Recommendation for emission reporting to endeavour sustainable transports

Operational guidance to fortify sustainability in the Volvo Car Group's logistic network

Bachelor Thesis in Economics and Manufacturing Technology

LINNÉA BÖRJESSON
EMELIE LINDBERG

Department of Technology Management and Economics
Division of Logistics and Transportation
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2014
Report no. E2014:049

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LINNÉA BÖRJESSON
EMELIE LINDBERG

Examiner:
Ph.D. Sönke Behrends, department of Technology Management and Economics,
Chalmers University of Technology

Supervisor:
Ph.D. Sönke Behrends, department of Technology Management and Economics,
Chalmers University of Technology

Technical report no E2014:049
Department of Transports and Logistics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

Chalmers Reproservice
Gothenburg, Sweden 2014

ACKNOWLEDGEMENTS

This report is the result of a bachelor thesis performed within the Economics and Manufacturing Technology at Chalmers during the spring of 2014. The thesis work was carried out at the department of inbound and outbound logistics at Volvo Cars, Gothenburg.

There are some people we especially would like to thank for making this thesis possible. First we would like to thank Bert Larsson at Volvo Cars, who handled the first contacts with the company and directed us to the right people. Secondly, we would like to thank our supervisor Sönke Behrends at Chalmers for all his help and support during this project. We would also like to thank Magnus Ödling and Mattias Bergström at Volvo Cars for showing us the logistic network and providing us with support along the way.

Last but not least, we send our thanks to all the people involved in this thesis, for letting us contact them, for all the interviews we have been able to hold and all the emails we have gotten answered continuously throughout our work.

Linnéa Börjesson & Emelie Lindberg

Gothenburg May 2014

ABSTRACT

Increasing levels of Greenhouse gas emissions causing global warming and climate changes are major challenges in today's society. One important contributor is the freight transport sector, which accounts for 20 % of all EU greenhouse gas emissions (Cefic, 2011). The automotive industry is meeting rising demands from external customers and public bodies as well as internal demands for accounting and reporting of emissions. These transports constitute an important role when it comes to minimizing environmental threats like global warming and air pollution. Especially since the amount of transports are not expected to decrease and the affects that our lifestyle have on the environment is becoming more and more apparent for everyone. This increases the need for companies to control their transports and to find ways to lower their emissions.
Due to a recent reorganisation within the Volvo Car Group, the inbound and outbound logistics have become insourced within the company group. This resulted in a need for evaluation of each transport mode and the emissions deriving from each transport. The purpose of this thesis is to create a recommendation for emission reporting of greenhouse gases, sulphur oxide, nitrogen oxide and particulate matter to endeavour sustainable transports, within the Volvo Car Group. The recommendation is developed for quantification of emissions per each transported distance. Two examples of logistic chains are evaluated with the use of default values and operator specific values, hence a comparing analysis between the methods is made. Also the existing and future legal demands concerning each mode of transport are discussed.

The research methodology is based on qualitative semi-structured interviews with the carriers of different modes of transport. Subsequently, literature studies were conducted to comprehend the methodologies used for emission reporting.

The result from the interviews shows that the way of working with emission reporting varies in different companies and that some companies have well defined emission goals while others are more diffuse and visionary. The maturity level of emission reporting is closely linked to the enforcement of regulations from authorities. In the future, sea transports is the mode of transport with greatest challenges ahead, due to the Sulphur Emission Control Area (SECA) regulations coming into effect next year. In the comparison of calculating emissions based on values from Eco Transit, NTM and operator specific values, the result indicates that values from Eco Transit produce higher emission values compared to the values deriving from NTM and the transport operators.

The generated recommendation for Volvo Cars suggests that emission reporting should be based on operator specific values in sea transports and default values in road, rail and air transports. The recommendation is to implement a strategy for improving the accuracy level from operator specific values on a yearly basis. For reporting greenhouse gases the recommendation is to use the CEN standard. For SO_x, NO_x and PM the recommendation is to use NTM emission factors.

Legal demands will be the best way to decrease the amount of emissions from the transport sector, since it is competition neutral, and enforces organisations to step up without risking losing customers.

Key words: logistics, sustainability, GHG emissions, modes of transport, emission reporting

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GLOSSARY AND ABBREVIATION

The intention of this section is to provide the reader with a summary of the most utilised acronyms and definitions, ameliorating the reading and comprehension of this thesis.

Allocate
When freight from more than one company is being transported the total energy consumption must be allocated in a fair way so that the created emissions are divided equally
Capacity utilisation
The ratio between freight mass transported (including empty trips) and payload capacity
CSI
Clean Shipping Index
Deep sea shipping
Refers to maritime traffic that crosses oceans
DWT
Dead Weight Tonne. The measurement of the vessel's carrying capacity
ECA
Emission Control Area
EEOI
Energy Efficiency Operational Index
Emission factor
A number that shows the quantity of emissions that will be released for every unit of a specific fuel used
FTL
Full Truck Load. Shipment which are big enough to fill a significant share of the transport vehicles capacity. The shipments are usually transported directly between shipper and receiver
GHG
Greenhouse gas
HFO
Heavy Fuel Oil
Inbound
The activities of receiving, storing and disseminating incoming goods or material for use
IMO
International Maritime Organisation
Intermodal
Transportation with more than one type of vehicle, for example rail and truck
LNG
Liquid Natural Gas
Load Capacity
The maximal load capacity of a vehicle
Load Capacity Utilisation
The amount of load carried by the vehicle as a fraction of the maximal load capacity of the vehicle
LTL
Less Than Truck Load. Shipments which are too small to fill a significant share of the vehicles cargo capacity, hence it is consolidated with other shipments, resulting in milk-runs
MGO
Marine Gas Oil

MDO
Marine Diesel Oil
OBS
On-Board-System
Outbound
The movement of material associated with storing, transporting, and distributing goods to its customers
Payload capacity
Maximum weight of freight allowed (tonnes)
PM
Particulate matter
RoRo
Roll-on-roll-off vessel
SECA
Sulphur oxide (SO_x) Emission Control Area
Short sea shipping
Encompass the movement of cargo and passengers mainly by sea, without directly crossing an ocean
TEU
Twenty Foot Equivalent unit. Cargo capacity unit that represent a standard intermodal container
TEU capacity
Maximum number of containers allowed in TEU.
TTW
Tank To Wheel. The amount of emissions produced by burning the fuel from the vehicle's fuel tank
Vehicle gross weight
Maximum allowable total mass of the vehicle itself + passengers and cargo
WTW
Well To Wheel. Emissions produced during production of the fuel and when burning the fuel in the vehicle's fuel tank

1. INTRODUCTION

This chapter aims to describe the contextual background of the thesis and presents a section about Volvo Cars and sections that define the research purpose, research questions and the delimitations of the thesis. Furthermore, a disposition of the report is presented.

1.1 Background

Increasing CO_2 emissions causing global warming and climate changes are major challenges in today's society. One important contributor is the freight transport sector. From 1990 to 2008 CO_2 emissions from transports have grown by 44 % mainly due to globalization and the growing significance of trade from east (Cefic, 2011). Today, transport (freight and passenger) accounts for 20 % of all EU greenhouse gas emissions. In order to limit the negative effects of climate change, the European Union (EU) agreed to drastically reduce the greenhouse gas emissions. EU has the goal of cutting greenhouse gas emissions by 20 % by 2020 and in the long term by 80-90 % by 2050 compared to the emitted levels in 1990 (European Commission, 2014). Freight greenhouse gas reporting is therefore becoming an increasingly important topic for the industry and cannot be ignored. Besides climate change freight transport also significantly contributes to noise, traffic congestion, traffic accidents and air pollution causing negative effects on eco systems and public health (Odette, 2013).

The automotive industry is an important sector for economic growth in Europe representing 6.9 % of the EU's Gross Domestic Product (GDP) (ACEA, 2014).The industry is facing a great challenge of matching economic growth while reducing the environmental footprint of its products, services and production facilities. A significant contributor to the automotive industry's environmental impact is the logistics sector. A modern car consists of approximately 10 000 parts from suppliers all over the world, and all of them need to be transported to the assembly plant (Kannegiesser, 2013). The finished vehicles are subsequently being distributed worldwide. Hence, the supply chains in the automotive industry are complex. Companies and organisations, which have the ambition of mitigating their environmental footprint need to have a long term perspective for achieving this. Management and reduction of energy consumption in transport are key to societal challenges in relation to climate change and security of supply (Clecat, 2012).

The automotive industry is meeting rising demands from external customers and public bodies as well as internal demands for accounting and reporting of emissions. In 2013, the French Decree, the first European legislation obligating transport service providers to report their greenhouse gas emissions, came into effect in France. In the future it will be essential for companies to have transparent and accurate emission reporting objectives in order to be seen as a credible player. Emission reporting will be a natural part of Corporate Social Responsibility (CSR) and fundamental to stay competitive.

1.2 Volvo

The Volvo Car Corporation is one of the automotive industry's strongest brands, with a long history of world-leading innovations. The company has made a decision to actively commit to sustainability with the conviction that it creates business opportunities and will reinforce their competitiveness in both the short and long-term. Environmental care is one of Volvo Car's core values, promoting a sustainable lifestyle and positive future for everyone (Volvo Cars, 2014). Volvo Cars wants to reduce the environmental impact from their operations by working towards more sustainable transport solutions. Volvo Cars endeavour taking actions for reporting and calculating emissions from contracted carriers in order to improve their sustainability work. In collaboration with Chalmers and the carriers the plan is to establish a guideline for achieving this.

Volvo Cars is endeavouring sustainable transport solutions and since environment is one of their four core values, it means that the guideline for emissions reporting needs to be integrated on an operational basis and to be a part of Volvo Cars corporate sustainability work. In EU there is a legislation forcing car manufacturers to label every new car with a value on fuel efficiency and CO_2 emissions (European Commission, 2013). Since the customer interest in eco-friendly products seems to increase it is only a matter of time before consumers request a declaration of carbon footprint from their cars as well. Environmental friendly products gives a competitive advantage for the company in comparison with its competitors. This advantage can only be expected to grow.

1.3 Purpose

The purpose of this thesis is to create a recommendation for emission reporting of greenhouse gases, sulphur oxide, nitrogen oxide and particulate matter to endeavour sustainable transports, and to provide operational guidance to fortify sustainability in the Volvo Car Group's logistic network, with the intent to create awareness of the environmental consequences of different transport modes in inbound and outbound logistics.

1.3.1 Problem Definition

Sustainability is one of four core values within the Volvo Car Group, for that reason it is important to improve the sustainability work in all departments in the company. In the logistic department, there is a need to strengthen the environmental awareness in the logistic network strategy. To endeavour sustainable transports, emission data from multiple carriers and default values from published recognized databases of highest possible accuracy level will be collected to perform emission reporting within the Volvo Car Group.
To develop a guideline for emission reporting, based on accurate and valid information, the following research questions have been defined;

1. How do Volvo's transport providers calculate emissions?
   1a. How accurate/reliable are their values?
2. What default values from public databases should be used?
3. What are the differences between operator specific values and default values, how do their results differ?
4. Which future legislations will have the highest impact on emission regulations and cost, in road and sea transports?
5. What is the recommended emission calculation guideline for Volvo Cars?
   5a.What methodology and which default values should be used?

1.4 Delimitations

Modes of transport will be limited to road, sea, rail and air. Eco driving will not be considered in the road sector, even though it may affect the fuel consumption. This is due to its complexity and the difficulties of quantification. Other factors of influence that will not be considered in the report are the different weather conditions, potential traffic congestion and road accidents which can affect the driving. Due to the difficulty of predicting how often this affects the transport industry this will not be included in the calculations. Exhaust gases from idling driving and loading will also not be taken into consideration. It is important to take into account that the emissions may vary depending on the standards of engine and fuel in that part of the world where they are being measured.

Only environmental impacts linked to the operation of vehicles and to fuel production will be considered in the report. Land use, noise and depletion of the ozone layer were not taken into consideration. PM emission from abrasion and twirling were not included. PM emissions are defined as exhaust emissions from combustion. The difference between emissions from port and open sea shipping was also not treated.

1.5 Disposition of the report

In order to make the disposition of the report more comprehendible, the structure of the report is presented below.

Introduction
The introduction presents the background, the purpose, the research questions and the delimitations of this thesis.

Theory
The theoretical framework lays the foundation of the theory used in this thesis work to provide an enhanced knowledge and understanding for the research result presented.

Methodology
This chapter presents the methodology used to reach the purpose of this bachelor thesis, in order to provide the scientific value of the presented results.

Results/Analysis
This chapter summarises the conducted interviews and analyses the results with regard to the defined research questions.

Discussion/Conclusion
This chapter discusses the result of the research questions in relation to the thesis purpose. The discussion chapter also provides a discussion of the reliability of the results. Finally the major conclusions from this thesis are presented.

Appendices
The appendix presents tables of emission factors, emission calculations, the interview templates and the transcribed interviews.

2. THEORY

This chapter presents the theoretical framework used in this thesis and covers different elements needed to answer the research questions. First, logistics is defined and related to CSR and sustainability. This is followed by a section describing the unsustainable impacts from transport. Subsequently, different modes of transports and different approaches to emission calculations are described.

2.1 Logistics

2.1.1 Definition of logistics

Logistics is essentially about the flow of materials and goods along a supply chain and includes all related activities. It is the process of strategically managing the procurement movement and storage of materials, parts and finished inventory (and the related information flows) through the organisation and its marketing channels in such a way that current and future profitability of maximised through the cost-effective fulfilment of orders (Christopher, 2011, p. 2).

The process of logistics management can be subdivided into several different activities, typically including logistics network design, warehousing, material planning and inbound and outbound transportation. Inbound transportation emphasizes the incoming parts to the assembly plant while outbound transportation includes the transportation of finished products to customers. The major and most utilised modes of transport are road, rail, sea and air freight. The infrastructure coverage and weight/volume of the goods could be limiting factors when selecting mode of transport. Larger consignments are transported by ship or rail while smaller consignments preferably are transported by truck. The frequency of transports also often decides which mode of transport to use, in the sense that a higher frequency speaks in favour for road transports since the departure time is more flexible with road transports than with sea transports. Other influencing factors are lead time, delivery precision, transport distance, value and sensitiveness of the product (Björklund, 2012).

2.1.2 CSR in logistics

In today's society Corporate Social Responsibility (CSR) is of great interest for companies and the way of approaching CSR is of crucial importance for attracting both shareholders and customers in order to stay competitive. The European Commission defines CSR as "*the responsibility of enterprises for their impacts on society"* (European Commission, 2011). CSR is aiming to encourage organisations to take their social, environmental, ethical human rights and consumer concerns responsibilities. These responsibilities should be established in collaboration with the company's stakeholders and closely integrated in the corporate strategy and business operation with the aim of maximising the creation of shared value for the owners/shareholders and society at large. For logistics companies to be successful in their CSR work it is necessary to integrate the CSR strategy in the organisational network while simultaneously enabling a value driven management (Gessner, 2013). However, CSR in logistics has a rather complex role in fulfilling the demands and expectations of its stakeholders. On the one hand, customers evaluate logistic processes by the degree of environmental, social and ethical transparency. But on the other hand, companies need to focus on reducing costs in order to stay competitive and offer their customers value for the money (Gessner, 2013).

The Swedish government recommends the use of international guidelines made by the United Nations (UN) and the Organisation for Economic Co-operation and Development (OECD). However, it is the company alone that decides how to work with these issues since the CSR work is owned by the company. Public authorities should only play a supporting role. (Regeringen, 2012).

2.1.3 Sustainable logistics

There are many different definitions and interpretations of sustainable development which are due to its complexity. The Bruntland commission defined sustainable development in "Our common future" in 1987 as (United Nations, 1987, p. 15):

"Development that meet the needs of the present without compromising the ability of future generations to meet their needs"

This report will base its view on the three dimensional approach of sustainable development that encompasses economic, social and environmental development. The economic dimension emphasizes efficiency, growth, stability, intergenerational equity and employment. The social approach has its main focus on reducing poverty, cultural heritage, intergenerational equity and citizens' participation in decision making-processes. The environmental dimension focuses on biodiversity, natural resources and environmental pollution (Singh, 2014). These three dimensions are strongly interrelated and are complementary to each other which can be seen in figure 1.

Figure 1: The three dimensional approach of sustainable development
Source: http://www.csr-matrix.com

If any changes are done in one dimension it will affect the other dimensions to some degree as well. It is important to have a holistic view in decision-making that encompasses all three dimensions. Changes due to cost reduction could in logistics have both positive and negative environmental effects in forms of increased fuel efficiency or by choosing a less environmentally friendly transport alternative to save money. Therefore, it is important for companies to be aware of the impact different business decisions may have on the environmental and the social dimensions. Companies must take a clear position regarding how much influence one of the dimensions can have in decision-making on expense of the other two dimensions (Björklund, 2012). Today in general, companies are focusing more on the environmental and social dimensions than before.

2.2 Unsustainable impacts of transports

This section presents the unsustainable impacts of transport and are categorized in greenhouse gas emissions, local emissions and traffic impacts.

2.2.1 Greenhouse gas emissions

In 2013, road transport was responsible for more than 72 % of the greenhouse gas emissions in the freight sector in Europe, where the air transport sector stood for 12,4 %, shipping for

14,1 %, railway for 0,6 % and other modes of transport 0,8 % (Generaldirektoratet för transport och rörlighet, 2013).

Greenhouse gases are defined as gases in the atmosphere that absorb and emit radiation within the thermal infrared range (Jana, 2011). The process helps regulating earth's climate to be habitable and is known as the greenhouse effect. The greenhouse gases are divided into natural and synthetic (man-made) greenhouse gases. Natural greenhouse gases are water vapour, methane, carbon dioxide and nitrous oxide while synthetic greenhouse gases are chlorofluorocarbons (CFCs), hydrofluorcarbons (HFCs), perfluorcarbons (PFCs) and sulphur hexafluoride (SF6). The concentration of greenhouse gases in the atmosphere has steadily increased due to the industrial revolution and an increasing global population with the need for fossil fuels in every-day life. Global temperature is rising because of this and can lead to potentially harmful threats for environment and humans.

Global warming potential

In order to measure the amount of greenhouse gas emissions and be able to compare the amounts in the atmosphere, the Global Warming Potential (GWP) is the accepted reference. GWP is a reference for how much heat a greenhouse gas traps in the atmosphere. The reference is 1 kg of CO_2 and is equivalent to 1 GWP. It is also referred to as carbon dioxide equivalent (CO_{2e}) and is the mass of pure CO_2 that would give the same global warming effect as the mix of CO_{2e} value in a given time span. The global warming potentials for the six principal Greenhouse gases are according to UNFCCC (2014) based on a 20 years horizon seen in table 1.

Table 1: GWP for different Greenhouse gases based on a 20 years horizon

Greenhouse Gas	GWP
Carbon Dioxide (CO_2)	1
Methane (CH_4)	56
Nitrous Oxide (N_2O)	280
Hydrofluorocarbons (HFCs)	460-9100
Perfluorocarbons (PFCs)	4400-6200
Sulphur Hexafluoride (SF_6)	16300

Carbon dioxide (CO_2) contributes to 60% of the increased amount of man-made greenhouse gases in the atmosphere and causes most problems. The level of carbon dioxide in the atmosphere is increasing with 10 percent every twenty years (West, 2014). CO_2 derives from the combustion of fossil fuels including coal, oil and gas (Odette, 2013). Vehicle emissions consist mostly of CO_2 but some methane as well. The majority of fuel used in freight transport is diesel where the emitted amount of methane is small. Due to methane's high GWP its effect cannot be neglected, especially when it comes to decision and comparison of alternative fuels. The level of methane is much higher in the exhaust gas from biogas and natural gas compared to petrol and diesel (West, 2014).

2.2.2 Local emissions and air quality

Traffic gives rise to emissions of air pollutants, which contribute to air pollutions. The most important emissions are Nitrogen oxides (NO_x), Sulphur oxides (SO_x) and Particulate Matter (PM). NO_x is a toxic gas, which is produced in the engine during combustion, due to a reaction between nitrogen and oxygen. Road transportation is the main source followed by the electricity supply industry. NO_x is carcinogenic and can cause pulmonary tissue damages (Almén, 2008).

SO_x is derived from the combustion of fuels containing sulphur. The most prominent sources are heavy oils and coals (DEFRA, 2014). SO_x can cause constriction in the airways, especially sensitive are people suffering from asthma and chronic obstructive lung disease (COL). Sulphur dioxide (SO_2) emissions are contributing to acidification of soils and water leading to loss of biodiversity. High levels of sulphur in nature are endangering the ecosystems by reducing levels of chlorophyll, -which is affecting the photosynthesis. Particulate Matter (PM) derives from a wide range of materials and sources and is categorized on the basis of size of the diameter of the particles. Particles arise primarily from combustion processes and secondarily from chemical reactions in the air. Exposure to PM can be lethal and cause cardiovascular and respiratory diseases.

