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Riia-Maria Jokela

The CO_2e Footprint of Freight Transportation

Determining the current level of CO2e-emissions caused by freight transportation and investigating opportunities for future reduction of the emissions in the case company

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Tekijä:	Riia-Maria Jokela
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TIIVISTELMÄ:

Tämän tutkielman tarkoituksena on tutkia rahtikuljetusten ympäristövaikutuksia. Tavoitteena on selvittää globaalin teollisuusyrityksen rahtikuljetuksista aiheutuneiden CO_2e-päästöjen tämänhetkinen taso, määrittää merkittävimmät päästöjen aiheuttajat sekä tutkia kehitysmahdollisuuksia ja -ehdotuksia tulevaisuutta varten. Kestävä kehitys ja päästöjen määrän vähentäminen ovat tärkeitä teemoja sekä yritysten että ympäristön kannalta. Yritysten tulee pyrkiä kestävämpiin toimintatapoihin ja rahtikuljetukset ovat suurena päästöjen aiheuttajana yksi potentiaalisimmista ja tärkeimmistä kehityskohteista. Ympäristövaikutusten ja päästöjen vähentäminen on myös globaalisti tärkeä ja kriittinen osa-alue. Ilmastonmuutos on aiheena koko ajan ajankohtaisempi ja keskustelu sen ympärillä vaatii toimenpiteitä yrityksiltä. Kestävä kehitys ja vihreät arvot ovat todella arvostettuja nykymaailmassa ja näihin asioihin keskittyminen ja oikeanlainen kehitys toimintatavoissa voi auttaa saavuttamaan parempaa mainetta ja kilpailuetua.

Tässä tutkielmassa toteutetaan määrällinen tutkimus, joka keskittyy toimeksiantajayrityksen rahtikuljetuksiin vuoden 2019 alusta vuoden 2020 toisen kvartaalin loppuun. Tässä tutkielmassa selvitetään CO_2e-päästöjen kokonaismäärä ja analysoidaan tutkimuksen kohteena olevaa dataa myös tarkemmin rajattuna käytettyjen kuljetusmuotojen sekä liiketoimintayksiköiden ja ajanjaksojen osalta. Tämä tutkielma on osa laajempaa projektia, jossa keskitytään CO_2e-päästöjen laskemiseen, datan pohjalta rakennettuun visuaaliseen esitykseen ja jatkuvaan parantamisen periaatteen mukaisten kehitysmahdollisuuksien tutkimiseen. CO_2e-päästöjen laskenta suoritetaan EN 16258 -standardin mukaisesti. Tutkimuksen lisäksi tässä tutkielmassa käydään läpi relevantteja ja tuoreita tutkimuksia muun muassa vihreään logistiikkaan ja kuljetusmuodon valintaan liittyen.

Tutkimuksessa selvisi, että CO_2e-päästöjen absoluuttinen määrä on laskenut vuodesta 2019 vuoteen 2020, mutta CO_2e-päästöt suhteessa lähetysten kokonaispainoon ovat olleet hieman korkeammalla tasolla. Kuljetusten kokonaismäärä laski vuodesta 2019 vuoteen 2020 ja erityisesti tuonnin osalta määrän lasku oli varsin huomattava. Vientilähetysten aiheuttamista päästöistä suurin osa johtuu lentorahdista, mutta tuontirahdin osalta suurimpana päästöjen aiheuttajana ovat merilähetykset.

AVAINSANAT: logistiikka, rahtikuljetukset, ympäristövaikutukset, kestävä kehitys, CO_2e-päästöt, energiankulutus, kuljetusmuodot, EN 16258 -standardi

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ABSTRACT:

The purpose of this thesis is to study the environmental impacts of freight transportation. Aim is to investigate the current level of CO_2e emissions caused by freight transportation of a global industrial company, to identify contributors that cause the emissions and to provide suggestions for future improvement. Sustainability and reducing emissions are very important issues for both companies and for the environment. Companies need to aim at more sustainable ways of working and freight transportation is one area with a lot of development potential in emission reductions. Reducing environmental footprint and emissions is extremely important topic globally as well. Climate change has become more and more actual and discussion around it demands actions from companies. Sustainability and green values are highly appreciated nowadays and focusing on these issues also gives companies opportunity to gain better reputation and competitive advantage by committing right kind of actions regarding these issues.

This thesis includes a quantitative study which covers case company's freight transportation from the beginning of year 2019 to the end of the second quarter of year 2020. This thesis studies the total amount of CO_2e emissions but a more detailed analysis about used transport modes, business unit level results and differences between years 2019 and 2020. This thesis is a part of a wider project that focuses on calculating CO_2e emissions, creating a visual presentation based on studied data, studying development possibilities and aiming towards continuous improvement. Even though main focus of this thesis is on the case study, a theoretical framework based on relevant articles discussing topics such as green logistic and transport mode choice is provided as well. Case study of this thesis is based on EN 16258 -standard which sets the limitations for the CO_2e emission and energy consumption calculations as well as determines the required accuracy level of the calculations.

It was found out that the absolute level of CO_2e emissions has been lower in year 2020 than in year 2019 but CO_2e emissions per weight have been slightly higher. The total number of shipments was lower in 2020 than in 2019 and especially the number of import shipments has been decreasing. Air freight shipments are responsible for the biggest share of caused CO_2e emissions of export shipments whereas for import shipments major part of CO_2e emissions are caused by sea freight.

KEYWORDS: logistics, freight transportation, environmental impacts, sustainability, CO_2e emissions, energy consumption, transport modes, EN 16258 -standard

CONTENTS

ABBREVIATIONS

CO_2e	Carbon dioxide equivalent
EMS	Environmental Management System
FCA	Free Carrier (incoterm, cost of transportation is paid by the buyer)
GDP	Gross Domestic Product
GHG	Greenhouse gas
GLEC	Global Logistics Emissions Council
GSCP	Green Supply Chain Practices
ICT	Information and Communications Technology
IPCC	The Intergovernmental Panel on Climate Change
ITU	Intermodal Transport Unit
LCA	Life Cycle Assessment
LSP	Logistics Service Provider
LTO	Landing / take-off
SBT	Science-Based Target
TTW	Tank-to-wheel
OD	Origin-Destination
VOS	Vehicle Operation System
VRP	Vehicle Routing Problems
WTT	Well-to-tank
WTW	Well-to-wheel

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1 INTRODUCTION

1.1 Background

The case company of this study is a global industrial company and a technology leader that operates in more than 100 countries. Arranging freight transportation is centralized in control towers of which one is located in Finland. This study focuses on export and import freight for which the freight costs are paid by the case company.

The environmental footprint of freight transportation is an important topic not only for the case company but also for the environment and society. As the climate change becomes more and more actual and discussion around it increases and becomes more intense, companies are required to take actions towards more sustainable ways of working. Situation is very challenging and quick actions are needed, but besides the challenges, this also provides companies opportunities. Working on green values and sustainability could help companies not only to get better reputation but also to gain competitive advantage, which certainly results also in financial benefits in the long run. In many cases choosing the greener option can actually result in cheaper freight costs as well.

This topic is important for both the case company and the society and its global importance is also significant. All companies worldwide are pressured to find more sustainable ways of working and since the CO_2e footprint of the logistics is obviously a major share of the total CO_2e footprint of industrial companies, demand and need for actions and development from the field of the logistics is massive. On the other hand, this also means that there should be a lot of potential for reducing the environmental footprint and emissions of logistics. This thesis focuses on calculating the current carbon dioxide equivalent footprint and level of CO_2e emissions of the case company and aims at finding solutions for adopting and implementing greener ways to arrange the freight transportation.

1.2 Case company's commitment

Case company has also published its own sustainability strategy towards year 2030. They aim to contribute to creating and maintaining low-carbon society and co-operating with their customers and suppliers for achieving sustainable solutions in their value chain and in the lifecycle of the case company's products and solutions. The sustainability strategy of the case company is in line with the 1,5 °C scenario of Paris agreement and also follows the guidelines of the Science Based Targets initiative. Sustainability targets are integrated in case company's decision-making processes to ensure that focus on achieving the goals exists and remains. (Case company's internal websites, 2021.)

Integrity and transparency across the value chain belong to case company's core values. Case company's sustainability focus areas are determined through a thorough materiality analysis that covers the expectations and requirements of key stakeholder groups that include for instance customers, government and civil society representatives and suppliers. Materiality matrix is supposed to be regularly reviewed and case company also regularly ensures that the strategy is meeting the expectations and benchmarks its practices and objectives against standards. Materiality matrix illustrates variables impact on case company as well as relevance to stakeholders and includes variables such as circular economy, responsible sourcing, carbon reduction, health and safety, diversity and inclusion and business resiliency. (Case company's internal websites, 2021.)

Case company is committed to supporting its customers in reducing customers' annual CO_2 by at least 100 megatons. Case company has also set a target of achieving carbon neutrality across in own operations by year 2030 and is engaged with its suppliers in order to be able to reduce emissions across the entire supply chain. Case company has already found areas where they can cut scope 1 and scope 2 emissions in one fifth of the current level and is continuously focusing on identifying opportunities for even bigger decrease of emissions. (Case company's internal websites, 2021.)

1.3 Research problem and research questions

Research problem of this study is to quantify the current level of CO_2e emissions caused by freight transportation paid by the case company. Quantifying the current level of CO_2e emissions is done by performing a quantitative research based on data of case company's export and import shipments and quantifying the CO_2e emissions on business unit level and also on company level. Data is gathered from the case company's system that includes data of majority of case company's freight transport on a shipment level and from the reports from freight forwarders (mainly data of import shipments). After gathering the data, it is further analyzed according to the guidelines set by the EN 16258 -standard.

In this study there are two main research questions:

1. What are the main contributors that cause the emissions?
2. How could the level of emissions be reduced?

1.4 Scope and objectives

In this study both export and import are included, covering export from Finland and import to Finland. Only freights that are paid by the case company are included, hence for instance freight with incoterm FCA (receiver is responsible for the freight costs) will be excluded. Scope of data is Q1 and Q2 of this year and also quarterly data from last year which will be studied as a starting level and for the comparison. The project around this study will later be followed up with taking future quarters into account as well.

Objectives of this study are:

1. To quantify CO_2e emissions caused by both export and import freight transportations paid by the case company.
2. To calculate CO_2e footprint of freight transportation that is in the scope of this study.
3. To provide literature review on recent and relevant studies on the environmental footprint from the logistics' point of view.

1.5 Structure of the thesis

This thesis consists of nine main chapters. The first main chapter is the introduction that covers introducing the topic, research problem and research questions as well as scope and objectives. In second chapter project, of which this thesis is one part, will be introduced. The third chapter will focus on the theoretical background that is based on three studies that discuss green logistics, GHG emissions, transport mode choice and drives and barriers impacting the development in reducing emissions. In the fourth chapter methods will be presented, quality of data will be discussed and used standard will be introduced briefly. The fifth chapter focuses on used standard and sixth chapter explains emission calculations. In the seventh chapter results will be presented and analyzed. In the eight-chapter discussion will follow, and the ninth chapter will cover the conclusions.

2 PROJECT

2.1 Project introduction

This thesis is a part of a wider project in the case company. Main goal of the project is to find out the current level of CO_2e emissions caused by freight transportation and to build a system based on Excel-data and PowerBI in order to present current and future results for continuous reporting and improvement. This thesis will provide the current level of CO_2e emissions as well as analysis of the results and future suggestions. Data for the calculations is the actual data of case company's freight transportation but the distances are rough estimations on sender / receiver country level – getting more accurate distances is one of the greatest possibilities for development in measuring.

Demand for this project was both external and internal. Measuring and aiming at reducing environmental impacts is required in order to earn and keep certain certificates so these issues are considered also in external audits. On the other hand, functions of logistics and freight transportation are responsible for significant share of all environmental impacts cause by case company, so actions are needed. Starting level of environmental impacts was not known beforehand, so this thesis and project creates a base for future measuring and comparing development.

2.2 Benchmark

A small-scale benchmark was also performed as a part of this project and study. Target company for this benchmark was a global company that executes for instance emission calculations and other consulting services for external companies worldwide. This company offers CO_2e emission calculations that consider each leg and transport mode of the total distance but on the other hand includes quite many assumptions for instance about the distances that are used in calculations. At some points their solution is more precise and at some other points we can take more things into account.

Benchmarked company would be able to use more accurate distances based on zip codes whereas our solution only considers one zip code per country for most of origins and destinations. This is maybe the biggest advantage of the solution that this company provides – our solution uses default values for fuel consumption and emission and energy consumption factors, but on the other hand external consulting company could not have more exact and actual information about these than case company has. Benchmarked company also makes more assumptions about used transport modes: for instance shipments over certain weight limit are automatically counted as sea freight whereas in our solution main transport mode is the correct one since it is defined based on the actual data from our system reports and carrier reports. Main transport mode is the variable that makes the biggest difference in caused CO_2e emissions and energy consumption, so it is relevant to emphasize its importance.

Also, case company probably has the best understanding and capability for the analysis of our own shipment data. Case company knows approximately what to expect and can make interpretations at business unit level. This project was also quite flexible and adaptive, in this thesis we were able to specify our targets for visual presentation and other graphs and tables as the project proceeded. There is also a lot of possibilities and potential for improvement, and it should be more or less effortless and efficient to develop this project that we have started by ourselves. For instance, the quality between export and import data varies a lot and it was emphasized during this project, so we also found other development targets through this.

2.3 Data flow chart

Below figure 1 illustrates the data flow in the project. Firstly, both export and import data is obtained, then it will be processed so that energy consumption and CO_2e emissions can be calculated at an individual shipment level. When data is processed and calculations are executed, Excel-data will be used as a master data in PowerBI. In PowerBI data is firstly processed so that it can be used for calculations in PowerBI as well – in this project the main function for the use of PowerBI is to be able to create visual presentation based on case company's shipment data and caused energy consumption and CO_2e emissions.

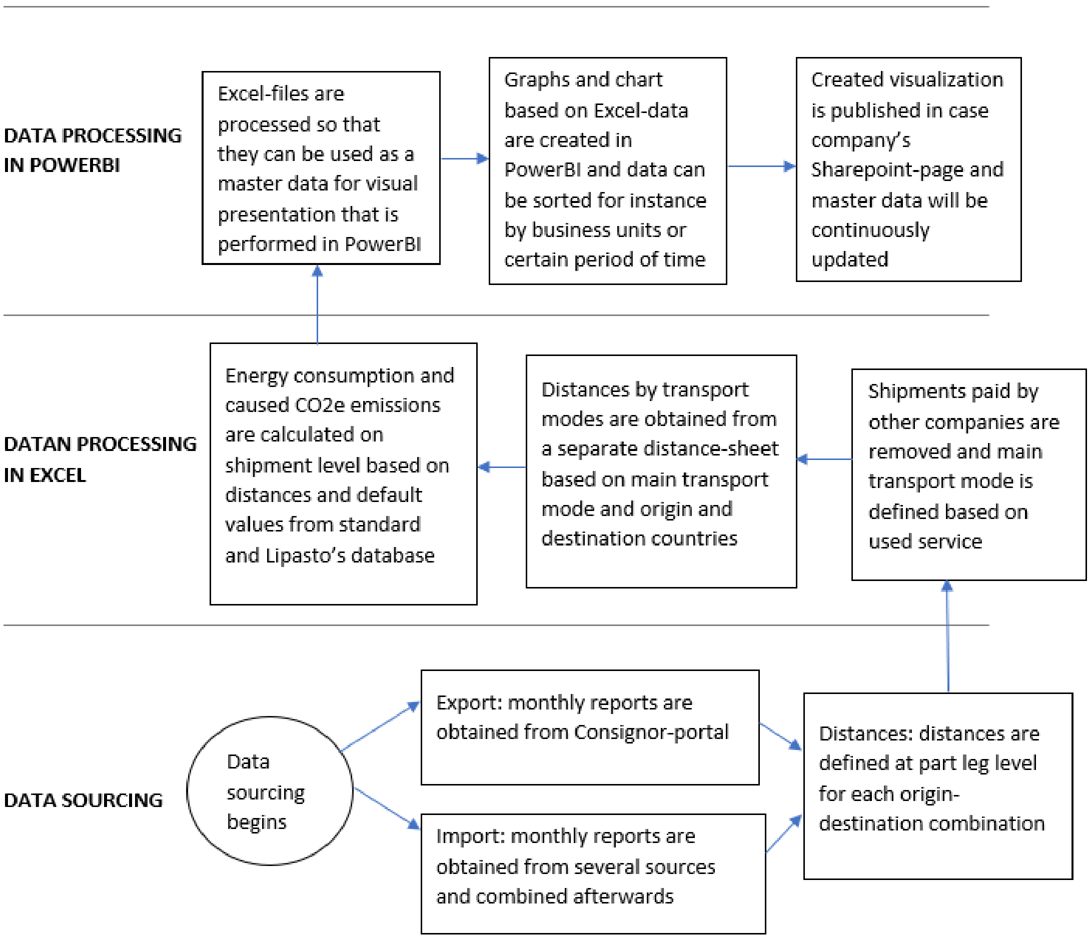

Figure 1. Data flow.

2.4 Visual presentation

Visual presentation in this project was performed in PowerBI as the previous chapter and figure 1 presented. PowerBI is a versatile tool for creating this kind of presentations and demonstrative and illustrative graphs and pie charts. In this presentation data can be sorted for instance by business units or by certain periods of time. For instance, certain month(s) of year 2019 and 2020 can be sorted and compared.

Below figure 2 illustrates the development of CO_2e emissions for both years 2019 and 2020. Data for September 2020 was not complete, but for all other months all of the export and import shipments are included. From here it easy to see that the total amount of CO_2e emissions has been lower in year 2019 than in year 2020 – however, these graphs only show the total amount but not the caused CO_2e emissions in respect of the total number of total weights of the shipments. The total amount of CO_2e emissions has been lower in every month but starting from April the gap between years 2019 and 2020 has been significantly bigger than during the first quarters. Also, the impacts of COVID-19 need to be considered even though the magnitude is not clear – it will be interesting to see the curves of the future years in this same figure.

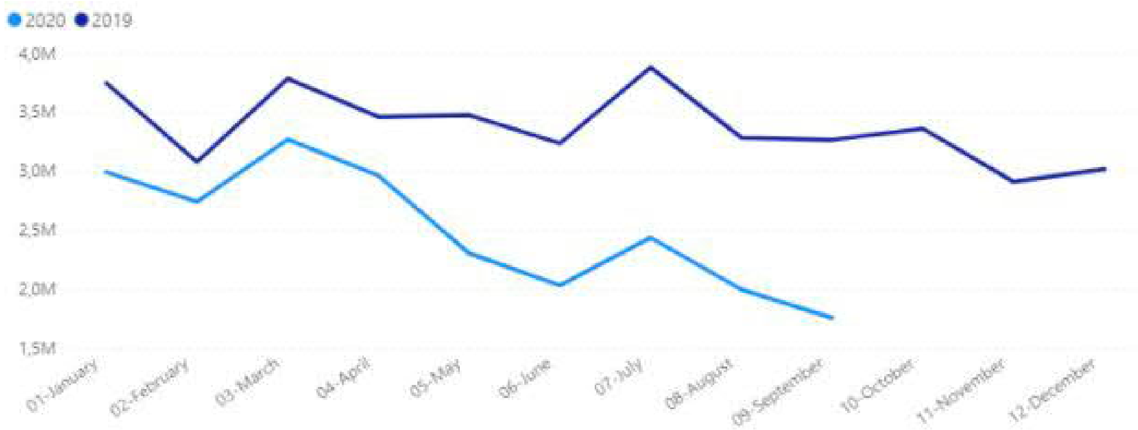

Figure 2. CO_2e emissions for years 2019 and 2020 ($kgCO_2e$).

Figure 3 below illustrates the caused CO_2e emissions by business units. It is easy to see that caused CO_2e emissions vary a lot between business units – for instance the business unit causing third most CO_2e emissions had caused less than half of the amount of CO_2e emissions caused by the business unit with most highest amount of CO_2e emissions. Business unit with fifth most CO_2e emissions had caused less than sixth of the amount of CO_2e emissions caused by the business unit with highest CO_2e emissions. There are five business unit that have caused more than 3,5 million kg CO_2e emissions and rest of the business units have caused less than one million kg CO_2e emissions.

Even though it is very clear that certain business units do have a major share of all caused CO_2e emissions in case company, each business unit is responsible for their own emissions. Each business unit has its own areas for development and each unit should be able to reduce their emissions. It is very important that results can be analyzed at business unit level since there can be and also are big differences between business units' volumes, production times, typical size and weight of a shipment and the geographical distribution of customers.

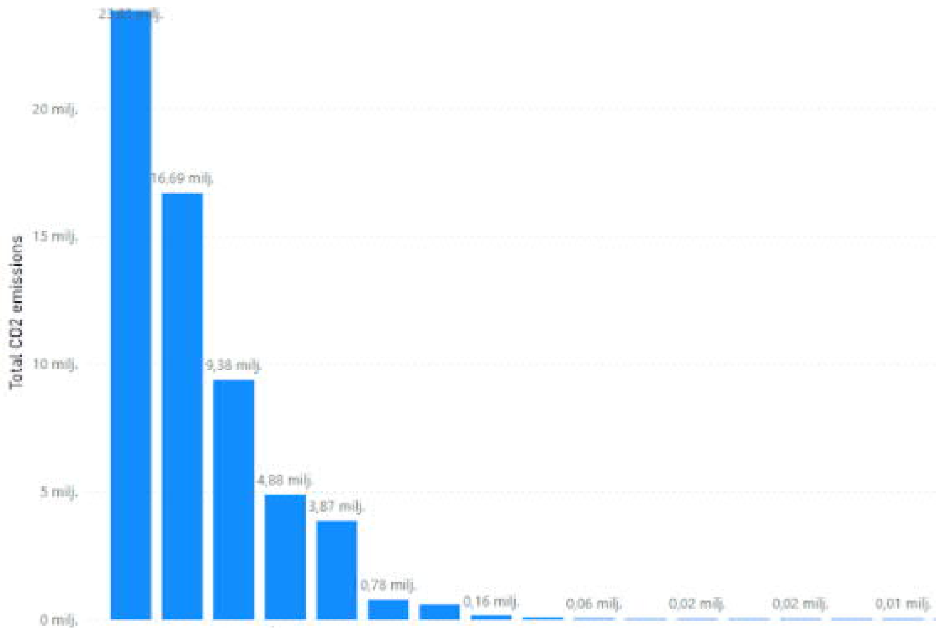

Figure 3. CO_2e emissions by business units ($kgCO_2e$).

