Reducing CO2 Emission for Inbound Logistics

Redesigning inbound logistical operations for environmental sustainability – A case study from Volvo Group.
This exam work has been carried out at the School of Engineering in Jönköping in the subject area Production Systems with a specialization in production development and management. The work is a part of the Master of Science program.

The author takes full responsibility for opinions, conclusions and findings presented.

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Abstract

Global warming caused by increased concentration of greenhouse gases has opened many debates and discussions over the last three decades. As a result, governments and private organizations have finally stepped up to battle the issue. Under the Paris climate agreement all governments agreed to a long-term goal of keeping the increase of global average temperature to well below 2°C above preindustrial era levels. Currently, freight transport is responsible for 7% of CO2 emissions worldwide. If current trend continues CO2 emissions from global freight transport are set to increase fourfold. Governing bodies all over the world are putting pressure on manufacturers to decrease carbon footprint in their operations. Carbon taxes are going to be enforced in many countries and companies have to file sustainability reports annually.

There has been a big number of researches concerning emission reduction technology, public transport emission reduction, urban emission mitigation, transport emission reduction for retailers etc. But most of these studies do not interest automotive manufacturers. Almost all automotive companies in the world has multiple production sites around the planet and a worldwide supply chain network. These companies transport heavy parts and materials in their production plants in big volume and often use multi leg transport system such as trucks, rail, air, and sea. All these inbound transportations emit a huge volume of greenhouse gases in the climate and manufacturers are setting targets to reduce emissions in next coming years.

This study focuses on automotive manufacturers current motions regarding CO2 emission reduction and figures out the crucial activities where they can make notable progress. To operate under sustainable conditions, firms need to change their company culture and communicate their sustainability goals prominently with their internal organisations. Manufacturers also need to collaborate with external partners about CO2 reduction but should be focused more on actions under their own jurisdictions. The report claims that reducing transport demand through capacity utilisation for trucks and containers, avoiding air shipments and additive manufacturing to be the most effective methods to mitigate emissions for the inbound logistics. Additionally, the report suggests manufacturers to consider bigger inventory size which should reduce the amount of transportation needed to the plant but cost effectiveness against the sustainability targets should be explored first. The study concludes with the appeal of further researches in the area for the automotive industry.

Keywords
Sustainability, Climate change, Production logistics, Sustainability strategies, Transport operations, Electro mobility, Additive manufacturing.
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Introduction

1 Introduction

This chapter introduces the topics of Climate change and Sustainable transport system. It starts with a background on Sustainability followed by the purpose and research questions, finally the delimitations and outline of the report are stated.

1.1 Background

Climate change is undeniably one of the most serious challenges human beings face. It poses a threat to the human rights of millions around the world--such as their rights to life, health, food, and water (Wewerinke, 2019). These risks are highest among developing countries, where natural disasters, farming failures and other emergencies related to climate change are projected to occur with greater frequency (Wewerinke & Yu, 2010). It is well accepted fact that climate change is done by human actions (Cook et. al., 2016). In 2015, a historic agreement was signed among all member nations on the United Nations which is widely known as the “Paris Agreement” (UN, 2020). The article 2 of this agreement urges to hold the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change (Paris agreement, 2015). Carbon Dioxide (CO2) is one of the main Greenhouse Gases (GHG) that is responsible for increased global temperature. CO2 emissions from energy sector and transportation dominates the trend. Currently, freight transport is responsible for 7% of CO2 emissions worldwide. And 80% of this emission is the direct result from road vehicle emissions (Edenhofer, 2014). If current trend continues CO2 emissions from global freight transport are set to increase fourfold (OECD, 2016).

There has been a global shift toward more sustainable way of working for companies in recent years (Winston, 2019). The biggest companies in the world are reporting on their environmental performance concerning GHG emissions and energy metrics more than ever (CDP, 2014). A large number of companies in the world have decided to have an external auditing of their environmental impact as they are to be judged by consumers (Tang & Demerit, 2018). Most of the countries in the world yet to tighten their environmental regulations for companies but this situation is changing rapidly. China is working on an environmental tax law and The United States is urging businesses to become greener (Sandalow, 2019). In 2014, The European Union (EU) introduced a new directive requiring companies operating inside the EU with more than 500 employees to report their environmental performance among other things. This covers almost 600 large companies and groups across the EU (Directive 2014/957EU, 2020).

Companies trying to be more sustainable usually starts with their own operation and soon finds out that most of the impacts are caused by the actions from their supply chain rather than in-house (Scott, 2019). Up to 5.5 times more GHG emissions are caused by supply chain activities comparing to company’s own operation (Scott, 2019). Researchers have taken a great interest at the sustainable improvement of supply chain management both within the manufacturer and between companies because it is seen as a source of competitive advantage (Prado et. al., 2016). Many multinational manufacturers are committed to sustainability more than ever now but most of them have concerns over logistic efficiency and implantation of sustainability strategies as they have a feeling of incompatibility between them (Andersen & Skjoett-Larsen, 2009). As a result, bringing sustainability into supply chain operations is being an uphill task (Prado et. al., 2016).
Introduction

Inbound Logistics

The CSCMP (Council of Supply Chain Management Professionals) defines logistics as:

“That part of supply chain (SC) management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers’ requirements” (CSCMP, 2013)

The purpose of logistics process is to get the right quantity and quality of materials or services to the right place at the right time, for the right client, and at the right price. The entire process of logistics can be divided into three parts: Inbound logistics, materials management, and outbound logistics (Sadjady, 2011). Inbound logistics associates with the portion of business logistics which deal with set of operations that are designed to create flow of materials and information, from the source of raw materials to the entrance at the factory (Takita & Leite, 2019). According to Berman & Wang (2006), in a typical supply chain operation there are suppliers that sells raw materials or parts to a plant which get further processed to form into a product. They demonstrate a case for an automotive company, where a car is assembled at one of the company’s assembly plant. This plant does not produce all the parts necessary to build a complete product. As a result, they must procure parts (for example: tires, engines etc.) from different suppliers in the supply chain. A two-level supply network is created by the suppliers and the assembly plants. Raw materials from suppliers are usually transported to the plants by trucks. Air, rail, and ships are also widely used mostly for international shipments (Berman & Wang, 2006).

1.2 Problem Description

All transportations used for inbound logistics directly releases a lot of CO2 gas in the atmosphere as discussed above. Different transportation has different GHG emissions as shown in figure 1. Tavasszy & Piecyk (2018) state that sustainability in the freight transport operations brings a significant challenge from technical, operational, and political point of views. They added, only new transport technologies cannot solve the problem, but it will require a revised design for production and logistics processes. Different research has suggested different methods to reduce CO2 emission for inbound logistics. For example, Niwa (2009) discusses modal shift for the transportation sector; switching from airplane & truck transport to railway & ship as ships and trains emit less CO2 comparing the other modes. Bae et. al. (2008) recommends use of alternative fuels and electro mobility for the freight transportation sector. Wehner’s research in 2018 presents a case for capacity utilization for trucks to reduce the climate impact. Halim et. al. (2018) has developed a model towards decarbonisation in the maritime sector. There has not been much research which explores automotive manufacturer’s sustainability related activities in their transport system. Most sustainable transport research is directly aimed towards the activities of transportation companies and manufacturers need to collaborate with their transportation service providers to cut emissions (Goswami et. al., 2020). It might be necessary to redesign inbound logistics setup to mitigate transport CO2 emissions. Therefore, there is a need for exploring and developing transport related sustainability activities for automotive manufacturers.
Figure 1. CO2 emission by type of transport (Niwa, 2009)

1.3 Purpose and Research Questions

The purpose of this study is to:

*Explore and develop automotive manufacturer’s sustainability related activities in their transport system.*

For a manufacturer, this problem can be divided into two portions: internal and external operations. In the internal part, manufacturer can guarantee their side of the commitment. In the external portion manufacturers have little control over the actions of third-party logistics service providers, suppliers, and drivers. As of now, it seems most big scale manufacturers has figured out some activities to reduce transport emissions with a 5 years, 10 years, and 30 years target in mind, see Appendix 2. And that led to the following research question.