2.2.3 Traffic impacts

When transport users compete for the limited transport system capacity, congestion arises. An increase in traffic and congestion also leads to noise in urban areas which is getting worse year by year. More traffic also increases the risk of accidents causing pain, grief and suffering and are a burden for society (Behrends, 2011).

2.4 Modes of transport

In this section, the different modes of transport are presented, and explains each mode's advantages and disadvantages. First, it presents the context of road transports in relation to technology, operational measures and modal shift. Secondly, sea transports is presented followed by subsections presenting air transports and rail transports.

In the selection of which transport mode to choose, many parameters need to be taken into account. Road transport might be the most cost-efficient and flexible option for a short-haul transport but for a long-distance journey sea might be the best option. Other factors of influence are the amount of emissions released, social and environmental impacts and current laws affecting that specific mode of transport.

2.4.1 Road transport

The benefits with road transportation is its flexibility and ability to reach customers far out on the countryside, and at the same time the driver makes sure that the goods are safe. It is both cost and time efficient. The main disadvantages are the emissions, the limited freight capacity and the dependence of available drivers (NTM, 2010). External effects of road transports are accidents, noise, air pollution, water pollution and damage to ecological systems (Jourquin, Rietveld, & Westin, 2006). At the same time, road carriers are affected by rising fuel prices, traffic congestion and worsen working conditions for the drivers (European Union, 2012). Today, the tough competition on the roads put high pressure on the prices for the forwarding agencies which already have small margins. This has also led to an increase in foreign agencies on the Swedish roads (ACEA, 2014).

During the last decade, road transports have increased significantly due to economic growth and improved trading ability. Declining freight prices make road transport the most economical alternative compared to other transport modes (European Union, 2012). Globally, the transport sector emits a share of 14 % of the total greenhouse gas emissions in which the road sector accounts for three- quarters. In addition to greenhouse gas emissions the exhaust gases also consists of a variable amount of NO_x and PM. Today, the most frequently used fuel for trucks is diesel, however the quality of diesel can vary significantly depending on country of origin and where the fuel has been refined. To decrease emissions and improve energy efficiency, three different aspects need to be taken into consideration: technology, operational measures and modal shift.

Technology

Technology can contribute to make the vehicles more fuel-efficient, for example by a better vehicle and engine design, but also by adding an on-board-system to monitor fuel consumption and distance travelled. To reduce the emissions from traffic the road sector needs to constantly adapt to new legal demands as for example with the Euro class I-VI standards. The concept of the Euro classes is to signify a level of requirements for the exhaust gases deriving from road traffic. It refers to the EU requirements, and put certain demands on automotive engines that must be satisfied. (Transportstyrelsen, 2014). The purpose of the Euro emission standards known as Euro Standards is to decrease the emissions of local air pollutants, e.g. PM and NO_x. Euro I-VI are standards controlling conventional pollutant emissions for automotive motor vehicles which are being regulated by the European Union and corresponding directives. The current standard is Euro 5b but will be replaced by Euro 6 in September 2014. Euro 3 and 4 introduced stricter fuel regulations, regulating a minimum diesel cetane number of 51, maximum sulphur content, maximum petrol sulphur content. Sulphur-free diesel and gasoline fuels became mandatory from 2009. A Particle Mass (PM) emission measurement method was introduced with the Euro 5 as well as a PM emission limit and a mass Particle number (PN) mass emission limit was introduced with Euro 5b. Euro 6 will demand stricter NOx requirements which will increase health benefits with 50-90% over Euro 5 (Miller, 2014).

Operational measures

At an operational level, different efficiency measures have been identified. Logistic efficiency aims to improve the load factor by choosing the best vehicle type and to optimize the whole transport chain. The technological efficiency can be improved by better design of vehicles with decreased fuel consumption and decreased resistance of tires. Drive efficiency can be established by educating the drivers in eco-driving. Another important parameter is road efficiency which include information on itinerary and road conditions to optimise routing (Léonardi Jacques, 2004).

Modal shift

The dominating opinion is that intermodal transports are more environmental friendly than unimodal transports (Jourquin, Rietveld, & Westin, 2006). Intermodal transport is the movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without moving the goods itself in changing modes (Behrends, 2011). Intermodal road-rail transport is a good way to maintain flexibility yet decrease the external costs (Behrends 2011). A longer distance fit perfectly for rail transport, where the freight can be consolidated with other shipments which gives both environmental and economic advantages. For short-haul or collection and distribution of freight, road transportation is most suitable (Behrends, 2011).

2.4.2 Sea transport

Shipping enables trade and collaboration between countries all over the world, 90 % of the global trading is transported by sea (IMO, 2014). Maritime transport is an energy efficient way to transport a big mass of goods over a long distance. However, there is still a lot to be improved concerning the emissions exhausting from shipping. Over a long period of time, emissions from shipping were overlooked. The legislation concerning shipping allowed quite high levels of emissions. But for the last ten years things have begun to change and focus have been on reducing the sulphur level coming from ships' exhaust gases. However, there is still a problem on how to control the traffic performed on International water, and hence, most of the legislation is limited to port areas close to land.

Shipping is an international industry and it is of great importance that standards and regulations are agreed upon, adopted and implemented on a global level. This is the intent of the International Maritime Organisation (IMO). IMO is an agency of the United Nations and has responsibility for the safety and security of shipping along with the prevention of marine pollution (IMO, 2014). IMO has regulations concerning the level of sulphur oxide and particulate matter inside certain Emission Control Areas (ECA). According to Annex VI from 2013 there are four sea areas included in ECA (IMO, 2014). These are Baltic Sea (SO_x), North Sea (SO_x), North American (SO_x, and NO_x and PM) and United States Caribbean Sea ECA (SO_x, NO_x and PM). The fuel oil's sulphur levels has become stricter over the years and the sulphur level also affect the amount of particulate matter.

The European commission has published a strategy for how to manage and lower emissions, preferably on a global level (European Commission, 2014). A firm grip needs to be taken concerning surveillance, reporting and verifying of emissions to be able to further discuss this matter in Europe and in the rest of the world. Each year, the global shipping industry releases emissions of CO_2 covering one billion tonnes. The shipping sector accounts for three percent of the world's total greenhouse gases, and four percent of the European Union's total emissions. The demand for maritime transport is expected to grow due to the growth of world trade. Without any actions taken, this will lead to the double amount of emissions by the year 2050. This is not consistent with the agreed mission of keeping the global warming below two degree Celsius, which will require a 50% reduction of the total greenhouse gases from 1990 until 2050.

It is a well-known fact that fuel consumption is strongly dependent upon the speed of the ship (NTM, 2008a). One way to be fuel-efficient is to make sure to follow the time schedule by not starting any journey by being late. If the ship is late, it might want to compensate by going faster than usual. Many big shipping companies are lowering their speed as a way of saving fuel and in that way money. However, the main reason for reducing speed was to reduce the capacity in the market. In the economic crisis the demand for sea transports dropped considerably which had a negative effect on freight rates reducing the income of the shipping companies. By reducing the speed the companies reduced the capacity with the goal to increase the freight rates.

2.4.3 Air transport

Within the automotive industry, air freight tends to be used only in emergencies or for transporting prototype parts and vehicles. The volumes tend to be low, mostly by economic reasons. Due to high fuel usage, greenhouse gas emissions per tonne of carried freight tend to be high. Although, because of the low volumes shipped, automotive companies might find the total air emissions low compared to their total freight emissions (Odette, 2013). The greatest environmental impacts from air transports come from aircraft noise and emissions. Globally, aviation represents two percent of the total carbon dioxide emissions. Many efforts have been made to prevent these numbers from increasing. Today, the result of this work shows that, the fuel consumption per passenger and kilometre has decreased by 70 % compared to 40 years ago. The most common type of fuel used by aviation is JETA-1. However, these savings are offset by an ever-increasing demand for air transport services, with the effect that absolute emissions are still growing.

Emissions from aviation contain CO_2 and NO_x, but also give condensation trails and cirrus clouds. The CO_2 emissions are by far the largest part. Exhaust gases from a jet plane contains about 8 percent carbon and 0.5 percent nitrogen, unburned hydrocarbons, carbon monoxide and sulphur dioxide. The other 91.5 percent consists of water vapour and nitrogen. Carbon dioxide emissions are directly related to the fuel consumption and are therefore easy to calculate. Where or at what height carbon dioxide is emitted does not matter, the effect is the same (GKN, LFV, SAS, Swedavia, 2014). However, the emission of some non-CO_2 substances at high altitudes by airplanes also have an impact on global warming. According to scientific studies the total climate impact of aviation at a certain point of time is two to four times bigger than the impact of CO_2 emissions (CE Delft, 2011).

2.4.4 Rail transport

Rail freight has low direct and indirect amount of greenhouse gas emissions and is considered to have the lowest energy consumption of all other competing transport modes. In rail transports, the train can be either diesel or electrical. The diesel quality differs depending on country of origin and refinery. The composition of electricity also varies depending on what energy source is used.

Diesel trains produce most of their emissions by direct fuel consumption. Best option would be to use electric trains, which only uses an electricity mix from renewable energy. The low energy consumption is among other factors due the low rolling resistance between wheels and rail (Andersson, 2011). However, electric trains using renewable energy emit particles and are therefore not totally emission free. These particles come from wear of rails, brakes and wheels. One of the disadvantages with rail freight is its limited modal shift potential due to the built up railway network (Behrends, 2011). The infrastructure of rail demands a great amount of land which must be considered during the establishment processes. In order for the railway network to be more efficient existing network needs to be upgraded to handle new technologies and future travel- and transport demands (Andersson, 2011). The amount of travels and freight transports by train in the European Union (EU) is decreasing. This is mainly due to the neglected expansion of rail ways around Europe. To change this trend, EU has introduced a new rail-way strategy with many structural changes to improve the infrastructure of the rail-way network and to make the decision making in the rail-way sector more efficient (Europeiska Commissionen, 2013).

2.5 Calculating emissions in the transport sector

This section presents SS-EN 16258:2012 (CEN-methodology), Nätverket för Transport och Miljö (NTM) and Eco Transit approaches to emission calculations in freight transport.

Since recently, there has been a considerable variety in approaches to greenhouse gas reporting within the transport sector. Today, a few methods have evolved and databases are becoming more and more advanced. The most commonly used standard in Europe is the CEN standard. Other methods used for emission calculation is NTM and Eco Transit. Today’s databases have been upgraded to also include data concerning different operating parameters, for example mode of transport, type of vehicle and utilisation level. It is of great importance that the emission factors used are derived from the same source and not taken from different references. The greenhouse gas emission factors should preferably derive from the information given from the fuel supplier. If those values are not available, the emission values given from CEN-standard should be used (Odette, 2013). Emission factors are regularly being updated and the calculations should therefore be flexible enough to handle changes along the way.

Since the biggest part of emissions derive from the combustion of fuel, the approach of calculating should be based on looking at how much emissions is produced burning one litre of fuel. This could be based on a tank-to-wheel (TTW) or a well-to-wheel (WTW) approach. The WTW approach includes both the production of fuel, known as the upstream phase, and the operating phase. The TTW approach only include the operating phase (Odette, 2013). SO_x and CO_2 are dependent of the fuels carbon and sulphur content. That is why the correct amount of SO_x and CO_2 in the exhaust emissions derive from the information on the fuel specification. Emissions like NO_x, HC, CO and PM are related to the combustion process inside the engine and are therefore difficult to calculate. However, it could be done using emissions data presented by vehicle manufacturers, data from on board diagnosis equipment or by using information from laboratory tests of engines and vehicles (NTM).

Emission reporting often becomes a complex issue because of the complexity of transport chains. For example, there is often more than two parties involved. There is one transport buyer and another party acting in between as a transport user. There can also be other parties involved handling different parts of the service, for instance 4 Part logistic (4PL) services. During the transport, different transport modes are often involved and the goods might go through consolidation and deconsolidation. Each leg of the transport can be carried out by a different transport operator. The cargo might also include goods belonging to other customers therefore there will often be a need for allocation.

2.5.1 Emission factors

There are two types of emission factors. One that shows how much GHG that is generated when burning one litre of fuel. Another type of emission factor shows the amount of GHG resulting from transporting units of material, specific distances with certain types of transport, e.g. CO_2 per tonne km for different trucks (Odette, 2013).

In Odette (2013) three different standards are compared by performing emission calculation by all three standards. The standards are CEN, French Decree and NTM. The result of the comparison demonstrates that there is a variation in the result when using emission factors from different origin, hence, caution should be taken when comparing results from different sources. However, the range of variation is generally small and probably within the level of variation in regard to other aspects of the process.

2.5.2 CEN methodology

The European Committee for Standardization (CEN) is an international non-profit association offering European standards and technical specifications (CEN, 2014). The EN 16258:2012, hereafter referred to as the CEN standard was made available in 2012 and has since then been adopted and published by the National Standards organisations in several European countries. This is the only standard specifically published for a European-wide audience and to be adopted by European legislative bodies. The standard has been developed to achieve more accuracy, transparency and consistency in the calculation of energy consumption and greenhouse gas emissions in the logistics sector. A common approach is provided and a framework for the calculation and declaration of energy consumption and emissions for transport services regardless of the level of complexity.

Calculation methodology

The CEN methodology enables calculating greenhouse gas emissions and energy consumption for each transport service in CO_2 equivalents (SIS, 2012). The CO_2 equivalents are declared in both Tank-To-Wheel (TTW) and Well-To-Wheel (WTW) numbers. The amount of emitted greenhouse gas emissions depends on the amount of fuel combusted. In the Vehicle Operation System (VOS) all assumptions and specific circumstances for each transport activity is presented and shall include information regarding the number and type of vehicles and if possible, the period of time of each activity. Calculations should include all vehicles used to perform the transport service, including those operated by subcontractors. In the CEN standard, the total fuel consumption is referred to as F(VOS). Fuel consumption from each energy carrier used by each vehicle and all loaded and empty trips made by each vehicle should be included. Fuel consumption for each leg of the transport service should be identified and subsequently lead to calculation of energy consumption and greenhouse gas emissions of each leg. Parameters that are recommended to take into account are; fuel consumption, distance, fuel consumption per distance, load, load factor, vehicle capacity and empty distance.

S(leg) is defined as the factor used to calculate the share of the VOS's energy and emissions which is allocated to a transport service for the leg. The share is based on relative proportions of the transport activity for the leg and for the associated VOS. T(leg) is defined as the transport service's transport activity for the leg and for the associated VOS. T(VOS) is defined as the transport activity of the VOS which is related to the leg.

The calculation methodology for one leg of one transport service is conducted by;
- Establishing the Vehicle Operation System (VOS) related to this leg
- Quantification of the total fuel consumption for this VOS
- Calculation of total energy consumption and greenhouse gas emissions for this VOS
- Allocation to the leg of a share of each of the four results

The CEN methodology has four accuracy levels and the ambition should always be to get the highest accuracy level. The first accuracy level exists when having specific measured values. The second level is to have transport operator specific values. The third level is to have transport operator fleet values. The fourth and least accurate method is to have default values.

The formulas for calculating greenhouse gas emissions and energy consumption are;

$$E_w(VOS) = F(VOS) \times e_w$$
$$G_w(VOS) = F(VOS) \times g_w$$
$$E_t(VOS) = F(VOS) \times e_t$$
$$G_t(VOS) = F(VOS) \times g_t$$

$E_w(VOS)$ is the well-to-wheels energy consumption, $G_w(VOS)$ is the well-to-wheels greenhouse gas emissions, $E_t(VOS)$ is the tank-to-wheel energy consumption and $G_t(VOS)$ is the tank-to-wheel greenhouse gas emissions. Two different emission factors are used, where e_w is the energy consumption for WTW and g_w is the greenhouse gas emission factor for WTW the corresponding emission factors for TTW are e_t and g_t.

Method for allocation

The principle for allocating the emissions of the total vehicle to each cargo should correspond to the consignee's relative share of the transport activity performed within the VOS. The allocation parameter should be the transport activity and is quantified by multiplying the quantity of freight by the distance travelled. The unit for quantity of freight should be mass and distances should be the real distance travelled. The corresponding allocation unit is tonne kilometre (t.km). Mass may be replaced by another unit if it is more relevant for quantifying freight due to capacity limitations of the vehicle. This could for example be volume, pallet or lane meter. The unit for quantity of cargo in outbound is per passenger car, with default value 1 500 kg, length 6 m, and width 3,1 m.

In aviation the distance should be expressed in Great Circle Distance plus 95 kilometres. For maritime transport the allocation method should be based on either mass or area. In general, the transport activity should be quantified by multiplying the quantity of freight by the distance travelled.

2.5.3 NTM method

Nätverket för Transporter och Miljön (NTM) is a non-profit organisation and was initiated in 1993 with the ambition of creating a common European ground for how to calculate environmental performance in road, rail, sea, and air transports (NTM, 2008b). NTM provides methods for performing emission calculations and default data when there is no specific data available. NTM gives rather low values on emission data when using a well-to-wheel approach. This is because NTM uses Swedish fuel data. The difference between Swedish average diesel fuel and European fuel can be explained by a higher refining energy efficiency in Swedish refineries. Sweden also uses lower amounts of fossil fuel based electricity.

Road

In road transports, the first step is to collect information about shipments weight, volume and cargo holders (NTM, 2010). Information on operation distance per vehicle should also be collected. Next step is to select vehicle type, load capacity utilisation, fuel type and fuel consumption. Fuel consumption can be either a specific value from the supplier or by the use of NTM's default values.

The amount of emissions deriving from road transports depends on factors like load capacity utilisation (LCU), vehicle type and operational performance. Default values for load capacity, load capacity utilisation, fuel consumption and emission factors are available for ten different vehicle types. Each vehicle type is categorized by Euro class, length and weight. NTM separates road transports between integrated transport systems and direct transports (single or frequent shipment). If it is a frequent shipment NTM suggests an utilisation degree of 75 % of max load capacity. When performing a single shipment NTM suggests an utilisation degree of 50 % of maximum load capacity. The fuel consumption changes depending on road- and vehicle type. NTM differentiate among motorway, rural- or urban roads. If there is no information about the road type, values from national statistics could be used instead. NTM suggests that the emissions related to the positioning trip before the transport is added to the emissions from the actual transport. Emissions related to empty running after delivery is not considered, unless the vehicle operates in a shuttle system. Emissions for the positioning trip should be calculated based on fuel consumption for an empty vehicle. If no information about prepositioning is given for the distance, a factor of 20 % of the transport distance could be used for calculating the positioning distance.

Single shipments
The transport is carried out once by a vehicle travelling directly from the shipper to the consignee. Positioning before and after the transport will decrease the total capacity utilisation. NTM recommends that the emissions related to the positioning trip before the transport is calculated and added to the emissions from the vehicle during the actual transport. If there is no information available of the pre-positioning distance a factor of 50 % of the transport distance could be used for calculating the positioning distance. The fuel consumption should be for an empty vehicle.

Frequent shipments
The transport is carried out repeatedly by a vehicle travelling back and forth between the shipper and the consignee. If the vehicle is specially adapted to the cargo, the vehicle is often used as a shuttle, i.e. returned empty. The positioning distance is in this case 100 % of the distance. If there is no information available of the pre-positioning distance a factor of 20 % of the transport distance could be used for calculating the positioning distance. The fuel consumption should be for an empty vehicle.

Distribution round trip with several stops
Milk-runs normally start with a longer distance and subsequently a distribution round trip with several stops. For outbound logistics, the specific load factor for each distance depends on the number of car dealers, amount of cars to each car dealer and the distances involved. The CEN standard recommends that for a distribution or collection round trip, all transport activities for the whole round trip should be included. The distances involved should be based on either the use of the Great Circle Distance or by the use of the shortest feasible distance. Milk-runs utilises the truck efficiently, where the average load factor in terms of truck space utilisation becomes higher. It results in less environmental impacts, including decreased amount of emissions. A high loading factor is obtained partly because cargo from different transport buyers is collected in the same truck (Singh Brhar, Saini, 2011). If no specific data can be obtained, NTM suggests a load factor of 50 % for all transports that are employed in pick-up and delivery. Distances should primarily be in GCD and secondly in shortest feasible distance.