Figure 4 below shows the distribution of CO_2e emissions by different transport modes for export shipments. This figure gives a good base when it comes to analyzing the biggest causes behind CO_2e emissions. Share of the air freight shipments is more than half of total CO_2e emissions so it seems to be major development possibility for export shipments. This kind of graphs can be done at business unit level as well which is very informative when analyzing business unit level results. Figure below shows only caused CO_2e emissions but not the total weight of shipments by transport modes or total number of shipments by transport modes – having all these graphs next to each other gives us more information about why below figure is distributed as it is.

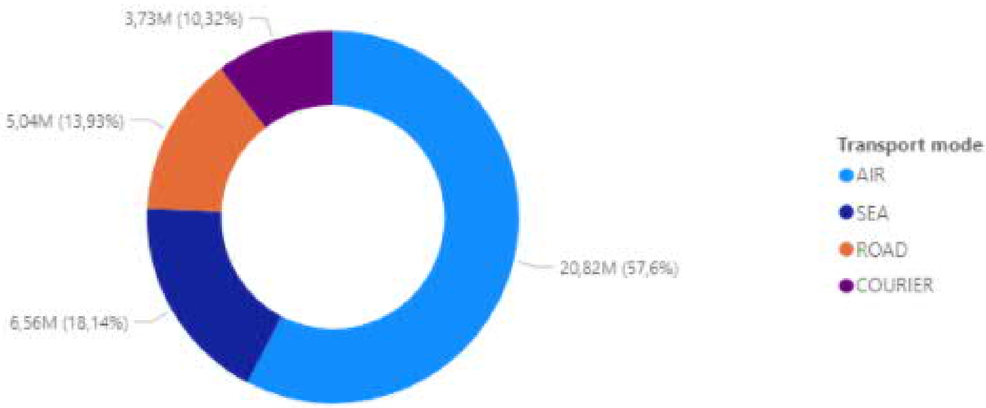

Figure 4. CO_2e emissions by transport modes for export shipments ($kgCO_2e$)

3 THEORETICAL BACKGROUND

In this section, standards that are relevant to this study will be introduced. This section also presents some previous research about green logistics and environmental footprint. There is a lot of previous research about this topic, but environmental footprint is often analyzed from freight forwarders' point of view instead of studying environmental footprint from logistics service buyer company's point of view. This section provides the theoretical background for the study focusing on decarbonization of logistics, green logistics, GHG emissions and transport mode choice. The articles that were chosen to this section include topics such as green logistics as a wider entity, measuring the environmental footprint and chose of the transport mode.

3.1 Standards

The standard that is used as a guideline in this study is EN 16258. This standard sets limits to the calculations, describes calculation principles and methods, advices on allocating the emissions to cargo and passengers as well as gives the frame for reporting calculation methods and results. This standard also provides the energy and GHG emission factors for the most common fuels. In this study we calculate only GHG emissions and energy consumption caused by the use of the fuel. We do not have the actual values available, so default values provided by the 16258 standard and Lipasto are used. (Lipasto, 2020.)

The energy consumption and GHG emissions are in the focus of calculations and reporting according to the EN 16258 standard. The unit for GHG emissions is carbon dioxide equivalent (CO_2e) that takes the six most important greenhouse gases into account, these six greenhouse gases will be introduced later on. For instance, carbon monoxide and sulfur dioxide are not considered in this standard. According to the EN 16258 standard calculations should be conducted in the most accurate possible way but default values can be accepted when more accurate data is not available. The three central factors in the EN 16258 -standard are transport service, leg and vehicle operation system (VOS). Transport service means the transportation activity from the origin to the destination for which energy consumption and GHG emissions shall be calculated. Leg means the part of the route or travelled distance using a certain vehicle or mode of transport. (Lipasto, 2020.)

Another relevant standard for this topic is ISO 14001 that belongs to environmental managements standards. ISO 14001 -standard is the most common international standard for an effective environmental management system (EMS). Companies can also certify to ISO 14001 -standard. ISO 14001 for instance helps companies to gain competitive advantage through better use of resources and waste reduction. This standard is suitable for both small and big companies and it expects companies to consider all environmental issues that are relevant to its operations. Using ISO 14001 -standard can result in benefits such as increased leadership involvement and employee engagement, achieving strategic business aims and providing competitive and financial advantage. (ISO, 2015.)

There are also other standards that focus on environmental issues, for instance ISO 14040 and PAS-2050. ISO 14040 -standards give the framework and describes principles for Life Cycle Assessment (LCA), for instance scope and goal of LCA is defined but detailed LCA techniques are not provided (ISO, 2015). The aim of PAS 2050 is to provide an internationally applicable method that helps to quantify products carbon footprint (GHG Protocol, 2020).

3.2 Impacts caused by greenhouse gas emissions

According to EN 16258 -standard there are six greenhouse gases (GHG) listed in Kyoto protocol and these gases should be considered in calculations. These gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and hexafluoride (SF_6). In this paragraph above mentioned six gases and their impacts will be introduced shortly.

Carbon dioxide (CO_2) is the most significant GHG that is caused by human activities. Carbon dioxide has an environmental warming effect due to its feature to allow light to pass through and also to absorb a lot of heat radiation. The amount of CO_2 is rising by 2 ppm every year and when it reaches a level of 450 ppm it has been estimated to cause the melting of glaciers. In year 2020 the level of CO_2 in atmosphere has been estimated to be almost 420 ppm (Finnish Meteorological Institute, 2020).

Methane (CH_4) is responsible of approximately one fifth of the total heating effect of all GHGs. Methane does not stay in atmosphere longer than around ten years, but its heating effect is much stronger than heating effect of CO_2. Methane also weakens the ozone layer of atmosphere. More than a quarter of all methane emissions globally are caused by the acquisition and use of fossil fuels – logistics has a major impact to total methane emissions.

Nitrous oxide (N_2O) is a GHG with much stronger impact than CO_2, but its main source is agriculture. Nitrous oxide has had the most significant impact on ozone layer during the 21st century. Hydrofluorocarbons (HFCs) accelerate global warming with even 1000 times stronger impact than CO_2, but they are not harmful for ozone layer unless they are reacting with chlorine or bromine. Perfluorocarbons (PFCs) are harmful to humans, animals and environment and also very persistent. Hexafluoride (SF_6) does not weaken the ozone layer but causes global warming and stays long in the atmosphere.

3.3 GHG Protocol

GHG Protocol introduces accounting and reporting standard that provides both guidance and requirement for accounting and reporting principles, identifying emissions and setting boundaries, allocating emissions and setting targets and tracking emissions for instance. This standard covers the six main GHG that were introduced in previous chapter: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and hexafluoride. Need for cutting global CO2-emissions by 85 % by year 2050 creates a situation in where existing government policies are not enough for solving the problem. This means that innovations in businesses are necessary but also beneficial for companies. An effective strategy for reducing impacts on the climate requires a comprehensive understanding of company’s current GHG-impacts. Companies should not only focus on their own operations but also value chains and product portfolios when it comes to more comprehend understanding and measuring of GHG-emissions and also risks and opportunities that are related to them. (GHG Protocol, 2020.)

GHG Protocol Corporate Standard classifies companies’ GHG emissions (both direct and indirect) into three scopes of which all scope 1 emissions and all scope 2 emissions are obligatory to report while including scope 3 emissions to reports is more optional. Scope 1 emissions are direct emissions for either owned or controlled sources, scope 2 emissions are indirect emissions caused by consumed energy and scope 3 emissions are other indirect emission that occur in reporting company’s value chain. Below figure 5 gives a good overview of GHG Protocol scopes and emissions across the value chain. (GHG Protocol, 2020.) This thesis studies emissions caused by freight transportation and these emissions belong to scope 3 emissions – indirect emissions that occur in case company’s value chain. Studying emissions caused by fuel and energy related activities would be the next step for extending this study. Emissions caused by waste generated in operations, business travel and company vehicles could also be relevant study objects in the near future. However, all examples on below figure have a significant role when it comes to the total amount of caused emissions.

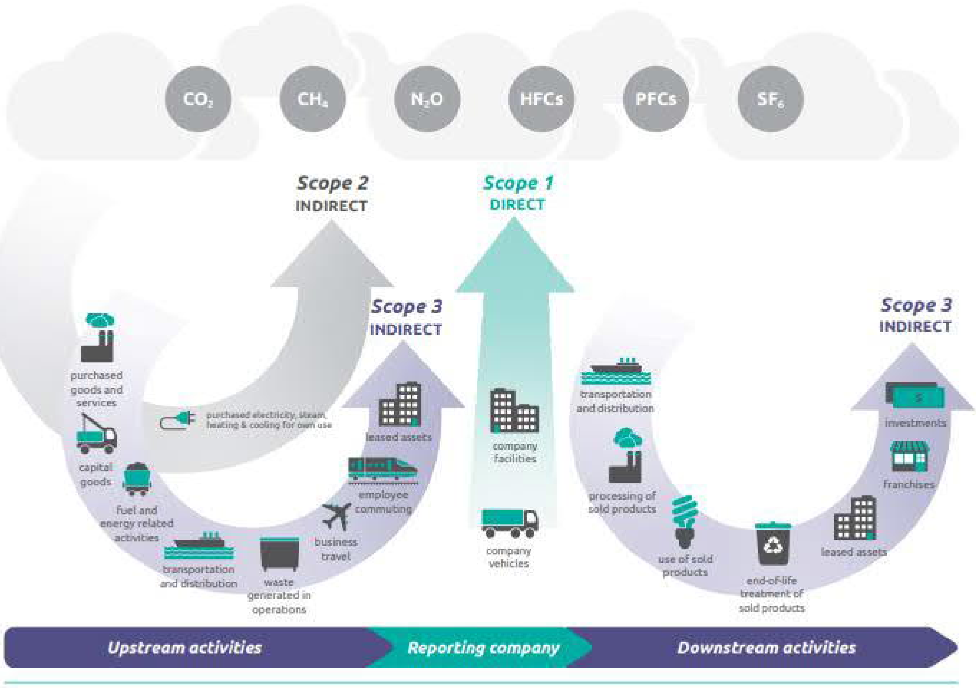

Figure 5. Scopes and emissions (GHG Protocol, 2020).

Studying scope 3 emissions and setting targets for reducing the level of emissions benefits companies in many ways. At first, companies should decide which business goals they want to achieve and then account for scope 3 emissions. Business goals could be for instance identifying and understanding risks and opportunities that are associated with value chain emissions, identifying GHG reduction opportunities, setting reduction targets and tracking performance and / or engaging value chain partners in GHG management or enhancing stakeholder information and corporate reputation through public reporting. Identifying and understanding risks and opportunities could make planning for potential future carbon regulations easier and also help companies to prevent reputational risk through keeping stakeholders updated about the potential emission impacts and planned actions for reducing the associated risks. Also new market opportunities can be found and recognized since demand for emission reducing products will most likely grow in the future. Identifying GHG reduction opportunities helps companies to identify the largest emission sources in the value chain and focus on reducing the impact of those, for instance if majority of emissions comes from logistics, increasing the use of low-carbon logistics providers could make a significant difference. (GHG Protocol, 2020.)

GHG-related risks are for instance regulatory, supply chain cost and reliability, product and technology, litigation and reputation. Opportunities include factors such as efficiency and cost savings, drive innovation, increasing sales and customer loyalty, improving stakeholder relations and company differentiation. Making customers pay the increased costs related to energy or emissions is risk for supply chain business interruption. On the other hand, demand for products with high GHG emissions is decreasing while demand for products with lower emissions increases. Reducing GHG emissions usually decreases costs and increases operational efficiency, low-emission costs and services also are more valuable to customers and demand for new emission reducing products will grow. Public reporting of GHG emissions and planned actions (especially voluntary GHG reporting programs) can also strengthen companies' relationships with customers and differentiate companies from their competitors. (GHG Protocol, 2020.)

Scope 3 reduction opportunities can be divided into game changing opportunities that have high GHG reduction and incremental change opportunities with lower GHG reduction. These can be further divided into long-term implementation opportunities and short-term implementation opportunities. Below figure 6 presents strategic carbon opportunities. Incremental change opportunities focus on collecting and mapping data whereas game changing opportunities are more related to the actual actions. Both are important especially for long-term improvement and utilizing existing potential, but game changing opportunities are necessary for reducing the emissions. (GHG Protocol, 2020.) For the case study in this thesis, the most relevant game changing opportunities from below figure are working with transport providers to reduce the current carbon footprint and reducing use-phase impacts (of fuels). Incremental change opportunities are important as well and collecting transportation data was done as a part of the case study.

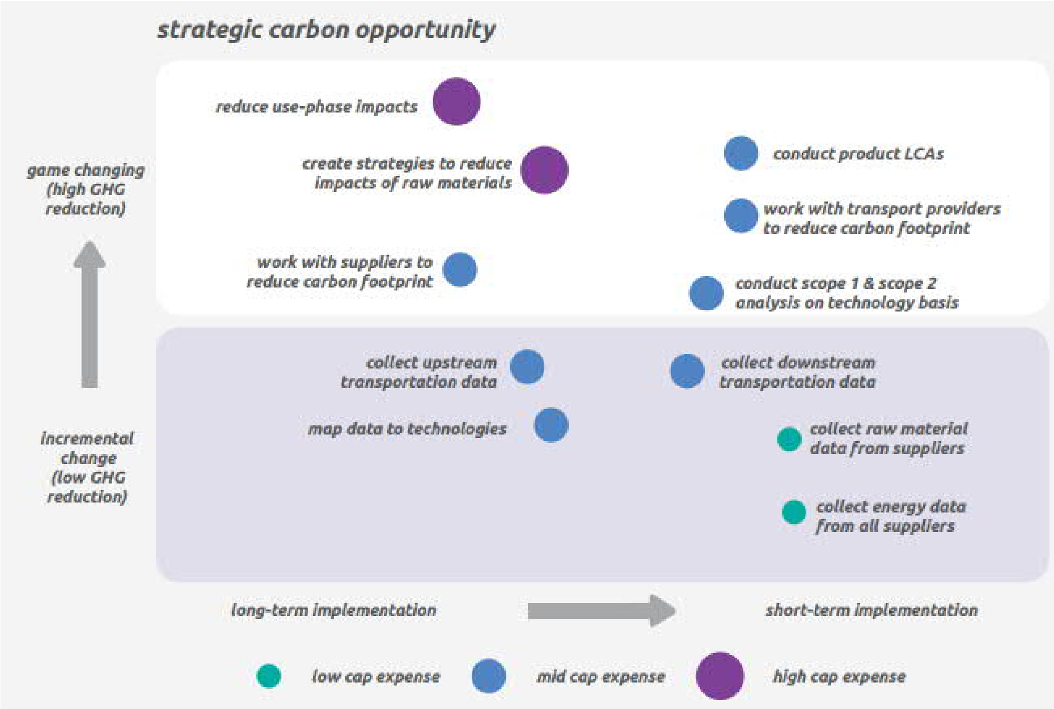

Figure 6. Strategic carbon opportunities (GHG Protocol, 2020).

3.4 Decarbonizing logistics

Alan McKinnon has studied literature that focuses on decarbonization of logistical activities and opportunities for cutting emissions caused by transport. The IPCC has predicted that transport emissions might reach 12 billion tons of CO_2e by year 2050 – this would mean a 60 % share of all permissible emissions. Total GHG emissions caused by transportation would need to decrease to 3 billion tons in order to it remain at its current share – this is a huge challenge for transport system planning and management. Both governments and companies are trying to find solutions for decreasing the carbon intensity in freight transportation operations, but the magnitude of needed actions is often underestimated. Another challenge is that companies usually express the reduction targets in terms of carbon intensity, meaning grams of CO_2e per tkm for instance, while governments set targets in absolute total amounts of GHG emissions. (McKinnon, 2018.)

Freight volumes are expected to be tripled by year 2050 and freight vehicles are a major oil consumer, so it is important to find solutions for reducing emissions caused by logistics and freight transportation. Transport related emissions are expected to cause 60 % of all allowable emissions in 2050 if the growth will continue at the current pace. Freight transportation has also been pointed out as one of the most challenging economic activities when it comes to decarbonization and it is considered as an essential human activity. The situation is challenging as the demand for freight transportation will grow significantly but at the same time freight transportation is still strongly dependent on fossil fuels in the near future. (McKinnon, 2018.)

Future growth of transportation will probably be robust and highly dependent on economic development, cross-sectoral decarbonization, the climate-proofing of agreements and infrastructure. Decarbonization actions need to focus on driving down the carbon intensity of transportation to a fraction of current carbon intensity, especially if reducing the total tkm turns out to be impossible. Five carbon intensity reducing factors can be listed: supply chain structure, modal split, vehicle utilization, energy efficiency and energy mix. Supply chain structure has a direct impact of travelled tkm – for instance the development of economies has resulted in more direct distribution channels which results in reduced tkm. On the contrary, procurement has become more geographically extensive which has increased carbon intensity. The centralization of inventory has also increased the carbon intensity of logistics and companies may have to return to more decentralized warehousing in order to be able to cut carbon intensity, even though that would probably increase warehousing emissions per unit of throughput which might lead to carbon penalties. However, the actual transportation usually causes 8-9 times bigger carbon footprint than warehousing, hence a full carbon trade-off analysis is needed in order to be able to make conscious decisions. (McKinnon, 2018.)

The effectiveness of freight modal shift bases on the fact that the average carbon intensity varies significantly between different transport modes. Freight modal shift often includes rail freight or waterborne – The European Commission has a target of having 30 %

of all freight tons travelling at least 300 km by rail or water by year 2030. This growth would also require the European rail infrastructure capacity to increase which is quite an expensive option. Vehicle utilization includes factors such as capacity and truck size and weight. All transport modes tend to underutilize the capacity so there is potential to cut carbon intensity trough more effective use of capacity. Utilizing the capacity is also very cost-effective way to cut carbon emissions since raising vehicle loads is usually self-financing. Of course, there are some factors that make the full use of capacity difficult, for instance demand fluctuations, geographical imbalances, vehicle size and weight restrictions, nature of packaging and handling equipment and lack of load consolidation facilities. (McKinnon, 2018.)

Energy efficiency is defined as energy consumed per vehicle-kilometer and there has been significant improvement in the energy efficiency of all transport modes. However, energy efficiency can and needs to be increased even more. Also, operational changes have resulted in the increasing energy efficiency. For instance, *slow steaming*, meaning ships operating at less than design speed, was firstly introduced in 2007 when fuel prices were high and trade volumes decreased – this resulted in cutting average fuel consumption by 27 % for five years. After this container ships have been designed to sail at slower speeds which effectively embedded this carbon-reducing practices in sea freight transportation. The use of low-carbon energy is still at very early stage, for instance in most countries the share of carbon in grid electricity is still relatively high so carbon benefit is not significant. Decarbonization of electricity generation is needed for getting the benefit from vehicle electrification. After that, significant carbon cuts can be made in countries with electrified railway networks and extensive battery recharging infrastructures. For long-distance road freight the increased use of low-carbon fuels is more probable way for decarbonation. Low-carbon fuels are the main option for decarbonation for sea freight, air freight and rail freight that operates in non-electrified networks. (McKinnon, 2018.)

Kaya Identity names four drivers that determine the amount of GHG caused by human activity. These four drivers are population, affluence (GDP, gross domestic product), energy use and the carbon content of the energy. Kaya Identity also defines "freight identity" equation that considers freight transport intensity of the economy (distances), energy intensity of freight movement (used energy for tkm) and GHG intensity of the energy. Five ways of decarbonizing freight transport can be listed, and they are cutting GPD, lowering freight transportation intensity, shifting transport mode, improving energy efficiency and switching to lower-carbon energy sources. (McKinnon, 2018.) Of these five ways at least three could be applied at individual company level: shifting transport modes, improving energy efficiency and switching to lower-carbon energy sources. Shifting transport modes could be done by increasing the proportion of sea freight and rail freight and decreasing the proportion of road freight and especially air freight. Use of lower-carbon energy sources, such as biofuels or electricity, could be increased and energy efficiency could be improved through optimal loading and routing for instance.

Quantifying the amount of caused GHG emissions of different activities is necessary in order to be able to identify where the emission reduction actions should be focused. Regular monitoring also creates possibility to measure the impact of emission reduction strategies. At an early stage, logistics-related emission calculations have lacked guidance on the measurement, analysis and reporting of the emissions – used methodologies and emission factors have neither been sufficient nor coherent. Diversity itself is not a problem as long as calculations are based on consistent set of principles, but unfortunately this has not been the situation. As recently as in year 2016 a framework for logistics emissions methodologies was published by Global Logistics Emissions Council (GLEC). This framework is mostly based on already existing and widely used methodologies such as Clean Cargo Working Group (for container shipping), EcoTransIT (for rail) and both EN 16258 and the US SmartWay system for trucking. GLEC recommends simplicity and flexibility so that results would be easy to comprehend and in order to allow methodology to be adaptable for all business models and transport modes. Collected data is also recommended to be relevant, complete, consistent, accurate and transparent (McKinnon, 2018.) In this study EN 16258 is used and it sets limits for the calculations and provides default values for formulas for instance. All mentioned seven criteria are not fulfilled in this case study, but that is quite a normal situation due to diversity of logistics activities and high propensity of outsourcing the logistics services for instance.