- **Research question 1:** Which activities automotive manufacturer is focusing on to cut transport CO2 emissions?

In all probability, not all sustainable related activities will turn out to be effective against CO2 mitigation. Some might have a bigger impact comparing to others. And, for a manufacturer it would be beneficial to know what these activities are in the very early stages of sustainability transformation. And that led to research question 2.

- **Research question 2:** Which activity/activities has the most potential in reducing transport CO2 emissions?
1.4 Delimitations

Delimitations define the parameters of an investigation. They are choices made by a researcher for a study. Categorically, a segment of delimitations could include choices such as the selection of objectives, variables, or theory. The main idea is to clearly state what the study will include and exclude. Simon & Goes (2013) states:

"The delimitations of a study are those characteristics that arise from limitations in the scope of the study (defining the boundaries) and by the conscious exclusionary and inclusionary decisions made during the development of the study plan."

The first step for delimiting is the choice of problem itself. It should indicate that there were other related areas to study but were screened off. The purpose statement should announce what the study is planning to accomplish. This could be repeated in the delimitations but with a mention of what the study does not aim to cover (Simon & Goes, 2013).

This study is only focused on inbound transport related emissions in the automotive manufacturing industry. And it examines the sustainability operations for only one case company which is limited to a feasibility study. Only CO2 emission will be considered as the case company is not considering other GHG emissions at this point. No implementation has been carried out at this stage as the case company plans then to start around the beginning of 2021. This study is also only focused on the case company’s transport operation in Thailand.
1.5 Outline

The report is divided into six chapters. The first chapter has introduced the topic of sustainability, climate change and inbound logistics operations. It also includes the purpose of the study, key research questions and delimitations of the study. The second chapter provides a detailed theoretical background in the area of climate change, sustainability, freight transport system and an introduction about engine classes, and additive manufacturing. The third chapter explains the research methods and approaches used to give the study reliability and validity. It provides good details about how the study was run as a standard project in the case company and the research tools used along the way. The fourth chapter describes the case company, their operations and transport setup. The fifth chapter is all about the findings during the research in the case company. It also analyses all these findings to examine the current and future trends. The final chapter sums up the study with an objective discussion and conclusion where many suggestions have been made to improve sustainability. Other relevant information can be found in the appendices.

Figure 2. Outline of the report.
2 Theoretical Background

This chapter provides a theoretical overview on Climate change, Sustainability, Engine classes, Transport Operation, Transport optimization, Additive manufacturing, and Lean production.

2.1 Climate Change

The change of weather patterns over decades or longer period of time is widely known as climate change (Brath et. al., 2015). It is well accepted fact that climate change is done by human actions. The Intergovernmental Panel on Climate Change (IPCC) has confirmed in several reports climate change is manmade and caused by the excessive emission of greenhouse gases (GHGs) since industrialization (Wewerinke et. al., 2010). A greenhouse gas (GHG) is any gas that absorbs and re-emit heat and therefore heating the atmosphere (Brander, 2012). Figure 3 shows CO2 in the atmosphere and annual emissions over last 270 years. CO2 emissions has increased almost 37 times during last 150 years as demonstrated in the figure 3. Edenhofer (2014) states:

“Anthropogenic GHGs come from many sources of carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and fluorinated gases (HFCs, PFCs and SF6). CO2 makes the largest contribution to global GHG emissions; fluorinated gases (F-gases) contribute only a few per cent. The largest source of CO2 is combustion of fossil fuels in energy conversion systems like boilers in electric power plants, engines in aircraft and automobiles, and in cooking and heating within homes and businesses. While most GHGs come from fossil fuel combustion, about one third comes from other activities like agriculture (mainly CH4 and N2O), deforestation (mainly CO2), fossil fuel production (mainly CH4) industrial processes (mainly CO2, N2O and F-gases) and municipal waste and wastewater (mainly CH4)”.

In 2015, a historic climate agreement widely known as” Paris agreement” was signed between all United Nation member countries by recognizing the need for an effective and progressive response to the severe threat of climate change on the basis of scientific knowledge available. The article 2 of this agreement urges to hold the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change (Paris agreement, 2015).

Emissions from the energy sector such as electricity production and from transportation dominate the global trends. Energy sector emissions have tripled since 1970, and transport has doubled worldwide. Since 1990 emissions from electricity and heat production increased by 27% for the most European countries; in the rest of the world the rise has been 64%. Over the same period, emissions from road transport increased by almost 29% in European countries and 61% in the rest of the world. Emissions from these systems are highly dependent on infrastructures such as power grids and roads, and thus changes from these sectors would hardly arrive (Davis & Caldeira, 2010).

GHG emissions from transportation sector have increased at a faster pace comparing to any other end-use sector. It has reached 7.0 Gt CO2 equivalent in 2010. And 80% of this emission is the direct result from road vehicle emissions. Reducing transport emission will be a challenging task given the increase of demands, slow turnover and sunk cost of stocks mainly in aircraft, train and large ship industries. The global
transport industry which includes manufacturers of vehicles, logistic service providers and constructor of infrastructures have taken research and development activities to become more Carbon efficient (Edenhofer, 2014).

![Figure 3. CO2 in the atmosphere and annual emissions (1750 - 2020) (Lindsey, 2020).](image)

2.2 Climate Action
As climate change is the defining crisis of this century, it is urgent to take action to limit consequences (UNSCAP, 2019). The United Nations prioritized seven key areas to handle the crisis: Renewable energy, energy efficiency, transport, carbon capture and reuse, non-CO2 emissions, land use climate action and adaptation co benefits (UNCCS, 2015). The EU has announced their own green deal to fight climate change. The European Commission wants Europe to reach climate neutrality by 2050 (EC, 2020). This will require a 55% emission reduction target by the year 2030. According to the European Commission, CO2 emission from burning fossil fuels are the biggest source of GHG emission in the EU. To achieve climate neutrality the EU plans to invest highly on renewable energy sources. The transport sector in EU has the lowest amount of renewable energy, at 6%. The EU plans to increase this to 24% by the year 2030 through further development and deployment of electric vehicles, advanced biofuels, and other renewable and low carbon fuels as part of a holistic and integrated approach (EC, 2020). The EU believes that their citizens want to live in a sustainable, fair, and resilient continent. The Europeans can greatly contribute to decarbonisation by making more sustainable purchase decisions and lifestyle choices. Sustainable life choices supported by actionable and reliable information will play a key role in decarbonisation (EC, 2020).

2.3 Sustainability
According to Veiderman, sustainability is like a vision of the future that provides us with a plan and helps us focus our attention on a set of values, ethical and moral principles by which to guide our actions (Fricker, 2001). And sustainable development
what meets the needs of the present without hampering the ability of future generations to meet their own needs (Munier, 2005). Sustainable development requires trade-offs and choices because resources are finite (Edenhofer, 2014). Sustainability has three wings namely environmental, social & economic (Kourdi, 2012). It is not a methodology as it depends on the will of people for a change (Munier, 2005). Fricker (2001) states the following about the challenges of sustainability:

"The challenge of sustainability is neither wholly technical nor rational. It is one of change in attitude and behaviour. Sustainability therefore must include the social discourse where the fundamental issues are explored collaboratively within the groups or community concerned. We do not do that very well, partly because of increasing populations, complexity, distractions, and mobility, but more because of certain characteristics of the dominant paradigm that are seen as desirable."

Sustainability could be seen as a process which involves people, organizations, natural resources, and the environment. It must be implemented collectively and should be points to the future. Sustainability involves changes over time, mainly in behaviour, attitudes, consumption habits, spending and purchasing patterns, and how society perceives and values the environment. It could also depend on policies being enacted and enforced, such as recycling or engine classes for vehicles (Munier 2005).