When handling goods of different characteristics volumetric weight can be used (NTM, 2010). The volumetric weight, sometimes called the dimensional weight, is the weight obtained as the commercial calculation factor [kg/m3] is multiplied by the volume [m3] of the shipment, yielding a factious weight measure (w(dim)). The physical and volumetric weights for each shipment are then compared, and the largest is used for the calculation of price and environmental load. The volumetric weight is thus used for shipments with a density below the commercial calculation factor, which is usually set to 333 [kg/m3] for European road transport and 280 [kg/m3] for national Swedish road transport. The load capacity utilisation for the integrated transport system is then calculated by dividing the dimensional weight (w(dim)), by the actual carrying capacity, yielding a higher capacity utilisation than would the physical weight be used. This method is chosen since the dim-weight better reflects the actual load capacity utilisation of the vehicle. The capacity utilisation varies between different companies, regions, seasons etc. and that is why it is important to seek for specific data for the investigated cargo.

Less than Truck Load (LTL) is problematic to handle due to the complexity of shared cargo. The transport service normally has a collection round trip to start with, and subsequently a longer distance to the assembly plant. The load factor may vary a lot during the collection round trip depending on the amount of load from different consignees. The route differs since the number of pickups varies and by that the load factor. The allocation of freight may be very complicated since the cargo may consist of different materials and densities. The unit for allocation of freight may therefore be different even for freight in the same truck.

Rail

The main indicator for calculating energy usage and emissions of rail transport is the energy consumption of the total train depending on the gross tonne weight of the train. The average gross tonne weight of a European train is 1000 tonne. The maximum gross weight is up to 2000 tonne for international traffic (UIC, 2009). When calculating the energy consumption and emissions released from train transport the parameters needed are train weight, emission standard, load factor and empty trip factor. The load factor depends on what type of cargo is carried and if empty trips are included. It is also necessary to know freight weight and type of freight. The axle load limit of a railroad line is the restricting factor for load capacity of a freight train. The cargo is categorized as Volume, Bulk or Average. The available energy data for diesel traction varies between 2.6 and 9.7 g/gross tonne km (/railways companies 2002, UIC 2009).

Sea

NTM's (2008) calculations are only based on the environmental performance of the main engine and while seagoing. To calculate the emission profile of the main engine NTM presents three important input parameters; engine emission profile, fuel consumption and cargo capacity utilisation (CCU). The vessels in NTM are categorized into different groups, RoRo cargo and RoPax ferries, container and general cargo. Roll-on-Roll-off (RoRo) vessels have a CCU of 90 % and are treated as pure freight vessels. CCU for ferries are not given due to the complex issue of allocation among cargo- and passenger ferries. Passenger RoRo ferries are approximated to have a freight capacity of 500 lane meters. General cargo ship should be used as ship type if the vessel type cannot be specified and the CCU for inland is 50 % and coastal and ocean is 60 %. The fuel quality, type of engine used and the engine power output are parameters that decides the emission profile for ships. The different engine models to choose from in NTM are; SSD (Slow Speed Diesel), MSD (Medium Speed Diesel, HSD (High Speed Diesel), ST (Steam Turbine).

The distance for transport routes should always be the distance travelled over-ground. For deep-sea shipping a detour factor of 2 % should be applied in order to compensate for route deviations due to weather conditions and currents. The uncertainties in calculations are due to difference in vessels, different conditions in different time and places as weather, currents, water depth, ship design and navigation procedures. NTM propose that these factors influence and effects the result in a span of - 20% to +40%. The default values if no specific information available are; CO_2 is 3,180 kg CO_2/tonne fuel and the main engines energy consumption is 41MJ/kg fuel.

Air

The NTM (2011) database has default values for two different air freights, Airbus (A) 310-300 F with maximum payload 40 500 kg (Air Charter Service, 2012) and Boeing 757-200 SF with maximum payload 27 215 kg (Boeing, 2014).

Parameters needed are distance for each flight, the aircraft model, load factor, cargo capacity utlization, fuel characteristics and the weight of the shipment or chosen unit. Load factors for cargo aircrafts are 50, 75 or 100 %. The capacity utilisation (CU) is calculated by using interpolation of different load factors assuming linearity. Distance is based on Great Circle

Distance (GCD) and is defined as the shortest distance on the surface of a sphere and is calculated using the following formula;

$$D = R\ \cos^{-1}[\sin(lat\ 1)\sin(lat2) + \cos(lat1)\cos(lat2)\cos(lon1 - lon2)]$$

Latitude and longitude coordinates can be extracted from ICAO Location Indicators Database. All aircrafts are assumed of using JetA-1 fuel. The emission factors are divided into two groups, CEF and VEF. Constant Emission Factors (CEF) correspond to fuel usage during takeoff and landing. Variable Emission Factor (VEF) is multiplied with the great circle distance in km as illustrated in the formula below:

$$TE = CEF + (VCF \times D)$$

Fuel consumption is calculated by dividing the CO_2 emission by the fuel specific CO_2 emission. FC (kg) = CO_2 (kg)/ 3.16 (kg). Volumetric weight is used for aircraft cargo. The industry conversion factor for air freight is 167 kg/m3. The chargeable weight is mostly defined as the transported weight.

2.5.4 Eco Transit method

The Eco TransIT project was initiated by B Rail, Schweizerische Bundesbahnen (SBB), J AB, Trenitalia S.p.A and Société Nationale des Chemins de Fer Français (SNCF) in 2000 (Eco Transit World, 2014). Eco Transit World provides data for all modes of transport world-wide based on average annual energy consumption. The environmental parameters covered are energy consumption, greenhouse gas emissions and air pollutants such as nitrogen oxides (NO_x), sulphur dioxide (SO_2), non-methane hydro carbons (NMHC) and particulate matter (PM).

Road

Road transports in Eco Transit (2011) are focused on international long distance transports. In Europe the gross tonne of trucks have been defined as 40 tonnes in Sweden and in Finland 60 tonnes. In order to calculate the fuel consumption Eco Transit has developed a gradient parameter representing the geographic topology of countries, differentiating between flat, hilly and mountainous countries. The default value is for hilly countries. Sweden, Denmark and the Netherlands are defined as flat countries and their fuel consumption is assumed to be 5 % lower than hilly countries' fuel consumption. Austria and Switzerland are defined as mountainous countries and their fuel consumption is assumed to be 5 % higher than hilly countries. Outside of Europe, all countries should be classified as hilly. Eco Transit assumes that the fastest way/route is chosen and to differentiate fuel consumption due to different road types, Eco Transit uses a resistance factor. The resistance factor is multiplied with the fuel consumption to compensate for different road conditions. The resistance factor for motorways is 1, for highways 1.3, for Big City Streets 2.4, City Streets 3.5 and Small City Street 5.0. The influence of load factor on the fuel consumption can be stronger depending on driving characteristics and gradient. According to Eco Transit, the fuel consumption of an empty vehicle is estimated to be 1/3 below a fully loaded vehicle's fuel consumption.

Sea

Emission factors in Eco Transit (2011) model is based on a bottom-up approach, in line with International Maritime Organisation's (IMO) approach. A bottom-up approach provide activity and technical data estimating emissions from individual ships as well as group of ships and ship types. Differentiated vessel in Eco Transit are General Cargo Vessels, Dry Bulk, Liquid- and Container Carriers and RoRo vessels. The energy consumption model Eco Transit uses separate emissions from main and auxiliary engines at sea and auxiliary engines in ports. Emissions from vessels are averaged over the entire return journeys, taking the load factors and empty returns into account. Emissions are the sum of emissions from main engines at sea and auxiliary engines at sea and in ports.

Rail

The NTM methodology and Eco Transit methodology for rail transport is the same and both uses the same approach to perform emission calculations. So for more information see the rail section in the NTM method 2.5.3.

Air

The basis for fuel consumption and emission data in Eco Transit (2011) is deriving from the CORINAIR Emission Inventory Guidebook. The data in CORINAIR is based on an average fleet and the calculated values are expected to be 10 % below or above the real fuel consumption.

The calculation of flight distances is based on the Great Circle Distance (GCD) between two airports. The real flight distance is longer than the calculated GCD, due to arrival and departure procedures, stacking, congested airspace and adverse weather conditions. Eco transit suggests that the detour within a circle of 185, 2 km around airports is approximately 60 km and that en-route deviations is in average 4 % of the GCD in Europe. Hence, the Eco Transit formula for calculating real flight distances is;

$$Real\ flight\ distance = (GCD - 185{,}2\ km) \times 1{,}04 + 185{,}2km + 60km$$

For flight distances shorter than 185,2 km, the formula is as follows;

$$Real\ flight\ distance = GCD + 60km$$

2.5.5 Interest organisations

Today, there are a number of different non-profit environmental initiatives, some of them are offering companies memberships as a way of enhancing their sustainability approach. Some of the organisations develop guidelines for emission reporting, while others have databases with information about transports service providers’ environmental statuses. In this section, some of the initiatives and guidelines that have been of interest during the thesis work are presented.

Greenhouse gas protocol

The greenhouse gas (GHG) protocol promotes CSR reporting that includes both external and internal demands. External demands can be legal obligations, customer requests, CSR-surveys and Industry Benchmarking. Internal demands are identified as internal supporting strategic objectives. They are mainly focused on some areas or activities undertaken of the organisation, such as business regions, plants or particular transport networks (WRI,WBCSD, 2011).

Clean Shipping index

Clean Shipping Index (CSI) is offering their members a tool for cargo owners and transport purchasers to select environmentally well performing shipping companies (Sköld, 2012). CSI has a ranking system for both vessels and carriers and the obtained credits are due to maintenance, operation and technical improvements. CSI goes beyond current laws and regulations meaning that if a company wants to be highly ranked it needs to perform better than the regulations. The shipping companies fill in a list with 20 questions about two ships from their fleet. The shipping companies are for example evaluated on emitted levels of CO_2, NO_x, SO_x and PM.

Odette

Odette Sweden is an organisation which is financed by members' fee from stakeholders within the automotive industry (Odette, 2103). Odette Sweden is a part of Odette International. The aim of Odette is to develop a standardized mode of operation within the automotive supply chain for greenhouse gas reporting. In 2013, Odette released "*Guidelines for reporting freight greenhouse gas emissions",* a guideline specific for the automotive sector. The report aims to make recommendations based on already existing standards as the CEN standard, The French decree, ISO 14064 and the GHG protocol for how companies should develop a methodology for reporting greenhouse gas- emissions. The guideline provides step by step recommendations adapted to easily being used on an operational basis.

Energy Efficiency Operational Indicator (EEOI)

The EEOI is developed by the International Maritime Organization with the ambition of providing a recommendatory guideline for monitoring the energy efficiency of a ship in operation. The expression of the EEOI is defined as the ratio of mass off CO_2 (M) emitted per unit of transport work (IMO, 2009).

French Decree

The French government has constituted a mandatory reporting on CO_2 emissions starting in 2013 (Ministère de l'écologie, du développement durable et de l'énergie, 2012). This requires transport service providers to inform service users of their carbon dioxide emissions. The French decree covers all transports, both passenger and freight, that start and/or end in France. The French decree prescribes mandatory reporting but leaves some flexibility, at least in the initial phase, to use other methods than recommended in the French decree. A methodological guide for transport service providers was drafted in 2012 under the leadership of ADEME and the French Ministry for Ecology, in consultation with OEET (French Environment and Energy Management Agency, 2014).

International Organisation for Standardization (ISO)

ISO has published more than 19 500 different international standards covering different aspects off business and technology (ISO, 2014). One of the most popular is the ISO 14000 family, which covers several aspects of environmental management and provide companies and organizations with practical tools to identify, control and mitigate their environmental impact. ISO 14001:2004 is providing a framework for environmental management systems and can be certified to. The ISO 14001:2004 certificate is an assurance to stakeholders, employees and company management that the company's environmental impact is being measured and improved.

3. METHODOLOGY

In this chapter, the methodology of the thesis is described. First, an introduction to the research approach chosen will be presented. This is followed by a brief case description of Volvo Cars' logistics transport network. The consecutive sections describe the mode of procedure for collecting empiric material by using literature studies and qualitative interviews. The section about qualitative interviews presents information about the interview guide, selection of respondents, how the interviews were conducted and analysed and finally the reliability of qualitative interviews is discussed.

3.1 Research approach

Research methodology is fundamental to systematically and logically conduct scientific research, and the research design has an important role for achieving this, and lays the basic conditions for fulfilling the purpose of the thesis. Hence, the methodology is a tool for problem solving and academically obtaining new reliable knowledge in a research field and the research approach is defined as the way of conscious scientific reasoning (Holme. Solvang, 1997).

The purpose of this thesis and the defined research questions are constructed to get a better understanding for emission calculations in different modes of transport based on operator specific values and default values, in order to create a recommendation for emission reporting within Volvo Cars logistic department. Hence, this research takes a cases study approach. Case study research focuses on understanding the dynamics present within single settings (Eisenhardt, 1989). Case studies investigate a contemporary phenomenon within real-life settings (Yin, 2003). The empirical data is collected by conducting qualitative interviews and literature studies simultaneously.

In logistics research, the positivistic deductive model of research approach is mostly used, even though there is a need of more inductive and abductive approaches in order to enhance the theory development (Kovacs, 2005). The deductive research approach works from a general law to a more specific perspective with conclusions followed from logically premises. The inductive research approach moves from specific observations to broader generalizations and theories, where the conclusions are based on premises (Kovacs, 2005). Abduction has a research approach that is combining and altering the deductive and inductive processes (Järvensivu & Törnroos, 2010). The abductive approach is focusing on particularities within specific situations which deviate from more general structures, and the abductive reasoning present plausible, not logically correct conclusions. The abductive research approach enables the researcher to interpret and examine things in a new perspective, and better distinguish the general from the particular, thereby, enhancing the understanding of a phenomena. In logistics research, it is common that theories are borrowed from other fields of science, making the abductive research approach suitable since it provides new ways of interpreting reality. The abductive approach as with the inductive research approach primarily lay the foundation of the theoretical framework and build up a comprehension and knowledge for the theoretical field. Subsequently, a theory matching process takes place, an iterative process which aims to match real life observations with existing literature, in order to understand new phenomenon or establish new theories. Finally, the abductive approach uses the deductive approach's way of creating hypothesis or propositions for the empirical process (Kovacs, 2005).

In this thesis the abductive research approach was considered most suitable, since both a practical reasoning and a scientific inquiry will be applied, with the aim to find the best general and plausible conclusions for the defined research questions.

3.2 Literature study

The theoretical framework was collected through literature search. To obtain credible and accurate information only well-known and trusted sources of information have been used. Sources of information that mainly have been used are databases from Chalmers library as well as different legal documents from the European Union, information sheets from the carriers and trusted Internet pages.

3.3 Case description

In this thesis, the study object was the logistics network of Volvo Cars. The logistic network composes inbound and outbound transportations. Inbound logistics are transports from the global suppliers to Volvo Cars automotive plants located in Göteborg (Sweden), Gent (Belgium) and Chengdu (China). Modes of transport utilised in inbound are rail, road, sea and air transports. The outbound logistics function is to ensure that factory complete cars are delivered to dealers all over the world. The modes of transport utilised for the outbound logistics are sea, road and rail transports. Transport carriers that are consigned for 80 % of the total transports in Volvo Cars supply chain were interviewed, to analyse the carriers' level of environmental awareness and to conclude which methodologies for emission reporting were most frequently used. A short description of each carrier is presented in the following section, due to confidentiality the different operators are kept anonymous. Hereafter, they are referred to in letters, from A to J.

Operator A, B, C, D, and E were interviewed within the road sector. For the sea sector, F, G, H were interviewed. The rail sector was represented by operator I. The air sector was not represented in the interviews due to its small share of Volvo's overall transports, however the transport mode was represented in the default values from Eco Transit and NTM.

Operator A, is a worldwide logistic provider in different modes of transport and encompasses three divisions, Express, Global Forwarding and Freight and Supply Chain. Volvo Cars is mainly contracting A for inbound land transports.

Operator B is a global company providing integrated logistic services in transport networks including land transports, sea- and air transports and storage concepts. Volvo Cars is mainly using operator B for inbound land transports.

Operator C is a global supplier of transport and provider of logistic solutions in three different areas, Road, Air & Sea and Solutions. Volvo Cars is mainly using operator C's road division in inbound logistics.

Operator D is a French logistic company specialized in cargo and vehicle logistics for road transports. Volvo Cars is mainly purchasing their cargo logistic services for inland road transports.

Company E is a Swiss company with offices in six different countries providing rail and road network logistic services. Volvo Cars purchase E's road network logistic services for inbound and outbound land transports.

Operator F owns two third of the new car market in Sweden. F drives the trailer truck shuttle between Volvo Torslanda (VCT) and Skandiahamnen and Älvsborgshamnen and locally in Gothenburg for Volvo Cars outbound logistics.

Operator G is utilised by Volvo Cars for deep-sea shipping in outbound, most frequently operated route is Gothenburg to USA.

Operator H is providing Volvo Cars with short-sea transport solutions for both inbound and outbound transports. The two most frequently utilised routes for Volvo Cars is Sweden - Denmark and Sweden – Poland.

Company I performs freight shipping by RoRo vessels on medium sea distances in both inbound and outbound logistics for Volvo Cars. The most frequently used routes are Gothenburg – Immingham and Gothenburg – Zeebrugge.

Operator J is a rail freight company. Volvo Cars uses J for transporting chassis from Olofström factory to the Gent factory. J is also used in outbound for transporting factory complete cars from Gothenburg to Luleå.

3.4 Interviews

Qualitative interviews were chosen to get in depth understanding of the methodology for measuring and reporting emissions with the carriers. With qualitative interviews it is not necessary to strictly follow the interview template, it rather promotes the respondent to be the one who controls the interview. Quantitative interviews had been better suited if the purpose of the thesis was for example to quantify frequencies of different scenarios with standardized questions. Qualitative interviews are characterized by giving a large amount of data with highly complex and detailed answers (Trost, 1997).

3.4.1 Selection of respondents

In a qualitative interview the selection of respondents is of great importance to get accurate and valid data (Holme, Solvang 1997). Therefore, the selection of finding the right respondent in each and one of the companies has been based on information from our supervisor at Volvo or someone from the purchasing department at Volvo Cars. An employee, responsible for supplier contacts, from Volvo Cars has established the first contact with the carriers explaining the aim of the interview. The respondents were chosen due to the amount of transports they are contracted for at Volvo Cars. All respondents have good knowledge of the companies' environmental policies and approach to emission calculations. In total, ten interviews were held. Out of ten interviews, six were held with road hauliers, three with shipping companies and one with a railway company.

3.4.2 Interview guide design

The interview guide utilised in the interviews has been designed with support from scientific literature and standards. The interview templates have had the same basic structure and almost the same questions were asked to all respondents with some exceptions for questions concerning different modes of transport. The questions were of open character to give as exhausting answers as possible and to have a flexible interview situation with the possibility of asking follow-up questions. The first questions have been of more open character in order to obtain a more relaxed interview situation. The basic structure of the interview templates used can be seen in appendix D in appendices.

3.4.3 Conducting the interviews

Before each interview an interview guide has been sent to all respondents. This action has been made to give the respondent a proper amount of time to prepare and find relevant and correct information for the questions, with the ambition of improving the accuracy level and validity of the answers.

The interviews were after approval from the respondent recorded and subsequently transcribed. Advantages of recording the interviews are that you can pay more attention to the respondent during the interview, instead of being occupied with taking notes. This will facilitate the interpretation of tone of voice and symbolic communication e.g. gestures which are as important as the spoken word for understanding. It promotes as well the possibility of asking follow-up questions and by listening to the recorded interviews you can learn from your mistakes and improve your interviewing skills. Disadvantages with recording the interviews are that it is very time consuming and there is a chance of focusing too much on details instead of understanding the general picture (Trost, 1997).

3.4.4 Data analysis

The transcribed material has been summarized and if the interview was held in Swedish, translated into English. The information from the carriers have been used to make accurate assumptions regarding fuel type, load factor, type of vehicle, fuel consumption and allocation method etcetera. The information have subsequently been used to make valid assumptions in each mode of transport and to distinguish if specific values from the carriers can be used or if default values from recognized databases are better suited. Default values if chosen, have derived from NTM and Eco Transit. NTM and Eco Transit have been chosen due to their recognition and reputation as trustworthy sources of information in the transport sector.

The interviews were subsequently summarised and analysed. Specific information from the interviews concerning data needed for emission calculations and default values from NTM and Eco Transit have been processed and adopted to the aim of the thesis and to fit in a written academic report. The processed values have subsequently been used as fundamental bricks in the development of a recommendation for calculating emissions from the Volvo Car Group’s inbound and outbound logistics.

