While reducing the fossil-fueled vehicles in the fleet, by leasing PHEVs and later BEVs, The Company must measure the *average carbon emission of the leased vehicles per year.* The target of this KPI is to eliminate the total carbon footprint by 2030. However, Sweden aims to have 100% renewable electricity production by 2040. Thereby, it is only possible to achieve exactly 0 kg carbon emission per year by 2040, when the total life cycle, including production of electricity, is taken into consideration while measuring the carbon emissions (CO_2ekv WTW). Therefore, the target of this KPI by 2030 is set as approximately 0 kg per year and the KPI should be assessed once a year.

With today's technology it is not possible to use a fuel that is 100% fossil-free in tractors. However, The Company must still aim to have fossil-free fueled tractors by 2030. The KPI named as *the annual fossil-free fuel percentage* helps The Company monitor the increase in the fossil-free fuel consumption in the tractor fleet in the following years. The target for this KPI is to have 100% fossil-free fuel consumption by 2030 and it should be assessed annually. This KPI covers both fossil-free alternatives i.e. electric tractors and tractors driven on 100% biofuels.

The performance of the electric forklifts is not sufficient to handle The Company's demand of driving outside. Therefore, it is not possible to have 100% fossil-free warehousing transportation operations, at the moment. For this reason, it is recommended for The Company to measure the fuel consumption of LPG and diesel to monitor the GHG emissions. The recommended KPI for measuring this is the *average purchased fossil fuel per month per forklift*. Therefore, this KPI should be measured once a month, with a moving average of 12 months. This allows The Company to ensure that they are optimizing the fuel consumption and thereby, reducing the GHG emissions. The target for this KPI by 2030 is to purchase 0 liter of fossil fuel per month.

The recommended KPI for the trucks should be measured by the LSPs and reported to The Company periodically. The aim is to provide 100% fossil-free deliveries for The Company by 2030. Therefore, LSPs must assess the fossil-free fuel consumption of the trucks. The KPI that must be measured is the *annual fossil-free fuel percentage* and it should be measured annually.

Table 6.1: Recommended KPIs

	Vehicle	KPI	KPI calculation	Targets by 2030
The Company	Leasing vehicles	Percentage of electric vehicles in the fleet per year	$\frac{Total\ number\ of\ electric\ vehicles}{Total\ number\ of\ vehicles}$	100%
	Leasing vehicles	Average carbon emission of the leased vehicles per year	$\frac{\sum CO2\ emissions\ for\ the\ leased\ cars\ per\ year}{Total\ number\ of\ leased\ cars}$	~0 kg/year
	Tractors	Annual fossil-free fuel percentage	$\left(\frac{Total\ fossil\ free\ fuel\ in\ liter}{Total\ fuel\ in\ liter}\right)^{*}$ *Used for the entire fleet per year	100%
	Forklifts	Average purchased fossil fuel per month per forklift	$\frac{\sum Purchased\ fossil\ fuel\ over\ the\ last\ 12\ months}{12\ months}$	0 liter/month
LSPs	Trucks	Annual fossil-free fuel percentage	$\left(\frac{Total\ fossil\ free\ fuel\ in\ liter}{Total\ fuel\ used\ in\ liter}\right)^{*}$ * Used for the entire fleet per year	100%

6.2. The recommended roadmap for fossil-free transportation

The fossil-free transportation roadmap is developed and presented in Figure 6.1, based on the analysis presented in Chapter 5. It is recommended as a tool for The Company to provide a plan to achieve the sustainability requirements in the transportation operations stated in the sustainability manifest by 2030. The milestones are spread over 10 years, from 2020 to 2030, to not have all the investments and activities towards the end of the period and therefore, make it possible for The Company to make the financial and time plans in a predictable manner.