After the carbon emissions have been quantified, targets should be set. There can be two kinds of targets: absolute targets that aim to cut total logistics-related emissions and intensity-based targets that aim to reduce emissions relative to the level of logistics activity. Companies usually prefer intensity-based targets because they fear that absolute targets would prevent business growth, but problem with intensity-based targets is that the absolute level of emissions can continue rising even though intensity would decrease. The Science-Based Targets (SBT) aims to make the gap between absolute and intensity-based targets smaller through advising companies about setting carbon reduction targets consistent with the climate science. Setting a science-based carbon reduction target for logistics is difficult due to logistics' role as a support service for many other sectors – these sectors have different potentials for reducing GHG emissions and this variation should be considered when carbon reduction targets for each sector and logistics is determined. (McKinnon, 2018.)

3.5 Green Logistics and GHG Emissions

Green Logistics can be defined as actions of measuring, analyzing and reducing the environmental impact of logistics activities (Blanco & Sheffi, 2017). Even though concept of logistics covers several other actions than only freight transportation, this thesis focuses mainly on the environmental footprint and Green Logistics from freight transportation's point of view. According to Blanco and Steffi (2017), freight transport is responsible for about 90 % of estimated CO_2 emissions caused by freight transport and logistics activities. Thus, it is justified to focus on freight transportation when measuring the environmental impacts of logistics.

The goal of green logistics can simply be defined as an aim to mitigate the environmental impact of logistics and logistics related activities. The environmental impact of logistics is in most cases result from five main factors: distance, mode, equipment, load and operation. Each of these five factors can be used when designing greener logistics systems; distances can be reduced, intermodal transport modes used, cleaner equipment sourced, load planning developed, and operational excellence improved. A commitment at management level is essential for reducing the impact of the mentioned five factors, otherwise the needed actions will not take place. (Blanco & Sheffi, 2017.)

All introduced five factors are a bit different when it comes to the transport service buying companies' possibility to effect on them in order to get reductions in environmental impacts. One major factor that effects on environmental impacts is the mode of transport – this one is decided by the transport service buying company, but on the other hand the decision is often made on the basis of schedule requirements. Load depends on the product itself and is difficult to effect on, with the exception of the packaging for instance. Distances can be affected through routing but is more of the responsibility of the carriers, as well as equipment and operations. Through closer co-operation with carriers all five factors can be affected on but resources for this will be required.

Blanco & Steffi (2017) also state that achieving environmental reduction does not always result in increasing costs. In a case study it was found that 10 % CO_2e reductions cause less than 1 % increase in costs. On the contrary, for achieving 25 % CO2 reductions a more significant cost increase (15 %) is required. Blanco & Steffi (2017.) However, since freight transportation is responsible for a major share of total CO_2e emissions in logistics, 10 % reductions in environmental impacts really make a difference. Since focus on environmental impacts is not a self-evident priority for companies, getting concrete results with just a little cost increase might be one critical factor to drive companies towards development in this area. Measuring the trade-off between decreasing environmental impacts and increasing costs is one challenge that companies will face, but even simple estimation models should indicate if the development is going to the right direction.

There are two approaches that are commonly used in logistics decision-making: network design and vehicle routing. Logistics network design has a direct impact on distance reduction and mode shift that are the most important factors for green logistics. Network design models are widely in use in logistics sector and they usually include trade-offs at cost and service level. From the perspective of energy and Greenhouse gas (GHG) emissions, vehicle routing and scheduling is usually the activity with most environmental impacts. Models aiming to solve vehicle routing problems (VRP) most often focus on minimizing distance, time or cost of the routes and even though the correlation is high, minimum distance does not always lead to minimum environmental impacts. When focusing on the environmental impacts of vehicle operations, speed of travel is another relevant dimension; consumption by speed for a light-weight vehicle forms a U-shaped curve that presents the optimal speed of 40km/h. (Blanco & Sheffi, 2017.)

The possibilities and responsibilities for greening freight transportation are more on freight forwarders side than on transport service buying companies' side. Freight forwarders are responsible for many actions such as vehicle routing and network design that are introduced in previous chapter. Usually transport service buying companies are mostly just buying and using the transportation services and not necessarily involved in the planning and development activities at all. Of course a share of all freight transportation is more customized for a certain customer or transportation but need for a special transportation comes often from needs for urgent schedules and / or having challenging cargo, which means that there is not always possibility to choose the solution or route with least environmental impacts. Creating more profound co-operation between freight forwarder and transport service buying companies would improve transport service buying companies' possibilities to make a difference and develop greener freight transportation practices and policies. Also, when it comes to calculating and reporting the emissions, practically transport service buying companies' only chance to get more accurate data and calculations than by using default values is to demand reports from freight forwarders and rely on their accuracy and precision.

It has been estimated that transportation sector globally consumes 19 % of all used energy and causes 23 % of energy-related CO_2 emissions. As stated earlier, acts of freight transport are responsible of 90 % of these emissions. One of the main impacts of transportation operations are GHG emissions that affect the climate globally. The Intergovernmental Panel on Climate Change (IPCC) has recognized that transportation activities produce tree direct greenhouse gases, which are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The impact on mentioned greenhouse gases can be expressed in terms of carbon dioxide equivalents (CO_2e) and is often referred to as carbon footprint. (Blanco & Sheffi, 2017.) CO_2e emissions caused by freight transportation is also a main study objective in this thesis in together with energy consumption.

There are three different standards for estimating GHG impact, one of them covering precisely quantifying GHG emissions from freight and focusing on carbon footprinting in the transportation sector. This standard is EN 16258 and it is the newest of the three standards for GHG impact estimations as it was established 2012. All three standards use emission factors and variations of equations, the main difference between different standards is the scope of the GHG calculations. In EN 16258 transport GHG calculations are advised to include WTW-emissions as others only require TTW-emissions (however, including WTW is recommended by other standards as well). WTW (well-to-wheel) is the sum of the emissions that are related to the extraction, production and distribution of fuels that are used during transportation until the fuel is placed in the vehicle (WTT – well-to-tank) and all the emissions that are generated during the combustion of the fuel during transportation (TTW – tank-to-wheel). (Blanco & Sheffi, 2017.)

The EN 16258 standard is the first European standard for measuring emissions caused by transport. This standard will be introduced more thoroughly in methods section, but in brief it covers the definition of the scope of calculations, describes calculation principles and phases, advices on allocating the emissions for the freight and passengers and gives the frame for reporting the calculation methods and results. As stated in the previous chapter, the EN 16258 requires transport emission calculates to be calculated on WTW-level, covering emissions thorough the whole life cycle of the energy source. One basic calculation principle of the EN 16258 is to allocate all energy consumption and emissions to the cargo, meaning that travelled (return) distance without cargo is also considered. (Lipasto, 2020.)

Calculating GHG emissions is challenging due to the allocation of the emissions. It is very complex to allocate the emissions from a corporate or individual route level to an individual shipment level. In order to provide a consistent and simple calculation method that can be applied in many different organizations, some factors have to be left out from the method. For instance, considering such things that routes can have different efficiency levels and specific vehicles do not always have same performance metrics makes emission calculations more and more complex. However, the EN 16258 -standard aims at more detailed approach and for instance using weight of product and the actual travelled distance as the allocation parameter. The EN 16258 -standard aims at emission factors and consequently the calculations to be as accurate as possible. Effective use of the EN 16258 -standard requires consistently and continuously collecting data across every transportation route including such information as shipment information, sequence and travelled distance. Standards create certain frame to GHG calculations, but there is still variation in GHG Metrics due to data availability, scope and / or assumptions. Usually companies have to choose between integrative and useful metrics and between robust and valid metrics for instance. (Blanco & Sheffi, 2017.)

In this study the calculations include quite many assumptions. For instance, travelled distance without cargo is not considered at all since the assumption is that empty drive does not happen. Unfortunately, neither actual travelled distances nor actual fuel consumptions are available, but default routes are defined at country level and default fuels chosen for each transport mode. Number of shipments in the scope of this study is very high (hundreds of thousands of individual shipments in total) which causes a need to perform the calculations in a simple form. Even though there are many assumptions, this study provides good and sufficient understanding about the current level of the caused CO_2e emissions and energy consumption as well as we get informative trend curves. This study gives a decent frame for this topic and builds a good base for improving this project and calculations in the future.

Blanco and Steffi (2017) also mention some challenges concerning the implementation of Green Logistics strategies. Two main challenges are the need of focus and demand for collaboration. There is not always enough attention paid to this kind of issues since they are not prioritized by management. Another challenge is the need of collaboration; successful implementation of Green Logistics demands both internal and external collaboration. Additionally, case studies about Green Logistics initiatives implementation through collaboration are introduced. Collaboration also often leads to a win-win situation as greener supply chain can result in cost reductions for instance. Successful implementation and use of Green Logistics strategies always requires a solid measurement foundation of GHG or another measured factor. Measuring is often challenging due to environmental metrics being tentative and still being developed. (Blanco & Sheffi, 2017.)

Blanco's and Steffi's article about Green Logistics provides a good overview about the environmental impacts of freight transportation and logistics as well as challenges in developing greener solutions in the mentioned field of industry. In the case company the most critical factor affecting on environmental impacts is the choice of transport mode. In practice this decision is often set by schedule requirements or / and freight cost. In the future environmental impacts should be systematically considered as one influencing factor alongside schedule, cost and other factors that currently effect on the choice of transport mode. One of major challenges in the case company is that logistics functions are outsourced – co-operation with carriers is critical for obtaining up-to-date and actual information of variables that effect on caused CO_2e emissions for instance. There is a lot of potential when it comes to reducing the environmental impacts of the freight transportation in the case company even though many of the possible actions require close co-operation and development work together with carriers.

3.6 The Freight Transport mode choice

Bask and Rajahonka (2017) have studied the role of environmental sustainability in the freight transport mode choice. It is stated that companies have begun to use environmental sustainability as a source of competitive advantage due to risen awareness of environmental impacts of industrial production and trade that have caused climate change. Despite of its environmental impacts, transport is necessary for the economy and society, and therefore more environmentally sustainable solutions and practices need to be developed and implemented. Transport is the second biggest source of greenhouse gas (GHG) emissions in European Union with its 23 % share of total GHG-emissions. It is necessary to understand the role and importance of the companies that are continuously making decisions about how to arrange transport. Transport service buying companies are responsible of decisions concerning the purchase of transport, but Logistics Service Providers (LSP) are responsible of providing solutions for supply chains and thereby enhancing environmentally sustainable development. (Bask & Rajahonka 2017.)

According to Bask and Rajahonka (2017) EU has promoted environmentally sustainable transport and especially intermodal transport (rail and waterborne) for past two decades already but at the moment most used transport modes are also the ones that cause most environmental impacts (road freight and air freight). Road and air freight are also the most used transport modes in the case company so a lot of improvement could be achieved. In EU intermodal transport modes cover less than one fifth of total transport whereas the target is to change 30 % of current road freight to intermodal transport modes (Bask and Rajahonka 2017). In the case company the use of intermodal transport is not widespread either which leaves space and also a significant need for future development. In Finland railway network is challenging, but for instance switching the transportation between two common locations from road freight to rail freight would make a difference. There are numerous of origins and destinations in domestic transport, but also a lot of regular routes that cover a good share of total domestic transport – not all road freight is needed or even possible to change into rail freight, but there is a lot of development potential, both domestically and in other countries as well. (Bask & Rajahonka 2017.)

Bask and Rajahonka (2017) state that it is important to understand the decision-making behind the transport selection, for instance which criteria are used and what role environmental sustainability and intermodal transport have in this, due to EU's efforts for promoting environmentally sustainable transport have not been as successful as was expected. This is why Bask and Rajahonka (2017) study the topic from the transport service buying company's perspective; LSPs also have a big influence on whether their goals can be achieved through environmental sustainability policies. Also, this thesis studies the environmental impacts and CO_2 footprint from company's point of view, which makes this article a relevant part of the theoretical background of this thesis. One thing that Bask and Rajahonka (2017) point out is that environmental issues can be included in contracts or quotations between logistics service buying companies and LSPs – this is also something that the case company could and should utilize in the future with its main contract partners. Including environmental issues already in contracts would clarify shared interests for reducing environmental impacts and also ensure that defined targets will be achieved (Bask & Rajahonka 2017).

Some criteria behind the freight transport mode choice are discussed and one major factor behind the mode choice seems to be transport cost. It is also stated that it is difficult to identify mode choice affecting factors without having knowledge of decision-makers individual preferences. Transport mode choice is also pointed out to be only a part of a company's logistics strategy and a part of a complex decision process. Decision makers do not seem to know much of those transport modes that they do not use regularly; they are able to describe their typical shipment and its characteristics but cannot do the same for other shipments with a different transport mode. Decision making affecting factors can be divided into six groups: customer requirements, product characteristics, company structure, government interventions, available transport facilities and decision maker's perceptions. Transport cost, reliability, flexibility, transport time and safety are five factors that can be listed as important performance criteria for shippers when concerning transport modes. (Bask & Rajahonka 2017.)

In the case company most of the transport planning is centralized in a separate function so level of expertise is sufficient when it comes to adequate and considered transport mode choices. On the other hand, regular shipments are mostly booked with nominated carriers and transport mode choice is usually based on price and transport time. Price and transport time are often inversely proportional; for instance, air freight is often much more expensive than sea freight but on the other hand transport time is significantly faster. Sea freight is preferably used for large intercontinental shipments but often air freight is required due to scheduling reasons even though it is not the best option when it comes to environmental impacts. Road freight is widely used in Finland and Europe and replacing parts of it with rail freight should be considered. One important factor that should be considered is the flow of information from customers to business units and further to transport planners. For instance, the availability of actual and up-to-date information about the schedule requirements is crucial for reducing environmental impacts and achieving cost savings through avoiding unnecessary use of air freight.

Bask and Rajahonka (2017) also mention that first studied article that brought up environmental sustainability as an equivalent mode selection criterion in comparison with other criteria was published 2013. In addition to environmental sustainability five other criteria were mentioned: transport time, flexibility, reliability and quality. Another article that included environmental sustainability in the transport mode decision making was published 2014 and considered *emission costs* along with the traditional trade-off between transportation costs and lead time – however, it came out that the emission-related charges do not have a significant impact and considering emission costs does not usually effect on the choice of the transport mode. (Bask & Rajahonka 2017.) Hence considering environmental sustainability as an equivalent selection criterion is quite a recent policy and impacts are not yet significant.

Bask's and Rajahonka's (2017) study also discusses different preferences effecting of the choice between intermodal and unimodal transports. The shippers that preferred using unimodal experienced the quality of intermodal transport lower than single modal transport. Large shippers with large volume most often had the quality of intermodal transport at higher level and it was found out that choosing intermodal transportation was particularly challenging for smaller shippers. A previous study also indicated a low reliability for intermodal rail transport which means that increasing the reliability and decreasing the freight costs of intermodal transport should be a priority. Bask's and Rajahonka (2017.)

The mode choice is not only based on mode choice criteria, but it can be dependent on the shipment size as well. The mode selection is strongly linked to the choice of carrier since relationship and collaboration between shipper and carrier covers many of the most important selection variables used by shippers and carriers. Carriers' knowledge of shippers' needs, carriers' reputation and carriers' ability to trace shipments and transit times can be mentioned as examples of selection variables. In the literature mode choice has previously been seen more often as shipper's dilemma but in more recent articles it is considered more as LSP's dilemma. The discussion around transport mode decisions has previously focused on comparison between separate, individual modes, and intermodal transport has gained more attention later and seems to be growing topic nowadays. Earlier the goal was more about finding and choosing the most efficient solution that brings the maximum utility to the decision maker and on the contrary, environmental sustainability as a motivation factor and especially as a mode selection criterion is rather new. (Bask & Rajahonka 2017.)

Bask and Rajahonka (2017) also found out that the content of a logistics service is not always clear for service buyer companies and freight transport companies. Sharing the costs and benefits caused by environmental actions seems to be prevented by the lack of standard methodology for measuring environmental impacts. Including green requirements in contracts does not always result in actual changes in processes. Measuring environmental performance or handling incompliance was not always taken into account even though environmental performance would have been considered in the transport contracts. Nevertheless, including this kind of issues in the contracts is relevant since it has a positive correlation to performance improvements. CO_2e emissions and energy use are mentioned as the most common performance metrics in the contracts and transport manager’s role in including environmental factors in contracts was found crucial. (Bask & Rajahonka 2017.)

Decision criteria such as transport costs, transport times and reliability get usually significantly more weight than environmental issues or transport mode related issues. Only a few of the studied articles found a connection specifically between environmental sustainability or carbon emissions and transport mode choice. The development of environmental actions seems to be hindered by the lack of standardized measuring methodology. One of the most significant benefits of intermodal transport is its lower environmental impacts but it is difficult to promote its wider use without solid evidence of environmental impacts. Discussion on environmental issues together with intermodal transport is not a traditional topic, instead it is a relatively recent yet rapidly increasing field of study. LSPs have lately been strongly involved in environmentally sustainable development which includes intermodal transport as well. (Bask & Rajahonka 2017.)

3.7 Drivers and barriers impacting on the green initiatives of LSPs

Evangelista et. al. (2018) focused on logistics service markets in two EU-countries. In the case countries road transport is a major part of the freight transportation entity and majority of companies are either small or medium size. Hence, the case countries and companies do have similar features as Finland and Finnish companies which makes this study relevant for this thesis. Evangelista et. al. (2018) study and discuss both the internal and external drivers and barriers that have an impact on how logistics service providers adopt green initiatives.

Nowadays environmental sustainability issues are one of the key areas at the management level. Customers are increasingly demanding ecological products and services and environmental regulations have been getting stricter as well. The transport and logistics sector are crucial for trade and also for economic growth in many countries but especially freight transportation has also its negative environmental impacts that shall be considered. Thus, environmental sustainability should be seen as a priority and a possibility to gain competitive advantage, and implementation of environmental strategies should be prioritized by logistics service providers (LSP). The environmental strategy can be defined as the environmental organizational culture and the set of both internal and external factors that influence the implementation of the culture and strategy. (Evangelista et. al., 2018.)

In order to be able to implement sustainable strategies in practice, companies need to develop an organizational culture that enhances collaboration and proactive attitude among employees. Organizational capabilities, quality of human resources as well as the amount of knowledge of green issues have a positive correlation with the intention to adopt green innovations. Organizational support – emphasis on the support from top management – is essential for employees' motivation and resources, hence it has a key role in advancing the implementation of green practices. Two different drivers for developing green initiatives can be stated: employees' initiatives or bottom-up approach, and management and board involvement, also known as top-down approach. (Evangelista et. al., 2018.)

Green initiatives can be defined as the set of actions and decisions that aim to reduce the negative environmental impact caused by the actions of a company. The impact and magnitude of green initiatives depend on both the type and the scope of the actions. In the field of logistics, the role of multimodal transport is emphasized as it is a potential area for reducing negative environmental impacts, for instance emissions. For implementing multimodal transport and thereby improving environmental performance, the role of customers and competitors is crucial. Green initiatives can also be divided into two groups, “point” initiatives that are initiatives inside the company and “supply chain” initiatives that have impact on different stages of the supply chain also outside of the company. (Evangelista et. al., 2018.)

Factors that influence the implementation of green initiatives are drivers and barriers and these can be divided further into two categories: internal and external. The more knowledge of green initiatives in the company there is, the more willingness there is to adopt green actions in practice. Also, stakeholders do have an impact on the environmental management practices. The most important factors that influence the adopting of green initiatives are the pressure from the customers and the environmental awareness of management. Long-term contracts have been recognized as a one important driver of the implementation of green measures in logistics companies. Also, environmental reputation and need for creating a green image have to be considered as key motivations for adopting Green Supply Chain Practices (GSCP). (Evangelista et. al., 2018.)

As well as drivers, also barriers can be divided to internal and external barriers. Some barriers belong to both categories, for instance high level of investments and uncertainty concerning payback times is both internal and external barrier for development of green measures. Other internal barriers can be for instance lack of human resources in green initiatives, lack of financial resources and lack of ICT skills for managing green initiatives. On the contrary, lack of customers environmental awareness, lack of funding and lack of well-defined regulations can be mentioned as examples of external barriers. Different internal and external drivers and barriers exist and highlight in different companies and countries. (Evangelista et. al., 2018.)

Evangelista et. al. (2018) found out that in order to have a recognizable environmental strategy, at least medium priority for green initiatives is required. Also, top management has the primary responsibility of this area in most cases. It is also stated that companies that outsource their transport services are not concentrating on green initiatives since the impact on the sustainability of the transport services in overall supply chain would not be particularly significant. Those companies that are taking care of the transport services themselves are more capable to implement green initiatives concerning the freight transportation. For instance, cost reductions and improvement of customer relationships together with desire and need to improve the corporate image are mentioned as important drivers for adopting green logistics initiatives. (Evangelista et. al., 2018.)

Customers do have a significant impact on the adoption of the green logistics initiatives: high level of environmental awareness among customers can be a driver and lead to increased environmental sustainability of the supply chain. In contrast, if customers are having a low level of environmental awareness and are not requiring or expecting development of green logistics initiatives from LSPs, customers can be seen as barriers. It is also concluded that there is neither clear and well-defined approach for implementation of an environmental sustainability strategy nor coherent awareness of the importance of the environmental sustainability. There is ability and willingness on companies' side to invest in environmental sustainability programs if achieving clear benefits can be ensured. (Evangelista et. al., 2018.)

This study by Evangelista et. al. was performed from the LSPs point of view, in other words from carriers' point of view. This is still remarkably relevant for the companies buying the freight transportation services since there is so much potential to decrease CO_2e emissions and energy consumption through co-operation with carriers. Co-operation with carriers is necessary in order to be able to get accurate information about used fuels, average fuel consumption for certain VOS and distances for instance. Close co-operation between carriers and service buying companies can benefit both parties: long-term contracts would be a good base for fulfilling the need for continuous comprehensive reporting and detailed information.