3.4.5 Reliability

Advantages of a qualitative methodology are that it promotes a holistic approach, a deeper understanding for a scientific problem, a contextual view and more flexibility (Holme, Solvang, 1997). The disadvantages of qualitative methods are that the researchers’ pre-understanding and earlier preferences may affect the way the result was interpreted and analysed. Therefore precautions have been taken to reduce the subjectivity of the report by structuring the empirical data and methodology according to well-recognized standards and method databases with default values. Another factor that has reduced the amount of subjectivity is that the thesis is conducted in pairs meaning there has always been a dual perspective in the analysis.

4. RESULT

In this chapter, the results from the research questions are presented and analysed. Firstly, the most important findings from the interviews with Volvo Cars transport providers are presented, with the aim to explain their strategy for working with emission reporting and emission calculations. Extended versions of the interviews can be seen in appendix E in appendices. This is followed by a section that presents the obtained operator specific values concerning Volvo Cars transports, as well as processed default values from NTM and Eco Transit. In order to compare operator specific values with default values from NTM and Eco Transit, the different values obtained are used in the calculation of two transport chains. In the section that follows, future legislations affecting road and sea transports are presented. Finally, a recommendation for emission reporting is presented.

4.1 How do Volvo's transport providers calculate emissions?

What can be concluded from the interviews is that the environmental work being performed varies a lot between different transport operators. All companies have environmental goals but the standard and degree of explicitness is diverse. Some of the companies have goals that are more specific, measurable and followed up every year with a base year. Other companies have more indirect and diffuse goals where the reduction goal is more of a vision than actually a reduction target. The main method for reducing costs is being fuel-efficient and choosing the right type and quality of fuel. Having a low fuel consumption is important due to its direct influence on the costs. All of the respondents are continuously working to be as fuel efficient as possible. The most common way to calculate the emissions is by multiplying the fuel consumption with a specific emission factor. Most carriers have a Well-To-Wheel approach when calculating their emissions. The calculation methodologies mostly used are CEN and ISO. Other mentioned methods are EEOI, French Decree, GHG protocol, Eco Transit and NTM. Many of the transport companies have got their own emission calculating tools, in compliance with the CEN standard. In this way, the customer can make an estimation on the transport provider's website before purchasing the transport and also evaluate the environmental performance of the transport performed. The interviews have shown that most customers only request a number of the CO_2 value from their transports even though the carrier could provide emission numbers on other pollutants as well.

4.1.1 Road

The road sector is ahead of the other transport sectors when it comes to emission reporting. This is mainly due to stricter regulations concerning road traffic and that road transports are affecting humans in a more direct way. Road transports are well integrated in society and are seen everywhere making them more visible for the human eye. The lifespan of a truck is relatively short compared to ships and the regulation of Euro classes expedites the change of trucks in the fleet. Having the highest Euro class is a competitive advantage and customers most often demand the highest Euro classes for their consigned shipments.

Many drivers are responsible for reporting their fuel consumption to the head of transports at each company. All of the companies have chosen to focus on high impact changes. In almost every company eco driving is advocated as something important and by educating the drivers in eco driving the fuel consumption is expected to decrease. Most of the respondents have said that the fuel consumption and emissions are being calculated on a yearly basis, even though the information often is documented for each trip. Emission calculations are most often derived from fuel consumption, however, fuel consumption is most often classified information and identified as sensitive information for the transport companies. This makes it very difficult to get access to this information.

One difficulty for the truck companies is how to allocate each customer’s share of emissions from the transport activity’s total emissions. Especially since the cargo often is mixed and delivered to different locations along the way. Many truck carriers have gps-systems installed in their trucks containing information on distance, which can be used later on for documentation. If the trucks are owned by the company, it is easier to collect information about the total distance travelled even if the transport performed is a milk-run. The distance performed by subcontractors are harder to keep track of.

The complexity of allocating the emissions of a shared transport

Today, most transport companies do not use a standardised method for how to allocate the total emissions of a vehicle down into what each transport buyer is responsible of. Those companies that do calculate this, use the methodology promoted by CEN. The way a shared transport is being performed can differ a lot between companies and therefore different methodologies for allocating the emissions can be found. One scientist who has a view in this matter is Dr Raul Carlsson at the Victoria Institute (2014), who proposes the use of a milk-run allocation by looking at the costs. Carlsson (2014) suggests two different approaches in the matter. The first method consists of the use of a flat rate. Meaning that everyone pays an equal share, since all of the cargo owners utilise the existence of the total system. The logic of flat rate is that the cargo owners together share one single service.

The second approach involves focusing on each and one’s individual share. The individual share of the total emissions of the actual milk-run is based on the individual share of the total sum of the emissions if there were not combined in a milk-run. The logic of individual shares is that A) all benefit from the logistics provider's efficient milk-run system, but B) since they argue about who should pay the most, they should each take full individual cost share. The resulting allocation should then be multiplied with the share of the cargo load provided to the milk-run of each individual pickup/delivery, independent of distance. One may argue to also include a system of zones, similar to urban public transport systems, if necessary

4.1.2 Sea

Recently, the shipping business has undergone a lot of pressure from legal regulations concerning restrictions of permitted amounts of SO_x emissions. Because of this, many ship owners have felt the need to document their emissions and control the amount of SO_x being released from the fuel combustion. This has created a need for new technologies and fuel types. Many companies have made significant investments to be prepared for the new and stricter ECA-regulations (see chapter 4.7 for further information).

Most of the shipping companies are documenting estimations of their total emissions on a yearly basis. This is achieved by looking at the fuel consumption over the whole year. One problem for the shipping industry is how to deal with allocation of emissions, especially if it is a ferry with both passengers and freight on-board. In long-distance routes overseas, many variations can occur concerning positioning distances due to different weather conditions. It is easier to estimate the fuel usage when it is a frequent shipping route with the same vessel performing the journey every time, in comparison to routes where several different vessels are utilised each time. This makes it much harder to keep the information correct and updated.

Within shipping, one common way to evaluate the environmental impact from the industry is by letting an independent partner verify the ship and its effect on the environment. Some of the interviewed companies are members of the Clean Shipping Index (CSI). One company was a member at first but decided to leave since they experienced that they had a deeper knowledge and different methods compared to CSI.

4.1.3 Rail

The interviewed railway company uses Eco Transit and NTM for calculating the emissions. The respondent is describing that by using Eco Transit's online-tool it is possible to calculate the emissions for one trip and by dividing the number with the energy consumption and distance travelled the emission factor used by Eco Transit can be extracted. Calculating emissions from the company's own trains, for which the energy usage and distances are known, is easy. However, when it comes to subcontractors' trucks and trains in other countries –it gets a lot harder. As mentioned earlier, it is always easier to calculate the emissions caused by one's own vehicles than a subcontractor's vehicles.

The Swedish railway company only uses renewable energy from water power plants as source of electricity, thereby the most part of the emissions derive from the extraction of water power. In Europe a significant share of the electricity is produced from fossil fuels, for example by using coal power plants. There is also a difference between which diesel is used. In Sweden the diesel is low sulphur diesel MK 1, however, in the rest of Europe a thicker and dirtier diesel is being used. When it comes to emissions, railway customers are mainly interested in the CO_2 number of their transports but by knowing the energy consumption, other emissions could be calculated as well. This is not something being done within the company today; however, it could be done in the future if the customers demand it.

4.3 How accurate/reliable are these results?

In this section, a short description of the carriers' environmental work and emission calculations will be given to be able to evaluate the accuracy level of the operator specific values presented by the transport providers.

4.3.1 Road

Operator D

The operator calculates CO_2 emissions for every transported vehicle in accordance with the French decree. D's vehicle fleet consists of 2 % Euro 2, 20 % Euro 3, 27 % Euro 4 and 21 % Euro 5. Information on fuel and fuel consumption were not for disclosure.

Operator B

B has developed its own online emission calculator *Emission report* where Volvo Cars can obtain specific data for their share of transports. The Emission report delivers an approximation of the real emissions. The information on fuel consumption and emissions per vehicle class and vehicle size derives from NTM. Since 2013 the tool is in compliance with the CEN standard and the emissions are also defined in CO_{2e} and WTW. The tool categorizes the transports belonging to each customer into amount of shipments, total weight of cargo and transport work in tonne-km. The result displays total fuel consumption and CO_2 in TTW. Ever since the CEN standard was implemented the result also includes energy usage, CO_2, CO_{2e}, HC, NO_x, PM and SO_2 in WTW. This enables the customer to view their total emissions per month, year and route or for their top-ten most frequently utilised routes.

Operator A

More than 75 % of the company's European fleet of road vehicles complies with the Euro 4 standard or higher. The total CO_2 emissions of the company are being calculated and documented on a yearly basis to accomplish the agreed reduction goals. Information about fuel consumption are classified and not for disclosure. For information about CO_{2e} footprint and reporting Volvo Cars are directed to the local sales team. The local sales team were not contacted in this thesis. The company also offers an additional reporting product to its customers called the Carbon Dashboard. The web-based tool enables the customers to access statistics on the emissions generated by the transport of their freight. Based on these numbers, the customers can also consider scenarios for optimizing their carbon footprint.

Operator C

The operator has decided to use an average blend of 5 % biofuel in diesel used for all road vehicles in Europe when calculating the company's emissions, even though the percentage probably is a bit higher today. The average fuel consumption of the trucks is said to be 0,3054 l/km. This number derives from information collected yearly on average fuel consumption per distance from own and subcontractors' vehicles in Europe. According to C, empty transports are not included in the value of average fuel consumption. The average gross weight per trailer is 9845 kg. C's share of euro classes in their fleet are as follows: Euro 0-2: 3,61 %, Euro 3: 21,08 %, Euro 4: 20,08 %, Euro 5: 53,77 % and Euro 6: 1, 46 %. The numbers given are based on the total transports conducted by C during the first quarter in 2014.

Operator E

The company calculates its emissions from transports by multiplying an average value on fuel consumption with distance travelled multiplied with an emission factor. The calculations cover the total fleet and are also sometimes performed on customer level. Of the total fleet of road vehicles, 10 % are Euro 6, 80 % Euro 5, and the rest is below Euro 5. The average fuel consumption of the trucks was not given and the company has at the moment no possibility to calculate the emissions coming from transporting only Volvo Cars' goods.

Operator F

The company gather information on fuel consumption and distance travelled from the drivers. The information is stored in an Excel-file and an average value on fuel consumption is calculated. The average fuel consumption differs depending on if the transport is performed as a shuttle or not, therefore two values are given on fuel consumption. The average fuel consumption for a LTL is 0,462 l/km and the average fuel consumption for a shuttle transport is 0,595 l/km. The shuttle transport is more fuel consuming since it is conducted on urban roads and the traffic situation results in many stops. According to F, empty transports is assumed to have 0,5 litre less fuel consumption per kilometre. The fuel type used by F is MK 1 diesel from Statoil and Preem. For the shuttle transport all of the vehicles are Euro 5. In general the vehicle fleet consist of 27 % Euro 3, 23 % Euro 4 and 55 % Euro 5. The numbers given are based on transports conducted during the first quarter 2014.

4.3.2 Rail

Operator J

The operator is using emission factors from Eco Transit when calculating emissions from all of their trains, electric and diesel, these numbers are given in table 5. In general, Volvo Cars' transports are loaded in three 20 feet containers. Transports between Olofström-

Göteborg have approximately a payload of 19 tons/wagon and normally include 26 wagons totally dedicated for VCT. Transports between Göteborg-Olofström have a payload of approximately 8-9 tons per wagon and include 26 wagons totally dedicated for VCT. The route Olofström-Gent has approximately the payload 25 tons/wagon and include 18-20 wagons but is shared with the Volvo Group. The route Gent-Olofström has a payload of 8 tons per wagon and has in total 18-20 wagons shared with the Volvo Group. The transports between Luleå-Göteborg and Göteborg-Luleå have approximately a payload of 3-8 tons per wagon and Volvo Cars has in average 2-3 wagons per train.

4.3.3 Sea

Operator I

Volvo Cars transports are conducted in two RoRo vessels called Magnolia and Begonia. Magnolia is operating on the line Göteborg-Immingham and has an average fuel consumption of 70 tons per route. Begonia operates on the route Göteborg-Gent and has an average fuel consumption of 78 tons. The fuel consumption that has been given from Operator I is calculated by summarizing the total fuel consumed for one vessel during one year and is then divided with the amount of transports performed with the vessel that same year. Both routes are direct transports going in both directions with freight. The load factor varies in the different directions but due to confidentiality the load factor is unknown. The fuel used is HFO RMG 380 with sulphur max 1 0 % or 3,5 % depending on if the vessel is fitted with a scrubber or not. The operator recommends using www.sea-distances.org to extract distances.

At I, a passenger car is approximated to utilise 1,7 lane meters and a 16,5m truck 17,26 lane meters. Tor Begonia has a total freight capacity of 4650 lane meters and Tor Magnolia has a total freight capacity of 3831 lane meters. According to I, the big problem is to allocate the emissions for a vessel with mixed cargo, primarily a mixed cargo of passengers and freight. At the moment, the concept that is being discussed within the industry is to split the emissions according to the space allocated to each type of revenue earners. For instance passenger cabins, restaurants, public areas, shops, cinema etc. would be allocated to passengers and space on cargo decks allocated to freight. The uncertainty then becomes how to allocate the space used by the cars the passengers take with them.

For pure cargo ships the situation is a bit easier. For RoRo vessels it is basically space that is being sold (in contrast to weight for most ship types). RoRo ships have dedicated cargo lanes (normally 2.9 – 3,0 m wide) where one parks the rolling freight. Most freight take up full width of a lane e.g. a normal lorry once it is secured. Other cargo take up more or less width. A passenger car when shipped as pure cargo (as opposed to with passengers in it) will not take up a full lane, on the other hand the units used to ship goods for the paper industry – The SECU boxes – takes more than a lane. I therefore work with standard figures for various types of cargo and measure these in LM (Lane Meters). A trailer of 13 m length would occupy 13.6 LM (full lane width and a bit extra length space for securing). A passenger car is 1.7 LM as it is possible to park 4 cars side by side in 3 lanes, but the ferries also got “hanging decks” making it possible to divide a part of a deck in to 2 or 3 decks with lower height and then make more room for low height cargo like cars. Finally due to the construction of vessels some spaces in the cargo holds cannot be used for full height cargo but it is possible to place a passenger car in this space. It is all these factors that made I decide that a standard car occupies 1.7 LM or “normal” cargo space. This is however only applicable for I and will vary from ship to ship, but they have decided to work with one figure across their whole fleet.

Operator H

H documents the total fuel consumption for each ferry year by year. By dividing the total fuel consumption for one ferry with the amount of single trips made with that same ferry an average value on fuel consumption per voyage will be established. Average fuel consumption for the two ferries performing the distance Göteborg-Fredrikshavn is 7,9 tonnes fuel per voyage in 2013. The two ferries sailing between Karlskrona and Gdynia has an average fuel consumption of 29,13 tonnes fuel per voyage in 2013. Fuels used are Heavy Fuel Oil (HFO) and Marine Diesel Oil (MDO), both with maximum sulphur levels of 1 %. On the Denmark-route, HFO stands for 80 % of the total fuel consumption, the rest is MDO. On the Poland-route, HFO stands for 86 % of the total fuel consumption.

The basis for allocation between passengers and freight at H is the area method derived from the CEN standard. H has measured the square meters for passenger and freight area on all of the decks at one of their ferries, the plan is to do the same thing with the other ferries. The ferry which area has been measured is routing Göteborg to Fredrikshavn and the area for passengers have been estimated to be 9343 m^2 and the area for freight is estimated to be 4297 m^2. The area for freight is thereby 31 % of the total area. A semitrailer is approximated to use 17 m in length and 2,6 m in width resulting in a square meter of 44 m^2.

Operator G

G did not want to share any information on their fuel consumption, the only value given was in grams of CO_2 per tonne-kilometre. This value is 29,39 gCO_2/tkm for Volvo Cars. The emission factors used were gathered from the database of EEOI. Actual sulphur level for all fuel used in 2013 was 1,49 %, giving a SO_x emission of 5,2 kg per carried car in 2013. G did not give any information on the specific load factor for Volvo Cars transports due to confidentiality. The information provided was that the load factor for deep sea is uneven depending on an existing trade imbalance on the Atlantic. This is due to that more cargo travels east to west than vice versa. Therefore, the emissions from west to east needs to be based on a lower utilisation. G’s RoRo vessels are engaged in round trips all around the world. This affect the possibility of calculating positioning distances and makes it more or less impossible since the pre-positioning route may differ a lot from route to route.

G uses weight when allocating their total emissions to the cargo because that is how the company document and evaluate their cargo in other contexts as well, in weight of mass transported.

Accuracy level of operators specific values

The accuracy level of the obtained operator specific values varies, since the transparency in information sharing varies among the carriers. The obtained values varies depending on what methodology is being used as well as the assumptions made concerning empty trips, allocation of cargo, fuel used and to which extent they are willing to share information. Even if specific answers were asked concerning Volvo Cars’ share of transports the obtained information may not always be correspondent. The accuracy of the answers depends on the degree of environmental knowledge and to which extend sustainability work is prioritized within the interviewed company.

4.4 What default values from NTM and Eco Transit should be used?

In this section, default values from NTM and Eco Transit are presented. The default values have been processed and accommodated to be applicable in Volvo Cars transports. Firstly, the default values from NTM will be presented and subsequently the default values from Eco Transit. N.B, that the default values for rail transports are the same for NTM and Eco Transit due to cooperation between the two standards and equality concerning methodology and sources of data.

4.4.1 NTM

Road

For inbound road transports vehicle type Mega trailer (number 9 in NTM nomenclature) will be used as default value for all operators since this is the most common type of truck used for inbound transports at Volvo Cars. Specific parameters for mega trailer are shown in table 2.

Table 2: Default values of input parameters for Mega trailer from NTM

Type of vehicle	**Max Weight**	**Vehicle length**	**Load capacity Typical values, inner dimensions**					**Fuel consumption [l/km]**					
								Motorway		Rural		Urban	
	[tonne]	[m]	[tonne]	pallets	[m]	[m3]	TEU	LCU %		LCU %		LCU %	
								0	100	0	100	0	100
Megatrailer (nr9)	40-50	16,5	33	33	13.6	110	2	0,246	0,445	0,251	0,495	0,317	0,634

For outbound road transports vehicle type HGV Truck + semitrailer (nr 8) and HGV lorry/ truck + trailer or semitrailer on dolly (nr 10) will be used as default values for all operators in outbound road transports. The specific parameters for each and one of them are seen in table 3. These two types of trucks were chosen on recommendation from one of the operators involved in outbound road transports for Volvo.

Table 3: Default values of input parameters for HGV Tractor + semitrailer and HGV truck + trailer from NTM

Type of vehicle	**Max Weight**	**Vehicle length**	**Load capacity Typical values, inner dimensions**					**Fuel consumption [l/km]**					
								Motorway		Rural		Urban	
	[tonne]	[m]	[tonne]	pallets	[m]	[m3]	TEU	LCU %		LCU %		LCU %	
								0	100	0	100	0	100
HGV Tractor + semitrailer (nr8)	28-40	16,5	26	33	13,6	92	2	0,23	0,36	0,23	0,40	0,29	0,54
HGV Truck + trailer (nr10)	50-60	24 -25,25	40	51	7,7 + 13,6	140	3	0,28	0,54	0,33	0,61	0,37	0,78

Sea

In NTM, no data on fuel consumption were listed for RoRo vessels and ferries. This is due to the large number of different vessels operating, all with different characteristics affecting fuel consumption making them incomparable. To be able to calculate the emissions from sea transports in the second transport flow, data from example two in NTM (2008a) is used. The information is presented in table 4 below.

Table 4: Fuel consumption and emission factors for a RoRo ferry, deriving from main engine

Vessel type	**Fuel consumption**	**CO_2**	**NO_x**	**SO_x**	**PM**
	[kg/km]	[kg/tonne fuel]			
RoRo ferry	70	3179	76	54	1,8

Air

Default values for air freights are deriving from NTM and include two types, Boeing 757-200 SF and Airbus 310-300 F and their specific parameters can be seen in table 5. The values are based on the fuel Jet A1.

Table 5: Illustrates default values for two air freights

Aircraft	**Max Payload**	**Load factor (weight)**	**Max Distance**	**CO_2**		**NOx**	
				CF	VEF	CF	VEF
	[kg]	[%]	[km]	[kg]	[kg/km]	[kg]	[kg/km]
B 757-200 SF	27 215	50	7051	4431	15,2	26,4	0,05
		75	6712	4744	15,2	29,7	0,05
		100	5184	5073	15,3	33,3	0,05
A 310-300 F	40 500	50	9137	5628	20,7	49,5	0,09
		75	9563	6159	18,3	55,2	0,07
		100	7955	7033	18,0	65,2	0,07

To calculate the fuel consumption, the amount of CO_2 in kilogram should be divided with 3,16 kg/kg which is the amount of fossil CO_2 in Jet A-1 fuel. Thereby the amount of SO_x emissions can be calculated based on the sulphur content in Jet A-1 which is 0,025 % (%-weight) or by using the emission factor for SO_x 0,50 g/kg.