The initialization of the project starts in 2020 to bring the stakeholders together and discuss the ultimate goals of 2030. An as-is analysis should also be performed together with the initialization of the project, where the recommended KPIs are calculated. The roadmap covers four types of vehicles including both internal and external transportation operations: leasing vehicles (personal cars and commercial vans), trucks, forklifts, and tractors.

The change plan for the leasing vehicles has been spread over a period of 9 years due to the 36 months leasing period, with an aim of having 100% BEVs in the fleet by 2029. Since the leasing period is 36 months, the existing vehicles can be used for another three years until 2023. Until then, The Company must start leasing PHEVs and have a fleet of 100% PHEVs by 2023. Additionally, by 2026, The Company needs to assess the performance of BEVs and consider leasing BEVs starting from 2026. However, if the performance of the BEVs is not adequate by then, The Company can lease PHEVs for another period of 36 months. Finally, they should have 100% BEVs in the fleet by 2029.

The goal for warehousing and orchards transportations is to use fossil-free fuels by 2030. However, there is a lack of technology on today's market to satisfy the requirements. To improve the sustainability of the activities in today's conditions, The Company should start optimizing the routes of the forklifts in the warehouses by the end of 2020. Moreover, they should consider whether the existing tractors can be driven on biofuel mixtures by 2022. Other than these, the warehouse manager and the orchards manager must start monitoring the market for the development of fossil-free forklifts and tractors from 2024. They should also provide periodic update reports to the supply chain manager, including the market status of the above-mentioned vehicles, and the advantages and disadvantages with investing in new vehicles. Later, The Company should finalize the investment plans for these vehicles by 2027 to become fossil-free in the transportation operations in the orchards and warehouses by 2030.

Concerning trucks, the LSPs have been constantly working on becoming fossil-free in transportation operations. The Company should discuss initiatives for HVO deliveries in the last months of 2020 for the contract of 2021. Since it is a 10-year change plan, it is not urgent for The Company to change the LSPs. However, if the LSPs cannot promise fossil-free operations for 2030, The Company should start considering changing the LSPs from 2022. The first milestone for the LSPs is to use at least 50% fossil-free fuel by 2026 and therefore halve the GHG emissions by then. This milestone indicates the achievability of the ultimate aim of becoming 100% fossil-free and eliminating the GHG emissions to the greatest extent possible by 2030. The change plan is spread over 10 years for the external transportation operations for The Company and the LSPs to implement the changes needed, and to analyze and solve potential problems in the meantime.