Sustainability and climate change are interlinked and interdependent. The climate crisis must be solved in order to move towards a truly sustainable future. Sustainability and sustainable development present us with reliable, real world solutions to the climate change situation. Things can be done in personal level as well as locally, nationally, and internationally and globally. It does not only affect the environment but also the economy and society. It would be foolish to only rely on world politicians to lead the on this battle. Strict government policies are needed, nevertheless, to begin this fight time is of the essence (Munier, 2005).

**Sustainability as Corporate Strategy**

Companies throughout the world are embracing the concept of sustainability. Sustainable business practice should be anchored deep with a company’s business strategy, day-to-day operation as well as new areas of capital investments. With the constant threat of Climate change industries need to find new creative solutions, trust, and forthrightness to build and maintain a good reputation with stake holders (Percy, 2000).

In future success will go to those who are able to deliver across all three sectors of sustainability – economy, environment, and equity. The right reputation of a manufacturer can differentiate itself in a very crowded market. A lot of progressive companies have started to publish annually their environmental and social performance. Value adding and strategic partnerships are important for successfully implementing sustainability objectives in company operations. To be truly sustainable companies, need to integrate them fully with business strategies and hold the line accountable. It is also important to set visible targets and report progress. Manufacturers need to confront their biggest environmental challenge head on, in an open and direct way. Constantly generating feedbacks and looking for new ideas are also vital (Percy, 2000).
2.4 Sustainable Transport Strategies

The main objective of sustainable transportation is to restrain pollution level, resource depletion, and to enrich the quality of life and economic status of a city (Rajak et. al., 2016). The United Nation Economic and Social Commission for the Asia and the Pacific (UNESCAP) suggests four strategies for a sustainable transport system by mitigating CO2 emissions. They are shown in the table below:

*Table 1 Strategies for CO2 mitigation in the transport system (UNESCAP, 2015)*

<table>
<thead>
<tr>
<th>Approach</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reduction of transport demand</td>
<td>Avoid</td>
</tr>
<tr>
<td>2. Promotion/Improvement of more energy efficient and environment friendly transport modes</td>
<td>Shift</td>
</tr>
<tr>
<td>3. Improvement in the efficiencies in the transport process or Transport optimisation</td>
<td>Improve</td>
</tr>
<tr>
<td>4. Introduction of new technology</td>
<td></td>
</tr>
</tbody>
</table>

Reducing transport demand could be achieved by freight load sharing, avoiding empty freight loads or capacity utilisation, improving freight logistics etc. Shifting from air transport to sea shipment and road transport to rail would provide a more energy efficient and environment friendly transport options. Introducing lower carbon fuels and energy efficient vehicles would further cut CO2 emissions in the transport sector (IDB, 2013).

The European Union has also prioritized three main areas for action to reduce CO2 in transport (EC, 2016). They are very similar to the approaches of the UNESCAP. These areas are:

- Increasing the efficiency of the transport system by encouraging the shift to lower emissions modes of transport.
- Speeding up the deployment of low-emission alternative energy for transport, such as advanced biofuels, electricity, hydrogen, and renewable synthetic fuels and removing obstacles to the electrification of transport.
- Moving towards zero emission vehicles. (EC, 2016)

**Biofuels and Natural Gases**

Biofuels are a great source of renewable energy which is also environment friendly. The first-generation biofuels are produced from sugar, starch, vegetable oil and animal fats which can have a negative impact on food security. The next-generation biofuels are primarily produced from lignocellulose, non-food materials, algal biomass, and energy crops grown on marginal lands. Biofuels are sustainable and has the potential to address climate change by reducing CO2 emissions. However, obstacles such as high production cost, lack of realistic purchase cost, enforcement of mandates, poor supply chain, and adherence to quality norms are some of the barricades for their commercialization. (Kumar et. al., 2020).
Compressed natural gas (CNG) or Liquid natural gas (LNG) can be used in gas powered vehicles. CNG is more suitable for small sized vehicles such as cars, pick-up trucks, and scooters. LNG is more suited to freight operations using heavy duty vehicles and long-haul distances. Most freight operation are run by diesel fuels. Using CNG or LNG would as a fuel source would reduce energy usage by a good margin as shown in figure 4 (ITF, 2018).

![Figure 4. Volumetric energy relative to Diesel (ITF, 2018)](image)

**Electric commercial vehicles**

Growing concerns about CO2 levels and bad air quality in cities have contributed to the development of electric vehicles. But, at the moment it’s only limited to light commercial vehicles on an urban scale. Future bans on diesel and gasoline cars in cities across Europe are inspiring the industry to adapt and meet the challenge of providing vehicles run by alternative fuels. For example, the city of Paris has announced it would ban the use of diesel vehicles by 2024 and gasoline by 2030. Electric vehicles require charging facilities and have specific requirements for maintenance. The infrastructure to support these are not there yet around the world. The market for electric light commercial vehicles is only at 1% but growing fast. Without government subsidies and other incentives, businesses would find a hard time to invest in this technology giving the operating cost (ITF, 2018).

**Load Sharing and Capacity Utilisation**

Load sharing or logistics pooling or Co-loading presents companies with a very important solutions to battle CO2 emissions. Several factors such as high cost of freights, low filling rate of vehicles, and CO2 emissions in operations have made companies think about this type of logistical solutions. As battling climate change alone is an impossible task it is advisable to collaborate with partners who has the same vision. Pooling can also restrict the distance travelled and improves the filling rate which saves CO2. Pooling requires collaboration between multiple players who are not in the same supply chain. Cost allocation problem and estimation of benefits from the joint planning of network have been discussed in the scientific literature to successfully implement load sharing between farms (Mrabti et. al., 2020).
Improving filling rate for freight or passenger transport is normally known as the best way to improve energy efficiency and CO2 emission reduction without compromising mobility (Rizet et al., 2012). The load factor or filling rate is the ratio of the average load to total vehicle freight capacity (vans, lorries, train wagons, ships). Empty running is excluded from load factor calculation. The expression for both load factor and empty running are in percentage (Mckinnon, 2007). In order to create a full load, a practice called Consolidation is deployed which is the combination of several different shipments (Khooban, 2011). To increase load factor the carrier has to organize consolidation platforms which increases the distance travelled by the vehicle as the route is not straight to the factory anymore (Rizet et al., 2012).

Utilizing the maximum capacity of a vehicle is often far below from the theoretical maximum. For some cases it is even impossible, and some cases (chemical products, milk) require specialized vehicles where a return load is almost impossible to find. For some commodities, the available volume or surface area is reached before the weight. Few countries have indirectly handled the issue by logistical optimization, supply chain or fleet management system. In Europe it is being considered to increase the maximum authorised vehicle weight to increase load factor. Increasing transport cost is considered to be the best motivation to improve load factor as well as other inefficiencies. Many logistic improvement programs, like the ones implemented in UK and France define that loading factor is one of the performance indicators to help monitor the CO2 emitted (Rizet et al., 2012).

**Firm Level Strategies**

Mathivathanan, Kannan, and Haq (2018) in their research concerning sustainable practices in Indian automotive industry identified top management support and commitment as a crucial element for success of any sustainability effort at firm level. Cognitive base of top management could play a significant role in shaping and implementing the firm’s strategies when it comes to continual support. This is achieved by top management’s belief structure in analysing and responding to the environment and use these beliefs to guide their administrative behaviours (Lee et al. 2014; Yuan et al. 2020). Oberhofer and Dieplinger (2013) have emphasised upon continuous execution and monitoring of operational level sustainability-related activities for causing positive changes in transportation and logistics sector particularly from a commodity and transport planning related perspective. It is crucial for manufacturers and their transportation partners (Third part logistics suppliers) to collaborate more effectively in order to be more sustainable in their transport operations (Goswami et al., 2020).