Rail

Default values of energy and fuel consumption were extracted from NTM and are seen in table 6. To simplify the result, only the most commonly used train size was looked at. The average train size was also verified by J as the most commonly used.

Table 6: Default values of energy and fuel consumption for electrical train (A) and diesel train (B) from NTM.

Train type	**Train gross weight** [tonne]	**Cargo type**	**CCU** (incl. empty trips)	**Flat terrain**	**Hilly terrain**	**Mountainous terrain**
Electrical train						
Average train	1000	Bulk Average Volume Shuttle	60 % 50 % 40 % 50 %	17 kWh/km	21 kWh/km	26 kWh/km
Diesel train						
Average train	1000	Bulk Average Volume Shuttle	60 % 50 % 40 % 50 %	4,65 l/km	5,82 l/km	6,98 l/m

The calculated energy/emission value per gross tonne kilometre has to be divided by the capacity utilisation in order to calculate the emission per net-tonne kilometre. For electricity train, the data presented for capacity utilisation and electricity demand can be combined in order to present the kWh consumed per net-tonne x kilometre (NTMrail).

Table 7. Definition of standard railway wagon in Eco Transit

No of axles	**Empty weight [tonnes]**	**Payload capacity [tonnes]**	**Max. axle load [tonnes]**
4	23	61	21
			(Source: NTM)

The limiting factor for payload capacity of a freight train is the axle load limit of a railroad relationship between payload and total weight of the wagon (Eco Transit). Table 7 illustrate a definition of a standard railway wagon.

4.4.2 Eco transit

Road

In Eco Transit five different types of trucks were presented, from which the trucks of 24-40 and 40-60 tonnes weight were chosen as default values. These two sizes of trucks were chosen since they best correlated with the chosen HGV from NTM. Parameters describing the load and weight capacity of the tuck were only given for the 24-40 tonnes truck and smaller ones in Eco Transit. The fuel consumption is given for different load factors. Parameters of a truck driving on a motorway in a hilly country, are seen in table 8.

Table 8: Default values of input parameters for 24-20 and 40-60 tonnes trucks from Eco Transit

Truck type	**Empty Weight (tonnes)**	**Payload capacity (tonnes)**	**TEU Capacity (TEU)**	**Max. Total Weight (tonnes)**	**Fuel consumption l/ 100 km**		
					Full 100 %	*Average 50 %*	*Empty 0 %*
24-40 tonnes	14	26	2	40 (44)	37,1	30,2	22,7
40-60 tonnes	-	-	-	-	52,3	40,4	27,1

To obtain the fuel consumption for different road types or gradients (flat, mountainous) the fuel consumption should be multiplied with the resistance factor given for that specific road type and gradient, these can be seen in table 9.

Table 9: Resistance factors to be multiplied with energy consumption depending on different traffic conditions related to street category and gradient

Different categories of resistance	**Resistance factors**
Resistance of street categories	
Motorway (category 0)	1,0
Highway (category 1)	1,3
Big city street (category 2)	2,4
City street (category 3)	3,5
Small city street (category 4-6)	5,0
Resistance for gradient	
Hilly countries	1,0
Flat countries	0,95
Mountainous countries	1,05

Sea

Ferries and RoRo vessels are treated as extensions of the road network in Eco Transit. The assumption is that the whole truck is put on a ferry and could be seen as a virtual road. The resistance for ferry routes are divided into three different groups; preferred with resistance 1,0, standard with resistance 5,0, and avoid with resistance 100,0. Preferred meaning preference to choose ferry over land-route, standard meaning ferry chosen if shortest route and avoid meaning aiming to avoid ferries. The resistance factor for each situation should be multiplied with the energy consumption (l/km) that is given for trucks. However, due to ambiguities of interpreting the suggested approach above, another default value has been chosen. Eco Transit suggests that the fuel consumption for an average HGV 24-40 t on a ferry is 38 g per ton kilometre.

Air

In Eco Transit the dedicated air freighters Boeing 737-200C, Boeing 767-300F and Boeing 747-400F were chosen as default aircrafts and their specific values can be seen in table 10. The aircrafts are categorized in short haul aircrafts which can fly distances up to 1000 km, medium haul aircrafts which can fly distances between 1000 km and up to 3700 km and long haul aircrafts which can fly distances over 3700 km. The design range is defined as the maximum range when the whole structural payload is utilised.

Table 10: Default values for the dedicated air freighter B 737-200C, B 767-300F and B 747-400F

Type	Distance Group	Type of aircraft	Aircraft code	Design range (km)	Max payload (tonnes)
Freighter	Short haul	Boeing 737-200C	B732F	2,240	17,3
Freighter	Medium haul	Boeing 767-300 F	B763F	6,025	53,7
Freighter	Long haul	Boeing 747-400F	B744F	8,230	112,6

The fuel consumption for the different aircrafts selected is seen in table 11 and is depending on the flight distance.

Table 11: The fuel consumption in kilograms depending on flight distances, for the selected air freighters

Distance (km)	Boeing 737-200C (kg)	Boeing 767-300F (kg)	Boeing 747-400F (kg)
232	1,800	3,030	6,331
926	3,727	6,485	13,405
1,852	6,191	10,845	22,097
3,704	11,438	20,087	40,267
5,556	n/a	29,909	59,577
7,408	n/a	40,631	80,789
9,260	n/a	52.208	103,611
11,112	n/a	64,501	128,171
12,964	n/a	n/a	155,563
13,890	n/a	n/a	169,088

4.6 What are the differences between operator specific values and default values?

In this section, a comparison between data deriving from transport operators, NTM and Eco Transit is presented, by calculating emissions of two different transport activities. A more detailed description of the calculations can be found in appendix C in appendices.

Fuel consumption and emissions of two possible transports performed by Volvo Cars are calculated to analyse the difference in result when using three different methodologies. GHG emissions, SO_x, NO_x and PM pollutants for two transport flows are being calculated three times. The first time, the fuel consumption is based on obtained data from carriers, the second time the fuel consumption derives from NTM default values and the third time fuel consumption is extracted from Eco Transit default values. Subsequently, the results are being compared and analysed. The emission factors are presented in appendices A and B.

4.6.1 Example 1 -Outbound transport

The outbound transport activity is a road transport performed as a milk-run from Volvo Cars Torslanda (VCT) to three Volvo dealers in the Jönköping area, see figure 2. The distance from VCT to Ulricehamn is the longest. In Ulricehamn the truck offloads a part of the cargo and continues to Jönköping and Nässjö where the rest of the cargo is offloaded.

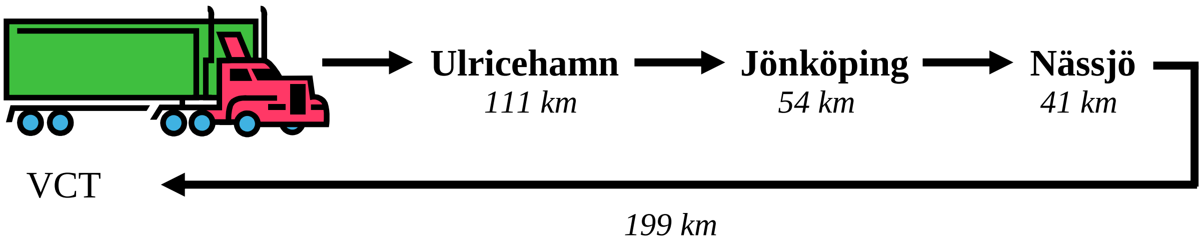

Figure 2: Actual trip performed by a truck transporting finished cars to Volvo dealers in Ulricehamn, Jönköping and Nässjö by a combined milk-run. Distances were derived from Google Maps (www.google.se/maps)

When calculating the milk-run in accordance with NTM methodology, the distance from VCT to each dealer is extracted, added and multiplied with the fuel consumption, see figure 3. The load factor is 50 % throughout the whole milk-run according to the milk-run approach defined by NTM. The fuel used is a diesel/bio-diesel blend 95/5 and the maximum load capacity of the truck is nine cars based on Operator F's average. The truck is assumed to be a Euro 4, since 70 % of F's fleet of vehicles are Euro 4 or higher. The presented information remains valid for the calculation of all three examples.

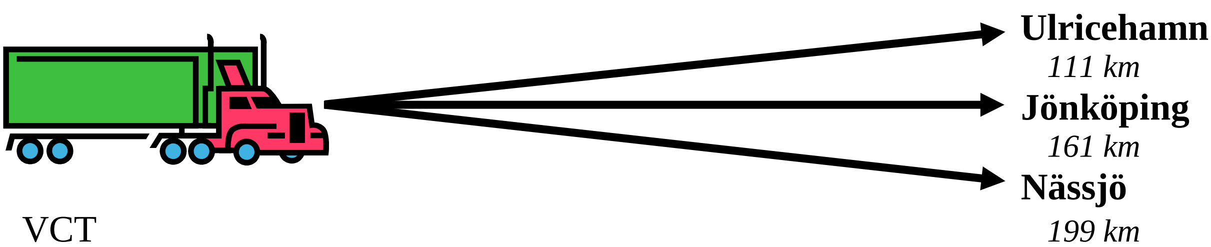

Figure 3: How the milk-run is being calculated in accordance with NTM methodology. Distances were derived from Google Maps (www.google.se/maps)

Emission factors for a 40-60 tonnes truck (nr9 & 10 in NTM) are taken from NTM and differ depending on road type. For NOx is an average value of 15,2 g/l used for all road types and for PM is an average value of 0,085 g/l used for all road types. The emission factors for diesel/bio-diesel blend 95/5 from the CEN standard are for g_w = 3,170 kg/l and for g_t = 2,54 kg/l.

Fuel consumption

Operator specific value -Operator F

The average fuel consumption is according to Operator F 0,462 l/km, hence the fuel consumption for the whole milk-run is 217,6 litres.

Default value -NTM

The fuel consumption for a 50-60 tonnes truck (nr10 in NTM) with 50 % LCU is extracted from NTM by the use of interpolation (see appendix C). The fuel consumption differ depending on road type; motorway gives 0,411 l/km, rural roads 0,471 l/km and urban roads 0,576 l/km. Since the transport is performed in Sweden, the Swedish national statistics for road activity will be used, providing a distribution of different road types as follows; motorway 21%, rural roads 56,7 % and urban roads 22,3 % (NTM, 2010). The result will be a fuel consumption of 226,93 litres for the milk-run.

Default value -Eco Transit

According to Eco Transit, the fuel consumption for a 40-60 tonnes truck with LCU 50 % driven in a hilly country on a motorway is 0,404 l/km. Sweden is a flat country, thereby is the fuel consumption assumed to be 5 % lower according to Eco Transit. The resistance factors for different types of roads from Eco Transit have been used in combination with national statistics for distribution of road activity in Sweden. Eco Transit's definition 'highway' is assumed to correspond with NTM's 'rural road' and 'big city street' was assumed to correspond with NTM's urban road. The resistance factor is according to Eco Transit 1 for motorways, 1.3 for highways, 2.4 for big city streets, 3.5 for city streets and 5.0 for small city streets. The final fuel consumption for the milk-run according to Eco Transit is due to previous mentioned factors 267,95 litres for the milk-run.

Example 1 -Summary

The operator specific fuel consumption for this milk-run shows a result of 217,6 litres. The fuel consumption for a milk-run based on default values from NTM is 226,93 litres.
The calculated fuel consumption for a milk-run based on Eco Transit values is 267,95 litres.
The total calculated GHG emissions, SO_x, NO_x and PM can be seen in table 12.

The result from this transport activity indicates that the operator specific calculated value is the lowest while Eco Transit has the highest calculated value. There are many possible reasons for this. One could be that the national statistics for different road types is not valid in this example, explaining why the total fuel consumption for the operator specific value is lower than the operator specific values. Another influencing factor on the result, is that the fuel consumption provided from the operators is an average value where empty transports/ positioning trips have been handled differently.

The use of a 50% overall load factor for milk-runs may provide a margin of error on the calculated total fuel consumption, since this is a simplified model that does not take into account variations in the load factor. Table 12 presents the emissions of the outbound transport for the three calculated examples.

Table 12: Fuel consumption and emissions of the outbound transport for the three calculated examples

Values	FC [litres]	CO_2e TTW [kg]	CO_2e WTW [kg]	CO_2 [kg]	SO_x [g]	NO_x [g]	PM [g]
Operator specific							
Total	217,60	552,70	689,79	569,02	1,81	1893,12	22,20
NTM							
Total	226,93	576,40	719,37	593,42	1,88	1974,29	23,15
Eco Transit							
Total	267,95	680,59	849,40	700,69	2,22	2331,17	27,33

4.6.2 Example 2 -Inbound transport

This inbound transport service is composed of three legs with starting point, Volvo Cars Torslanda (VCT) and ending point, Volvo Cars Gent (VCG). The example consisted of an intermodal transport by road, sea, and road again, see figure 4.

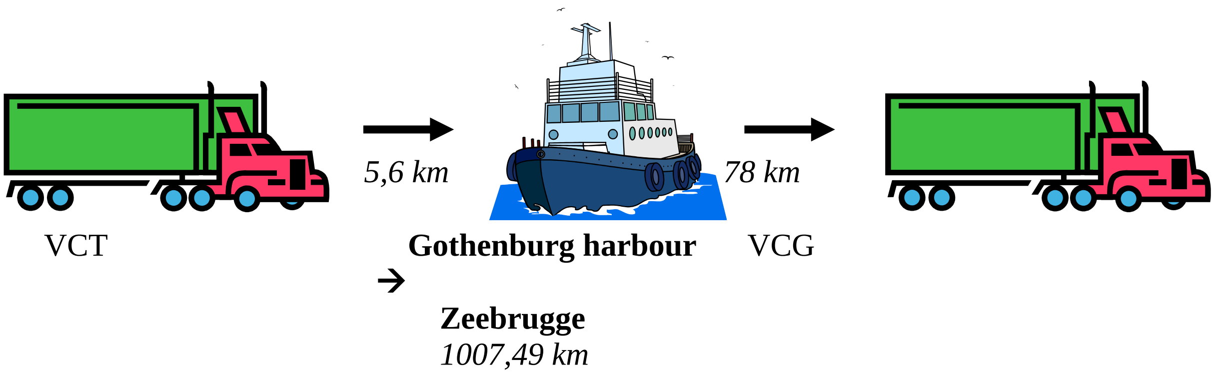

Figure 4: Transport modes and distances for a transport in inbound from VCT to VCG. Distances were derived from Google Maps (www.google.se/maps) and Sea-distances.org (www.sea-distances.org)

The first leg is performed by truck and is a shuttle transport between VCT and Port of Gothenburg. The transport is performed by Operator C with a mega trailer and the positioning distance is presumed to be 100 % of the travelled distance. The second leg is a ferry transport with Operator I from Port of Gothenburg to Zeebrugge (Eurobridge). No empty trip is included for the ferry route since the ship transports cargo in both directions, while the load factor is considered to be quite equal. The load factor of the ship is presumed to be 50 %. To get the emissions that each trailer is responsible for, the ships' total emissions are allocated by using the information on maximum load capacity given by Operator I. According to Operator I, a truck equals 13,6 lane meters and the total payload capacity for the ship is 4650 lane meters, which results in following allocation factor; $\frac{13,6}{4650/2} = 0,006$.

The third leg is a road transport between Zeebrugge and VCG. The positioning distance is presumed to be 100 % of the travelled distance. Operator C's vehicle fleet consists of 53,77 %

Euro 5, therefore, this road transport is assumed to be conducted with a Euro 5 vehicle. The fuel used by C is diesel/bio-diesel blend 95/5.

Estimations of distances are based on google maps and sea-distances.org. The distances are as follows:

1. VCT à Gothenburg harbour 5,6 km
2. Gothenburg à Zeebrugge 544 na = 1007,49 km
3. Zeebrugge à VCG 78 km

The emission factors are dependent on which fuel that is being used for each transport leg. The fuel consumption for each leg is multiplied with emission factors from both CEN and NTM. From CEN the TTW and WTW CO_2 equivalents were extracted for each leg. The emission factors from NTM were CO_2, SO_x, NO_x and PM. Thereafter, the total emissions of CO_{2e} TTW and WTW, CO_2, SO_x, NO_x and PM ware calculated for each leg by multiplying the fuel consumption for each leg with the distance travelled. The emission factors for diesel/bio-diesel blend 95/5 from the CEN standard are for g_w = 3,170 kg/l and for g_t = 2,54 kg/l. The emission factors for heavy fuel oil are g_{w2} = 3,31 kg/l and g_{t2} = 3,05 kg/l.

Fuel Consumption

Operator specific value -Operator C

Leg 1.

The average fuel consumption for this transport is 0,3054 l/km according to Operator C. The average fuel consumption is multiplied with the distance travelled to be able to obtain the fuel consumption for the whole distance.

Leg 2.

Average fuel consumption for this route is estimated to be 78 tonnes/route by Operator I. Firstly, the fuel consumption and total emissions for the whole ferry is being calculated. Thereafter the values are multiplied with the allocation factor described earlier to be able to calculate the emissions that the transported truck is responsible for. By knowing the density of the fuel, the unit describing the fuel consumption is changed from tonnes into litres. Fuel density for heavy fuel oil is according to Operator C 0.970 kg/l.

Leg 3.

Since this transport is performed by truck it can be assumed that Operator C handles this transport too. Average fuel consumption from Operator C is 0.3054 l/km.

Default value -NTM

The fuel consumption for each leg is extracted from NTM by knowing what type of vehicle that is utilised in the transport.

Leg 1.

This transport is performed by a mega trailer, Euro class 5, and with gross tonne weight 40-50 tonnes. Based on these parameters the fuel consumption is extracted from NTM. This transport is mostly performed in city traffic thereby using the fuel consumption for urban roads. According to NTM fuel consumption for a mega trailer with LCU 60 % on urban roads is 0,5072 l/km.

Leg 2.
This transport is performed by a RoRo ferry with proximally 10 tonne lorry cargo. According to NTM the fuel consumption for the ferry is 70 kg/km.

Leg 3.
Same assumptions were made as in *leg 1*.

Default value -Eco Transit

Eco Transit's background report provides information on fuel consumption for a number of vehicles depending on transport mode and vehicle type. First of all the fuel consumption for each leg is extracted, subsequently the fuel consumption is multiplied with the corresponding emission factor.

Leg 1
This transport is performed by a 40-60 tonnes truck, with Euro class 5 engine, and 60 % load factor including positioning. Since the truck is driving in a flat country (Sweden) the fuel consumption is 5 % lower than in hilly countries. Driving on big city streets gives a resistance factor of 2,4. The fuel consumption for 100 % load factor is 1,19 l/km and for 0 % load factor 0,617 l/km. 60 % load factor gives the fuel consumption 0,9605 l/km.

Leg 2
The specific energy consumption for a truck 24-40 tons, on a ferry is 38 g per ton kilometre. The total weight of the RoRo ferry is assumed to be 2800 tons, based on the assumption from the example from NTM. The density for heavy fuel oil is 0,970 kg/l.

Leg 3
The transport is assumed to be performed by a Euro 5 mega trailer, 40-50 tonnes truck, with 60 % load factor including positioning. The truck is driving in Belgium which is a hilly country, on big city streets which gives the resistance 2,4. The fuel consumption is 1,255 l/km for a 100 % load factor and 0,650 l/km for a 0 % load factor. This results in a fuel consumption of 1,013 l/km for a 60 % load factor.

Example 2 -Summary

The operator specific total fuel consumption for this transport is 274,86 litres. The fuel consumption estimated by NTM resulted in 522,12 litres. The fuel consumption from Eco Transit shows a result of 746,24 litres. The total calculated GHG emissions, SO_x, NO_x and PM per mega trailer for each leg and in total can be seen in table 13.

The calculated result shows that the result based on NTM default values has the lowest amount of emissions in comparison to operator specific values and default values from Eco Transit. A similarity with the result in example 1 is that the values from Eco Transit are higher than the other two values. In example 2 the numbers from Eco Transit are almost twice as big as the operator specific and NTM values. The difference in amount of emissions emitted is largest in leg 2, which involved a sea transport. Sea transports are more difficult to calculate and more assumptions regarding allocations of emissions and cargo have to be made in order to obtain a result. This could be factors affecting the calculated result. The operator specific value provides the lowest amount of emissions in the road transports in leg 1 and leg 3. As mentioned in example 1, this might be due to that only an average value were obtained from the carrier as well as the road types assumed to calculate the fuel consumption from default values may be inaccurate.