4 METHODS

4.1 Research methods

The main research method in this study is an GHG-analysis that meets the requirement of the EN 16258 -standard. The GHG-analysis is a quantitative research method. This study focuses on energy consumption and CO_2e emissions caused by freight transportation during the operational phase of a lifecycle, WTW-approach is not included at this point. Use of the EN 16258 -standard will be introduced more thoroughly in chapter 5.

In the first phase of this case study separate reports for both export and import are combined for one export and one import report. After that shipments which are not in the scope of this study are removed. Main transport mode is defined at a shipment level based on transport service -information on reports. For both export and import Excel-files separate Excel-sheets are created in which destinations are defined at part leg level for each origin country – destination country -pair. Next step is to create Excel-formulas that obtain correct distances for each leg of each shipment based on main transport mode, destination / origin country and sender / receiver zip code. Lastly, energy consumption and CO_2e emissions can be calculated for each shipment at a leg level and as total. Based on these calculations, visual presentations with graphs and charts can be created in both Excel and PowerBI.

4.2 Data collection and analysis

Data for this study was collected for case company's system that gathers the information of case company's freight transportation on individual shipment level and from carrier reports that have mostly the same content. Reports were taken on a monthly basis including data from last year (2019) and Q1 and Q2 from this year (2020). All shipments handled by the case company were included in the reports. Data was analyzed according to the guidelines set by the EN 16258 -standard and divided by time periods, modes of transport and business units. Below figure 7 presents process flow for data collection and calculations in this study.

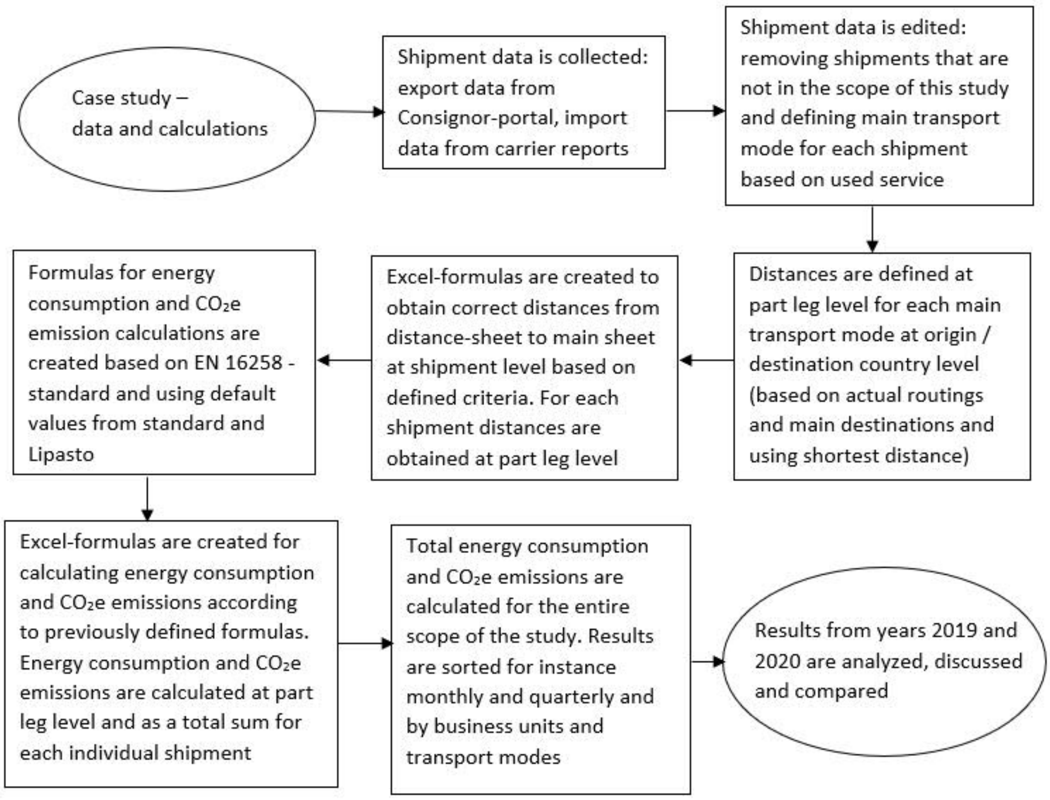

Figure 7. Data collection and calculations.

Master data from the system was obtained as Excel-files and it included shipment level data covering all import and export shipments. Master data included for instance shipment weight, destination and origin country, used carrier and service and shipment volume. Main transport mode was not mentioned in system data, but it was defined based on used transport service. Master data included neither distances nor fuel consumptions. Distance calculations were performed as described in previous chapter and emission calculations were performed based on calculated distances. Emission calculation formulas were built according to standard and considered variables are weight of the shipment, distance, fuel consumption factor and energy factor for energy consumption and CO_2e factor for CO_2e emissions. Weight of the shipment was available in system data, distances were calculated based on origin country, destination country and main transport mode and fuel consumption factors, energy factor and CO_2e-factor were available at used standard.

For export data there was one Excel-file for each month and for import data there were eight Excel-files for each month – all export files were combined to one Excel-file and all import files were combined to another Excel-file. This was very time-consuming phase in the project. After all files were combined, distances were defined and obtained to main data sheet as described earlier. The most challenging part in this was to build Excel-formulas that obtain values from distance-sheet based on several criteria – these formulas were also tested and validated many times. When distances were defined and obtained at shipment level, next step was to build Excel-formulas that perform energy consumption and CO_2e emission calculations. In here the main challenge was not building the Excel-formulas technically but defining what the formulas should calculate.

4.3 Limitations, reliability and validity

Limitations, reliability and validity of this study are mostly affected by the relatively high number of assumptions, the amount of manual work and the scope of the study. Assumptions are mostly related to distances, used fuels and fuel consumption default values. Variables such as shipment weight and main transport mode are known for every shipment. Amount of manual work is quite high when it comes to processing the reports – for instance import shipment data has to be combined for many separate reports. Distance, energy consumption and emission calculations are executed automatically in Excel but there is a possibility that some shipments would be lost when combining the individual reports. On the other hand, reports for import shipments are obtained externally, so that is also one risk factor for the reliability.

This study includes a number of assumptions. For instance, it is assumed that trucks are loaded full and there is no empty drive – information regarding possible empty drive is not available and even if it was, it would make calculations way too complex at this point. In the future this part of the calculations could be improved, and accuracy increased by including an average distance of empty drive if actual data could be received from forwarders. There are also assumptions regarding used seaports and airports: for each destination country only one airport and one seaport is used as well as for courier freight one airport per country is used. For majority of the road freight to Europe the actual used seaports are used in calculations as well, but some expectations may occur. Also, for this part accuracy could be improved through tighter co-operation with forwarders. One assumption related to defined distances is that shortest possible route is used as distance for each destination.

Besides assumptions listed above there are also other limitations. Accuracy of the calculations is one main limitation here; for instance, actual values for fuel consumption are not available and default values are used. Not much information from forwarders is available at the moment and accuracy of the calculations could be improved if more accurate data could be received from forwarders. It is also possible that some individual shipments are missing from the reports, yet this is not significant in the larger picture since the amount of shipment data is extremely massive during studied period of 1,5 years (hundreds of thousands of shipments for both export and import shipments). A lot of assumptions related to emission calculations is typical situation, especially when the amount of data is as massive as in this study. However, there is also a lot of potential when it comes to improving the accuracy, even though it requires very comprehensive reporting and input from the forwarders' side.

In this thesis export and import shipments from the beginning of the year 2019 to the end of June in year 2020 are included. 1,5 years – or six quarters in other words – is relatively short period of time in this context. This study gives a starting level of the CO_2e emissions and energy consumption caused by the freight transportation of the case company and gives the possibility to compare mentioned emissions and energy consumption between two first quarters of 2019 and 2020. The comparison is most relevant when it is done between two same time periods, for instance comparing January and October would not give much information. This means that at the moment calculations of Q3 and Q4 of the year 2020 do not have much value besides the starting level information they provide. Once the data from Q3 and Q4 from the year 2020 is available, comparison can be expanded to the end of the years 2019 and 2020. And actually, years 2019 and 2020 are not the most optimal years for this kind of comparison due to wide impacts of COVID-19. However, this thesis builds a strong base for expanding and developing these calculations for future years as well.

When it comes to reliability, automatization of distance calculations is important. The higher amount of manual work, the higher probability for human errors. Automatization also eases the workload and thereby leaves more time for more specific tasks. Distance calculations are done in Excel and tests are performed in order to make sure the reliability of the used formulas. In this study, the distance calculations are reliable as long as the distance tables do not include mistakes – distances in the distance tables are inspected many times, but reliability could still be increased by using some data base for distance calculations in the future. Formulas that calculate the caused CO_2e emissions and energy consumption are Excel-based too and are as reliable as the formulas for distance calculations. However, the user of the Excel should be aware that in order to get reliable results, the formulas need to be used correctly. To ensure this, the data including Excel-files also include instructions and the formulas in a separate sheet as a back-up.

Validity of this study is high: this study was supposed to measure the current level of energy consumption and CO_2e emissions and these issues were measured as well.

Research problem was to quantify the current level of CO_2e emissions caused by freight transportation which was successfully quantified. Research questions were about main contributors causing the emissions and how the level of emissions could be reduced, these questions were answered as well. Quantitative study in this thesis was as reliable and valid as was possible with the used case company's data that was available at the moment.

Reliability and validity could be improved in the future through increasing the reliability and accuracy of the available data. This challenge concerns especially import shipments; if import shipments would be booked in the same system as expert shipments, that would increase the reliability and uniformity of all data. If case company is dependent on carriers when it comes to import data, there is a bigger risk that there are faults in data or that data is incomplete. There is also several months delay with import data whereas export data from the system is available almost in real time. Another possibility for improvement is used fuels: at the moment calculations are performed based on default values but perhaps carriers would be able to provide more information about actually used fuels. Also, distances are rough estimates and actual distances are not available at the moment. For distances there are two possibilities to increase accuracy; get information about actual distances from carriers and / or source more accurate distances at more detailed level by using some database – at the moment distances are defined at country level only but in the future distances should be obtained at zip code or street address level.

5 USED STANDARD – EN 16258

5.1 EN 16258 in brief

The standard that is used as a guideline in this study is the EN 16258. In brief, EN 16258 can be described as a guideline that sets limits to the calculations, describes calculation principles and methods as well as gives the frame for reporting calculation methods and results. EN 16258 -standard also provides energy consumption and GHG emission factors for most common fuels, GHG emission calculations according to this standard consider CO_2e emissions that includes six most important greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and hexafluoride (SF_6). (Lipasto, 2020.)

In this study we are forced to include quite many assumptions so at this point it is not possible to get the full benefit from using this standard, but it gives a good frame for the calculations and ensures that the results are as accurate as possible. Using the EN 16258 -standard also helps to build a good base for the future development of this energy consumption and CO_2e emission calculation system. The EN 16258 -standard recommends using the most accurate available values, but for instance for fuel consumption default values are accepted if actual information is not available – in this thesis calculations are performed based on default values. In order to meet the requirements of the standard, each leg of every shipments is considered separately and energy consumption and caused CO_2e emissions are calculated for each leg separately based on used transport mode for each leg.

5.1 EN 16258 in this study

Variables that used in calculations are fuel consumption, distance, and load. Default values are used for fuel consumption, one value for one transport mode. Distances are calculated using one average distance for every origin country – destination country combination. Used load is based on real data from the company's systems, weight of every shipment is considered but volume is not considered separately. Energy and GHG emission factors that are used are default values of the standard. The table 1 below describes the used default values.

Table 1. Default values.

transport mode	default fuel	fuel consumption (l/tkm)	Ew (MJ/l)	Gw ($kgCO_2e/l$)	Et (MJ/l)	Gt ($kgCO_2e/l$)
road	diesel	0,016	42,7	3,24	35,9	2,67
air	aviation gasoline	0,24	41,5	3,01	35,4	2,5
sea	marine diesel oil	0,014	46,1	3,53	38,7	2,92
rail	energy (MJ /tkm)	0,24	CO_2e (g/tkm)	17,92		

In order to simplify the calculations, only one fuel was chosen for one mode of transport. In the future the accuracy of the calculations can be improved through including several fuels and / or default values for one mode of transport, but at this point values in above table 1. enabled the calculations to be accurate enough.

6 EMISSION CALCULATIONS

Distance calculations were conducted by dividing distances to distance by road, distance by sea, distance by air and distance by rail for every individual shipment. Road freight shipments in Finland (and Russia) include a road leg only, majority of other road shipment do include a sea leg (or several sea legs) as well. Courier freight shipments consist of road legs (one from sender to origin airport and another from destination airport to receiver) and air leg. Air freight shipments consists of one road leg and one air leg. Sea freight shipments includes one road leg and one sea leg. For air and sea freight shipments the road leg covers the distance from the sender to the origin airport or seaport.

Shipment data is divided monthly to individual Excel-sheets. In addition to the data that can be directly obtained from the system some columns need to be added and completed. Distances are not available directly so before being able to perform calculations there is a need to get distances by road, se and air to the data sheet. This is described more thoroughly in the previous chapter about data collection. In order to simplify the formulas for the calculations distance by road, distance by sea, distance by air and distance by rail columns are taken into account for every shipment – for instance for courier shipments distance by sea is zero and for sea freight distance by air is zero. Distance by rail is zero for all other shipments besides actual rail freight shipments and for instance road freight shipments to Italy.

Distance calculations described above are essential for the actual emission calculations. CO_2e emissions and energy consumption are calculated for each individual shipment by using the calculated distances, the weight of the shipment and certain specified default values from Lipasto and EN 16258 -standard. CO_2e emissions and energy consumption are calculated for each leg individually and also as total amount. Total amount of emissions for each shipment is of course the most important result, but CO_2e emissions and energy consumption for each leg is also informative when there is a need to investigate the data at a more detailed level.

Fuel consumption for each individual leg is calculated by using default values from Lipasto and leg distances that were discussed previously. CO_2e emissions are calculated by using default values from Lipasto as well.

Formula for carbon dioxide emissions in a simple form:
Fuel consumption (l) x fuel consumption factor (kg CO_2e/l) = X kg CO_2e
(Fuel consumption = distance (km) x default fuel consumption factor (l/km))

For instance a road shipment from Finland to Germany consists of three legs: first leg from sender location to Helsinki seaport (road leg), second leg from Helsinki seaport to Travemünde seaport (sea leg) and third and last leg from Travemünde seaport to receiver location (road leg). For all three legs energy consumption and CO_2e emissions need to be calculated separately at first and then total energy consumption and total CO_2e emissions of this shipment can be calculated as a sum of mentioned three legs. Another example could be for instance an air shipment from Finland to China – this shipment would consist of two legs only, road leg from sender location to Helsinki airport and air leg from Helsinki airport to destination airport. For all shipments road leg from sender to airport / seaport is consider but only for courier and road shipments road leg from airport / seaport to receiver is considered, air and sea shipments consist of road leg to airport / seaport and (main) leg by air or sea only.

7 RESULTS

7.1 Background

Aim of this study was to quantify the energy consumption and CO_2e emissions caused by freight transportation in a case company. Included data covers both import and export shipments from the beginning of Q1 in year 2019 to the end of Q2 in year 2020. Import and export shipments are studied separately. In the analysis calculations were divided and compared monthly and quarterly, also other time period limitations are possible to use with the studied data. In this thesis data was studied mainly at the company level, but with the studied data it is also possible to make analysis at business unit or even at receiver country level for instance. One of the major factors effecting on the environmental impact of an individual shipment is the used transport mode and therefore the use of different transport modes is widely studied in this thesis. In this thesis calculations and graphs are mostly performed in Excel, but this thesis is a part of a project in which the final presentation of the results will take place in PowerBI.

Case company has a lot of export shipments (courier and road freight) to many European countries – United Kingdom, Germany, Italy, Spain, Sweden could be mentioned as examples of high-volume destinations. The share of domestic freight is also significant. Basically, there is significant amount of transport to all big European countries and to all countries near to Finland. To Asia there is a lot of air and sea freight and also courier freight shipments to China, Korea and Singapore for instance. There is also high number of shipments to Australia and USA. Majority of all shipments is road freight and courier freight but while the biggest share of total weight of all shipments comes from road freight, total weight of courier shipments is lowest of all transport modes. Below figure 8 presents the 15 countries with highest number of export shipments. Destination country is one of these countries for 75 % of all export shipments.

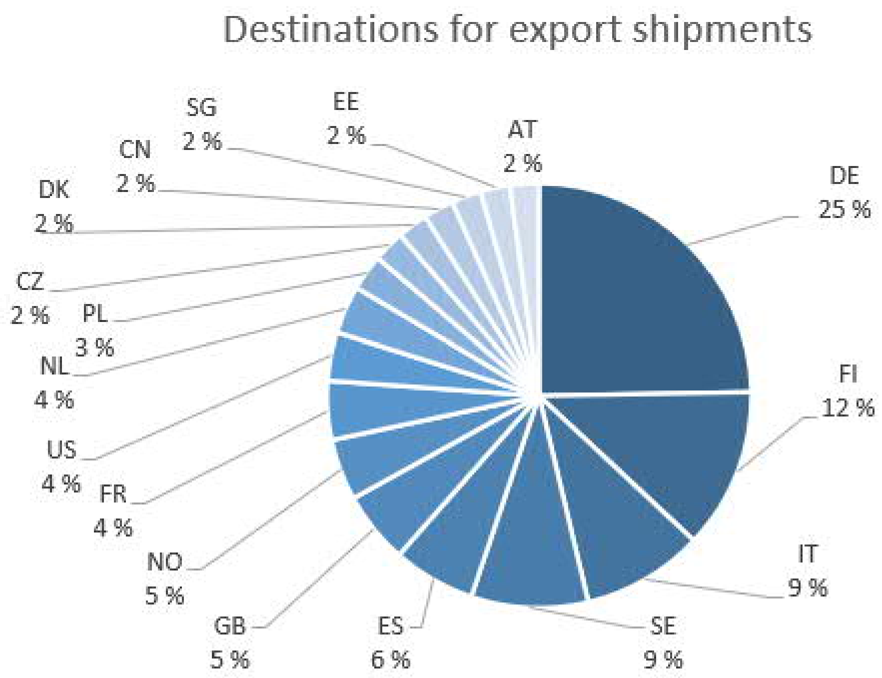

Figure 8. Destination countries for export shipments.

For import shipments there has been almost 90 origin countries during the studied period of time – even though quite many of these origin countries has had very few or even only one shipment. Import shipments are more focused on a few origin countries since more than 90 % of import shipments come from seven origin countries: Finland, Estonia, China, Germany, Poland, Sweden and Italy. Besides these countries there are import shipments for instance from India, USA, Malaysia and many European countries, for instance from Switzerland, United Kingdom, Spain, France and Denmark. While majority of export shipments is road freight and courier freight, import shipments are more focused on road freight and sea freight and share of air freight and courier freight is quite small. Below figure 9 presents the 13 countries with highest number of import shipments – more than 95 % of all import shipments has one of these countries as an origin country.

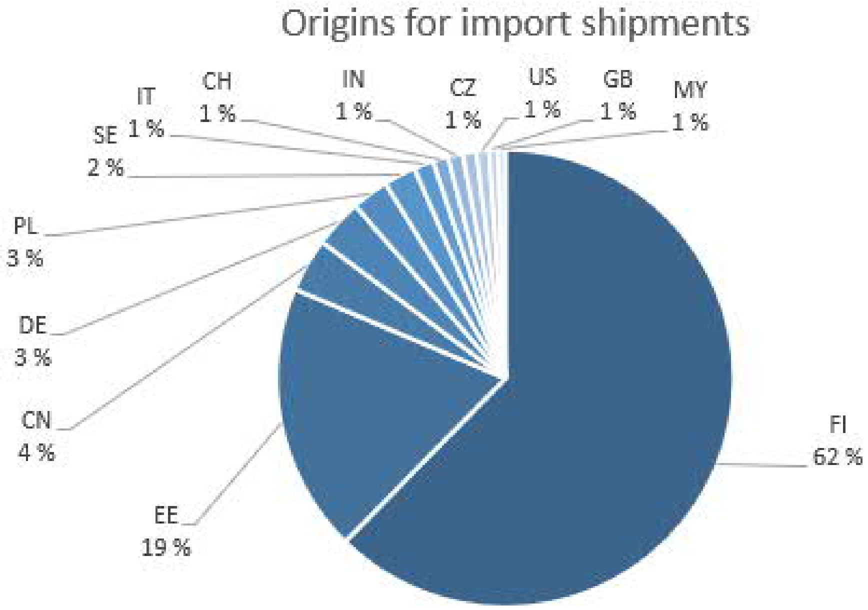

Figure 9. Origin countries for import shipments.

7.2 Expectations

The most important expectations were to define the current level of emissions and to get a declining trend curve for CO_2e emissions. The goal about declining trend curve weas set by an external audit and was one of the requirements for maintaining the standard ISO 14001. This expectation was mostly met, and the results will be introduced more thoroughly in this chapter. For the future aim is to achieve and maintain further declining trend curves, in other words to continuously get lower CO_2e emissions and energy consumption per an average shipment.

7.3 Results

Table 2. below gives a good overall view of results: total CO_2e emissions for export and import separately as well as total CO_2e emissions for all shipments and changes for all mentioned results during the considered period of time. Total amount of CO_2e emissions

has been lower during first two quarters in year 2020 than in year 2019 but this alone is not informative enough – for instance COVID-19 certainly has an impact here. Whereas table 2. only presents the absolute total amounts, table 3. includes CO_2e per weight which is much more informative and useful indicator here. Table 3. shows that even though for export shipments CO_2e emissions have been at lower level in year 2020 than in year 2019, for import shipments there has been an increase in CO_2e emissions per weight. Even though CO_2e emissions per weight have been 13 % lower for export shipments and 14 % higher for import shipments, there is an increase of 8 % in total CO_2e emissions per weight when all shipments are considers.