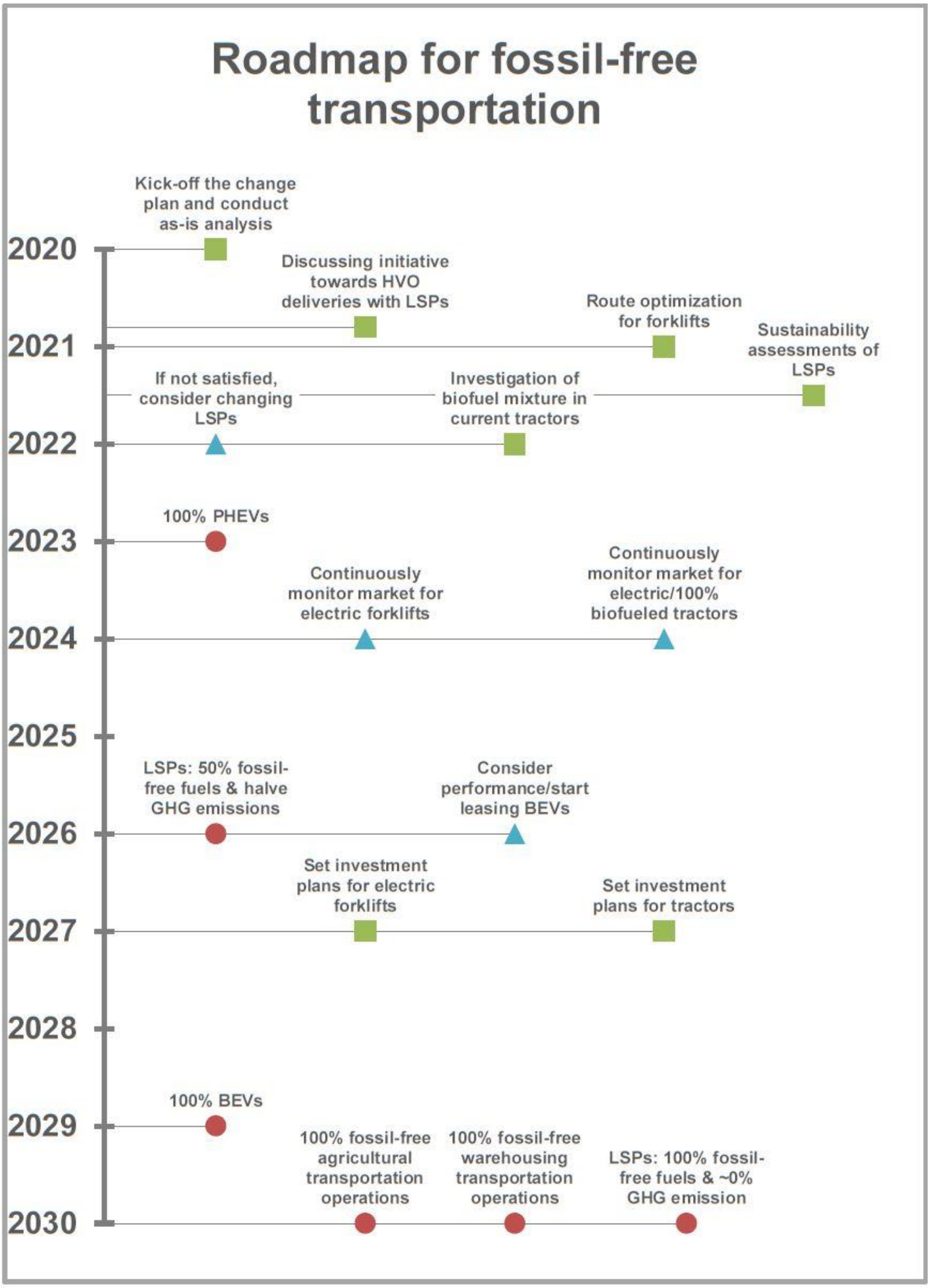

Figure 6.1: The development roadmap for fossil-free transportation

7. Conclusion

This chapter summarizes the conclusions and explains how the research questions are answered, based on the discussions and analysis stated in this report. Moreover, it provides insights for the future research and briefly explains how this report contributes to the theory.

7.1. Research questions

The research questions presented in Chapter 1.4 are answered in this chapter based on the information and discussions provided in *Literature review, Empirical data, Analysis* and *Recommendations*.

7.1.1. Research question 1

RQ1: How does the current transportation map look at The Company and what is the environmental impact?

The current transportation map of The Company is presented in Figure 4.1. This figure presents the truck, forklift, and tractor operations. On the other hand, it does not cover the leasing vehicles since they are personal vehicles, and therefore do not have a specific route.

Later, the environmental impacts of the transportation activities are presented in Chapter 4.3. In this chapter, one finds the environmental impacts in terms of GHG emissions of the vehicles. In conclusion, it is possible to state that currently none of the transportation operations of The Company is fossil-free, and all have some environmental impact.

Nevertheless, supported by the literature provided by Gardner and Cooper (2003), it is fair to state that the logistics map in Figure 4.1 allows The Company to understand the dynamics of the system and determine the inefficiencies. Furthermore, the map has helped this project gather necessary knowledge to develop the fossil-free transportation roadmap. It will also help The Company take required decisions to become fossil-free in transportation, in the future.

7.1.2. Research question 2

RQ2: What are the alternative fuels and transportation modes to reach the sustainability goals?