The manufacturing sector should be considered as one of the major sectors where transformative changes are needed to mitigate emissions. This would indicate towards a more resource efficient mode of production. A recent addition to this is “Additive manufacturing (AM)” or “Three-dimensional printing (3DP)” technology. Unlike traditional manufacturing subtractive processes, AM introduces additive means of production. Three-dimensional physical objects are produced through layer-by-layer formation of matter based on a digital blueprint. AM has the potential to reduce resource, energy demands and process related CO2 emissions. It also has the potential to make supply chains less transport intensive. However, currently the relative effect on sustainability by introducing AM to manufacturing world is rather small. The reason is the low share of additive manufacturing in mass production markets as consumer products and automotive industry (Gebler et al., 2014).
Global electronic product manufacturer Fujitsu wants to promote green logistics throughout their group by improving loading efficiency ratio for trucks and modal shifts for international logistics (Fujitsu, 2015). They have introduced the following approaches to improve logistics efficiency and CO2 reduction:

- Reducing truck transportations by consolidating factories.
- Reducing truck transportations by incorporating external warehouses inside their factories.
- Improving truck load efficiency by optimizing packaging boxes.
- Reducing shipping distances by redesigning logistics routes.
- Reducing truck transport between factories.
- Implementing modal shift by moving to ocean from air transport. (Fujitsu, 2015)

2.5 Transport Operation for Manufacturers

Transport operation for manufacturers moves materials using different vehicles or hardware such as trucks, ships, trains, pallets, trains, containers, planes etc. between origins and destinations. Transportation is considered as the most important element in logistics due to its considerable cost (Ghiani et al., 2004). According to Khooban (2011):

“A transportation system is an organization that designs, arranges, sets up, and schedules freight-transportation orders during a given and limited time period with technical restrictions at the lowest possible cost”

The importance and key role of transportation is undeniable in logistics as it often accounts for between 33% - 66% of total logistics cost. Moving of any shipment in a logistic system such as raw materials from supplier to manufacturer and finished products towards retailers needs reliable transportation system. With increased overall consumption and advancement of science and technology, global commerce highlights the importance of transportation in all processes. The quality of customer service is so much dependent on good transportation system, resulting high level competition between manufacturers and also transportation owners. Other crucial competitive factors are costs, reducing lead times and delays, reliability, safety, and efficiency in the service (Hoff et al., 2010).

Third party Logistics (3PL)

Logistics activities such as transportation are often outsourced to Third Party Logistics (3PL) operators by manufacturers. These 3PL operator’s greater expertise helps increased flexibility and efficiency in logistics operations to cover extended geographical areas, borders. It helps to lower costs and same time offer better quality of service (OECD, 2002).

In a 2003 survey, Aghazadedh found out 40% of users in 2000 relied heavily on 3PLs for transportation services. According to Lieb (1992, p. 229):

“Third-party logistics are external companies which perform logistics functions that have traditionally been performed within an organization. The functions performed by the third party can encompass the entire logistics process or selected activities within that process”.
Theoretical Background

3PLs are also known as Logistics service providers or LSPs. During, 1990’s multi-national parcel and express companies such as DHL, TNT, UPS emerged in the market as new 3PL actors. Normally, their 3PL services are based on their experience with expedited freight and global air-express networks (Alireza & Alagheband, 2011).

Rao & Young (1994), points out the main functions for transportation 3PL activities as:

- To coordinate transportation mode
- To track and trace shipments
- Line-haul services.
3 Method and Implementation

This chapter describes the methodological approach of the study. The literature study and case study are explained as well as the data collection and techniques for analysis used throughout the process.

3.1 Research Approach:
An appropriate research approach is essential for any reliable research project. Research approach according to Creswell (2014) could be defined as below:

“Research approaches are plans and the procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation. This plan involves several decisions, and they need not be taken in the order in which they make sense to me and the order of their presentation here. The overall decision involves which approach should be used to study a topic. Informing this decision should be the philosophical assumptions the researcher brings to the study; procedures of inquiry (called research designs); and specific research methods of data collection, analysis, and interpretation.”

A framework for research is shown in a diagram below:

![Framework for research](Creswell, 2014).

Fighting climate change will need a pragmatic approach (Atkinson et al., 2011). The research problem is closely connected to fighting climate change. The researcher holds a pragmatic philosophical worldview and thus a mixed method research approach was considered in the beginning. Pragmatism does not subscribe to any one system or reality which applied to mixed method research (Creswell, 2014). However, due to lack of operational resources the study was limited to Qualitative only.
Qualitative approach is the experimental way of approach, in other words, it mainly concentrates on scientific way of approach of analysis by getting answers for the question by investigating about the research, and by systematic operation of answering the questions in a predefined way by collecting evidence and producing the findings which are beyond the present limitations. Qualitative approach helps in providing the complex information about the research. It provides information in the view of human, which is mainly concentrated on different behaviour, emotions, relationship between the humans, opinions of different individuals. Qualitative has become a strong research in the field of science. Good ideas emerge when there are interruptions in the qualitative research (Barney & Glaser, 2008).

The research started with a literature study, followed by a single case study which includes an orientation study, many interviews, and observations. The case study was chosen to experience the research problem in a real-life context and find valid answers to the research questions.

3.2 Literature Study

The literature study, which was essential for this study, was mainly conducted in 3 areas namely: Climate change, sustainable transport strategies, and freight transport operation. The goal was to learn about the topic as much as possible before the orientation study takes place to prepare the right questions for the case company employees. The databases that were followed mainly ResearchGate, Scopus and Jönköping University’s own online library system. These databases help greatly to narrow down the search and find suitable articles for the queries. Booth et. al.’s (2016) selection process was used for screening articles. Screening of titles was the first step. After screening the title, next job on the list is to examine the abstract. Very often articles were selected for thorough study through the screening of titles and abstracts. Finally, the full text was studied and a handful of them were screened out in that stage due to irrelevance. Figure 6 displays the process of this method:

![Figure 6. Process of selecting studies (Booth et. al., 2016)](image-url)
The keywords for the queries were: Inbound logistics, sustainability, climate change, freight transport operation, sustainable freight transport, third party logistic provider, etc. The study on Climate change focused on climate initiatives taken by the government, institutions and companies, different pollutant gases, climate gases and their impact on the environment. While studying literature on sustainability the focus was on current practices and future trends followed by governments and organizations. Transport operation searches were mainly about logistics development techniques such as filling rate, packaging etc. Different engine classes of diesel engines were also a part of the study to know their emissions when it comes to CO2.

3.3 Case Study

In modern days case study is a commonly used research strategy (Bartlett, 2016). Schramm (1971) defines case study as:

“The essence of a case study, the central tendency among all types of case study, is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result.”

Yin (2014) offered the following definition of a case study:

“A case study is an empirical inquiry that investigates a contemporary phenomenon (the case) in-depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident. In other words, you would want to do case study research because you want to understand a real world case and assume that such an understanding is likely to involve important contextual conditions pertinent to your case.”

According to Yin (2003), a case study is useful to explore a contemporary research phenomenon within its real-life context. Dubois and Gadde (2002) theorize that the case study strategy is the best choice when it comes to understanding the interaction between a phenomenon and its context. If no of citation is any indicator, then Yin and Eisenhardt are probably the most influencing authors in case studies.

A good case study design depends on four conditions to ensure its quality: (a) Construct validity (b) Internal validity (casual case studies or explanatory case studies) (c) External validity (d) Reliability. For case studies, five factors of a research design are necessary:

1. Questions of a study.
2. It’s propositions (Given there is any)
3. It’s units of analysis
4. The reasoning linking the data to the propositions
5. The criteria for interpreting the findings (Yin, 2003).

A theoretical framework should be conducted by an investigator for a case study to get full benefits from the above mentioned five components. A good researcher should not avoid working on this theoretical background, no matter whether the study is to be explanatory, descriptive, or exploratory. In order to generalize the results of a case study, it is significant to use of theory. It also helps to define the most appropriate research design (Yin, 2003).