Table 13: Calculated emissions for example 2 in kilograms per truck, where leg 1 is by truck, leg 2 by RoRo vessel and leg 3 by truck

Values	FC [per truck] [l]	CO_2e TTW [kg]	CO_2e WTW [kg]	CO_2 [kg]	SO_x [kg]	NO_x [kg]	PM [kg]
Operator specific							
Leg 1.	2,65	6,731	8,40	6,93	0,00002	0,023	0,00027
Leg 2.	482,47	1471,55	1596,99	1487,77	25,27	35,57	0,84
Leg 3.	37,00	93,980	117,290	96,755	0,0003	0,322	0,0038
Total	**522,12**	**1572,26**	**1722,68**	**1591,46**	**25,27**	**35,92**	**0,844**
NTM							
Leg 1.	2,84	7,214	9,003	7,427	0,00002	0,0247	0,00029
Leg 2.	436,23	1330,50	1443,92	1345,17	22,85	32,16	0,76
Leg 3	39,56	100,482	125,405	103,450	0,0003	0,344	0,0040
Total	**478,63**	**1438,20**	**1578,33**	**1456,05**	**22,85**	**32,53**	**0,764**
Eco Transit							
Leg 1	5,38	13,665	17,06	14,069	0,00004	0,047	0,00055
Leg 2	661,86	2018,66	2190,74	2040,92	34,67	48,79	1,16
Leg 3	79,00	200,660	250,430	206,585	0,0007	0,687	0,0081
Total	**746,24**	**2232,99**	**2458,23**	**2261,57**	**34,67**	**49,52**	**1,174**

4.6.3 How do the results differ?

In this section the main differences of the result is analysed, depending on if the emission data derives from operator specific values or default values from NTM and Eco Transit.

The default values presented in Eco Transit are higher than NTM in general, much because of the influence on the result that Eco Transit's unique way of handling diverse road types, gradients and resistance factors. By handling the sea transports as extensions to the road network a rough estimation is made. This way of calculating emissions from sea transports is quite difficult to interpret and to use in a correct manner. This needs to be taken into consideration when comparing the three different ways of calculating emissions. NTM does neither have default values on energy consumption for sea transports. Only a few examples are given on fuel consumption for different ferry types in NTM. Most likely this is due to the large variation when it comes to fuel consumption depending on what type of ferry is utilised.

The operator specific values generate the lowest amount of emissions. This could be due to the fact that only average values for energy/fuel consumption were obtained. The load factor is in most cases unknown, generating a margin of error on the result. This margin of error's impact on the result, may vary from one transport activity to another and is therefore difficult to put a number or percentage on. Another margin of error, is that positioning trips were assumed to be included in the average fuel consumption, while positioning trips were calculated for default values. This could be one of many explanations to why the total emissions based on default values were higher.

Even though, the operator specific values were specifically asked to only reflect Volvo Cars' transports, it cannot be ruled out that the numbers given are average numbers for all transports conducted last quarter and not specifically reflecting Volvo Cars share of transports.

4.7 Which future legislations will have the highest impact on emission regulations and cost, in road and sea transports?

Sea

The sea sector is regulated by the International Maritime Organisation (IMO). In 2008, IMO presented a new agreement regulating sulphur content in marine fuels which is the revised annex VI to MARPOL 73/78. SECA had the following timeline presented:

- January 2015- the SECA limit of sulphur in marine fuels should be reduced to 0,1 %.

- January 2020: The global limit will be reduced to 0,5 %. This will be revised in 2018 to see if it is achievable otherwise IMO has the authority of postponing the implementation.

- January 2025: Global limit is set to 0,5 % but will depend on the review of the SECA timeline regulation in 2018.

To be in compliance with the new regulations different technologies or new fuels can be utilised. The ones that are mostly discussed as possible alternatives to meet the new regulations are Low Sulphur Fuel oil (0,1 %), installation of exhaust gas treatment systems on the vessels, or converting or building new ships powered by Liquid Natural Gas (LNG). The best option among low sulphur fuel oil is using Marine Gas Oil (MGO) with a maximum of 0,1 % sulphur content. This alternative would generate higher fuel costs, as much as 40-60% higher prices than of HFO fuel. Today, there is also a limiting refining capacity, meaning that there would not be enough fuel to fulfil the market demands. The option provided with installation of Exhaust gas Treatment is scrubbers. Scrubbers lower the sulphur content of HFO fuel by extracting sulphur from the exhaust gas. Scrubbers are expensive and complicated to install and will demand 1-3 % higher fuel consumption. There is also a problem with the waste disposal. The use of LNG and a LNG-powered engine is a very environmentally friendly method, however the exhaust gases from LNG consist of a high level of methane, which is one of the greenhouse gases. More negative issues concerning this alternative are that this fuel type demands other temperatures and other types of engines. It demands larger space, thereby decreasing the freight capacity of ships. Moreover, the bunker facilities in the ports are limited and the price of fuel is unknown.

The SECA regulations will have a deep impact on the shipping industry. In order to be in compliance with the new regulations the shipping companies need to make big investments. This will also have effects on the price tariffs in freight transports.

For NO_x applies the TIER I-III engine standards valid for new engines in 2016 in emission control areas (ECA). The TIER III NO_x standard will give a 80% reduction of NO_x compared to TIER I. Actions made to be in compliance with TIER III engine standard could be the use of selective catalytic reduction technology, exhaust gas recirculation, and water injection strategies (pdf eca). The global emission standards are Tier II for new engines with a 20 % NO_x reduction starting in January 2011. Tier I will be valid for existing engines which demand a 15-20 % NO_x reduction from current uncontrolled levels. This is will be achieved after the renewal survey which is done approximately every fifth year.

The European Commission wants to take a global approach to reduce the emissions from international shipping. As a step in cutting the emissions, the European Commission propose that, starting from the year 2018, the owners to all big ships using EU ports should report their emissions on an annually basis (European Commission, 2014).

Road

European Commission has set targets for greenhouse gas emissions and the use of renewable energy. The next coming years focus will be on meeting 2020 years targets. The Europe 2020 Strategy sets the objective to create 20 % of energy consumption from renewable energy sources and increasing energy efficiency by 20 % by 2020. The greenhouse gas emissions within EU are expected to decrease by 24 % in 2020 compared to 2012 years numbers. The share of renewable energy is predicted to continue rising and by 2020 the amount should end up 21 % higher compared to 2012 (European Commission, 2014).

The government of Sweden has set up a goal to be fossil independent by the year 2030. In 2050 the goal is to have a sustainable and resource-efficient energy supply with no net emissions of greenhouse gases in the atmosphere. A special investigator has been engaged to identify possible courses of action and to identify measures to reduce the emissions and dependence on fossil fuels in line with the vision for 2050. Measures may relate to all the relevant aspects that are important for achieving the strategic priority for 2030 and vision for 2050 within the transport sector. This may include providing energy to the vehicle fleet and investment in infrastructure, vehicles and different types of traffic.

The starting point should be that sustainable renewable fuels and electricity need to increase their shares in the transport sector, while vehicle efficiency must be improved and greenhouse gas emissions reduced (Sveriges regering, 2014-04-02).

4.8 Recommendation to Volvo Cars

The guideline for emission reporting at Volvo Cars should preferably be based on operator specific values since that would provide the highest accuracy level as these values are specifically adapted to the logistic strategy of Volvo Cars. However, the environmental work in the interviewed companies is quite diverse, due to different maturity levels, willingness to share information and investments in sustainability work.

Based on the knowledge and processed information in this thesis and the state of environmental awareness in the logistic department within Volvo Cars, the recommendation for each mode of transport is as follows;

In road transport, the recommendation is to use NTM default values on fuel consumption. The reason for this is that NTM values are based on processed information from reliable sources and that NTM is a well-established and recognized network in the freight transport sector. Furthermore, the methodology is based on multiple parameters which are explained logically and in a detailed manner.

In sea transports, the recommendation is to use operator specific values on fuel consumption, with the ambition of improving the accuracy level of these values as well as their underlying assumptions continuously. The reason for choosing operator specific values and not default values, is due to the great divergence of vessel design, which affect the fuel consumption substantially. Allocation of cargo should be based on the area or mass method, in compliance with the CEN-methodology. For distances, the recommendation is to use sea-distances.org when no distance is known and to use a 2 % detour factor for distances in deep-sea shipping.

In air transports, it is recommended to use the default values on fuel consumption from NTM, due to the NTM's user-friendly and comprehendible methodology. The distance travelled in GCD should be measured according to the CEN-methodology (GCD + 95 km).

In rail transports, the recommendation is to use default values deriving from Eco Transit on fuel- and energy consumption. These values should be used together with the obtained operator specific values to acquire the highest accuracy.

Emission factors
For reporting greenhouse gases the recommendation is to follow the CEN standard. For SO_x, NO_x and PM the recommendation is to use NTM emission factors. The ambition should be to improve the accuracy level and update the values each year.

5. DISCUSSION AND CONCLUSION

In this chapter, a discussion based on the result and the analysis is presented in relation to the stated purpose and the defined research questions of this thesis. Finally, a conclusion based on the research questions will be presented.

5.1 Discussion

"Calculating emissions from transports can be one of the simplest thing in the world but also the most difficult", as one of the respondents stated during an interview. Nothing could be more correct, after gaining knowledge about this matter.

One factor influencing the accuracy level of the result is the obtained information's degree of accuracy. Can the information from the carriers be trusted? Are they providing Volvo Cars with joy figures or are the numbers really true? How have these numbers been produced, for the whole fleet or specifically for vehicles utilised for Volvo Cars' goods? There might be a difference concerning what is said to be done and what is actually being done. What can be noticed, is the various result in fuel consumption coming from different transport suppliers. Through an environmental perspective, low numbers on fuel consumption is a positive thing. However, through the eye of the customer a low fuel consumption at the carrier can lead to questions concerning the price levels of the freight transports. Being fuel efficient is the best way of saving money for the companies. Due to competitive reason, the information concerning fuel usage might be sensitive and hard to get by for a third part. Especially, since the tariff for freight is to a great extent based on the fuel cost. If the prices are much higher compared to the fuel costs transport buyers might protest, making fuel consumption and efficiency the only way to compete.

There are many parameters affecting the amount of emissions. These parameters have different influence on the result and some may be more important to handle than others. The accuracy level of the result varies depending on if it is the carrier who performs the calculations or the transport buyer. A transport buyer has access to less detailed information compared to the carrier and it would demand a great amount of time to gather all the information needed. Some of the information may not even have any effects on the final result. A common standard would prevent this since all companies would use the same calculation methods and have the same logic behind their data and results.

The default values from NTM and Eco Transit are only valuable if they are used and interpreted correctly. Their method documents explaining the logic behind the default values are quite rigid and contain plenty of information to process, making it very time consuming to fully adapt its content. This could lead to misinterpretations. However, these methods have many parameters covered which enables the user to adopt the information to each transport activity with high flexibility. Furthermore, the default values used need to be controlled continuously to be up to date, which demands the user to implement a routine for keeping the numbers up to date.

The complexity of emission calculating derives from all the assumptions that need to be made and the lack of a common standard for the freight transport sector. The Odette guideline has made an attempt to provide a recommendation for which standards to use within the automotive industry. The response has been poor, even though the report is easily applicable on an operational basis, the automotive industry is not yet mature enough to be able to use the guideline and adopt the methodologies given. The automotive industry needs to better understand their own transport chains before being able to take in and compare different methods. First and foremost, Volvo Cars needs to establish a strategy and management for mapping, handling and reporting emissions from their subcontractors. As a third part logistic provider, it can be difficult to obtain all the data necessary for calculating emissions. This could possibly be due to subcontractor confidentiality but also due to lack of data because of low priority of the subject and sometimes lack of knowledge. This creates a relation of dependence between transport buyers and sellers. To get as accurate data and information as possible, co-operating becomes crucially important. Since every company is dealing with the same environmental issues, a common standard should exist. Co-operation would save time for all parties but also make sure that the same methods are being used so the numbers can be compared. For the future, the best way to go would be to use a common business system and enter partnerships with the suppliers in order to share specific information about fuel consumption, emission factors and load factors.

The most efficient and perhaps fairest way to reduce the emissions deriving from transports is the enforcement of laws. The shifting environmental work being done at the transport companies could be interpreted as an important reason to why legislation is so important. SECA enforces the shipping industry to become greener and IMO has forced the shipping industry to take their responsibility and lower the levels of sulphur. In the short perspective this law enforcement might lead to an increase of road transports in the ECA area. But in the long run, it might enforce stricter regulations concerning all modes of transport. Our opinion is that the regulations within the ECA area should be enlarged and be applied in all areas of the sea. As it is now, as soon as the vessel leaves the ECA area, fuel with higher levels of sulphur is being used. The environmental benefits from SECA diminishes and the holistic aspect is lost. This is what the international community needs to prioritize.

5.2 Conclusion

This thesis shows that emission reporting is a complex issue, demanding a great deal of time and knowledge. In order to receive as accurate information as possible, it is essential to have good relations with the contracted transporters, promoting transparency in emission reporting. The purpose of this thesis has been fulfilled, by establishing a recommendation for emission reporting at Volvo Cars. This will contribute to an increased environmental awareness in logistic decision making, contributing to the overall corporate sustainability work within the Volvo Car Group.

The recommendation for Volvo Cars is to continue the process of emission reporting, by improving existing operator values through increased co-operation with the carriers and Volvo Cars should demand them to share more specific values. If the supplier does not share this information Volvo Cars should consider discontinue the agreement with the specific operator. Volvo Cars is the paying customer and thereby has the right of demanding this. Further, it is important in a strongly competitive business as the automotive to have suppliers who are in line with their environmental work, enhancing and strengthen their CSR work. To create credibility and fully live up to the core values and the profiling as a sustainable car manufacturer it is essential that Volvo Cars uses the information in decision making and really make an effort to reduce their environmental impact. For example by choosing railway whenever possible, especially in Sweden were the electricity generated is deriving from renewable energy sources.

Future work

To improve the accuracy of the result further research should be executed in the different modes of transport. A Bachelor thesis has a limited amount of time to fully cover this matter of subject, if more time was given a more accurate and detailed comparison could have been accomplished. If more transport activities had been investigated and calculated with the use of different default values, the result would have been more reliable and diverse.

In the future, the best way to conduct emission reporting is by using a commonly shared EDI-system. Then information would flow over the borders between business partners and a lot of time could be saved by decreasing the amount of time spent on data gathering. This would increase the accuracy level and the information of emissions emitted during each trip would allocate itself to the cargo carried. For the most exact values, measurement equipment should be positioned in the tailpipe of the vehicle. Hence, this is something for Volvo Cars to further investigate.

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8. APPENDICES

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Appendix A

Emission factors for greenhouse gas emissions from the CEN standard

	Density (d)	Energy factor				GREENHOUSE GAS emission factor			
		Tank-to-wheels (e_t)		Well-to-wheels (e_w)		Tank-to-wheels (g_t)		Well-to-wheels (g_w)	
Fuel type description	kg/l	MJ/kg	MJ/l	MJ/kg	MJ/l	kgCO_2e/kg	kgCO_2e/l	kgCO_2e/kg	kgCO_2e/l
Diesel/bio-diesel blend 95/5	0,835	42,8	35,7	52,7	44,0	3,04	2,54	3,80	3,17
Jet Kerosene (Jet A1 and Jet A)	0,800	44,1	35,3	52,5	42,0	3,18	2,54	3,88	3,10
Heavy Fuel Oil	0,970	40,5	39,3	44,1	42,7	3,15	3,05	3,41	3,31

Appendix B

Emission factors for different modes of transport deriving from NTM

Mode of transport	Fuel/ Engine mix	Density of fuel	CO_2		SO_x		NO_X	PM	CH_4
Air NTM	Jet A	0,8102 kg/l	2,6 kg/l	3,16 Kg/kg	0,41 g/l	0,50 g/kg	-	-	
SEA NTM									
General cargo	SSD-RO 60%, MSD-RO 38%, HSD-RO 2%		3179 kg/tonne		54 kg/tonne		81 kg/tonne	2,2 kg/tonne	
Container	SSD-RO 92%, MSD-RO 6%, Other 2%		3179 kg/tonne		54 kg/tonne		89 kg/tonne	1,7 kg/tonne	
RoRO cargo	SSD-RO 46%, MSD-RO 50%, HSD-RO 1%, ST-RO 2%		3179 kg/tonne		54 kg/tonne		76 kg/tonne	1,8 kg/tonne	
Passenger/ RoRo cargo	SSD-RO 3%, MSD-RO 71%, HSD-RO 10%, HSD_MGO 10%, other 6 %		3179 kg/tonne		46 kg/tonne		63 kg/tonne	2,1 kg/tonne	
RAIL NTM/Eco TransIT									
Diesel	Sweden		2637 kg/l		0		58 kg/l	1,5 kg/l	0
	Europe		2637 kg/l		0,58 kg/l		46 kg/l	1,2 kg/l	0,10kg/l
Electric	Sweden		0,00		0,00		0,00	0,00	
	Europe		0,41 kg/ kWh		1,21 g/kWh		0,69 g/kWh	0,29 g/kWh	
Road NTM	Diesel	Euro class	[g/l]						
28-40 ton									
Motorway		0	2615		0,00125		35,2	1,41	0,0313
		I	2615		0,00125		26,7	1,25	0,0338
		II	2615		0,00125		27,8	0,686	0,0212
		III	2615		0,00125		21,7	0,500	0,0183
		IV	2615		0,00125		14,8	0,079	0,00100
		V	2615		0,00125		8,35	0,079	0,00101
Rural		0	2615		0,0083		36,6	1,30	0,0332
		I	2615		0,0083		29,0	1,10	0,0367
		II	2615		0,0083		30,3	0,511	0,0238
		III	2615		0,0083		23,2	0,464	0,0202
		IV	2615		0,0083		15,3	0,083	0,00104
		V	2615		0,0083		8,74	0,083	0,00104
Urban		0	2615		0,0083		35,0	1,46	0,0430

		I	2615	0,0083	28,1	1,31	0,0453
		II	2615	0,0083	30,1	0,567	0,0300
		III	2615	0,0083	23,3	0,563	0,0254
		IV	2615	0,0083	15,2	0,108	0,00138
		V	2615	0,0083	8,76	0,107	0,00139
40- 60 tons							
Motorway		0	2615	0,0083	35,4	1,4	0,0299
		I	2615	0,0083	27,0	1,27	0,0334
		II	2615	0,0083	28,0	0,699	0,0206
		III	2615	0,0083	21,9	0,506	0,0179
		IV	2615	0,0083	15,0	0,077	0,00098
		V	2615	0,0083	8,40	0,077	0,00098
Rural		0	2615	0,0083	37,3	1,24	0,0283
		I	2615	0,0083	29,4	1,09	0,0332
		II	2615	0,0083	30,0	0,492	0,0212
		III	2615	0,0083	23,0	0,442	0,0177
		IV	2615	0,0083	15,4	0,074	0,00089
		V	2615	0,0083	8,61	0,074	0,00089
Urban		0	2615	0,0083	35,2	1,44	0,0409
		I	2615	0,0083	28,4	1,32	0,0442
		II	2615	0,0083	30,1	0,572	0,0289
		III	2615	0,0083	23,3	0,558	0,0244
		IV	2615	0,0083	15,2	0,103	0,00132
		V	2615	0,0083	8,70	0,102	0,00132

Appendix C

A comparison between operator specific values, NTM and Eco Transit by calculating emissions from two example distances. Emission factors for CO_{2e} TTW and CO_{2e} WTW were taken from the CEN standard. Emission factors for CO_2, SO_x, NO_x, and PM were taken from NTM.

Example 1.

The first transport example is a road transport from Volvo Cars Torslanda (VCT) to three Volvo dealers in the area around Jönköping. It is a Milk-run performed in outbound.

Operator F (Operator specific value on fuel consumption)

Average fuel consumption is according to Operator F 0,462 l/km.
Total fuel consumption for the milk-run: 0,462 × 471 km = *217,6 l*

NTM (Default value on fuel consumption)

Since the transport is performed in Sweden, the Swedish national statistics for road activity will be used, providing a distribution of different road types as follows; motorway 21%, rural roads 56,7 % and urban roads 22,3 % (NTM, 2010).