Table 2. CO_2e emissions (tons).

	CO_2e emissions (tons of $kgCO_2e$) Q1-Q2 2019	CO_2e emissions (tons of $kgCO_2e$) Q1-Q2 2020	Change
Export shipments	10439	9646	-793 (-7,6 %)
Import shipments	10811	6820	-3991 (-37 %)
All shipments	21250	16466	-4784 (-23 %)

Table 3. CO_2e emissions per weight.

	CO_2e emissions (tons of $kgCO_2e$) / kg Q1-Q2 2019	CO_2e emissions (tons of $kgCO_2e$) / kg Q1-Q2 2020	Change
Export shipments	0,38	0,33	-0,05 (-13 %)
Import shipments	0,19	0,22	+0,03 (+14 %)
All shipments	0,25	0,27	+0,02 (+8 %)

7.3.1 Quarterly results

In this chapter results will be introduced at quarter level. All four quarters from year 2019 are included, from 2020 two first quarters are studied. For the comparison the most relevant results are from Q1-Q2 of 2019 and Q1-Q2 of 2020, but it is important to note that the global situation with COVID-19 has made a remarkable impact also on freight transportation in year 2020. This also emphasizes the importance of continuous reporting and monitoring in this field; the more years are in the comparison; the more reliable results are obtained.

Table 4 below presents the total CO_2e emissions for each quarter separately, for both export and import shipments separately and also the total amount of CO_2e emissions of each quarter. All shipments together have caused less CO_2e emissions during Q1 and Q2 in year 2020 than in year 2019 – for Q1 the decrease in the total amount is around 16 % and for Q2 around 29 %. Total CO_2e emissions are lower in 2020 than in 2019 for both export and import shipments separately as well. Of course, year 2020 has been extremely exceptional and further monitoring of CO_2e emissions is required in order to confirm this favorable development, but at this point it seems that the trend curve for the total CO_2e emissions has been descendent as the goal was set. However, the distribution of used transport modes will be to be studied later since the choices of transport modes makes the biggest difference in caused CO_2e emissions.

Table 4. CO_2e emissions Q1 2019 – Q2 2020.

	Total CO_2e emissions (tons of kgCO2e) – all shipments	Total CO_2e emissions (tons of kgCO2e) – export shipments	Total CO_2e emissions (tons of kgCO2e) – import shipments
Q1 2019	10887	5220	5667
Q2 2019	10363	5219	5144
Q3 2019	10511	5819	4732
Q4 2019	9352	5282	4070
Q1 2020	9093	4953	4140
Q2 2020	7373	4693	2680

Table 5 below presents the total energy consumption for each quarter, again the quarterly sum for all shipments as well as total energy consumption for export and import separately. The only difference between CO_2e emission calculations and energy consumption calculations was the used default factor, so it is obvious that also the energy consumption for Q1 and Q2 in 2020 was lower than in year 2019.

Table 5. Energy consumption Q1 2019 – Q2 2020.

	Total energy consumption (MJ) – all shipments	Total energy consumption (MJ) – export shipments	Total energy consumption (MJ) – import shipments
Q1 2019	149173374	72530966	76642408
Q2 2019	142253340	72513355	69739985
Q3 2019	145318656	81038597	64280059
Q4 2019	128536656	73388781	55147875
Q1 2020	125072221	68711056	56361165
Q2 2020	101818140	64942799	36875341

Table 6 below presents the total weight of all shipments and total weight of export and import shipments separately. This gives us better understanding about the actual changes – even though if total weights have been decreasing it can have caused the declining trend curve for CO_2e emissions and energy consumption even if the use of different transport modes had not changed. Total weight of all shipments has decreased by 24 % in Q1 and by 34 % in Q2, so the differences are quite significant here. Even though the total weight of all shipments has decreased from year 2019 to year 2020, the total weight of export shipments has been higher in 2020 than in 2019 – significant decrease in total weight of import shipments has caused the decrease in total weight of all shipments.

Table 6. Total weight of shipments Q1 2019 – Q2 2020.

	Total weight of shipments (1000 tons) – all shipments	Total weight of shipments (1000 tons) – export shipments	Total weight of shipments (1000 tons) – import shipments
Q1 2019	42,9	13,3	29,4
Q2 2019	43,6	14,4	29,1
Q3 2019	38,1	14,7	23,4
Q4 2019	32,7	14,3	18,3

Q1 2020	32,4	15,1	17,4
Q2 2020	28,6	14,5	14,1

However, table 6 does present only the total weights for each quarter but not divided by used transport modes. Table 7 below presents caused total CO_2e emissions per total shipment weight (kgCO_2e / kg), again for all shipments and for export and import shipments separately. Table 7 shows that CO_2e emissions per weight for all shipments is higher for both Q1 and Q2 in year 2020 than in year 2019. CO2 emissions per weight for export shipments only have decreased from year 2019 to year 2020, but CO_2e emissions per weight for import shipments have increased.

Table 7. CO_2e emissions per weight Q1 2019 – Q2 2020.

	CO2 emissions / weight – all shipments	CO2 emissions / weight – export shipments	CO2 emissions / weight – import shipments
Q1 2019	0,254	0,390	0,192
Q2 2019	0,238	0,362	0,177
Q3 2019	0,276	0,396	0,202
Q4 2019	0,287	0,368	0,222
Q1 2020	0,280	0,329	0,238
Q2 2020	0,257	0,324	0,189

Figure 10 below illustrates the values from table 6. From figure 10 it is much easier to see that even though absolute numbers do not differ from each other that much, the relative differences are remarkable. Especially when the total amount of shipment is high - here it is hundreds of thousands – even minor changes at individual shipment level will result as significant changes in the big picture. Even though during the whole studied period the CO_2e emissions per weight are lower for import shipments than for export shipments, the increase in CO_2e emissions per weight for all shipments is result from increase in CO2e emissions per weight for import shipments – CO_2e emissions per weight have been decreasing in Q1 and Q2 from 2019 to 2020 when looking at the export shipments only. It is also important to note that CO_2e emissions per weight for import shipments are significantly lower than for export shipments – this could be result from different distribution of used transport modes or shorter travelled distances for instance.

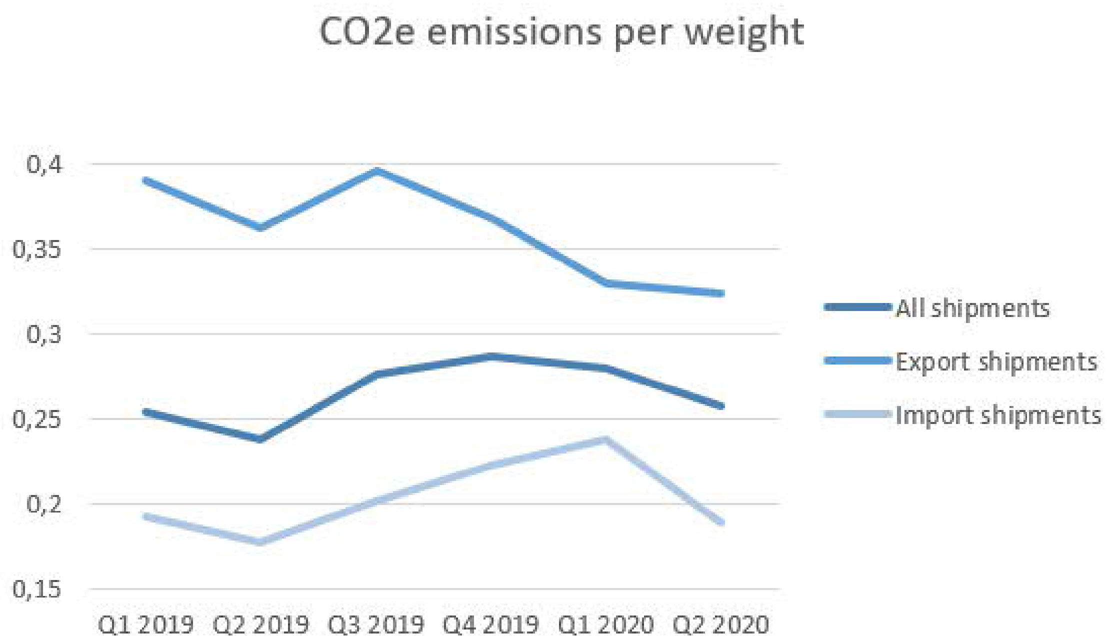

Figure 10. CO_2e emissions per weight.

From this quarterly analysis it can be concluded that even though the total amount of CO_2e emissions has been lower in Q1-Q2 of year 2020 than in Q1-Q2 of year 2020, the CO_2e emissions per weight have been higher. Total weight of import shipments has decreased quite significantly while total weight of export shipments has slightly increased. The impact of the COVID-19 is significant even though its magnitude is not easy to estimate. The difference between CO_2e emissions per weight for export and import shipments is interesting and will be further analyzed in later in chapter 7.3.3 that studies the distribution of different transport modes.

7.3.2 Monthly results

A comparison of the monthly results is done between Q1 2019 & Q1 2020 and Q2 2019 & Q2 2020 in order to get the comparison relevant and informative. Monthly comparison between Q1 2019 & Q1 2020 and Q2 2019 & Q2 2020 will be analyzed as well as graphs for total weights of shipments divided by transport modes.

Figure 11 below illustrates the monthly comparison of caused CO_2e emissions per weight between years 2019 and 2020 for export shipments. Total CO_2e emissions per weight have been lower in 2020 than in 2019, only exception being April with slightly higher CO_2e emissions per weight in year 2020 than in year 2019. When we take a closer look at the data, it can be seen that total weight of road shipments has been increasing, total weight of air shipments decreasing, total weight of courier shipments slightly increasing and total weight of sea shipments increasing (monthly comparison). Total weight has been increasing as well, so share of the road and sea freight shipments is bigger than in year 2019. Road and sea shipments cause less CO_2e emissions than air and courier shipments (weight of shipment and travelled distance needs to be considered) which explains the favorable development of the level of CO_2e emissions when comparing years 2019 and 2020.

Another thing that can be seen from figure 11 is that there is not much variation in CO_2e emissions per weight in 2019 or in 2020, the level CO_2e emissions per weight have been quite the same especially from January to March in both years 2019 and 2020. This could indicate that the distribution of used transport modes or travelled distances might be quite constant for export shipments.

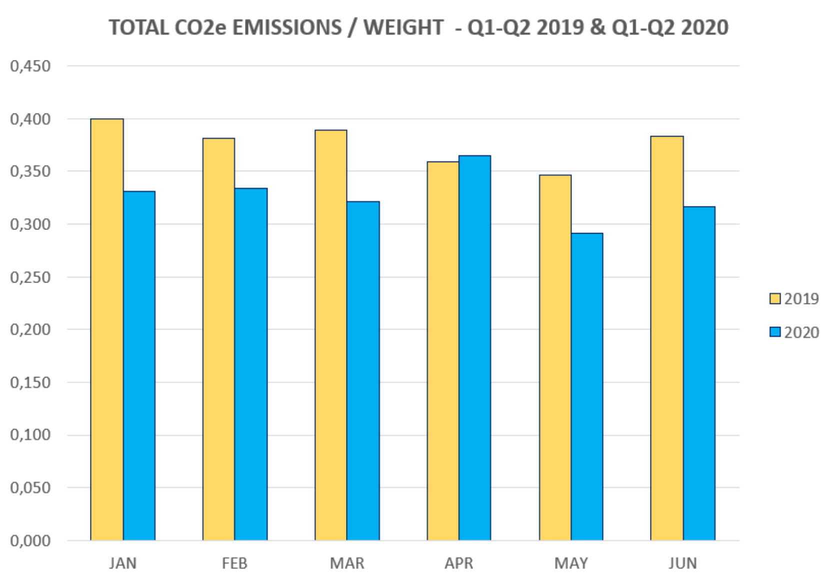

Figure 11. Export shipments: CO_2e emissions per weight.

Figure 12 below illustrates the total weight of all shipments as well as the total weight of each transport mode from the beginning of Q1 in year 2019 to the end of Q2 in year 2020. It is evident that the total weight of road shipments is a major share of the total weight of all shipments; during the whole studied period the total weight of road shipments is between 3000 tons and 5000 tons while the total weight of other transport modes remains below 1000 tons. However, a major share of road shipments is domestic transport while for instance sea shipments are intercontinental, so the environmental impact of each transport mode cannot be concluded from total weight at all.

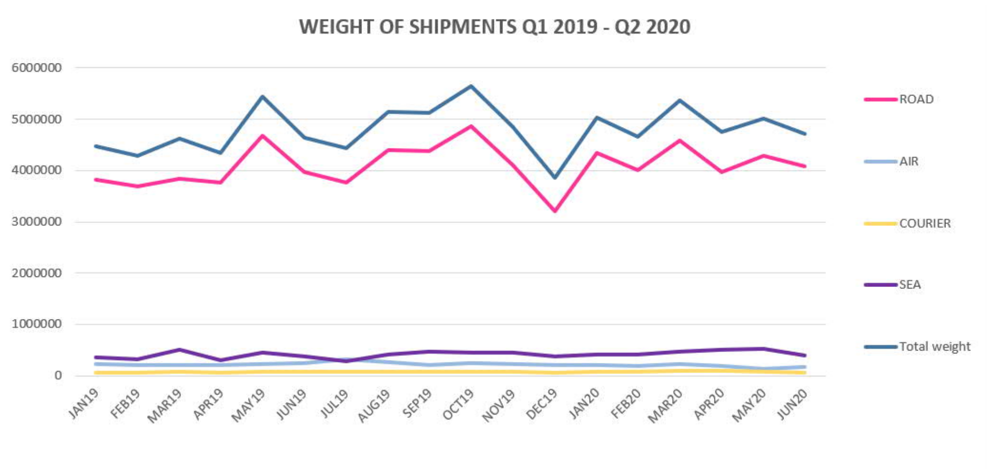

Figure 12. Export shipments: total weights (kg) of shipments by transport modes.

Figure 13 below illustrates the monthly comparison of caused CO_2e emissions per weight between years 2019 and 2020 for import shipments. It can be seen that CO_2e emissions per weight have mostly been at higher level in year 2020 than in year 2019. As was stated in the previous chapter, the total amount of CO_2e emissions caused by import shipments have been lower in year 2020 than in year 2019 even though CO_2e emissions per weight have been higher. This is probably a result from changes in the distribution of used transport modes and for these changes there are many possible reasons – COVID-19 has had an effect for sure and for instance the situation with inventories might be another one. To analyze reasons behind this development of CO_2e emissions per weight, we need to go deeper into the data and take a look at the total weights of the shipments divided by different transport modes.

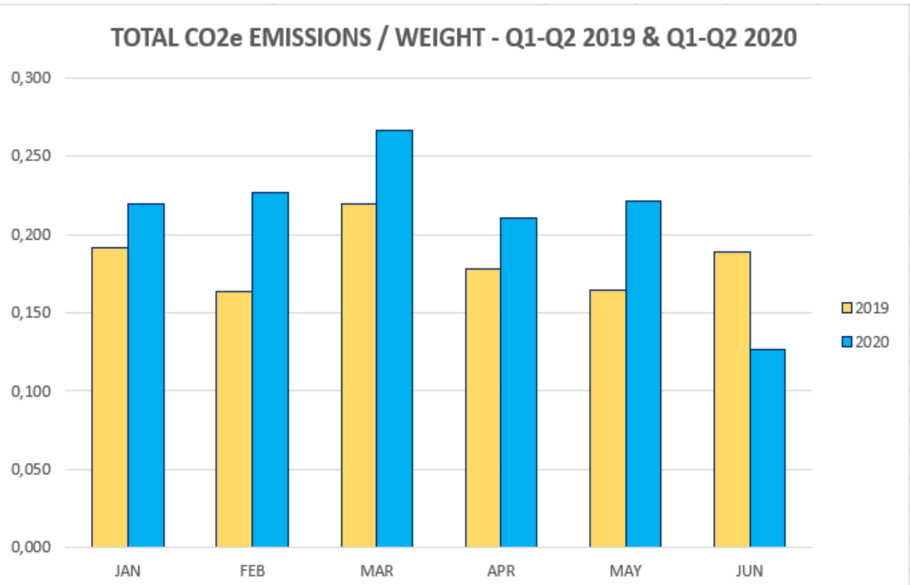

Figure 13. Import shipments: CO_2e emissions per weight.

Figure 14 below shows the total weight for import shipments by transport modes which gives a clear explanation for the increase of CO_2e emissions per weight: total weight of road and sea freight shipments has decreased significantly while the total weight of courier and air freight shipments has remained at the same level. Road and sea freight shipments cause significantly less CO_2e emissions than air and courier (for courier shipments main transport mode is air as well) shipments. There are many reasons that explain this development; for instance it has already been stated that total weight of import shipments has been lower in 2020 than in 2019, from which can be concluded that absolute need and demand for import shipments has been lower in year 2020. It also can be concluded that bigger share of total number of import shipments has been urgent in year 2020, which has led to preferring faster transport modes (air, courier) that also cause more CO_2e emissions in comparison with slower transport modes road and especially sea.

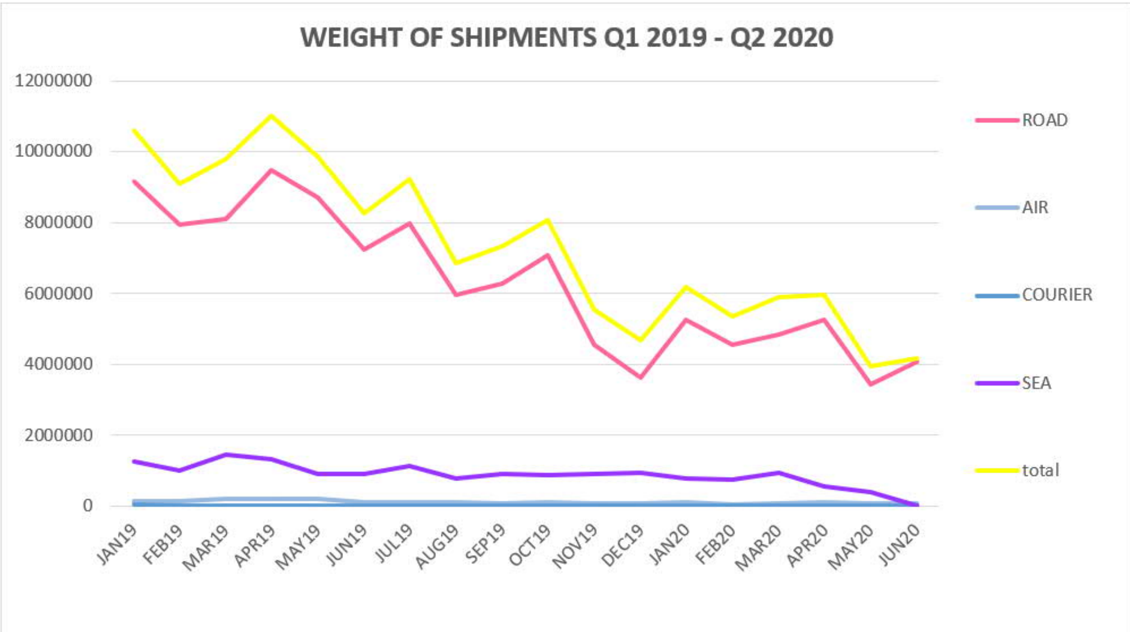

Figure 14. Import shipments: total weights (kg) of shipments by transport modes.

While for export shipments the graphs for total weights of individual transport modes and all shipments did not have remarkable variation and deviation was small, similar figure for import shipment showed significantly more variation over time. All graphs in figure 14 are mainly descending while for export shipments the graphs were much steadier over time. Once again, the effect of COVID-19 has to be highlighted – it is quite unlikely that two consecutive years would differ from each other this much in normal situation. This also underlines that CO_2e emissions per weight gives more information than just absolute amount of CO_2e emissions, even though the reliability of CO_2e emissions is lower when there are unusual factors effecting the shipments and transportation.

7.3.3 The distribution of different transport modes

Table 8 below gives a summary of total weight and total CO_2e emissions caused by each transport mode individually and also shares, weights and CO_2e emissions for all export shipments. Table 9 presents the same information for import shipments. All these factors will be further presented and discussed more thoroughly with individual pie charts for mentioned factors. Only Q1-Q2 2019 and Q1-Q2 2020 are included in these tables and following figures so that the comparison is relevant.

Figures later on this chapter illustrate the distribution of different transport modes. Number of shipments divided by transport modes is illustrated separately for both export and import shipments as well as is total weight of shipments divided by transport modes.

Below tables show that even though based on the master data the total number of export shipments is significantly higher than the total number of import shipments in both years 2019 and 2020, the total weight of export shipments is lower than import shipments. Average import shipment was more than three times heavier than average export shipment in year 2019 and in year 2020 average import shipment was more than twice as heavy as average export shipment. CO_2e emissions per shipment are higher for export shipments, but what is more relevant and informative, CO_2e emissions per weight are lower for import shipments. This can be explained by higher share of sea freight of the total shipment weight which also explains why there was no big difference in total export and import emissions in year 2019 even though there is a significant difference in total shipment weight between export and import.

Table 8. Export: shares of shipments, weight of shipments and caused CO_2e emissions.

	Share of all shipments – Q1-Q2 2019	Share of all shipments – Q1-Q2 2020	Weight (tons) – Q1-Q2 2019	Weight (tons) – Q1-Q2 2020	CO_2e emissions (tons) – Q1-Q2 2019	CO_2e emissions (tons) – Q1-Q2 2020
ROAD	48,2 %	52,3 %	23774	25291	1453	1457
AIR	5,3 %	3,9 %	1327	1105	6238	4996
COURIER	45,4 %	43,7 %	413	451	955	1231
SEA	1,1 %	1,3 %	2292	2712	1793	1962
TOTAL	100 %	100 %	27805	29559	10439	9646

Table 9. Import: shares of shipments, weight of shipments and caused CO_2e emissions.