According to Yin (2003), there are four kinds of case study designs: single-case (holistic) design, single-case (embedded) designs, multiple-case (holistic) designs and
multiple-case (embedded) designs. They are mainly known as two types of designs as single and multiple case study designs. It is a difficult task to design a study between single or multiple case studies. To answer the research questions, it’s necessary to choose the appropriate case study design. And of course, this needs to be done before the collection of data. A single case study correspondent to a single experiment. A single case study is appropriate in many situations. Yin (2003) gives five rationale to choose a single case study when it represents:

1. A critical case in testing a well formulated theory.
2. An extreme or unique case.
3. A typical or a representative case.
4. A revelatory case (previously inaccessible for scientific testing).
5. A longitudinal case (studying a same single case for two or three points in time).

The research topic requires an in-depth appreciation of the problem in a real-life context. That is why a case study approach was chosen. The case study for this research was conducted as a single case study design. The research problem can be seen as a mix between Yin’s rationale 1 and 3. Rationale 1 has a well formulated theory with a clear set of propositions. To confirm, confront or extend the theory a single case study might be enough to meet all the requirements. In the other hand for a typical or representative case, the goal is to obtain the affairs and conditions of an everyday or commonplace situation. The case study might represent one project among many other projects in a manufacturing firm. This project could be common for many other manufacturers in the same industry (Yin, 2003). The main criteria to choose this specific case was that it should be in a multi-national automotive manufacturer with a vast supply chain network. The unit of analysis for the case study was sustainability related activities. The study was conducted in the company as a standard project where the researcher was appointed as a project leader and two interns were placed in the team to help with data collection and analysis. The steering committee for the project is shown below:

![Steering committee diagram](image)

Figure 7. Steering committee for the project
Method and Implementation

Orientation Study & Interviews
Before the feasibility study started, 12 detailed interviews with case company’s top management were held to get an overview of their transport setup processes and their current stand on sustainability. A few follow up interviews were also conducted to update knowledge about case company’s sustainability related activities. During these interviews both open ended and close ended questions were asked. The type of the most interviews could be characterized as semi-structured interviews. Semi-structured interviews allow a greater flexibility whilst conducting the interview compared to structured interviews (Williamson, 2002). See table 2 for more details.

Table 2 Orientation study, overview of unstructured interviews

<table>
<thead>
<tr>
<th>Position</th>
<th>Unstructured interviews</th>
<th>Duration (Approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vice president (Transport operations APAC)</td>
<td>3</td>
<td>1 hour each</td>
</tr>
<tr>
<td>Vice president (Plant logistics)</td>
<td>1</td>
<td>1 hour</td>
</tr>
<tr>
<td>Director of transport purchasing APAC</td>
<td>1</td>
<td>1 hour</td>
</tr>
<tr>
<td>Director of business control APAC</td>
<td>2</td>
<td>1 hour each</td>
</tr>
<tr>
<td>Project manager (Transport optimization)</td>
<td>1</td>
<td>2 hours</td>
</tr>
<tr>
<td>Logistics manager</td>
<td>1</td>
<td>1 hour</td>
</tr>
<tr>
<td>Purchasing manager</td>
<td>1</td>
<td>2 hours</td>
</tr>
<tr>
<td>Sustainability manager</td>
<td>1</td>
<td>1 hour</td>
</tr>
<tr>
<td>Senior manager (Planning &amp; OtD)</td>
<td>1</td>
<td>1 hour</td>
</tr>
</tbody>
</table>

Observation:
Observation involves systematic surveillance, description, analysis and interpretation of an entity’s behaviour in their natural setting (Sanders et. al, 2012). Observation requires researchers to be present at the scene and take intelligent notes (both mental and physical) to utilize in the findings and analysis.

In this study a few observations were carried out in the manufacturer’s assembly plant, warehouse and one major supplier location. The primary purposes of these observations were to get a first-hand look of the operations and compare the validity of the information/data collected from the semi structured interviews. Observations in the supplier’s loading facility was also very important to ensure reliability of the interview answers.
Data Analysis

Numerical data that was collected from the case company included shipping information such as routes, volume, weight, mode, filling rate etc. These data were used to calculate CO2 emissions using EcoTransIT Online Emission Calculator (www.ecotransit.org). Both “as is” and “as if” scenario was calculated to see the differences in CO2 emissions between modes and engine classes (trucks). Qualitative data gathered from interviews were all documented and later verified through observations and cross checking.

3.4 Reliability & Validity

Joppe (2000) describes reliability as:

“The extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable.”

Reliability is related to the extent to which the results of a study are repeatable in different prospects (Bryman, 2001). Thus, it is important to confirm findings by revisiting data in different prospects. Keeping detailed notes on resolutions made throughout the process will add to the study’s’ trustworthiness and, therefore, reliability (Roberts et. al., 2006). In quantitative research three types of reliability is referred by Kirk & Miller (1986): (1) the degree to which a measurement, given repeatedly, remains the same (2) the stability of a measurement over time; and (3) the similarity of measurements within a given time period. Reliability is divided into two segments: Internal and external reliability. Although the researcher may be able to prove the research equipment’s repeatability and internal consistency, and, therefore reliability, the instrument itself may not be valid (Golafshani, 2003).

Validity characterize the degree to which a measure accurately represents the notion it claims to measure (Punch, 1998). There are two main ranges of validity: internal and external. Internal validity represents the logics for the outcomes of the study and helps to reduce other reasons for these results. Three approaches to assessing internal validity are content validity, criterion-related validity, and construct validity (Roberts et. al., 2006). In quantitative research, the ultimate question is whether it is possible to draw valid conclusions from a study given the research design and controls employed (Ryan et al., 2002). However, in qualitative research, internal validity refers to the credibility of case study evidence and the conclusions drawn (Ryan et. al. 2002). During research design, the threats to internal validity include insufficient knowledge of, or contradictions in the logic (Ihantola & Kihn, 2011).

By choosing to interview and collect information from all the top managers in the organization, the internal reliability and validity of this study was ensured. Most of the outcomes of the feasibility study can be used directly at the different brands in the case company. The external reliability and validity of this study were ensured by a thorough literature study. Qualitative research has the tendency to lack external reliability and validity. Both these factors were strengthened by using literature-based findings to match the outcomes of the study. Additionally, Semi-structured interviews and observations were used for method triangulation to ensure external validity. Method triangulation basically means to use more than one method to collect data for assuring
the validity of a research. External validity determines whether one can draw more general conclusions on the basis of the model used and data collected, and whether results may be generalized to other samples, time periods and settings (Ihantola & Kihn, 2011). The result of this study could be generalized until some extent. This case study is performed under the standard practices in the logistics business in Thailand. Many findings and results will shape with accordance to these local proceedings. So, automotive companies in the same country and situation might have a more valuable use of the results.
4 The case company and transport setup

This chapter presents the description of the case company, their worldwide operation, and inbound transport setup.

4.1 Volvo Group

The case company Volvo Group consists of 12 brands, 100k employees in 190 markets. They have production facilities in 18 countries and their products include Trucks, Buses, Construction equipment, marine engines, and industrial engines. Volvo Group has a global supply chain presence which touches down in every continent. In the Asia Pacific (APAC) region Volvo Group has operation in 7 countries namely Thailand, Japan, south Korea, India, China, Singapore, and Australia. An example for Volvo. To procure material for production and deliver finished product, the company relies on various transportation method such as Trucks, rail, ocean freights and airplanes. During the Volvo group leadership summit in May 2019, the company came up with 3 strategic objectives for future transformation. One of these ambitions is to achieve world’s most sustainable transport system by cutting its transport CO2 emission by 30% by 2025. As the changes in climate is threatening the very existence of all species in the planet, it is very important that we do everything in our power to fight prevent it. And reducing our dependency on fossil fuel is on the top of the lost to do so. Volvo APAC aims to create a roadmap towards emission reduction with Bangkok operations as pilot and then possibly expand the method in the region.