Calculating the total fuel consumption for the milk-run by the use of default values from NTM on fuel consumption:

(111 + 161 + 199) × (0,411 × 0,21 + 0,471 × 0,567 + 0,567 × 0,223) = 471 × (0,08631 + 0,267057 + 0,128448) = 471 km × 0,4818 = *226,93 l*

Eco Transit (Default value on fuel consumption)

According to Eco Transit, the fuel consumption for a 40-60 tonnes truck with LCU 50 % driven in a hilly country on a motorway is 0,404 l/km. Sweden is a flat country, thereby was the fuel consumption assumed to be 5 % lower according to Eco Transit. The resistance factors for different types of roads from Eco Transit have been used in combination with national statistics for distribution of road activity in Sweden. Eco Transit's definition 'highway' was assumed to correspond with NTM's 'rural road' and 'big city street' was assumed to correspond with NTM's urban road. The resistance factor is according to Eco Transit 1 for motorways, 1.3 for highways, 2.4 for Big City Streets, 3.5 for City Streets and 5.0 for Small City Streets.

The final fuel consumption for the milk-run according to Eco Transit is due to previous mentioned factors: *267,95 l.* The fuel consumption is calculated by multiplying the distance with fuel consumption per distance.

471 km × ((0,404 × 0,95 × 0,21 × 1) + (0,404 × 0,95 × 0,567 × 1,3) + (0,404 × 0,95 × 0,223 × 2,4)) = 471 × (0,080598 + 0,28289 + 0,2054) = 471 × 0,5689 = *267,95 l.*

Example 2.

This transport service is composed of three legs with starting point at Volvo Cars Torslanda and ending point in Volvo Cars Gent.

Estimations of distances are based on google maps and sea-distances.org. The distances are as follow:

1. VCT à Gothenburg harbour 5,6 km
2. Gothenburg à Zeebrugge 544 na = 1007,49 km
3. Zeebrugge à VCG 78 km

Operator C (Operator specific value on fuel consumption)

Leg 1.

The average fuel consumption for this transport is 0,3054 l/km according to Operator C. Average fuel consumption for an empty transport is 0,169 l/km.
Fuel consumption for leg 1: (0,3054 x 5,6) + (0,169 x 5,6) = 2,65 l

Leg 2.

Average fuel consumption for this route is estimated to be 78 tonnes/route by Operator I. One truck's part of the ferry's total fuel consumption is given by the following equation:
(78000/0,970) x 0,006 = 482,47 l

Leg 3.

Average fuel consumption for Operator C is 0,3054 l/km. This is a shuttle with 100 % positioning distance. Fuel consumption for leg 3: (0,3054 x 78) + (0,169 x 78) = 37 l

Result by using emission factors from CEN

CO_{2e} TTW = Leg 1 + Leg 2 + Leg 3 =
(2,65 x 2,54) + (78000/0,970 x 0,006 x 3,05) + (2,54 x 37) = 6,73 + 1471,55 + 93,98 = 1572,26 kg

CO_{2e} WTW = Leg 1 + Leg 2 + Leg 3 =
(2,65 x 3,17) + (78000/0,970 x 0,006 x 3,31) + (3,17 x 37) = 8,4 + 1596,99 + 117,29 = 1722,68 kg

Result by using emission factors from NTM

Leg 1.

Operator C has 53,77 % Euro 5 engines in their vehicle fleet. That is why only values for euro 5 engines will be used in the calculations.

CO_2: 2,615 kg/l
SO_x: 0,0000083 kg/l
NO_x: 0,0087 kg/l
PM: 0,000102 kg/l

Total emissions Leg 1:

CO_2: 2,615 x 2,84 = 7,4266 kg
SO_x: 0,0000083 x 2,84 = 0,0000236 kg
NO_x: 0,0087 x 2,84 = 0,0247 kg
PM: 0,000102 x 2,84 = 0,0002897 kg

Leg 2.
Total fuel consumption for leg 2 is 78 tonnes. The ferry chosen is a RoRo cargo ferry. Only the fuel consumption from the main engine will be considered.

CO_2: 3179 kg/tonne fuel
SO_x: 54 kg/tonne fuel
NO_x: 76 kg/tonne fuel
PM: 1,8 kg/tonne fuel

Total emissions Leg 2 (for the ferry):
CO_2: 3179 x 78 = 247962 kg
SO_x: 54 x 78 = 4212 kg
NO_x: 76 x 78 = 5928 kg
PM: 1,8 x 78 = 140,4 kg

Leg 3.
CO_2: 2,615 kg/l
SO_x: 0,0000083 kg/l
NO_x: 0,0087 kg/l
PM: 0,000102 kg/l

Total emissions Leg 3:
CO_2: 2,615 x 37 = 96,755 kg
SO_x: 0,0000083 x 37 = 0,0003071 kg
NO_x: 0,0087 x 37 = 0,3219 kg
PM: 0,000102 x 37 = 0,003774 kg

NTM (Default value on fuel consumption)

Leg 1.
Total fuel consumption for leg 1: 0,5072 x 5,6 = 2,84 l.

Leg 2.
Fuel consumption for leg 2: 70 x 1007,49 km = 70 524,3 kg = 70,524 tonnes

Leg 3.
Fuel consumption for leg 3: 0, 5072 x 78 = 39,56 l

Result by using emission factors from CEN
CO_{2e} TTW = Leg 1 + Leg 2 + Leg 3 =
(2,84 x 2,54) + (70524/0,970 x 0,006 x 3,05) + (2,54 x 39,56) = 7,214 + 1330,504 + 100,482
= 1438,2 kg
CO_{2e} WTW = Leg 1 + Leg 2 + Leg 3 =
(2,84 x 3,17) + (70524/0,970 x 0,006 x 3,31) + (3,17 x 39,56) = 9,003 + 1443,924 + 125,405
= 1578,3 kg

Result by using default value and emission factors from NTM

Leg 1.

Operator C has 53,77 % Euro 5 engines in their vehicle fleet. That is why only values for euro 5 engines will be in the calculations.

Total emissions Leg 1:

CO_2: 2,615 x 2, 84 = 7,4266 kg
SO_x: 0,0000083 x 2, 84 = 0,000023572 kg
NO_x: 0,0087 x 2, 84 = 0,024708
PM: 0,000102 x 2, 84 = 0,00028968 kg

Total emissions Leg 2 (for the ferry):

CO_2: 3179 x 70,524 = 224195,796 kg
SO_x: 54 x 70,524 = 3808,296 kg
NO_x: 76 x 70,524 = 5359,824 kg
PM: 1,8 x 70,524 = 126,9432 kg

Total emissions Leg 3:

CO_2: 2,615 x 39,56 = 103,449 kg
SO_x: 0,0000083 x 39,56 = 0,000328 kg
NO_x: 0,0087 x 39,56 = 0,344 kg
PM: 0,000102 x 39,56 = 0,004035 kg

Eco Transit (Default value on fuel consumption)

Total emissions Leg 1:

CO_{2e} TTW: 2,54 x 5,38 = 13,7 kg
CO_{2e} WTW: 3,17 x 5,38 = 17,1 kg
CO_2: 2,615 x 5,38 = 14,1 kg
SO_x: 0,0083 x 5,38 = 0,045 g
NO_x: 8,70 x 5,38 = 46,8 g
PM: 0,102 x 5,38 = 0,55 g

Leg 2

The specific energy consumption for ferries with average cargo (trucks 24-40 ts) is 38 g fuel/tonkm. The total weight of the RoRo ferry is assumed to be 2 800 tonnes. Distance is 1007,49 km. The total fuel consumption is 107 tonnes. To get the fuel consumption per truck, the total fuel consumption is multiplied with 0,006 (payload for one truck).

Total emissions Leg 2 (for the ferry):

CO_{2e} TTW: 107 000/0,970 x 3,05 = 336443,299 kg
CO_{2e} WTW: 107 000/0,970 x 3,31 = 365123,711 kg
CO_2: 3179 x 107 = 340153 kg
SO_x: 54 x 107 = 5778 kg
NO_x: 76 x 107 = 8132 kg
PM: 1,8 x 107 = 192,6 kg

Leg 3

It is assumed to be a mega trailer 40-50 tonnes truck Euro 5 with 60 % load factor including positioning. The truck is driving in a hilly country (Belgium) on big city streets (resistance 2,4).

The fuel consumption is for 100 % load 1,255 l/km and for 0 % load 0,650 l/km, which result in a fuel consumption of 1,013 l/km for 60 % load factor and distance 78 km. The fuel consumption is 79 l.

Total emissions Leg 3:
CO_{2e} TTW: 2,54 x 79 = 200,7kg
CO_{2e} WTW: 3,17 x 79 = 250,4 kg
CO_2: 2,615 x 79 = 206,6 kg
SO_x: 0,0083 x 79 = 0,66 g
NO_x: 8,70 x 79 = 687,3 g
PM: 0,102 x 79 = 8,06 g

Appendix D

Interview templates

Rail

How do you work with calculating the environmental impact of your shipments?

What is the environmental impact of electricity and diesel trains?
What percentage of energy consumption comes from renewable energy sources?

Do you have specific data on emissions for each train departure?
Do you have empty trips?

Which emissions are calculated and how are they being calculated?

Are you following any recognized standards e.g. ISO14000 and CEN?
Do you have data that shows the amount of fuel used?
Available data over distances and load size available?
Do you use any assumptions?
Are calculations on load based by weight or by volume?
The emission calculations are they based on actual figures from energy consumption and distance or are default values from databases (NTM) being used?

Are you using emission factors?

How do you manage of intermodal transport? Do you have cooperation with other carriers? How are the emission calculations for that?

How do you see the use of a common EDI system between haulage contractors that makes it possible to exchange information about fuel consumption and distance?

In the future which legislative changes do you see as your biggest challenge?

If you were asked to report on carbon emissions for Volvo in 2014, how would you proceed, what calculations would be performed and what would the accuracy of the result be? Is it possible for Volvo Cars to get their share of emissions from one transport?

Road

What is your environmental policy?
Is there a CO_2 reduction goal?

How do you calculate the emissions from transports? Which method would you prefer to use? Is the numbers produced annually or is emissions-data stored for every route?

What type of tracking and visibility systems do you have in your trucks?
- What are they measuring?
- Do you have an onboard detecting (OBD) system according to EURO IV?

Which emissions are being calculated today, and which calculation model is being used?
-Which variables are taken into account?
(Fuel consumption, weight, volume, load factor, distance etc.)?

-Are there any assumptions made?
-Is the cargo evaluated by weight or volume?
-Is emission factors used and where are they deriving from?

Is your system approach based on Tank To Wheel or Well To Wheel?

How do you measure the cargo load factor depending on the cargo carrier capacity of your freight?
What is the percentage of different EURO I-VI classes among your contracted road haulages?

How do you deal with allocations of cargo? Is it possible to calculate the amount of emissions every transport buyer is responsible for? Depending on:
-Part of the total cargo
- FTL or LTL
-Milk- runs.

How would you handle emissions allocating on intermodal transports?
How proactive are you in your organisation to act on future legal demands?
What is the biggest concern for your business regarding future environmental legislation?

If Volvo Cars would contact you regarding their share of emissions in total or by truck which numbers would you be able to extract and what would the accuracy level be?

Some more specific questions concerning Volvo Cars share of transports

The data received will be utilised in Volvo Cars own data base for calculating emissions coming from transports. According to the CEN standard the accuracy level of data can be categorized into four levels. The best accuracy level will be established if the numbers derive directly from the primary source instead of using default values. Hopefully you can provide us with this valuable information.

The parameters we are interested in are:

- Average fuel consumption (l/km)
- Fuel consumption (empty) (l/km)
- Fuel consumption (maximum weight)
- Average load factor
- Most common vehicle type
- Most common vehicle size and maximum cargo weight capacity
- Type of fuel
- Sulphur content of fuel
- Energy content of fuel

Sea
What is your environmental policy of the company?
Does your company have a CO_2reduction goal?
- If there is a goal, what is the target figure?

Which emissions are you calculating?
- Which methodology is being used?
- What accuracy level do the calculations have?
- Which ambition is expressed by the company?

Do you have specific data of emissions from each route?
- Or the fuel consumed?
- Cost of the fuel consumed?
- Distance travelled or size of the cargo?

Which emissions do you calculate today, or which emissions would you like being able to calculate in the future?
- Which variables are taken into account?
- Are there any assumptions made?
- Is the cargo evaluated by weight or volume?
- Is emission factors used?
- Where do the numbers that are being used derive from?

Is the calculations based on actual measured fuel usage and distance traveled or do they derive from a standard/database? In case of a standard/database, which one?

Is calculations based on Tank To Wheel or Well To Wheel?

Which demands do you make on the quality of the fuel used?

How would you say is the best way to calculate emissions from a carrier that transports both passengers and goods? How could the emissions be allocated to each cargo?

Is it possible to calculate the amount of emissions every transport buyer is responsible for?

Have you heard of Clean Shipping Index? Are you a member?

Do you have a tracing system for the cargo transported and would it be possible to also document the emissions? Would you be willing to share this information to transport buyers?

About the future, which upcoming legislation do you see as your biggest concern?

If you were to report the total amount of emissions from transports coming from Volvo Cars, how would you proceed? What accuracy level would the calculations have? Would the result differ depending on how fully loaded the carrier is?

Appendix E

Summary of interviews

Operator G

G is a logistic provider in shipping with Roll On Roll Off (RoRo) vessels of pure car /trucks carrier type. Volvo cars mainly uses G for outbound logistics by deep-sea shipping, mostly to USA from Gothenburg.

To be an environmental leader in the industry is one of the company's objectives and the absolute core of their business. G has a five principle framework. First of all they focus on high impact changes, secondly they want to be accountable and transparent, third is believing in exceeding their responsibilities, the fourth framework is that they want to invest in future technologies and the fifth and last one is to cultivate partnership with stakeholders to develop sustainable solutions. As a company G looks to be proactive rather than reactive and that is for example why a scrubber has been installed in one of their vessels on trial. There has not been any results yet, except that it is a complicated and expensive method. The company's CO_2 reduction goal is not linked to the volume, instead a relative CO_2 number is calculated for the total emissions. The methodology is based on a voyage data system which records actual distance sailed on voyages longer than four days. It also stores data on amount of cargo on the voyage and the time sailed. G also possess information on how much fuel that is inside a vessel in the beginning of the year and in the end of it. In between that, they have information on the amount of fuel purchased. Shipping along with aviation are the two industries that are going to have the biggest challenge decoupling from fossil fuel, because of the distance involved and the amount of power needed. Fossil fuel is going to be the only available option for a long time to come.

The proportion of fuel based costs has increased by 60 % over the latest number of years. Consequently, there is a strong commercial incentive to stay fuel efficient. Low sulphur fuel, with a fleet average of 1.5 %, has been used since 2003, first ECA was in 2007. It took financial commitment and gave the company a competitive advantage. Greenhouse gas reporting has existed since 2009. Det Norske Veritas AS has conducted a limited assurance third-party verification of the direct greenhouse gas emissions and the grams CO_2 per tonne km from G's ocean transportation in 2012. This was when G still were a member of CSI and the verification process was part of the deal with CSI.

When it comes to emission reporting G now uses the Clean Cargo working group's tools, although they are less general than other tools, it enables comparison with other containerships when used in the right way. Clean Cargo working group is a global business-to-business initiative made up of leading cargo carriers and their customers dedicated to environmental performance improvement in marine container transport through measurement, evaluation, and reporting (http://www.bsr.org/en/our-work/working-groups/clean-cargo, 2014-05-10). G will be ready for the new SECA rules in 2015, mostly by using diesel. This will not be an option in 2025 since there is not enough diesel on the market. Most of the new vessels will have scrubbers as well. Because of Californian law, G already have experience in switching the fuel in different areas. However it can take up to 3 days before all the fuel is shifted and only low sulphur diesel is being combusted. The procedure is also technically complicated due to the difference in temperature when operating the fuels. Heavy fuels must be heated to the right viscosity to burn and lighter fuels may not need to be heated.

G follows the Energy Efficiency Operational Index (EEOI) calculation methodology from IMO and the cargo is evaluated by weight. Emission factors used are also from IMO and the emission calculations are based on a Well-To-Wheel approach. G used to be a member of Clean Shipping Index (CSI) but has now withdrawn the membership due to difference of opinion. The CSI is a business to business tool for cargo owners to select clean ships and quality ship operators. G retreated the cooperation because according to G it is a one way reporting and CSI's only finding was that G should burn more low sulphur fuel which they already focused on (http://www.cleanshippingindex.com/, 2014-05-10).

Enforcement of regulation is the driving force for change. Enforcement level of ECA in Europe is a great start, however if you get caught the legal consequences are almost none existing. In the US, vessels get detained and you get high fees. Sulphur regulation has a cost, 12 000 dollars per day, per vessel, with the change to diesel.

Operator H (Short Sea RoRo)

H is an international transport and travel service company with Europe's most comprehensive route network. H is one of the world's largest ferry operators. The two most frequently used ferry routes for Volvo Cars is going between Sweden - Denmark and Sweden – Polen. The ferries perform short sea shipping and are categorized as RoRo ferries, executing inbound logistic services for Volvo Cars.

The environmental policy of H tells that they should lower the bunker consumption for the whole fleet by 2 % each year. The fuel consumption is measured in tonne for each trip and the CO_2 is documented in gram per tonne kilometre. This goal was established in 2006 but H has failed to reach the goal the last couple of years. It will be decided next year if the 2 % goal should be documented per vessel instead. The calculation of CO_2 emissions is on a yearly basis based on grams per tonne kilometre. The problem is the effect of the load factor. In a few years, there will be a law enforcement by EU, constraining shipment owners to report their emissions, probably on a yearly basis. H is therefore waiting for a common standard to be established on how to perform emission calculations.

Today H uses Heavy Fuel Oil (HFO) most of all but this will stop next year. The HFO emission factor is 3.11 and for marine diesel (MDO) 3.2. The allocation method used is based on the CEN standard. At the moment, the cargo load is evaluated by area. As a member of CSI, H prefers to use the methodology recommended by CSI which is volume, but H is hoping that another allocation unit will be used in the future. In the CEN standard it is possible to choose allocation method based on area or weight, not volume. The emissions calculated at H are CO_2, sulphur dioxide (SO_x) and nitrogen oxide (NO_x). These values varies depending on ferry type and type of fuel used. The CO_2 calculations are based on fuel consumption and emission factors.

Some of the ferries have catalysts which lower the amount of SO_x to 0.2 %. NO_x is evaluated in percent of the total fuel consumption and the percentage varies between 0.4 % and 6 %. During each voyage information about the total cargo carried is gathered from the dispatch office and sent to the Environmental coordinator at H. Since H collects information about how many vehicles of each vehicle type that is carried on each route, it is possible to allocate the total emissions into emissions per vehicle. The estimations are made by knowing the area occupied by each vehicle type. At one of the company's ferries the total area has been measured and documented in square meters for each section of the ferry. The plan is to measure the area on remaining ferries as well. H is currently installing measurement equipment on all their ferries to be able to measure fuel consumption and CO_2 emissions on each trip. In the future Marine diesel will be used mostly but H is also testing the possibilities with Methanol which is now being tested on one of their ferries.

Operator I

Since 1866, I has been involved in domestic as well as international trade, transporting both freight and passengers. For Volvo Cars, the transport company performs freight shipping by RoRo vessels on short sea distances. The goods transported are both for inbound and outbound. The most frequently used routes for Volvo Cars are Gothenburg – Immingham and Gothenburg – Zeebrugge.

Operator I is a logistic provider with several modes of transport and emissions derive from ships, trucks, rail services, terminals and headquarters. Their emissions are mostly from shipping which constitute 92 % of I Group's yearly CO_2 emissions. That is why the shipping sector is their major environmental focus area. Emissions that are being calculated are first and foremost CO_2 and SO_x. I has as well numbers on their NO_x emissions but in the light of regulations these numbers are only relevant when building new ships. They do not measure the emissions on the ships, instead information about fuel consumption and engine type is used for calculations on CO_2, SO_x and NO_x. This is calculated for each vessel on a yearly basis. There is always an uncertainty with CO_2 emission calculations. According to new EU documents on Measurement, Reporting and Verification (MRV) there are four ways to calculate. One method is to look at how much fuel has been purchased and is pumped into the tank. The uncertainty of this method is that not all of the fuel that is pumped in reaches the engine, due to spillage and evaporation. The fuel purchased comes with a receipt where the amount of fuel is specified with three decimals. The ships are equipped with flow meters, that measure and take into account air pressure and temperature for example. It is hard to know where the fuel originally derives from, it comes in to Rotterdam from Middle East or Africa. However it comes with a certification on the quality of the fuel.

Because of the French legislation I are forced to have a system that comply with the French regulations. The French legislation advocate a Well-To-Wheel (WTW) approach. When a customer places an order at the website an estimation of the emitted CO_2 on that specific trip is given. The data is based on default values given in g CO_2 per tonne kilometre, which according to the French decree only will be allowed for the next following two years then actual numbers on CO_2 emissions per vehicle must be utilised. The emission factors used by I are derived from documents that the French government has created. One can argue how precise these numbers are but since the French legislation came up quite suddenly this is a good starting point, I says. Fuel consumption and distance travelled are measured on a daily basis. It is hard to allocate the part of emissions one specific cargo owner stand for.