	Share of all shipments – Q1-Q2 2019	Share of all shipments – Q1-Q2 2020	Weight (tons) – Q1-Q2 2019	Weight (tons) – Q1-Q2 2020	CO_2e emissions (tons) – Q1-Q2 2019	CO_2e emissions (tons) – Q1-Q2 2020
ROAD	89,3 %	85,0 %	50608	27474	1385	610
AIR	2,2 %	2,6 %	986	494	1202	952
COURIER	7,1 %	11,0 %	142	154	2001	2091
SEA	1,4 %	1,4 %	6877	3447	6223	3168
TOTAL	100 %	100 %	58613	31568	10811	6820

Figure 15 shows the export shipments by transport modes for Q1-Q2 of year 2019 and Q1-Q2 of year 2020. Share of road shipments has increased in year 2020 while the shares of air and courier shipments have decreased and share of sea shipments has remained at the same level. Based on master data, total number of export shipments during Q1-Q2 has slightly decreased from year 2019 to 2020 (by approximately 4 %) but absolute number of road shipments has increased and absolute numbers of courier and especially air shipments have decreased. Based on master data, number of sea shipments has decreased by approximately 15 % but is still around 1 % of the total number of shipments.

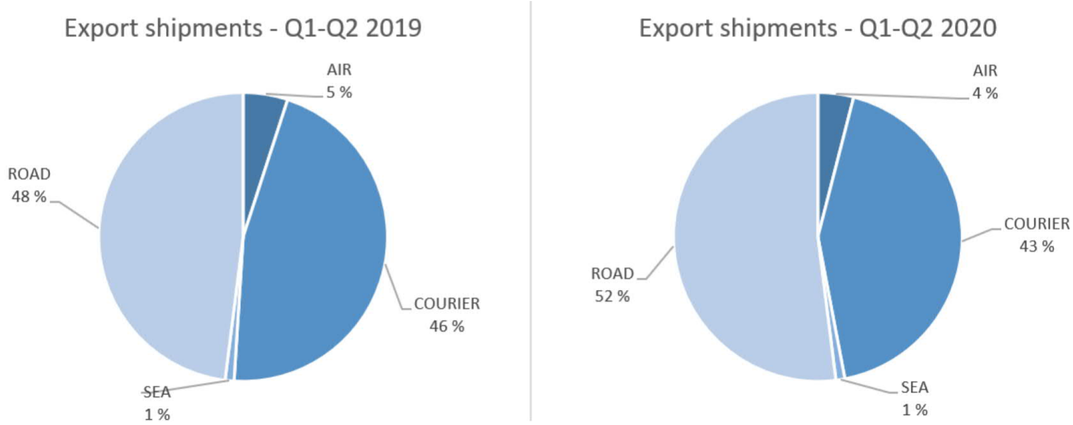

Figure 15. Export shipments by transport modes.

Figure 16 illustrates the total weight of export shipments divided by transport modes. Total weight of shipments for each transport mode is more conclusive than just the number of shipments for the environmental impacts of freight transportation. However, both number of shipments and total weight of shipments by transport modes are relevant when considering the environmental impacts and making future suggestions. While total number of road shipments has the biggest share of all shipments, also total weight of road shipments has the biggest share of total weight of all shipments. Otherwise pie charts for number of shipments and weight of shipments look very different: the share of courier shipments is almost half of all shipments in year 2019 and year 2020, but the weight of courier shipments is only approximately 1 % of total weight of all shipments in both 2019 and 2020. Even though the absolute number of courier shipments is actually high, courier shipments are apparently very lightweight in comparison with other shipments and therefore their impact of total amount of CO_2e emissions is not necessarily significant. The share of air shipments has decreased from 5 % to 4 % while the share of sea shipments has increased from 8 % to 9 %.

As was found out in previous chapter 7.3.1, for export shipments the CO_2e emissions per weight have been lower in year 2020 than in year 2019. Below figure gives a partial explanation for this since the total weight of air shipments has decreased while total weight of sea and road shipments have increased. At an individual shipment level there are three main factors that effect on environmental impact: shipment weight, transport mode and travelled distance. Shipment level distances are not studied here, but in practical the choice of transport mode is the only real choice when arranging freight transportation for the shipments – weights cannot really be affected at that point and distances are mostly set by geography and transport infrastructure. Thus, it can be stated that choice of transport mode is the most critical decision when it comes to reducing environmental impacts.

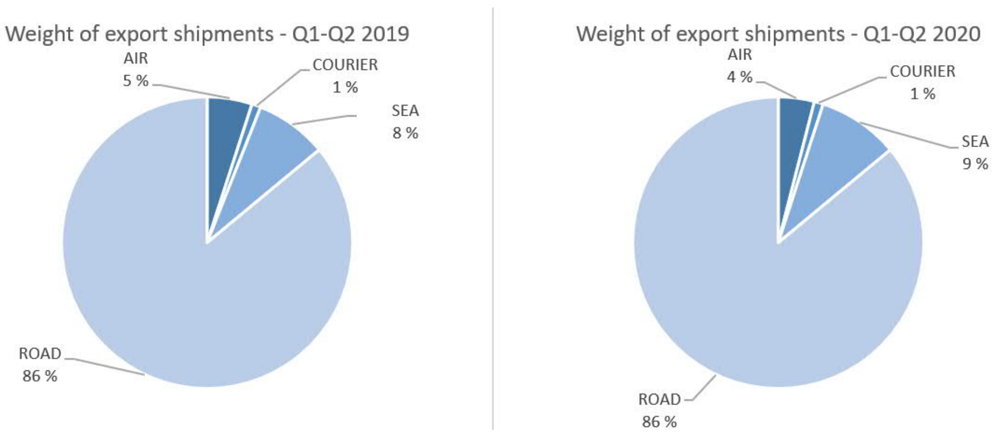

Figure 16. Weights of export shipments by transport modes.

Figure 17 below illustrates the total CO_2e emissions of export shipments, also divided by transport modes. Figure 17 shows that the share of CO_2e emissions caused by air shipments has decreased while shares of CO_2e emissions caused by sea and courier shipment have increased – share of CO_2e emissions caused by road shipments has increased from 14 % to 15 %. This development is in line with the development of total weights by transport modes: based on master data, total weights of sea shipments and courier shipments has increased, total weight of air shipments has decreased, and total weight of road shipments has slightly increased. Thus, it can be concluded that there is not necessarily much variation between destinations (hence distances) in years 2019 and 2020. Mass x distance calculations might indicate some variation at individual shipment level, but total sums remain at the same level.

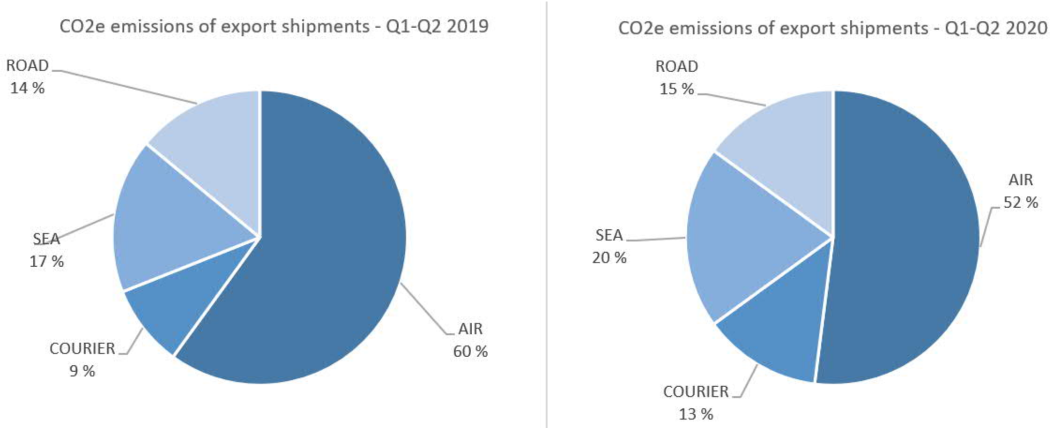

Figure 17. Total CO_2e emissions of export shipments by transport modes.

Figure 18 below presents the import shipments divided by different transport modes, studied period of time Q1-Q2 2019 and Q1-Q2 2020 here as well. Share of courier shipments and share of air shipments seem to have increased from year 2019 to year 2020, whilst share of sea shipments and share of road shipments have decreased. According to the master data, total number of import shipments has decreased from year 2019 to 2020 and actually the change here is quite significant; a decrease of 32,3 %. All transport modes have had less shipments in year 2019 than in year 2020 expect courier shipments: absolute number of courier shipments has increased, which has led to 4 percentage points increase in the share of courier shipments of the total number of all shipments.

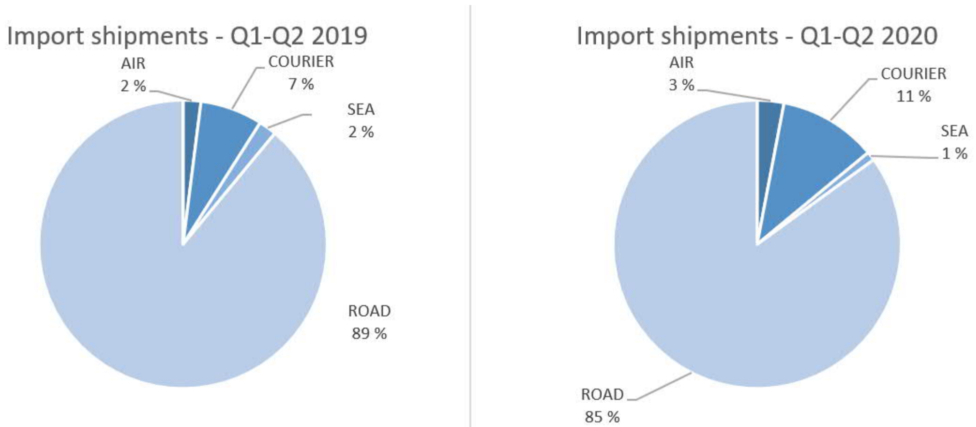

Figure 18. Import shipments by transport modes.

Figure 19 below illustrates shares of total weight of all shipments for each transport mode individually. While the number of road shipments has decreased by 36 %, the total weight of road shipments has decreased by 84 %. This should result in lower amount of CO_2e emissions caused by road transport, assuming that there is not significant variation between travelled distances from year 2019 and year 2020. Road shipments have the biggest share of both total number of shipments and total weight of shipments. On the contrary, the share of sea shipments of total number of shipments has been lowest in both years 2019 and 2020, but sea shipments do have the second biggest share of total weight of all shipments. This is of course very natural and also desirable, since large intercontinental shipments usually are and should be shipped by sea. The share of air shipments has remained at the same level in comparison with total weight of all shipments, even though the absolute total weight of air shipments in 2020 is roughly half of the total weight of air shipments in 2019. On the other hand, the absolute total weight of courier shipments has increased from year 2019 to 2020 which means that its share is bigger as well – even though the number and weight still have a small share of the total and the percentage rounds down to zero in below pie charts.

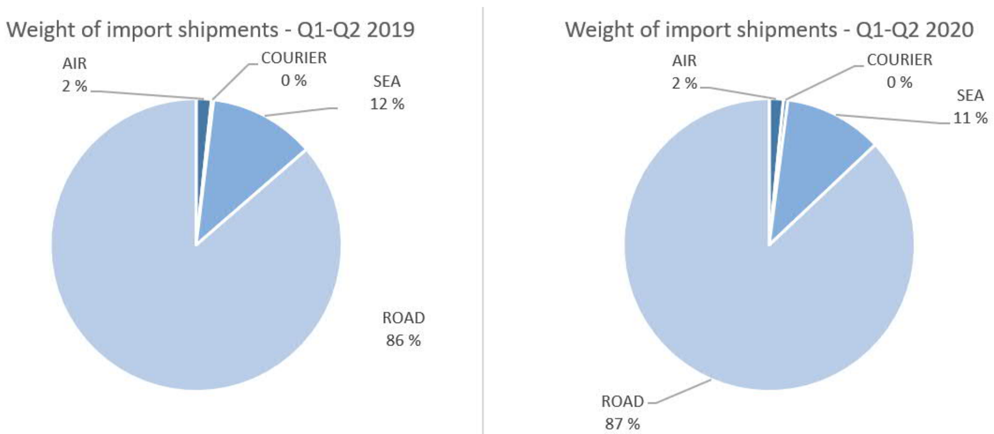

Figure 19. Weights of import shipments by transport modes.

Figure 20 below presents the CO_2e emissions caused by different transport modes. Share of courier shipments of total CO_2e emissions in year 2020 is almost twice as big as it was in year 2019 – this was an expected result since both shares of courier shipment number and weight had increased in comparison with total number and total weight of all shipments. All other transport modes have smaller shares of total CO_2e emissions in year 2020 than in year 2019 and also absolute amount of caused CO_2e emissions is lower in year 2020 for all transport modes expect courier. Especially CO_2e emissions caused by road and sea shipments have decreased significantly; CO_2e emissions caused by road shipments have decreased by 55 % and CO_2e emissions caused by sea shipments have decreased by 49 %. CO_2e emissions caused by air shipments have decreased by 20 % and CO_2e emissions caused by courier shipments have increased by 4,5 %. This also explains why CO_2e emissions per weight has increased from year 2019 to 2020; in year 2020 air and courier shipments have bigger shares of total CO_2e emissions than in year 2019.

In year 2019 road and sea shipments have caused 71 % of all CO_2e emissions while in year 2020 road and sea shipments have caused 55 % of all CO_2e emissions. This is result from many factors but once again the impact of COVID-19 has to be mentioned. Also, since the total number of import shipments is significantly lower in 2020, it could be that non-urgent import shipments have been postponed. This would also explain the increased shares of air and courier shipments which of course results in higher level of CO_2e emissions per weight.

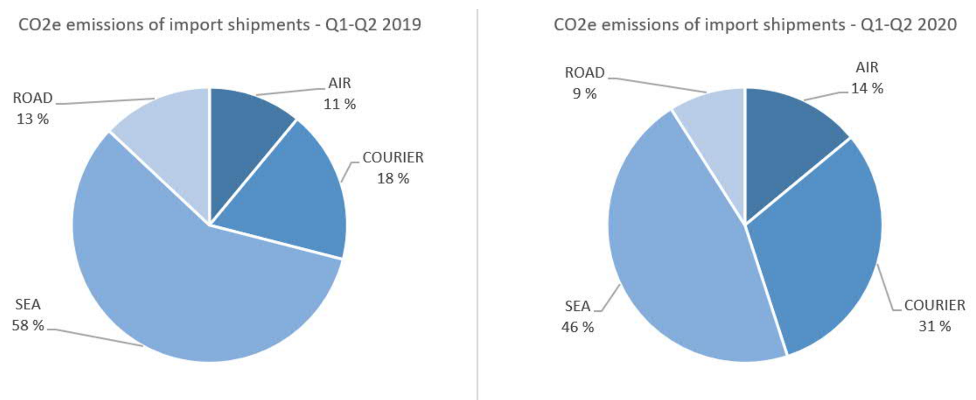

Figure 20. Total CO_2e emissions of import shipments by transport modes.

7.3.4 Export shipments

In this section export shipments will be analyzed more thoroughly. Table 10 below shows the monthly total weight shares of transport modes for all export shipments. Figure 18 illustrates the CO_2e emissions compared with both total weight of the shipments and total number of the shipments.

Below table 10 shows that the shares of each transport mode of all export shipment weight have not varied significantly over time. Based on master data, difference between lowest and highest total weight is around 24 %. Variation between quarters is even smaller and total weight of shipments is actually higher in Q1-Q2 in year 2020 than in year 2019. Even though the total weight has remained at the same approximate level, the impact of COVID-19 can be seen from shares of transport modes: the share of air and courier shipments of total weight is lower in Q1-Q2 of year 2020 than in Q1-Q2 of year 2019. This also gives a partly explanation why CO_2e emissions per weight have been lower in year 2020.

Table 10. Shares of total weight of export shipments per transport modes.

Shares of shipment weights	ROAD	AIR	COURIER	SEA
JAN19	85,4 %	5,2 %	1,5 %	7,9 %
FEB19	86,0 %	5,0 %	1,5 %	7,6 %
MAR19	83,1 %	4,6 %	1,5 %	10,8 %
APR19	86,8 %	4,6 %	1,5 %	7,0 %
MAY19	86,2 %	4,2 %	1,5 %	8,1 %
JUN19	85,6 %	5,1 %	1,5 %	7,9 %
JUL19	84,9 %	7,0 %	1,7 %	6,4 %
AUG19	85,4 %	5,1 %	1,4 %	8,1 %
SEP19	85,5 %	4,1 %	1,4 %	9,2 %
OCT19	86,2 %	4,4 %	1,4 %	9,8 %
NOV19	84,7 %	4,5 %	1,6 %	8,1 %
DEC19	83,4 %	5,4 %	1,5 %	9,2 %
JAN20	86,3 %	4,2 %	1,3 %	9,8 %
FEB20	85,7 %	3,9 %	1,5 %	8,1 %
MAR20	85,5 %	4,1 %	1,7 %	8,7 %
APR20	83,3 %	3,9 %	1,8 %	10,7 %
MAY20	85,6 %	2,7 %	1,4 %	10,3 %
JUN20	86,6 %	3,5 %	1,4 %	8,5 %

Figure 18 shows that for export shipments graphs illustrating CO_2e emissions in comparison with total weight of the shipments and total number of shipments have less variation than same graphs for import shipments (which will be presented in the next chapter). There are many reasons for this, but one possible reason might be that export shipments are steadier and more regular than import shipments. However, there are relatively clear peaks in these graphs as well. CO_2e emissions per total shipment weight is at highest in July 2019 and at lowest in May 2020. In July 2019 the total weight of road, courier and sea shipment is lower than in May 2019 whilst the total weight of air shipments is higher. This is one reason behind the ascending curve from May 2019 to June 2019, another thing that should be considered is travelled distance per shipment.

Graphs in figure 18 are lower in Q1-Q2 of year 2020 than in Q1-Q2 of year 2019 – as stated earlier, this is a result from lower total weight of courier and air shipments. Previous table also showed that the total weight of road and especially sea shipments had increased which might indicate that sea freight has been more preferred in year 2020. This is also result of the impacts of COVID-19: capacity of air freight has been lower and freight prices significantly higher than in year 2019 which has led to increased use of sea freight for intercontinental transport whenever possible. The total weight of road shipments had also increased which might be result from preferring road freight for shipments to other European countries.

It is quite clear and obvious that bigger shares for sea and road freight lead to lower CO_2e emissions per weight. Challenges that COVID-19 has caused to air freight have contributed to this favorable development of CO_2e emissions from year 2019 to 2020 and it is difficult to determine the magnitude for the impacts of COVID-19. However, this study gives a good frame for future measuring and gives us the best possible understanding of the development of the environmental impacts from year 2019 to year 2020. Table 10 above and master data also indicate that the global situation has not necessarily had major impact on the total number of export shipments – only the transport mode choices have been done in vastly different circumstances.

Below figure 21 also shows that the development of CO_2e emissions per shipment and CO_2e emissions has been quite the same. CO_2e emissions per weight is more informative and important indicator, but it is still favorable and notable that CO_2e emissions per shipment have been decreasing as well. CO_2e emissions per shipment does not take the shipment weight into account but still indicates the development of transport mode choices: for instance preferring sea freight and using less air freight will result in lower CO_2e emissions per shipment. Development of CO_2e emissions per shipment also emphasizes more lightweight shipments more than CO_2e emissions per kg in which each kg has an equal impact – this means that for instance lightweight courier shipments impact more on CO_2e emissions per shipment than in CO_2e emissions per weight.

Figure 21. CO_2e emissions compared to total weight and total number of export shipments.

7.3.5 Import shipments

In this chapter import shipments will be analyzed more thoroughly. As in previous chapter, comparison will be begun with a table that shows the transport mode shares of total weight of all import shipments as well as a figure that illustrates CO_2e emissions compared to total weight of the shipments and total number of the shipments.

While the total weight of export shipments did not have remarkable variation, the total weight of import shipments has been varying a lot. Master data shows a big difference between Q1-Q2 of year 2019 and Q1-Q2 of year 2020: the total weight of all shipments in year 2020 is around half of the total weight of all shipments in year 2019. For export shipments total weight of air and courier shipments had decreased but here the situation is quite the exact opposite with import shipments; air and courier shipments have remained at the same approximate level while the total weight of road and sea shipments have been decreasing significantly. Especially the total weight of all shipments in Q2 of year 2020 is significantly lower than the total weight of all shipments in any quarter of year 2019 – impacts of COVID-19 seem to have bigger magnitude for import shipments than for export shipments.

It is also interesting that the total weight of all import shipments decreases quarter by quarter in year 2019 – if the trend is similar in year 2020, the total weight of import shipments will be very low in the second half of the year 2020. On the other hand, if the total number and weight of import shipments would be higher in Q3-Q4 of year 2020 than in Q1-Q2 of year 2020, it is still possible that years 2019 and 2020 would not differ from each other as much as it seems at the moment. However, it is not highly likely that the second half of year 2020 would fully compensate the low number of import shipments during the first half of year 2020. Also, in the future it will be remarkably interesting to compare year 2021 with the results from years 2019 and 2020. Will the year 2021 compensate the lower amount of import shipments of year 2020 or will the total number and total weight of import shipments be further decreasing? Of course, the impacts of COVID-19 will not just disappear after this year, but it is still interesting to see what kind of development there will be in the near future.

Table 11. Shares of total weight of import shipments per transport modes.