4.2 Transport setup

Inbound logistics describes the logistics flow outside the plant – the flow from the suppliers to the receiving point in the plant. It is important that the supplier footprint is aligned with Volvo’s industrial footprint to have a lean and flexible material flow from supplier to plant. This helps to avoid long lead-times, tied-up capital and high transport costs. Close collaboration, mutual understanding, and early involvement by logistics experts in the supplier selection process, is key to optimize end-to-end flow. Figure 8 show the inbound logistics network for Volvo group.

![Inbound Logistics Network Diagram](image)

Figure 8. Inbound logistics network for Volvo Group
The case company and transport setup

Transport is vital in inbound logistics. High frequency and high filling depend on large volumes and clever planning to be cost-effective. The Volvo Group manages this by consolidated transport purchasing and centralized management of the transportation. Improvements in the inbound network are achieved through better planning, monitoring and controlling the transportation. Transport network design and transport planning to optimize frequency and cost, are important success factors. To ensure a transport network set-up with frequent pick-ups and at a low cost, Volvo plan the pick-ups and transportation carefully. The company utilize many different carriers for transportation and a transport network with consolidation and deconsolidation cross docks.

There are three main delivery solutions in the transport network:

- **Volvo managed flows**: Flows from material suppliers and internally produced components. These flows are transported by road, rail and sea, and they can be local, regional, or inter-continental. Large volumes are consolidated to optimize frequency and cost.

- **Supplier managed flows**: Long-distance flows where the suppliers deliver to an external warehouse. The delivery volume in these flows is a minimum of one Full Truck Load (FTL) or one Full Container Load (FCL) per destination and week. When the supplier pays for the transport it is key to have full loads to ensure the transport cost is competitive compared to a Volvo paid flow.

- **Flows from suppliers located nearby**: The suppliers deliver to an unloading point inside the plant. This is the required delivery concept for fasteners. For other suppliers this is to be considered as an opportunity if the supplier’s location is close to the plant and if the part fits into the delivery concept. The distance from the supplier to the plant is an important prerequisite for flexibility, lead-time, and cost of the flow. The impact of the distance from supplier to plant is further explained in the chapter External replenishment modes.

To keep track of and ensure that the consignment is delivered on time, several events are monitored, from pick-up at the supplier, to delivery at the end destination. This ensures that the company is on top of all transport deviations and provides an efficient and proactive transport monitoring. Figure 9 shows these operations. The following events are tracked:

- **TBR** – Transport Booking Request: No booking, no pick-up; this is the basis to start a transportation.

- **TBC** – Transport Booking Confirmation: Verification from carrier that the pick-up will be done.

- **POP** – Proof of Pick-up: Verification from carrier that the transport order has been collected on-time according to booking.

- **POA** – Proof of Arrival: Carrier has arrived on time at end destination according to the arrival schedule.

- **LC** – Load Confirmation.
The case company and transport setup

POD – Proof of Delivery: Goods have been received at plant. This triggers the payment to the carrier.

Figure 9. Transport operations
5 Findings and Analysis

This chapter presents the empirical findings or results in the case company and analyse these results. The findings part starts with an introduction and presents the results under three headlines. This part will answer RQ1. In the analysis part the most important findings will be analysed and RQ2 will be answered.

5.1 Findings

The Bangkok plant of the case company predominantly assembles and builds cabins for their UD trucks brand. They also assemble bus and trucks under the Volvo brand which is a fraction of their total volume processed there. The case company has decided a target of 30% reduction of CO2 in their transportation system by the year 2025. This 30% reduction is based on the emissions of the year 2017. To tackle this challenge, they have created a sustainability team in Sweden which is led by a sustainability manager and run under the end-to-end supply chain department. The case company’s worldwide operation is divided into four geographical areas namely Asia Pacific (APAC) operations, North America operations, South America operations and Europe-Middle East-Asia (EMEA) operations. Four representatives from these four regions along with two more representatives from materials supply and purchasing team reports to the sustainability manager and make plans going forward. So far, the case company has short listed three key activities and many sub-activities to reduce CO2 emissions in the inbound logistics transportation. These activities are the same for all worldwide locations but will differ in practice according to region and country. None of these activities has been tested or implemented yet with a target of CO2 emission reduction. The table below illustrates them:

<table>
<thead>
<tr>
<th>Key activities</th>
<th>Break down</th>
<th>CO2 reduction target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reduce transport demand</td>
<td>• Localising supplier bases</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>• Reduce air shipments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Reduce unbalanced and unnecessary shipments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Introduce 3D printing in the manufacturing system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Build new warehouses</td>
<td></td>
</tr>
<tr>
<td>2. Transport optimization</td>
<td>• Increase transport network anticipation and work more pro-actively.</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>• More consolidated flows of materials.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Possible load sharing with other partners or shippers to improve filling degree</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Increase load factor to utilise higher vehicle capacity</td>
<td></td>
</tr>
</tbody>
</table>
Findings and Analysis

| 3. Improve fleet efficiency | Fleet renewal (Road) | Deploy and follow up engine class requirements with LSPs | Possible use of alternative fuels (e.g. LNG, CNG) | High capacity transportation | Using 2nd generation biofuel for sea cargo | 15% |

Reduce Transport Demand

The case company targets a 6% emission reduction by reducing transport demand. Localising and nearshoring of supplier bases has been identified as a major activity. As these plans are in the development phase most internal organisations and departments throughout the company are not aware of such operations. The whole material purchasing team was gathered for an interview and they were not aware of new sustainability targets. They do require some sustainable operations from their suppliers such as waste management and social sustainability but not how the materials are transported to the plant. According to the material purchasing manager, the team is looking more into foreign suppliers instead of localising for cost reduction. Most of the local suppliers have higher prices comparing to OEMs in China. So, the trend is going in the opposite direction from sustainability activities. As the case company owns many truck brands all these producers use common parts or components for their products which is known as ‘part-sharing’. The majority of these common parts are manufactured by European or American suppliers. As a result, Bangkok plant must procure parts from there correspondingly. According to the Vice president of transport operation, in theory it is possible to find local or regional suppliers for these shared parts but there are always risks of quality deviation and confusion. It might also increase costs as all the suppliers of the same components have to produce less volume. The case companies Transport operations department believes cost reduction in transportation and CO2 reduction should go hand in hand. But the transport operation department has no say in choosing suppliers. Reduction of CO2 emission by localisation of supplier bases is not an option for Bangkok operations at this point.

Air shipments are frequent for the case company and Bangkok plant is no exception. In the year 2019 more than 700 shipments by air arrived there. According to the director of transport purchasing, it is a standard procedure to bring some small parts of modest volume to be delivered to Bangkok regularly by air freight. Most large volume air shipments occur because of human error or uncertainty. Human errors include warehouse mismanagement and occasional disappearance of goods from ocean shipments. Uncertainties include unforeseen large orders or customised product sales with shorter lead times. Although, air shipments are much more expensive comparing to ocean freight some customers in these categories are ready to pay extra. Natural calamities such as seasonal typhoons in the region also responsible for cancellations of many ocean shipments and changing them to air shipments in order to sustain production. A transport optimisation expert in the company explains, most requests for air shipments are not approved by the approval committee. An estimate of 5 requests out of 10 are approved and processed. But the company is aware of extra costs and
environmental impacts of air freights, so they are trying it to minimize by 2 approval per 10 requests. However, they are not aware of the severity of these emissions comparing to sea vessels and they do not have the right tools in operation to calculate them.

Volvo group intends to introduce additive manufacturing such as 3D printing into their operations for low running parts in small sizes. Their Skövde plant in Sweden is testing this modern approach of manufacturing now. But, according to the sustainability manager this technology is still in its infancy and Bangkok plant is not ready to adapt such technology into their operations. But he believes in near future transport demand will be reduced drastically once this technology is ready for automotive manufacturers.