At the moment the method I uses is dividing the amount of CO_2 released from one trip per year by the cargo owner's part of the freight compared to the total amount of cargo carried per year. This result in an average number of the load typically measured in land meter basis. The allocation method for a ferry with both passenger and freight is something that is being discussed right now. ISO standard 26258 has one approach. If it is a vessel with only freight, then the emissions can be allocated by land meter basis. For example a truck occupies 16, 5 meters of land. A car is smaller and slimmer so there must be another conversion factor for them. Since the weight, volume and form of the cargo varies a lot it gets harder to allocate the freight then for example if the cargo carried only was coal. There is no good solution to this problem yet. It is even harder with RoRo ships carrying both freight and passengers. For example if half of the area is used by passengers and half is for freight, then the emissions could be split fifty-fifty. But the issue is to decide which areas of the ferry belongs to the passengers and which areas belongs to the cargo. Definitions need to be determined.

I is a member of the CSI and have two ships verified by them. The two ships are those most often sailed from Gothenburg. For the future, I wishes to see a common standard set for the industry. I does not see any problems with the possibilities for a common EDI-system in the future and sharing environmental information with their customers. The most important for I is the advent of a common standard for shipping. New regulations are coming into force regularly and it costs a lot to obey these, there is not much money or time left to be long-sighted. I total CO_2 emissions of 2012 landed on just under 1.9 million tons.

For the trucks:
I uses mainly trucks from other companies but they also have own trucks in Gothenburg, Karlshamn, Gent and United Kingdom. They currently own about 250 trucks, and all of them fulfil at least the euro 5 emission standard. The emissions documented from trucks is the total amount released of the whole fleet in one year. There is a challenge with having most of the trucks owned by other companies, then the truck companies need to report their emissions to I on a yearly basis. To find out Volvo Cars share of the emissions is not possible today but will be in the future. It may take two years before a new system is fully developed. Most trucks today are equipped with telematic systems which automatically transfers information about the driver and the way of driving to the central. The drivers that drive most environmentally friendly are chosen to teach the other drivers in Eco driving.

Operator J
J is a national and international rail freight company. Volvo Cars uses J for transporting chassis from Olofström to the factories in Gent and Torslanda.

J is calculating emissions from the transports on the request from customers but also for their annual report. With the goods transported on railway it is easy because they know the amount of freight transported and the exact distance travelled, both for electrical and diesel trains. Then this is multiplied with an appropriate default value for emissions per energy unit. Earlier this was derived from NTM but this documentation is not published in the same way anymore so now they use default values from Eco TransIT instead. The numbers are extracted by going backwards in the methodology. The accuracy is as good as it gets, nobody has got measurement equipment in the tailpipe which would be the best way to get exact numbers.

J has specific data of all their traffic, however when it comes to transports by truck J asks the truck owner for data and the emission calculations are then based on actual numbers or estimations from the driver. The accuracy level is thereby lower in comparison with trains. Less than 5 % of the total transport work is performed by truck. The best thing is to know the distance travelled and the cargo capacity but if there is no information the numbers will be based on estimations. When calculating rail transports within Sweden it is easy since J has their own trains. It is more difficult to calculate the emissions for customers with transports outside of Sweden, it is possible but the accuracy level will be lower. J might know the starting point and point of finish but not the exact distance in between, it would be too much of a hustle to ask the foreign train companies about details like that. Customers are mostly interested in their CO_2 number and less interested in other emissions. But if you have the transport work it is possible to calculate the other emissions too by multiplying with a factor. There is a big difference in amount of emissions coming from diesel and electric train. For electric trains, most of the emissions derive from the extraction of water power which is the only energy source used by J in Sweden. The MKS diesel used for diesel trains in Sweden has the same low-sulphur diesel as used for trucks. The company does not have data on specific emissions coming from each departure, however it is possible to calculate by standard formulas per ton kilometre. To be able to obtain numbers for each departure it would demand an electricity meter on board the train.

The energy spent on empty transports is already taken into consideration in the calculations since the load factor is looked at for the entire system. When the emissions is calculated for one route back and forth, a certain factor for empty transportation is allocated to the result. J are certified according to ISO 14001. When allocating the emissions to each cargo owner the allocation method is based on weight. In special cases where the cargo is bulky, a bulk factor is used. The difference between different trains is not that big, biggest difference is between an electrical train and a diesel train. In the future it should be possible to separate the older electrical trains from the new, but right now they are calculated as the same. The energy consumption contains a mixture of both. If distance and cargo is known, calculating the emissions specifically related to Volvo Cars would be possible. A common EDI-system will not be manageable right now, because no packages are transported. J carries freight that is heavy and large for long distances.

Operator F

F distribute vehicles, mainly cars, in a quick, safe, cost-efficient and environmental friendly way in Denmark and Sweden. F owns two third of the new car market in Sweden. F drive the trailer truck shuttle between Volvo Torslanda (VCT) and Skandiahamnen and Älvsborgshamnen and locally in Gothenburg for Volvo Cars. From Skandiahamnen they also drive cars from the factory in Gent to Torslanda. The trailers have a 100 % load capacity utilisation (LCU) for harbour transports but are mostly running empty on the return trips which is thereby lowering the LCU and are mostly Full Transport Load for Volvo Cars. However on the rest of the transports they need to coordinate with other car producers, or else it will not be profitable. The transport from harbour to Torslanda takes 15 min and discharging and loading takes about the double. The amount of diesel consumed differs a lot depending on truck and trailer.

The company has indirect environmental goals, last year the goal was that 70 % of the trucks should be Euro class 4 or above. In the end F reached 67 % but with 10 new Euro class 5 engines the goal will be reached this year. F is documenting the fuel consumption per driven kilometre. Their vehicle fleet consist of 23 % Euro class 4, 43 % Euro class 5 and 44 % Euro Class 3. F is certified by ISO 14000. The trucks did have an onboard computer system but the system had accuracy issues. Distance and fuel consumption are two known factors that are possible to find out. The distance is determined by GPS, the drivers nowadays are always taking the shortest way somewhere because of the time pressure. 46, 3 litres per 100 km in average fuel consumption. The fuel consumption for each truck is looked at. Drivers are reporting fuel consumption manually, last year the rate was 100 % on reporting. The numbers on fuel consumption and distance travelled are saved in excel. That is where the emission calculations derive from.

The diesel is bought from Preem and Statoil and F is practicing a Well-To-Wheel approach. Customers like Scania and Volkswagen asks for their emissions on a yearly basis. To retrieve their emissions the total amount of emissions per year is divided by how many transports e.g. Scania stands for of all the transports. F has no transports in France and is thereby not affected by the new regulations from the French decree. When it comes to environmental issues it is important to focus on the major things that really matters. For example diesel consumption and the amount of new engines in the trucks, not how many tires that are worn-down. Most focus is on cutting down the fuel consumption, partly because of environmental reasons but also for economic reasons. F wants to be better than their competitors. To lower the fuel consumption, it is also important that the drivers practice eco driving. Concerning Milk-runs, the distance driven is always documented but it is a lot of work sorting out the data. Each car is scanned with a hand computer in the port. F does not have any foreign drivers, all the drivers speak Swedish. It is important to be able to communicate when reporting data to transport planners and suppliers. It has to be a fair market. That is not the situation today because of all the foreign road carriers.

<u>Operator C</u>

Operator C is a global supplier of transport and provider of logistic solutions in three different areas, Road, Air & Sea and Solutions. Volvo Cars is mainly using division Road for their inbound logistics.

The transport sector at C has the following environmental goals for 2014: Improve energy efficiency per transported net ton kilometre by 15 % (compared to 2010 years numbers) to 2015 and at least 60 % of their vehicles should have Euro 5 engines. C mainly uses large goods vehicles, larger than 25 tonnes in total weight, towing normally one cargo trailer for road transports in Europe. This also includes C's local distribution of goods in urban areas. All road transports are carried out from pick-up to delivery address (door to door) and 99 % of all transports are carried out by subcontractors. Since C settles costs with its subcontractors based on transport from door to door, C do not know the percentage of empty trips. If empty driven distance or repositioning is related to a road vehicle operation and is specifically included in an agreement with a customer values for this will be included in calculation of total fuel consumption, GHG emissions and energy consumption. C uses net tonne-km as the basis for allocation. Net tonne refers to the weight of the freight and do not include the weight of the container as with gross tonne. The majority of C's road shipments are palletized. Pallet weight is included indirectly in C's calculation basis, since energy consumption per tonne-km is calculated on the basis of the shipments net weight.

C collects information on average fuel consumption from own and subcontractor's vehicles in all European countries where C has activities. Since the mix of biofuel may differ in various EU countries C has decided for now to use an average blend of 5% biofuel in diesel used for all C road vehicles in Europe even though the percentage probably is a bit higher today. Distance is found via an own developed distance calculator tool that via Google Maps calculates the real distance that a vehicle has travelled via actual roads in Europe since C does not know the actual distance travelled by each subcontractor. Distance calculation is based on shortest possible distance between postal codes per shipment. C collects yearly information from own and subcontractors operating vehicles in Europe on their average fuel consumption per distance. In 2013 C collected this information from app. 10,400 vehicles all over Europe. An overall average from this information is calculated and used as a factor for calculating total fuel consumption, GHG emissions and energy consumption for road transports. All numbers on quantity of freight used in C's emission calculation originates from their internal transport system, Road Divisions Transport Management System. Information in Road Divisions Transport Management system on quantity of freight derives from customers booking details. This means that calculation of carbon emissions on road transports is performed on shipment level. LTL, part loads, groupage transports and Full truck loads are handled differently. For all types of transports the above mentioned average fuel consumption is used for calculating total fuel consumption, GHG emissions and energy consumption for road transports. Based on data from all transports registered in Road Divisions transport management system per year an average figure on weight of freight per trailer is used to calculate customer's part of the emission per transported shipment on LTL, part loads and/or groupage transports. When FTL transports are performed for customers and specific information on actual weight per FTL are available in Road Divisions transport management system this figure will be used as a factor for calculating fuel consumption, GHG emissions and energy consumption for road transports.

Operator D

D is a French logistic company specialized in cargo and vehicle logistics for road trnasports. Volvo Cars is mainly purchasing their cargo logistic services for inland road transports.

The Environmental goal for D concerning greenhouse gas emissions is to reduce their total GHG emissions by 50 percent until 2020. Through 2013 D has reduced their GHG emissions by 39 percent compared to the year 2006. Since D has transports in France they have implemented a tool for CO_2 emissions calculation in compliance with the French decree (Decree 2011-1336). CO_2 emissions coming from transports are calculated for every transported vehicle according to French legislation. Parameters taken into account are: the mode of transport, the energy consumption rate (per kilometre) by the mean of transport, the distance, the empty trips, the emission factor and the transported vehicle volume.

D intend to equip their trucks with an embarked data processing system. The system enables different features. For example the possibility to geotag trucks, follow driving times, get Eco driving information etc. Today, the emissions being calculated are GHG emissions. The volume transported is taken into account in the calculations. The trailers used are European road-trains with a maximum length of 18.75 meters. The percentage of different euro classes in their collection of vehicles are: Euro 2: 2 %, Euro 3: 20 %, Euro 4: 27 % and Euro 5: 21 %. On rail transport, D uses European emission factors. On intermodal transports, emissions are being calculated on every vehicle type used and then summarized to obtain the final amount. Concerning future legislations, D has a regulatory monitoring system which allows anticipation in changes. Their biggest concern lies in the eco tax on heavy trucks currently suspended by the government. Regarding calculating Volvo Cars' share of emissions, that would be possible for D to do in compliance with the French methodology regulation that they have implemented in their system.

Operator E

E Transport and Logistics is a Swiss company with offices in six different countries providing rail and road network logistic services. Volvo Cars purchase E's road network logistic services for inbound land transports.

The Company E Transport AG is based on economic principles, cost-conscious and performance-oriented. They invest in good technology and use efficient, environmentally friendly transport system. By continuous improvement processes according to ISO 14001 and the official CO_2 agreement EnAW (Swiss Federal Act on the reduction of emissions) the company wishes to increase their level of awareness and be able to comply with the legal demands. The emissions are calculated by taking the distance travelled in kilometres, then the fuel consumption is calculated with the help of average consumption. At last, the fuel consumption is multiplied with the value 2.61, a factor from Swiss Federal Act on the

Reduction of CO_2 Emissions. Inside their trucks is a telematics system which measure distance, fuel consumption, time, order data and if necessary temperature data etc. They also have an onboard detecting (OBD) Volvo-system in accordance to Euro 4.

E calculates the emissions coming from the total fleet but also on customer level. The variables taken into consideration are: distance travelled, fuel consumption, situational shipment number, weight, pallets, tonne, volume etc. No specific assumptions are being made. If the cargo should be evaluated based on volume or weight is very much situational. The interview person doesn't know if the company uses a Tank-To-Wheel or Well-To-Wheel approach. The trailers used by the company are mega, side curtains, frigo, box and plato. The percentage of different Euro classes in their fleet are: Euro 6: 10 %, Euro 5: 80 % and the rest 10 %. No allocation method is being used at the moment. They don't have any transports in France, except for Volvo Lyon, but that is not done in compliance with the French legislation. E is in legal compliance with ISO 9001 and ISO 14001, in addition to that they are also working with the authorities and associations to be up to date on legal demands. The biggest concern of theirs, regarding future legal demands, is reducing fuel consumption and further development on engines class 7 and up.

Operator A

A is a worldwide logistic provider in different modes of transport and encompasses three divisions Express, Global Forwarding & Freight and Supply Chain. Volvo Cars is mainly contracting A for inbound land transports.

Environmental Policy was formally approved by the Corporate Board in September 2010 and is the foundation of their environmental protection program, GoGreen. GoGreen aims to make logistics more sustainable and to minimize the impact on the environment. Improving the CO_2 efficiency of their operations is the main focus of the GoGreen program because the CO_2 emissions which the business generates from transporting, sorting and warehousing the customers' shipments make the most significant environmental impact. A was the first logistics company to set a concrete, measurable, voluntary goal for CO_2 emissions: The Group aims to improve its total carbon efficiency in its own business activities as well as those of its transportation subcontractors by 30 % by the year 2020 in comparison to 2007 levels.

The company calculate its total CO_2 emissions according to the internationally recognized GHG Protocol Corporate Standard and in accordance with the requirements of the European Emissions Trading System (EU ETS) and the ISO 14064 standards. The new GHG Protocol standards and the introduction of the CEN standard both expand the scope of carbon accounting to include upstream emissions of fuels. Both the GHG Protocol and the CEN standard expand the carbon accounting scope to include CO_2 equivalents. Therefore A also collects information on other greenhouse gases as well, such as methane and nitrous oxide. In addition to the emissions resulting from their own fuel combustion A also accounts for upstream emissions of fuels, i.e. those produced by their suppliers during fuel extraction, production and transport. The current reporting of scopes 1, 2 and scope 3 reporting categories "subcontracted transport services" and "business travel" account for 75 % of the company's total greenhouse gas emissions. Including the upstream fuel supply chain, the reporting covers 90 % of their total emissions. CO2e data is reported annually and stored in financial and reporting systems which can be used to generate a wide variety of reports. Some of the trucks have telematics systems. Unfortunately, statistics on this topic is not gathered and reported. Telematics systems report distance driven, driving times etc. Variables taken into account in emissions calculations are: Fuel consumption, weight, volume, load factor, distance, routing, type of vehicle and mode of transport etc. There are assumptions made concerning for example routings and fuel consumption by transportation subcontractors. The weight is evaluated by volume typically, sometimes by chargeable weight unless the shipment is very light for its volume. Emission factors are taken from approved official sources including World Resources Institute (WRI), the World Business Council for Sustainable Development (WBCSD) and the International Energy Agency (IEA).

A's carbon accounting system is based on Well-To-Wheel. For transportation subcontractors A uses industry averages from official sources e.g. IATA. The European vehicle fleet of the company is relatively young (average age of delivery vehicles is 3-5 years) and consists of more than 75 % Euro 4 standards or better. A follows recommended allocation methods in the CEN standard. The methodology used for intermodal transports is based on two steps. First breaking down the emissions by leg and then allocate the emissions according to the methods in the CEN standard.

The company says itself to be very proactive to act on future legal demands but fails to give an example on their biggest concern regarding future legislation. With reference to Volvo Cars' share of the emissions, A offer reports with various levels of detail depending on the customer's particular requirements. Air, Ocean and Road freight customers are offered an additional reporting product: the Carbon Dashboard. This is an especially user-friendly, web-based, version of the Carbon Report. With just a few mouse click, customers can access statistics on the carbon emissions generated by the transport of their freight. Based on these numbers, customers can also consider scenarios for optimizing their carbon footprint. The carbon emission calculations are based on fuel and electricity consumption data. This is combined with operations data. Then emission factors are added from WRI, WBCSD and IEA. The carbon reporting methodologies and calculation tools used in the Express and Air, Ocean and Road freight divisions have been verified by the Swiss-based Société Générale de Surveillance (SGS) since 2011. A were not able to provide specific values on Volvo Cars transports, instead this answer was given: For more detailed information on CO_2e footprint and reporting, please contact your A sales team in the first instance.

Operator B

B is a global company providing integrated logistic services in transport networks including land transports, sea- and air transports and storage concepts. Volvo Cars is mainly using B for inbound land transports.

B's environmental policy is to reduce their share of total CO_2 emissions in all mode of transports by 20 % in 2020 with base year 2006. Road transports have a reduction goal of 26 %, sea transports will cut their CO_2 emissions by 15 % and air freight by 25 %. The sea sector have already reached their goal of cutting their total CO_2 emissions by 15% so a new reduction goal has been set that will reduce their emissions by another 10 %.
For 2013 the Euro classes in the fleet of the contracted road carriers are; 30 % Euro 3, 20 % Euro 4, 48 % Euro 5 and the final 2 % are classified as Euro 2 and EEV.

The environmental policy of the Swedish division called Standard Operation Policy (SOP) is harmonized with the environmental policy of B. In Sweden the goal is to cut their total CO_2 emissions by 50%. The Swedish division was the initiator of the network KNEG in 2006. KNEG is a research project on climate-neutral road transport and consists of 15 members from different sectors and include for example fuel producers, universities and logistic service providers. The aim of KNEG is to halve the CO_2 emissions caused by road-based freight transports in Sweden compared to 2005 levels by 2020. The KNEG network is a good way of learning and sharing knowledge according to B.

In 1999 B introduced their own developed tool for calculating emissions called *Emission report.* From the beginning it functioned as an internal application from which emission reports could be calculated. In 2009 *Emission report* was introduced as a free of charge calculator for their customers. Emission report has been harmonized with the CEN standard since 2013.The logic in *Emission report* is derived from NTM but their emission factors are extracted from the CEN standard. To conduct accurate emission calculations *Emission report* needs some specific data, for example on how the transport has been produced including terminals, average load factor, amount of goods and the capacity of the vehicle. The distance travelled is measured with route logic, which defines distances with the help of postal zip codes. The weight of the package is determined either by actual weight or by bulky weight. The weight of the package determines as well which type of transport that will be used. Heavier packages will be distributed to the transport buyer straight away, while smaller packages will first be transported to the terminal in Bäckebol and subsequently distributed with a smaller truck.

B Sweden is collecting total fuel consumption from their contracted road carriers on a year basis. The road carriers specifies as well what type of fuel they are using. During 2013 16 % of the fuel used among contracted road carriers in Sweden is bio-diesel.
It is hard to find a way of approaching and finding an accurate level for allocation of transports. There are several factors affecting the calculations, for example was it a direct transport or a transport via terminals.

In Sweden B cannot differentiate between single or intermodal transports. This is due to that the contracted car carriers themselves chose if the freight trailer is put on railway or on road. In B's booking system these transports are classified as road transports but at the end of the year B Sweden is asking for the percentage of transports that are put on rail instead of road. This gives them an average percentage but not customer specific data on the amount of intermodal transports in Sweden.

In Europe, customers can buy intermodal transport solutions from B and then the emission calculations are based on that as well on a customer specific level. In order to deal with milk-runs B has chosen to use a load factor of 50 % and the distance is measured in Great Circle Distance. The 50 % load factor is the result from a study made from a German University on the behalf of B. B does not have any empty transports. Empty transports are avoided by in each route combining both distribution and collecting of goods.

B Sweden does not see any difficulties for them in handling the upcoming legislations neither on road transports nor on sea transports. B sees legislations as the best way of reducing emissions from transports since it is a neutral competitor.