Based on the literature review, there are different fuels discussed for different types of transportations. The alternative fuels in today’s market to become fossil-free is to use electricity or 100% biofuels. However, the technology is not equally developed for each type of vehicle. Therefore, not every vehicle is compatible with each type of fuel. In the light of the information provided in the previous chapters, it is recommended to The Company to have 100% BEVs as the personal cars and commercial vans, electric forklifts, electric tractors or 100% biofueled tractors and 100% HVO fueled trucks for the transportation operations.

The transport modes are not proposed to be changed. However, The Company must consider changing the LSPs in case the existing ones cannot satisfy the sustainability requirements.

7.1.3. Research question 3

RQ3: How should the logistics activities be changed in order to reach the sustainability goals?

The change in the logistics activities are based on the changes in the fuels of the vehicles both in external and internal transportation operations. The change is planned for a 10-year period from 2020 to 2030 and it is represented on the roadmap with a detailed description in Chapter 6.2. The roadmap explains what kind of changes are recommended for each type of vehicle with the milestones to become fossil-free by 2030. The roadmap also shows the ultimate goals for each vehicle type for the end of the time period. Table 7.1 summarizes the changes required changes in the logistic activities.

Table 7.1: Required changes in the logistics activities

Vehicles	**Changes to become fossil-free**
Leasing vehicles	100% BEV
Trucks	100% HVO fuel
Forklifts	100% electric forklifts
Tractors	100% electric tractors or 100% HVO fuels (depending on the market development)

7.2. Future research

As stated in Chapter 2.4, the purpose of the case research in this project is to build theory to understand the key variables and the linkages between them to develop a sustainability plan for the transportation operation at The Company. Initializing a project has many advantages such as bringing different stakeholders together and collecting information from different units. However, there are also some challenges. Since this is the first attempt of analyzing the situation regarding sustainable transportation, not all the required data have been available. The two main suggestions for the future research is to collect data regarding the carbon emissions of forklifts and tractors, and the cost data of the transportation operations.

In this research, it was not possible to identify KPIs for the carbon emissions of forklifts and tractors since this information was not available. Moreover, today’s technology does not allow to eliminate the fossil fuels in these vehicles. In the future, the researchers and The Company should focus on identifying KPIs for carbon emissions of forklifts and tractors with the help of the advancement in technology.

Furthermore, the applicability of the plan depends on the financial investments, as well. In this project, it was not possible to capture all the cost data, and since this was the initial project about the phenomenon, it is reasonable. However, when applicable, the future research should prioritize collecting and analyzing the cost data.

Moreover, the future research should further analyze advantages and disadvantages regarding BEVs. This analysis is not included in this project since it is assumed that the technology of BEV is going to be more developed by 2029, when it is recommended for The Company to lease BEVs. Therefore, the discussion and analysis about charging areas, driving ranges, safety, comfort, and weather influence on the performance of the BEV can be conducted when the technology is advanced enough to satisfy The Company’s requirements.

Lastly, future researchers can investigate other transportation modes in order to decrease GHG emissions. For instance, rail transportation can be an option for direct deliveries to customers from the central warehouse.

7.3. Contribution to the theory

This report has covered a broad scaled literature review about the phenomenon and shows that there are good initiatives on having fossil-free transportation, both in terms of technological developments and in the EU as well as in Sweden. However, it is seen that there is still a deficiency regarding the fossil-free vehicles and the comparisons between these with the fossil-fueled vehicles, especially regarding the internal transportation operations, such as warehousing and agriculture operations. It is also lacking in the literature how to become fossil-free in transportation operations. Therefore, this paper provides an overview of what kind of vehicles should be considered when converting to fossil-free transportation at a company and how to take the steps with the help of a roadmap. Moreover, it also presents some initial KPIs to measure the performance of the system.