**Transport Optimization**

The case company targets a 9% reduction of CO2 emission through optimizing their transport setups. The transport optimization team in Volvo, Bangkok recognizes that they need to have better anticipation in their transportation network setup and work more pro-actively. At the moment, most decisions are made on trial and error basis and firefighting is a daily activity. These development activities are primarily designed for cost saving but can also be used as another tool for sustainability.

Volvo is planning to have more consolidated flows to handle GHG emissions. They would also like to go intermodal by using more rail and sea networks. Unfortunately, it is not an option for the Bangkok plant as there are no available rail networks around the factory. Essentially all of their local suppliers are in a 300km radius and the nearest seaport is not very far away. Unlike in Europe, Asia does not have open borders. So, trains do not cross borders and trucks are very limited. There are two suppliers who are in Malaysia that can deliver via trucks, but ocean freights are a better option in these cases.

Load sharing or co-loading is another option that is on the table to be discovered. It basically means to share a truck or container with another company or supplies to have a better filing degree and cost savings. The director of transport purchasing referenced a start-up in Australia who are introducing a mobile app-based platform for load sharing. They are currently operational only in Australia and Singapore but will expand in the future. According to one executive load sharing for Volvo in Thailand is not a realistic idea.

Increasing load factor will be essential in the fight against GHG emissions as a production logistics manager in Volvo puts it. Currently, Volvo group Thailand has a filling degree of only 39% in volume for their local flows. Figure 10 shows weekly load factors from one logistic service provider according to weight and volume. In theory the company could save millions and reduce a significant amount of CO2 emission if average filling degree were up to 70%. But the reality is very different. In Thailand freight truck service is not sold by weight. So, either transporting 5 kilograms or several tonnes, one must pay for the whole truck. So, LSPs want companies to use as many trucks as possible. There are many materials which are not stackable resulting low filling degrees. Also, lean ideas such as just in time practice is responsible for low load factors. There are some materials which can be filled with higher degree in a truck. But the suppliers are not very cooperative in this matter as they need to make big investment in loading technology or just need to change their way working by some margin. Suppliers are responsible to order transportation so time to time they order more than necessary amount of trucks for their own convenience in loading. The communication
Findings and Analysis

 plataforma entre los proveedores y los LSP es muy defectuoso. El software a menudo interpreta demandas diferentes al LSP en comparación con lo que los proveedores solicitan. Consecuentemente, llegan más o menos camiones que los necesarios a la puerta del proveedor. Enviando tipos de camiones erróneos también es un evento regular. Se observó un bajo grado de ocupación durante una visita a un proveedor de marcos metálicos. Los marcos metálicos para camiones suelen tener espacios vacíos y son muy desafiantes de cargar dada su longitud y forma. El equipo de compra de Volvo está trabajando en soluciones para aumentar los factores de carga para los marcos. También hay un gran proyecto que se está llevando a cabo en la empresa para abordar el grado de ocupación para la mayoría de sus proveedores. Este proyecto comenzó con el examen de la actividad de reservas y carga de transporte de tres proveedores clave. Los fallos en el sistema de reservas están siendo identificados y se está considerando la colaboración de proveedores para mejorar la carga.

<table>
<thead>
<tr>
<th>Week</th>
<th>Weight Percentage</th>
<th>Volume Week</th>
<th>Volume Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>W32</td>
<td>26%</td>
<td>W32</td>
<td>30%</td>
</tr>
<tr>
<td>W33</td>
<td>25%</td>
<td>W33</td>
<td>29%</td>
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<tr>
<td>W34</td>
<td>31%</td>
<td>W34</td>
<td>30%</td>
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<td>W35</td>
<td>31%</td>
<td>W35</td>
<td>34%</td>
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<tr>
<td>W36</td>
<td>29%</td>
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<td>32%</td>
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<td>W41</td>
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<tr>
<td>W51</td>
<td>30%</td>
<td>W51</td>
<td>23%</td>
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</tbody>
</table>

Figura 10. Factor de carga semanal para transporte doméstico en peso y volumen

**Improve Fleet Efficiency**

La primera cosa en esta categoría es preguntar a los proveedores de servicios de logística (LSP) sobre sus condiciones de flota (por ejemplo, clases de motores, edad de la unidad). Casi todos los países tienen requisitos mínimos de clases de motores para sus vehículos de carretera. Volvo ha listado los requisitos para sus países de operación como se muestra en la figura 11. Como la figura muestra, Tailandia debe implementar la clausura mínima de Euro IV para nuevos vehículos de transporte de mercancías para 2022. Casi todos los camiones en Tailandia tienen motores Euro II o Euro III. La empresa de caso utiliza a la empresa X como su 95% transporte de carreteras y para otras operaciones de transporte de mercancías. La empresa X tiene sus propios objetivos de sostenibilidad para mitigar las emisiones de CO2 en 50% por 2025 comparado con el nivel de 2007. Una entrevista con los representantes de la empresa X sobre acciones relacionadas con la sostenibilidad fue realizada. Se encontró que la empresa X Tailandia no está alineada con su equipo global en los objetivos de sostenibilidad. Los representantes en la entrevista no tenían un conocimiento previo de las clases de motores
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and emissions. Company X Thailand does not own any trucks and is dependent on other local vendors for distribution. So, neither Volvo nor Company X has any control over the conditions of trucks which transport materials to the plant.

Volvo wants to have electric trucks for transportation in Europe and North America as soon as possible. In Asia, the target is to procure transportation who offers trucks using alternative fuels such as Liquefied natural gas (LNG) or compressed natural gas (CNG). LNG emits 20% less CO2 compared to diesel. LNG trucks were used some years before in Thailand but in recent year’s diesel prices plummeted and LNG prices have increased by a considerable amount. According to Company X representatives using LNG or CNG as the primary fuel in the trucks is no more an option in Thailand unless some dramatic change happens which is very unlikely. Volvo wants the use of second-generation biofuels for sea cargos and management in Belgium office is responsible for such contracts. Volvo wants to work with their technology department to deploy high capacity vehicles and trailers in countries where legislation has been approved. They also wish to introduce a sustainability award for carriers based on their emission-related performance.

As most of the key activities identified by the case company will not work in Thailand, the transport department recognizes that reducing CO2 emissions by 30% by 2025 is unlikely.

<table>
<thead>
<tr>
<th>Areas</th>
<th>2020</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>EU, UK, Norway and Switzerland</td>
<td>Euro VI</td>
</tr>
<tr>
<td></td>
<td>Russia, Turkey and Europe not in EU</td>
<td>Euro V</td>
</tr>
<tr>
<td>South America</td>
<td>Mexico Euro V/US 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brazil Euro III 50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brazil Euro V 50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>China CN IV (shared)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>China CN V (dedicated)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Korea (south) Euro V (shared)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Korea (south) Euro VI (dedicated)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>India BS III (shared)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>India BS IV (dedicated)</td>
<td></td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>Japan PNLT (shared)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Japan PNLT (dedicated)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Australia Euro V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Australia Euro V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malaysia Euro IV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malaysia Euro IV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Singapore Euro V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Singapore Euro V (shared)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Singapore Euro VI (dedicated)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indonesia Euro II</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indonesia Euro II</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>Except South Africa Euro III</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Except South Africa Euro IV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>South Africa Euro IV</td>
<td></td>
</tr>
</tbody>
</table>

Figure 11. Engine class requirements for countries where Volvo operates.
Findings and Analysis

5.2 Analysis

The case company is continuously looking for new ideas to mitigate CO2 emissions in the transport system and benchmarking with other world-class manufacturers. None of the above mentioned (Table 3) key activities have been tested or implemented in their worldwide operations. This study aims to figure out which of these activities are implementable for Thailand operations and which of activities will turn out to be the most crucial ones. The findings suggest that not every activity can be implemented for the Thailand operations as of now. The following table categorizes the findings into 3 sections: Not implementable currently, partially implementable, and fully implementable. Table 4 illustrates the categorization.