Shares of shipment weights	ROAD	AIR	COURIER	SEA
JAN19	86,6 %	1,2 %	0,3 %	11,9 %
FEB19	87,3 %	1,5 %	0,1 %	11,1 %
MAR19	82,7 %	1,2 %	0,3 %	14,9 %
APR19	86,0 %	1,8 %	0,2 %	12,1 %
MAY19	88,2 %	2,2 %	0,2 %	9,3 %
JUN19	87,6 %	1,1 %	0,4 %	10,9 %
JUL19	86,2 %	1,2 %	0,3 %	12,3 %
AUG19	86,8 %	1,5 %	0,3 %	11,3 %
SEP19	85,8 %	1,2 %	0,4 %	12,6 %
OCT19	87,6 %	1,2 %	0,3 %	10,8 %
NOV19	82,1 %	1,5 %	0,1 %	16,3 %
DEC19	77,5 %	2,0 %	0,1 %	20,4 %
JAN20	85,0 %	1,8 %	0,5 %	12,8 %
FEB20	84,8 %	0,9 %	0,5 %	13,8 %
MAR20	82,4 %	1,3 %	0,5 %	15,9 %
APR20	88,2 %	1,8 %	0,4 %	9,6 %
MAY20	87,3 %	1,9 %	0,6 %	10,2 %
JUN20	97,5 %	1,7 %	0,6 %	0,2 %

Figure 22 below illustrates CO_2e emissions in comparison with both total weight of the shipments and total number of shipments. Mostly these two graphs are in line with each other but there are also differences. This is due to variations in shipment weights and travelled distances.

Figure 22 shows that CO_2e emissions per total weight of the shipments is highest in December 2019 and the peak is very significant. One possible explanation for this can be found from table 11 above: the share of total weight for air and courier shipments in December 2019 is high in comparison with other months. Other peaks in below graphs are not as remarkable, but for import shipments there is more variation than in the same graphs for export shipments.

For import shipments the table 11 above is easier to interpret than figure 22 below. In the master data there can be seen some decrease in total weight of all shipments which might indicate that import shipments have been impacted more by COVID-19 than export shipments. The total weight of road and sea shipments have been decreasing remarkably but the total weight of air and courier shipments have not had as major changes – this might indicate that non-urgent shipments have been postponed and therefore faster transport modes with higher environmental impacts have been used more. The distribution of transport modes explains the increase CO_2e emissions per weight from year 2019 to year 2020, but the factors affecting the transport mode choices are more difficult to identify. However, the impacts of COVID-19 are significant and multidimensional.

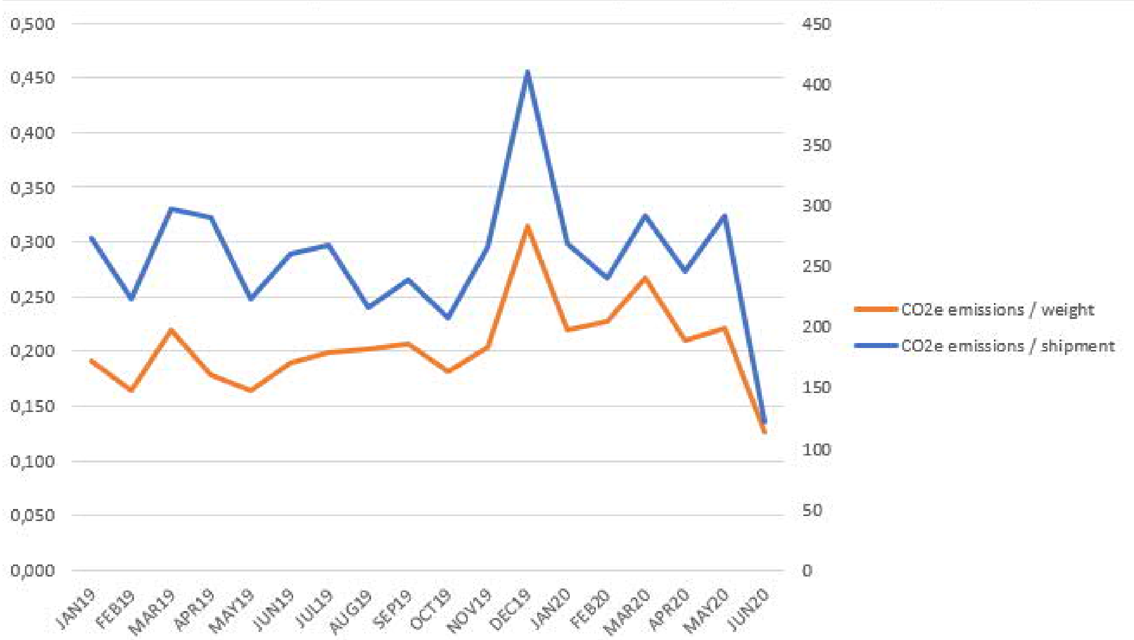

Figure 22. CO_2e emissions compared to total weight and total number of import shipments.

7.3.5 Results at business unit level

Even though this thesis focuses on company level results, also business unit level results have been analyzed for the case company. Here is a couple of examples of the results of two business units with high volume. This kind of business unit level results can and do vary a lot between different business units which is result from many factors such as volume, typical shipment size and whether the business unit manufactures spare parts and how big share of total volume the spare parts do have.

Measuring environmental impacts at business unit level is important in order to be able to share the responsibility based on results. All business units do not have equal number of possibilities or even needs to improve so it is reasonable that each business unit has its own results to analyze. Business units do have their own managements and ways to operate and strategies and practices for reducing environmental impacts will have differences as well. Shared responsibility would not be the most effective way to achieve improvement and it is clear that each business unit has to be responsible of their own environmental impact in the field of freight transportation in order to be committed enough to drive reducing environmental impacts. Each business unit should also have the best knowledge of their production lead times, customer needs and other contributing factors such as the typical size and packaging of the cargo.

Below figures show the distribution of different transport modes for both export and import for business unit A. Figure 23 shows the shares of shipments by transport modes in year 2019. Figure 24 shows the total weight shares of shipments by transport modes in year in year 2019 and figure 25 the total CO_2e emission shares of shipments by transport modes in year 2019.

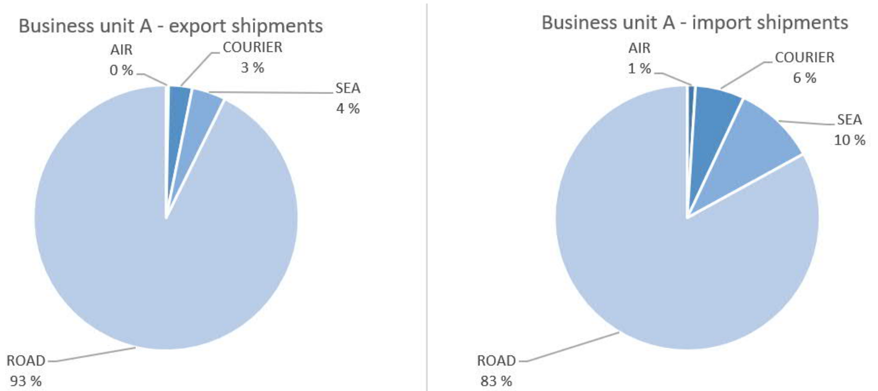

Figure 23. Business unit A – shipments by transport modes.

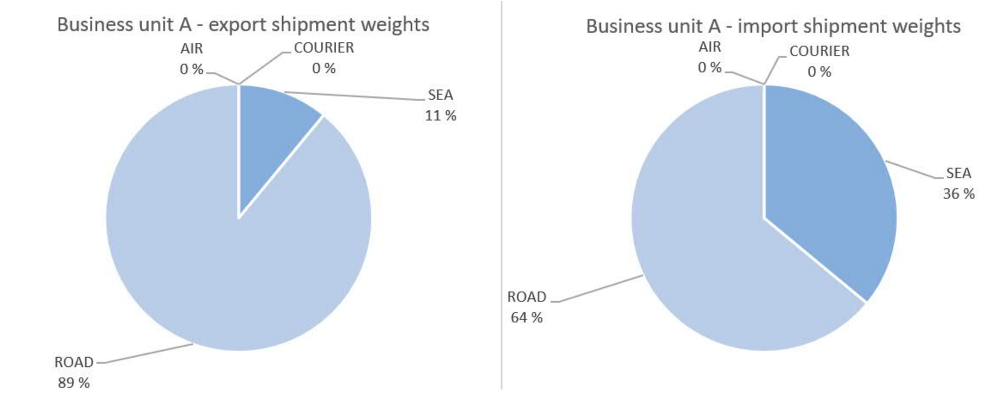

Figure 24. Business unit A – total shipment weights by transport modes.

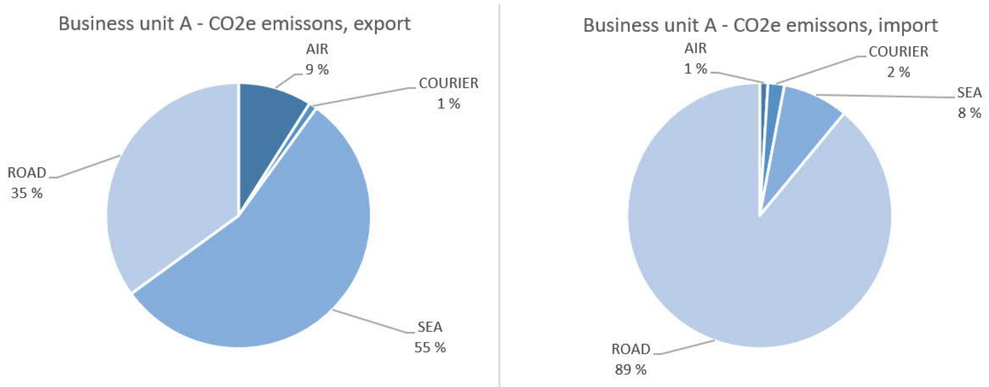

Figure 25. Business unit A – CO_2e emissions by transport modes.

Above figures show that even though major share of shipment number and total weight is road freight, major share of environmental impacts is caused by sea freight. Even for export more than half of CO_2e emissions is caused by sea freight but for import almost 90 % of CO_2e emissions comes from sea freight. Share of courier and air freight is significantly smaller for import than for export so apparently import shipments are less urgent and / or bigger in size. All in all, seems that this business unit has a lot of large shipments and therefore uses a sea freight widely. Road freight has the biggest share of total weight of all shipments but share of CO_2e emissions is smaller – this might indicate that distances for road freight are relatively short and there might be a lot of domestic freight for instance.

Following figures show the distribution of different transport modes for both export and import for business unit B. Figure 26 illustrates the number of shipments by transport modes and figure 27 illustrates the total weight of shipments by transport modes in year 2019. Figure 28 shows the total CO_2e emissions of shipments by transport modes in year 2019. These figures look quite different than previous figures for business unit A and these differences will be discussed later on.

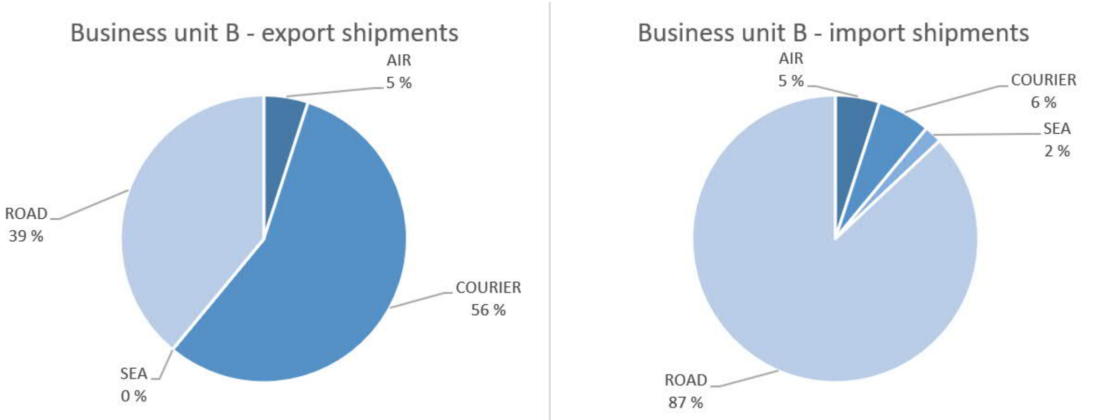

Figure 26. Business unit B – shipments by transport modes.

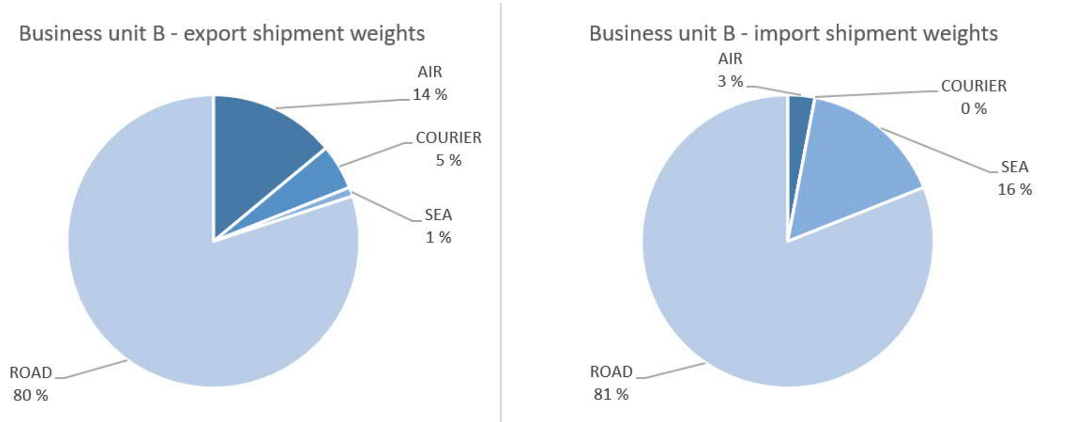

Figure 27. Business unit B – total shipment weights by transport modes.

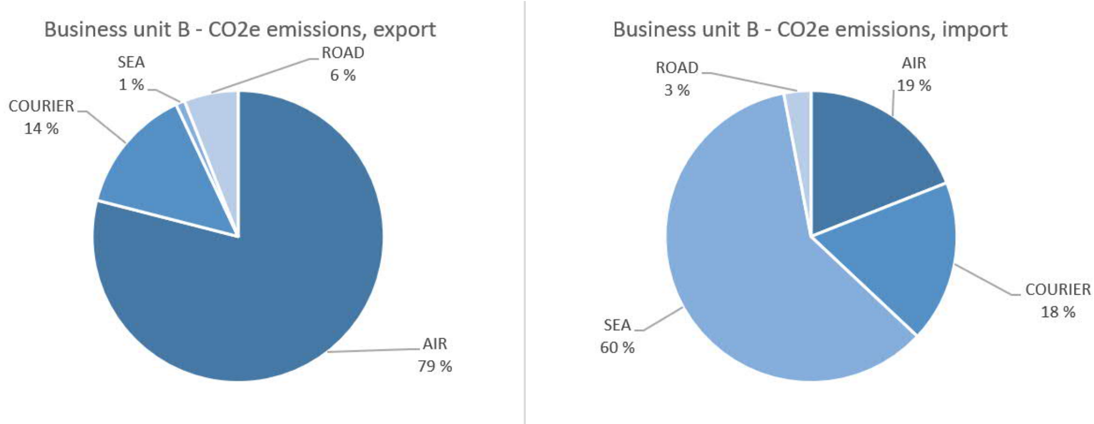

Figure 28. Business unit B – CO_2e emissions by transport modes.

Business unit B seems to use a lot of courier freight for export but significantly less for import. Road freight has the biggest share of the total weight of both export and import shipments. Biggest environmental impact for export shipments is caused by air freight but for import shipments it is caused by sea freight. It seems that import shipments do not have as urgent schedules as export shipments since distribution of transport modes is so different for both number of shipments and caused CO_2e emissions. Also here road freight has the biggest share of total weight of shipments but quite a small share of CO_2e emissions – most likely relatively short distances for road freight here too.

Business unit A uses a lot more sea freight than business unit B. Most likely business unit A has larger shipments than business unit B and on the other hand, business unit B has probably more shipments with need for fast schedules hence air and courier freight. Both business units do have major share of total weight in road freight, but its environmental impact is relatively low. This is an excellent example about why providing suggestions at company level is not the most effective way to aim at improvement: each business unit has its own characteristics when it comes to size of products, schedule needs and customer locations – this is why above figures look quite different even though both studied units do have high volume for both import and export shipments.

7.4 The role of the choice of mode of transport

As table 12. below illustrates, using air freight causes significantly more energy consumption and CO_2e emissions than using other modes of transport. Energy consumption and CO_2e emissions per tkm for air freight is more than ten times of energy consumption and CO_2e emissions per tkm for any other transport mode. If we would calculate caused energy consumption and CO_2e emissions for one 500 kg shipment from Helsinki to Shanghai, it really makes a significant difference whether the main transport mode is air or sea. Table 2. also shows that energy consumption and CO_2e emissions caused by rail freight per tkm are remarkably lower than for other modes of transport, around 60 % lower than even for road freight.

Values in Table 12. are based on the values in table 1. and present the caused energy consumption and CO_2e emissions per tkm each transport mode, in other words: caused energy consumption and CO_2e emissions for each transport mode when one shipment with weight of 1000 kg has travelled distance of 1 km.

Table 12. Caused energy consumption and CO_2e emissions per tkm.

	Energy consumption (MJ/tkm)	CO_2e emissions (kgCO_2e/tkm)
road	0,574	0,043
air	8,496	0,600
sea	0,557	0,042
rail	0,243	0,018

Below table 13 presents the results for mentioned example about 500 kg shipment and distance from Helsinki to Shanghai (7410 km for air freight and 24 700 km for sea freight). Table 13 also presents energy consumption and CO_2e emissions for one 1000 kg shipment and 420 km distance between origin and destination.

Table 13. Examples of the impact of transport mode choice.

	Energy consumption (MJ)	CO_2e emissions ($kgCO_2e$)
Helsinki – Shanghai AIR	31480	2220
Helsinki – Shanghai SEA	6900	520
1000 kg / 420 km ROAD	240	18
1000 kg / 420 km RAIL	100	7,5

As table 13 shows, changing from air freight to sea freight makes a big difference – as well as changing from road freight to rail freight. Both examples are realistic, and these routes do have lots of shipments. One shipment does not make a big difference at company level, but small changes make big impacts together. For instance, changing one weekly 1000 kg shipment with 420 km distance between origin and destination from road freight to rail freight would result in over 7200 MJ energy savings and 530 kg CO_2e emission reductions in a year. Changing one monthly 500 kg shipment from Helsinki to Shanghai from air freight to sea freight would result in almost 300 000 MJ energy savings and over 20 000 kg CO_2e emission reductions in a year. It is not always or even often easy to make this kind of changes, but choice of transport mode really is critical decision when it comes to energy consumption and CO_2e emissions. Making many minor changes at a shipment or route level will certainly result in major changes in total environmental impacts.

8 DISCUSSION AND SUGGESTIONS

8.1 Main contributors causing emissions

It is a clear result that main contributors causing CO_2e emissions at company level are air and courier freight for export shipments and sea and courier freight for import shipments. CO_2e emissions caused by export shipments could be reduced by using sea freight instead of air freight – of course it is not so simple in practice, but using more sea freight and less air freight would also result in significant cost savings. Changing transport mode for courier freight is maybe even more complicated since courier freight is usually used for urgent shipments only and individual shipments are quite small in average so using sea freight would neither be effective nor practical. Major share of CO_2e emissions caused by import shipments came from sea freight so there is not as much to do since sea freight is the transport mode with least environmental impacts when it comes to intercontinental shipments.

Main thing to do in order to reduce environmental shipments is to prefer sea freight over air freight and also rail freight over road freight. The shift between mentioned transport modes is not always even possible due to locations or schedule needs for instance but something can always be done. For instance, in Finland railway network is not the most widespread but on the other hand there is a lot of road freight between some origin and destination locations where railway can be used. Also at least some parts of road freight to and from Europe could be replaced with rail freight – currently rail freight is default transport mode from Germany to Italy, but there should be possibilities for wider use. Chances to increase the use of rail freight should be investigated in co-operation with carriers and contract prices negotiated to ensure that rail freight will be more common choice in the future. There is also a lot of export to China and import from China of which it might be possible to switch some shares of sea or even air freight to rail freight. For some import shipments from China to Finland rail freight is already in use but there should be a clear target to increase the share of rail freight. Russia could also be one potential destination / origin to and from where rail freight could be used more frequently as it currently is.

Basically, there are two possibilities: to start using transport modes that have lower environmental impacts and / or to make sure that shipments are shipped with as low environmental impacts as the used transport mode allows. For using each transport mode as environmental-friendly as possible it is necessary to have close co-operation with carriers. Used fuels have an impact on caused environmental impacts and route planning effects on travelled distances. Close carrier co-operation is also required in order to get the calculations as accurate as possible.

8.2 Challenges in reducing emissions

One of the biggest challenges for making transport mode choices based on environmental impacts is all the hurry and schedule requirements. Transport mode choices are usually based on price and transit time – if there is possibility to accept longer transit time and to choose sea freight over air freight, it will be done. On the other hand, if orders are already at the risk of being late, they might need to be shipped by air regardless the price or environmental impacts. From transport planning's point of view there is not always or even often a possibility to actually make the transport mode choice. For instance, delays in production can lead to situations where the fastest possible transport mode needs to be used and the actual transport planning phase is always extremely dependent on all the previous phases.

Another major challenge is inadequate resources. In the field of logistics there usually is not too many employees neither on carriers nor logistics service buying companies' side. It is difficult to find resources and time for development work when operative tasks can require most employee's full-time focus. Usually there is a need to prioritize and in that kind of situations daily operative tasks are more crucial than development work that in principle can be postponed. However, there really is a need to prioritize development work as well, otherwise anything cannot chance, and it will not be possible to achieve the set targets for reducing environmental impacts. There should be enough resources for measuring, reporting and analyzing environmental impacts especially on service buying companies' side but also at carriers' side when it comes to co-operation and reporting requirements.