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Appendix A: Interview Guide

Company	Interviewee	Interview method	Interview date
LSP2	Quality and Sustainability Manager	E-mail	05.02.2020
The Company	Supply Chain Manager & Sustainability and Product Development Manager	Face to face	06.02.2020
The Company	Orchards Manager	Face to face	25.02.2020
The Company	Warehouse Manager	Face to face	28.02.2020
The Company	Technical Manager	E-mail	16.03.2020
LSP1	Key Account Manager	Phone	27.03.2020

General questions asked to all interviewees:

- Can you introduce yourself and your position in The Company/LSP1/LSP2? How is it related to environmental sustainability?
- How do you see sustainability as a company? Why is it important?
- What kind of initiatives have you had so far to become more environmentally sustainable?
- What KPIs do you use today to measure environmental sustainability?
- What are your expectations for becoming fossil-free? How do you see it happen?

Specific questions to the supply chain manager and sustainability & product development manager at The Company:

- Which and how are the products carried in each arrow on the supply chain map?
- Where do you use LSP *(bulk/liquid carriers)*?
- Can you explain the warehousing/logistics operations in Kivik?
- How do you manage inbound and outbound operations?
- Where do you store the FG or the inbound products?

Specific questions to the orchards manager at The Company:

- Can you describe more about the orchards and tractor operations?
    - How many hectare orchards do you have in Lund and Kivik?
- How many tractors are there in the orchards in total (Kivik, Stenhamra and Lund)?
- Can you explain more about the tractors and how they are used?
- What kind of tractors are they and what are the environmental impacts?

Specific questions to the warehouse manager at The Company:

- Can you describe more about the warehouse operations and the vehicles that are used in the area?
- How many forklifts and other vehicles are used in Kivik, Stenhamra, and Lund?
- Do you have any specific information about the forklifts that you can share?
- What kind of forklifts are they and what are the environmental impacts of theirs?

Specific questions to the technical manager at Stenhamra facility at The Company:

- Can you explain more about your production steps and products?
    - What is the production capacity?

- Can you explain the warehousing/logistics operations in Stenhamra?
    - How do you manage inbound and outbound operations?
    - Who are the transportation partners?

Specific questions to LSP 1

- What kind of logistics operations do you perform for The Company? Can you explain the warehousing and transport activities?
- What are the dimensions and the fill rates of the trucks normally? Maximal weights or other restrictions?
- What kind of trucks are you using? What are the fuels that you have been using on the trucks?
- Are you using electric trucks? If not, are you planning to implement in the near future?
- Do you offer fossil-free transportation? What is the cost of different alternatives for The Company?
- Does LSP1 store alcoholic drinks? Why and for how long?

Specific questions to LSP 2

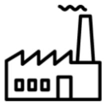
- Can you describe the logistics activities related to The Company?
- We have received the excel-file about all your transportation to/from The Company, together with CO_2 emissions. Are there any more transportations that we need to consider?

"As we understood, you use diesel, RME or HVO fuels. It is 7% of biofuel blended with diesel in international freights and 42% within Sweden."

- What is the motivation with the blending percentages, why is it not lower or higher?
- We have seen CO_2 emissions of the alternatives. What are the emissions (incl. NO_x, CO, HC, PM) of the fuel?
- Can you share costs for the fuels and mixtures, if possible? This is for us to make a cost analysis. We are not going to include the exact prices in the report if you do not let us. We will just include the cost ratios of alternative fuels.
- Have you ever considered changing to electric trucks or are you planning to implement it in the future?
- In the previous interview, you stated that you had different KPIs for fuel consumption, fuel mix X% diesel and X% fossil-free fuel, driving behavior, energy consumption. Can you describe them more, such as how you are calculating them? Is it possible for you to share the target levels and the current levels of the KPIs?

Appendix B: Logistics Map

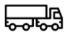
 - Orchards

 - Suppliers

 - Manufacturing

 - Warehouse

 - Customer

 Pallet/regular truck transportation (LSP1)

 Bulk transportation (LSP2)

 Forklifts

 Tractor