8.3 Different decisions and trade-offs

8.3.1 Strategic, tactical and operational decisions

Decision-making concerning GHG-emissions can be divided into three categories: strategical, tactical and operational decisions. Strategic decisions can be defined as long-term decisions for time period of 2-5 years. It is difficult to make changes in strategic decisions, so they are made at high level in the companies. Tactical decisions are for shorter time period, usually for 1-2-year timeline. Tactical decision-making phase comes after strategic decisions. Operational decisions are short-term decisions that are made at daily basis. Operational decisions are based on strategic and tactical decisions made at previous stage. (Misni and Lee, 2017.) Figure 29 below gives examples of strategic, tactical and operational decisions in logistics that impact on GHG-emissions.

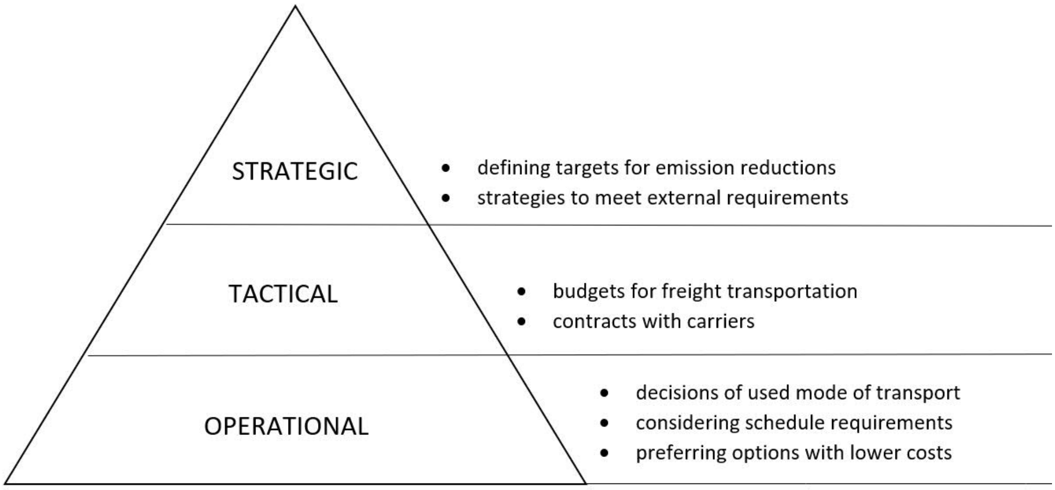

Figure 29. Strategic, tactical and operational decisions.

8.3.2 Trade-offs

There are also several trade-offs in logistics decision-making. For instance, when transit time is shorter, freight costs are higher. If transport mode decision is made based on costs only, that often leads to longer transit times, especially in intercontinental freight. Most common trade-off in day-to-day operational work is between cost and transit time – usually lower cost is preferred unless there is a need for shorter transit time and better schedule. This day-to-day decision-making gets a third dimension when environmental impacts need to be considered as well. Transport modes with lowest environmental impacts (road, sea, rail) are usually also the ones with lowest costs but longest transit times. On the contrary, air freight and courier freight have shorter transit times but both environmental impacts and costs are higher.

On the other hand, there are differences also inside individual transport modes: for instance, all road freight is not performed by using same fuels or with as optimal routing and so on. Carriers should be able to provide the case company services and solutions that include using fuels with lower environmental impacts – this would probably increase cost, so in this case reducing environmental impacts would increase costs but most likely not effect on transit time. Convertibility can also be valuable: road freight and courier freight have probably the highest convertibility while convertibility for rail freight and sea freight is low. This means that the possibilities to adjust the service or solution is higher for road freight and courier freight. Below table 14 gives some examples of trade-offs in day-to-day decision-making in logistics. For instance, address changes for road freight can sometimes be made in very late phase of freight transportation, but airport or seaport cannot be changed after departure. There are also more special solutions used in road transportation and service can be planned according to customers special needs – this is more difficult in air and sea freight. Routing is also pretty much defined in advance for air and sea freight and especially for rail freight but for road freight and even for courier freight it can be at least partly customized.

Table 14. Trade-offs in logistics decision-making.

Transport mode	Environmental impact	Cost	Transit time	Convertibility
rail	low	low	high	low
road	low	medium	medium	high
sea	low	low	high	low
air	high	high	low	medium
courier	high	high	low	high

8.4 The role of the carriers

The role of carriers is crucial. Environmental impacts could be improved through tighter co-operation, for instance by requiring carriers to provide more comprehensive reporting about environmental issues, requiring more environmental-friendly solutions for freight transportation and also by requiring more detailed information about fuel consumptions or used vehicles in order to improve the accuracy of the calculations executed by case company. Environmental issues need to be prioritized in order to be able to reduce environmental impacts – this is often challenging for both case company and carriers due to lack of resources and pressure on shorter transit times for instance. Usually freight cost is one of the most important transport mode choice criteria, so cheaper solution might be chosen over one with lower environmental impacts – being able to measure the cost savings that result from lower environmental impacts in the long run is important.

One factor with major effect on caused environmental impacts is distance, in other words routing. This is also carriers' responsibility but perhaps co-operation could be increased – for instance for full loads and for special deliveries case company might have possibility to effect on routing or at least to get accurate data of it. Routing and distances have a major effect on fuel consumption and therefore it is important that routing is optimized also from environmental issues' point of view. Fastest or shortest route is not always the best option for environment. Even though carriers are responsible for route planning, they should be able to give that information also for case company which would make more accurate distance calculations and thereby more accurate CO_2e emission calculations possible.

8.5 Development possibilities and suggestions

The most important thing for reducing the environmental impacts is to effect on transport mode choice. As discussed previously, it is not easy to make transport mode choices based on environmental impacts only since there often are schedule requirements that need to be met. However, transport mode choice is very important for reducing environmental impacts since the size of the cargo or distance to the receiver are much more difficult and often even impossible to effect on. Air freight and courier freight should be avoided as much as possible – especially for bigger shipments but also for smaller ones. At the moment there are lot of courier shipments to Europe and probably some share of it could be send by road in the future by changing the service from Express to Economy Express – this would also result in cost savings immediately. Possibilities for wider use of rail freight should be investigated and most likely a share of road freight to Europe could be replaced with rail freight. Processes should also be improved so that transport planning function would actually have better possibilities to make the transport mode choices.

Also, calculations in this study are quite rough and based completely on default values when it comes to energy consumption or CO_2e emission factors. Actual routes are not available either, and since this study considers only one destination for one country, there is a lot of room for improvement of distance calculation accuracy. Calculations could be improved through requiring for instance average fuel consumption values from carriers and trough building a system which uses more accurate distances – for instance by using Google Maps or some other database distances should be available at zip code or city level. There is also quite big of a difference between the quality of export data and quality of import data: export data is obtained from case company's own system and is up-to-date and as accurate as the information in the original bookings while import data comes from carrier and there is a delay of several months and some variety between data from different carriers. There would be improvement in accuracy and reliability for instance if in the future all data for both export and import shipments could be obtained from case company's own system – in this case it should also be possible to get the data for PowerBI-visualization directly from the system database and get the graphs to be updated automatically.

The role of packaging could also be investigated. For instance, for the lightweight courier shipments the difference between gross weight and net weight is sometimes quite big in respect of the total weight – could the packages for these shipments be made more lightweight? Otherwise majority of the environmental impact of certain shipment can be caused by packaging and not the product itself. Another to consider is the packages for bigger shipments, stackable packages can be heavier but on the other hand they make more efficient use of space possible. For instance, trucks should always be loaded as full as possible in order to make the environmental impact of individual shipment as low as possible – of course this is not considered in the calculations of this study but should be in the future. It also might be that packages are as optimal as possible, but these possibilities can always be re-investigated, and development possibilities found.

As mentioned before, routing has a major effect on environmental impacts, especially in road freight. This is a development possibility for both actual environmental impacts and measuring: possibilities for participating in route planning could be investigated and at least more comprehensive reporting about actual distances could be required in order to be able to perform the calculations at more accurate level. This kind of development also requires close co-operation with carriers.

For export shipments biggest share of environmental impacts comes from air freight. Number of air freight shipments is not high which means that the environmental impact and emissions caused by an individual shipment is high – this also means that every air freight shipment that is changed to sea freight makes a difference. Number of air freight shipments and number of sea freight shipments are low but the choice between air freight and sea freight makes a significant difference to total environmental impacts caused by all freight transportation of the case company. Rail freight is the transport mode with the lowest environmental impacts – use of rail freight is not very widespread at the moment and should be increased in the future. Perhaps shipments to China would be a good possibility to experiment using rail freight as a default transport mode whenever it is possible. Also, even though the environmental impact caused by road freight shipments is not the highest, the number of road freight shipment is very high. The total environmental impact caused by road freight could be reduced through optimal routing, optimal loading plans and using biofuels – this, again, requires co-operation with carriers.

On the contrary, for import shipments sea freight shipments cause the biggest share of total environmental impacts. Number of sea freight shipments is not the highest, but sea freight shipments tend to be large and therefore environmental impact is significant. Environmental impact caused by sea freight shipments could be reduced by using more rail freight – for instance 4% of all import shipments come from China, so rail freight should be chosen over sea freight and even over air freight whenever it is possible. The second biggest share of total environmental impacts comes from courier freight. Number and impact of courier freight could be reduced by avoiding courier freight in Europe and using road or even rail freight instead of it. For intercontinental shipments courier freight is usually used when shipments are urgent and / or small, so in those case sea freight is not as relevant option.

Below table 15 provides examples of actions that could be done in order to reduce environmental impacts of freight transportation. Also examples of requirements and challenges in taking these actions are given and consequences for transit times, cost and environmental impacts discussed.

Table 15. Actions for reducing environmental impact of freight transportation.

Action	Requirements	Challenges	Consequences
Choosing sea freight over air freight	No delays in production etc. hence possibility to make the choice	Schedule requirements	Longer transit times, lower costs, lower environmental impacts
Choosing rail freight over sea freight (and even over road freight)	Sufficient railway network, preferably carrier contracts	Poor domestic railway network, lack of routine, lack of contracts	No impact on transit times, impact on cost unclear, lower environmental impacts
Choosing road freight over courier freight	Destination / origin in Europe or Asia	Schedule requirements, origin-destination requirements	Longer transit times, lower costs, lower environmental impacts
Optimal routing	Carrier co-operation	Works best for FTL-shipments	Lower environmental impacts
Using biofuels	Carrier co-operation	Lack of control, how to ensure and measure impacts	No impact on transit time, higher costs, lower environmental impacts

Loads as full as possible	Carrier co-operation, stackable packages	Works best for FTL-shipments	No impact on costs, lower environmental impacts

8.6 Benefits of reducing environmental impacts

Green logistics and reducing environmental impacts of freight transportation can result in benefits for instance in cost savings, employee brand improvement, reputation improvement and even in increased market value. Allocating resources to environmental issues can increase costs at the beginning but should result in cost savings in the long run. Another thing is that especially young people tend to be aware of environmental issues nowadays which could be benefit in employee branding and recruitment. Getting reputation as an environmentally aware company would be great for company reputation and also marketing functions. Competitive advantage can be achieved through focusing on environmental issues and this could also increase the market value of case company.

In some cases, the transport mode with lower environmental impacts can also have lower costs – air freight is usually much more expensive option than sea freight, so using sea (or) rail freight more often results in direct cost savings. Also, if some of courier freight inside Europe could be replaced with Economy options (road freight services), it would result in cost savings as well. Courier freight and air freight are the transport modes with highest freight costs per se and also have the highest environmental impact – these transport modes should be avoided to achieve both cost savings and reduction of environmental impacts.

8.7 Literature views

Blanco and Steffi (2017) had stated that 90 % of estimated CO_2e emissions caused by freight transportation and logistics activities come from the actual freight transportation and that transportation sector is globally responsible of 19 % of all used energy and 23 % of energy related CO_2e emissions. Thus, it is justifiable to focus on freight transportation only. Total share of logistics in energy consumption and caused CO_2e is extremely big so reducing environmental impacts caused by logistics makes a big difference in all energy consumption and CO_2e emissions. The environmental impact of logistics usually is a result from five factors that are distance, mode, equipment, load and operation (Blanco and Steffi 2017). Transport mode, equipment, load and operation can perhaps be impacted – either by case company alone or in co-operation with carriers. In principle distances cannot be impacted but of course come improvement can be achieved through efficient route planning.

Blanco and Steffi (2017) also point out lack of resources and need for collaboration. It is common problem that there is not enough time or resources for this kind of issues and these issues are not often even prioritized by management. Successful implementation of green logistics requires both internal and external collaboration – internal in the case company between management and employees for instance and external between case company and carriers (Blanco and Steffi 2017). Co-operation with carriers is often challenging due to many reasons such as lack of resources at both sides and need for focusing on operative problems instead of long-term development work in environmental issues. On the other hand, Blanco and Steffi (2017) had found out that co-operation often leads to win-win situations and cost reductions for instance – increased attention towards carrier co-operation would for sure benefit both parties in the long run.

Bask and Rajahonka (2017) had introduced six main groups for decision making affecting factors. These factors are customer requirements, product characteristics, company structure, government interventions, available transport facilities and decision maker's perceptions. In the case company customer requirements have quite a big value, especially when orders are late and customers need the products urgently, air freight often needs to be chosen over sea freight. Bask and Rajahonka (2017) also list five important performance criteria for transport modes: transport cost, reliability, flexibility, transport time and safety. Transport cost and transport time are the usual two factors that guide the transport mode choice – the least expensive solution will be chosen if transit time is not important, but if there is a need for a short transport time due to production delays for instance, transport time is more important criteria than transport cost. Bask and Rajahonka (2017) also found out that even though transport cost is an important criterion, separate emission-related charges do not often have an effect on the transport mode choice. This is a very interesting observation since targets for cost savings usually are extremely important for companies.

Another interesting founding from Bask's and Rajahonka's (2017) study was that logistics service is not always clear neither for service buyer companies nor carriers. There is lack of standard methodology when it comes to measuring the reductions of environmental impacts which also prevents sharing not only costs but also benefits between service buying companies and carriers. Measuring environmental performance is not often considered even though environmental performance would have been included in transport contracts – however, it is extremely important to include these issues in contracts since it also tends to improve the performance. CO_2e emissions and energy consumption are the most common performance metrics in these kinds of contracts. Bask and Rajahonka (2017.)

8.8 Targets and actions – a couple of logistics companies as examples

In order to be able to achieve emission reductions systematically, it is important to set targets and plan actions for achieving set targets. Many companies in the field of logistics have set targets for having net-zero CO2e emissions by certain year and also some milestones for having some smaller targets on the way. In case company basically all logistics activities are outsourced, so the development of emission reduction is heavily dependent on carriers' actions. This also emphasizes the importance of comprehensive reporting and need for receiving enough and actual information from carriers. In following paragraphs some logistics companies' targets and activities are discussed. In addition to importance of biofuels and e-vehicles it was pointed out that customers' role is important – there has to be demand for environmentally friendly solutions in order to make the development profitable. Role of legislation is crucial as well, there should be a common pressure for all companies to aim at improving at sustainability.

Maersk is a shipping company that was established in year 1904 in Denmark. In 1970's container vessels and cargo consolidation were put into practice and in year 2001 APM terminals, independent business units providing port and inland infrastructure, were established. Maersk has set a target that its operations will have net-zero CO2 emissions by year 2050 and that its relative emissions would be reduced by 60 % from year 2008 to year 2030. By year 2020, CO2 emissions have been reduced by 41,2 % from year 2008 and of this reduction more than five percent was achieved in year 2019. Maersk mentions three areas in which development and breakthroughs need to happen in order to make achieving net-zero emissions possible, these three areas are: market, technology and legislation. Maersk has for instance put to use fuels that are carbon neutral from a vessel perspective and save approximately 85 % CO2 on a life-cycle basis. Biodiesels are crucial for reducing CO2e emissions caused by fuels. Maersk also emphasizes the need for effective policies for cutting the competitiveness gap between fossil and zero-emission fuels for instance – there is a need for legislation that pushes all companies towards emission reductions. Maersk has also launched "Maersk ECO Delivery product" where the carbon footprint caused by transportation will be neutralized through purchase and use of biofuels in Maersk network. (Maersk 2019.)

DHL has also set a target of zero emissions by year 2050. With this target DHL hopes to be able to give a significant effort for achieving the goal of limiting global warming below two degrees. DHL has also set some milestones that should be achieved by year 2025, for instance it aims at increasing the carbon efficiency of its own activities (and activities performed by its subcontractors) by 50 % from year 2007. These targets are a part of DHL's own environmental protection program, GoGreen. More than 50 % of sales should incorporate Green Solutions by year 2025 which would make customers' supply chains greener as well. DHL aims at training and certifying 80 % of its employees as GoGreen specialist by 2025 and goal is to involve employees in environmental and climate protection activities. DHL has also several products to increase transparency in carbon footprint, for instance DHL Carbon Report that helps to track GHG emissions, identify efficiency potential an generates detailed reports and DHL Quick Scan that provides opportunity to compare carbon efficiency to sector benchmarks, is easily accessible through entire supply chain and helps to identify potential green optimization levers. There are also actual logistics services for minimizing or even avoiding logistics-related emissions, such as DHL Green Danmar that is 5 % more carbon efficient than industry average and helps to neutralize emissions without any additional efforts. (DHL 2017.)

DB Schenker is an operator in Europe's biggest land transport network and has a target to make its transport activities in Europe emission-free already by year 2030. Intelligent climate-friendly solutions are planned to help relieving conurbations of air and noise pollution. Integrated logistics service provider also boosts the use of vehicles that use either electricity or fuel cells as well as prioritizes designing sustainable terminals and invests significantly in research and development. DB Schenker aims to converting all vehicles weighing up to 3,5 tons to electric drives or fuel cells by 2020 and even half of vehicles weighing 3,5-7,5 tons should be electrically powered by that time. Goal is to reduce CO_2 emissions caused by land transportation by 34 %, CO_2 emissions caused by air freight by 30 % and CO_2e emissions cause by sea freight by 66 %. This should be done through fleet modernization for all transport modes and for instance for land transportation through network operational excellence and for sea freight through vessel size and fuel optimization. (DB Schenker, 2021.)

9 CONCLUSIONS

In this thesis the biggest causes for CO_2e emissions were studied as well as challenges in reducing emissions, possibilities to achieve improvement in environmental issues and challenges in reporting and measuring. Probably most of the global industrial companies are facing these same challenges in measuring and reducing the environmental impacts caused by freight transportation. Focusing on environmental impacts is quite recent theme but its importance is increasing rapidly. Measuring environmental impacts of freight transportation is difficult due to lack of accurate data for instance about fuel consumption and actual distances – this is something that needs to be improved through co-operation with carriers. However, the role of transport mode choice in total environmental impacts of logistics is clear and major and there is a lot of potential to make transport mode choices in a more environmentally sustainable way.

Research questions in this case study were about main contributors causing the emissions and how the level of emissions could be reduced. A major share of CO_2e emissions caused by export shipments comes from air freight whereas a major share of CO_2e emissions caused by import shipments comes from sea freight. This could mean that export shipments are often more urgent and / or import shipments are so large that sea freight is chosen over air freight more frequently. However, it is interesting that import shipments focus more on sea freight – perhaps there is something that could be done similarly in export shipments as well. Use of rail freight is not very widespread at the moment but should be increasing in the future. Emissions could be reduced by choosing sea freight over air freight and in some cases even rail freight over sea freight – maybe some parts of domestic road freight and road freight to and from Europe could be replaced with rail freight as well.

In logistics and freight transportation lack of resources and time are quite common challenges. It is difficult to make transport mode decision based on environmental impacts only when there often is pressure for short transport times. Delays in previous functions, for instance in production, create challenges for transport planning function. All other functions must succeed as well in order to allow transport planners to actually make the transport mode choices. On the other hand, management needs to prioritize these issues enough and allocate enough time and employee resources on environmental issues. Reporting, calculating and analyzing requires time and knowledge and it is difficult to achieve any improvement without having time to consider these issues. Another thing that needs to be prioritized is the co-operation with carriers, not only to discuss operative issues and current problems but also to be able to strive to improvement together.

Not only case company of this study but all industrial companies and all operators in the field of logistics are forced to find more sustainable ways to arrange freight transportation. Transport mode choice is probably the most critical thing that can be affected on, but there are often other things such as schedule requirements that set limits for transport mode choices. Service buying companies need to require solutions with less environmental impacts from carriers and aim at finding more sustainable solutions and also at more comprehensive reporting through tighter carrier co-operation. Measuring the environmental impacts is one main challenge at the moment, so carriers need to be able to provide information from factors such as fuel consumptions or travelled distances in the future so that the calculations could be as accurate as possible.

At the moment case company is using a certain system for export shipments only but all import shipments are not always booked through any system but often by e-mail only. This caused challenges in reporting since while export data could easily be obtained from case company’s database, import data was obtained from external carrier reports that are received separately from each carrier for each month. In the future aim is to get all shipments to be booked through same system so reporting will be more coherent and reliable. On the other hand, in the case company major part of the freight transportation planning activities is centralized to a dedicated function – in other companies separate business units might be separately responsible of their bookings and there might be even more variety in shipment data. It is certainly a huge synergy benefit to have transport planning as its own function when it comes to defining CO_2e emissions caused by freight transportation at a company level. Also, carrier co-operation and development work in this area is more flowing when in the case company there is only one team or department to work with.

Transport sector and especially logistics is responsible of major shares of total global energy consumption and CO_2e emissions and the situation is very similar in the case company. Reducing environmental impacts of freight transportation would at the same time reduce the total environmental impacts caused by the case company significantly. Logistics service buying companies and carriers need to find more sustainable ways to operate and this can be achieved through co-operation. Accurate measuring has to be prioritized at both sides and environmental performance criteria should be included in contracts. Carriers are responsible of providing environmentally sustainable solutions and service buying companies are responsible of requiring and using them. The law of supply and demand applies here as well: logistics service buying companies need to demand for sustainable solutions in order to make it worthwhile for carriers to offer and develop these solutions.

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