Table 4 Implementable activity categorization for Thailand operations

<table>
<thead>
<tr>
<th>Not implementable currently</th>
<th>Partially implementable</th>
<th>Fully implementable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localising supplier bases</td>
<td>Reduce air shipments</td>
<td>Increased load factor</td>
</tr>
<tr>
<td>Load sharing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved fleet efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use biofuel (LNG or CNG)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3D printing of parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building new warehouses</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As the findings state that localisation of supplier bases is not implementable for Bangkok operations but in reality, it does not make a big difference. Alaane & Saari (2006) argues that localisation of supply chain may redistribute CO2 emission but not reduce it. It basically means local, regional, or global supplier choices do not reduce CO2 emission in the atmosphere but emits in a different location. Procuring globally will always be a standard practice as the combination of raw materials, matured technology and skilled workforce is hard to find locally. Load sharing with a partner, usage of biofuel, additive manufacturing and building new warehouses cannot be enforced at this point.

Although improving fleet efficiency for Thailand operations is difficult at this moment but this has to be implemented in near future. However, reducing 15% CO2 emissions from improved fleet efficiency might be proven as an uphill task which was revealed during the interview with Company X Thailand. As Volvo relies on Company X for road transportation and Company X relies on many other small vendors for providing vehicles, sustainability appointment will not be easy. Higher engine classes reduce emission of pollutant gases considerably as shown in Figure 12 but not so much for GHGs such as CO2. Air pollutant gases include Carbon Monoxide (CO), Hydrocarbons (HC), Nitrogen Oxides (NOx), Particulate matters (PM) etc.
Findings and Analysis

<table>
<thead>
<tr>
<th>Stage</th>
<th>Date</th>
<th>Test</th>
<th>CO</th>
<th>HC</th>
<th>NOx</th>
<th>PM</th>
<th>PN</th>
<th>Smoke</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>g/kWh</td>
<td></td>
<td></td>
<td>1/kWh</td>
<td>1/m</td>
<td></td>
</tr>
<tr>
<td>Euro I</td>
<td>1992, ≤ 85 kW</td>
<td>ECE R-49</td>
<td>4.5</td>
<td>1.1</td>
<td>8.0</td>
<td>0.612</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1992, &gt; 85 kW</td>
<td></td>
<td>4.5</td>
<td>1.1</td>
<td>8.0</td>
<td>0.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro II</td>
<td>1996.10</td>
<td></td>
<td>4.0</td>
<td>1.1</td>
<td>7.0</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1998.10</td>
<td></td>
<td>4.0</td>
<td>1.1</td>
<td>7.0</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euro III</td>
<td>1999.10 EEV only</td>
<td>ECE &amp; ELR</td>
<td>7.5</td>
<td>0.25</td>
<td>2.0</td>
<td>0.02</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2000.10</td>
<td></td>
<td>2.1</td>
<td>0.66</td>
<td>5.0</td>
<td>0.10</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Euro IV</td>
<td>2005.10</td>
<td></td>
<td>1.5</td>
<td>0.46</td>
<td>3.5</td>
<td>0.02</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Euro V</td>
<td>2008.10</td>
<td></td>
<td>1.5</td>
<td>0.46</td>
<td>2.0</td>
<td>0.02</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Euro VI</td>
<td>2013.01</td>
<td>WHSC</td>
<td>1.5</td>
<td>0.13</td>
<td>0.40</td>
<td>0.01</td>
<td>8.0x10^11</td>
<td></td>
</tr>
</tbody>
</table>

Figure 12. EU emission standards for heavy-duty CI (diesel) engines: Steady-state testing (Source: Dieselnet, 2019)

Figure 13 illustrates a few road shipments using realistic volumes, truck types, load factors and their corresponding CO2 emission by engine classes. The calculations were done with EcoTransIT online emission calculator open version. Switching from Euro III to Euro IV engine class might reduce CO2 emission 3-5% in average from these calculations. But no emission calculations are highly précised as so many external factors such as route selection, traffic characteristics, road slopes, driver behaviour etc. could affect fuel efficiency thus CO2 emission by some margin (Wang & Marzet, 2018).

The case company relies on air transportation a lot which is normal for multinational manufacturers. Reduction of some air shipments are possible. Although, it is hard to predict the total reduction as events like natural calamities or pandemic brings need for faster shipments to sustain lead time. Air transportation can provide companies with a clear competitive edge which the case company considers greatly. Air transportation can be more profitable as time for the capital to be tied up is decreased (Lumsden, 2007). The case company is aware of these competitive advantages but not so much about the emissions difference between air and ocean freights. Figure 14 shows an “as is” and “as if” situation for CO2 emissions. There are 15 heaviest shipments by air that
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the case company transported in 2019. Same aircraft (Boeing 767 freighter) and ocean freight (BC Intra-continental General <35K dwt) is used to calculate the emissions as the real carriers were unknown. Volume and other data are not presented in the figure because of confidentiality.

![Table 1: PORT OF LOADING As is: CO2 AIR (TON) As if: CO2 SHIP (TON)]

<table>
<thead>
<tr>
<th>PORT OF LOADING</th>
<th>As is: CO2 AIR (TON)</th>
<th>As if: CO2 SHIP (TON)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOthenburg, Sweden</td>
<td>60.791</td>
<td>2.434</td>
</tr>
<tr>
<td>Gothenburg, Sweden</td>
<td>44.611</td>
<td>1.786</td>
</tr>
<tr>
<td>Mumbai, India</td>
<td>13.822</td>
<td>0.5117</td>
</tr>
<tr>
<td>Frankfurt, Germany</td>
<td>37.567</td>
<td>1.54</td>
</tr>
<tr>
<td>Malmo, Sweden</td>
<td>35.762</td>
<td>1.56</td>
</tr>
<tr>
<td>Gothenburg, Sweden</td>
<td>33.056</td>
<td>1.3235</td>
</tr>
<tr>
<td>Gothenburg, Sweden</td>
<td>31.46</td>
<td>1.2596</td>
</tr>
<tr>
<td>Guangzhou, China</td>
<td>6.751</td>
<td>0.2011</td>
</tr>
<tr>
<td>Gothenburg, Sweden</td>
<td>22.471</td>
<td>0.8997</td>
</tr>
<tr>
<td>Shanghai Pudong, China</td>
<td>7.703</td>
<td>0.2107</td>
</tr>
<tr>
<td>Frankfurt, Germany</td>
<td>22.077</td>
<td>0.91</td>
</tr>
<tr>
<td>Malmo, Sweden</td>
<td>20.357</td>
<td>0.889</td>
</tr>
<tr>
<td>Chennai, India</td>
<td>5.268</td>
<td>0.19</td>
</tr>
<tr>
<td>Chennai, India</td>
<td>5.268</td>
<td>0.19</td>
</tr>
<tr>
<td>Malmo, Sweden</td>
<td>18.316</td>
<td>0.799</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>365.2801</strong></td>
<td><strong>14.7043</strong></td>
</tr>
</tbody>
</table>

Figure 14. Comparison between air and ocean freight emissions using the same freight aircraft and vessel. Calculations are done using EcoTransIT online emission calculator

It turns out that the CO2 emissions can be around 25 times more for the same amount of freight depending on the mode chosen. In theory, 350 tonnes of CO2 emission could be reduced from these shipments by using ocean freight but in practice it’s difficult to implement. So, the case company needs to find out unnecessary air shipments and take actions to prevent it in future.

Capacity utilisation or the case company puts it as ‘truck utilisation’ will play an important role in achieving environmental sustainability with accordance to the findings. It is also one of the most challenging sectors as it involves many different players. According to Hayes et. al. (2005), complexity in capacity utilisation comes from the interaction of different components such as physical space, equipment, operating rates, human resources, system capabilities, company policy and dependability of the suppliers. An effective way to improve load factor could be by limiting the demands on the short lead times and reducing just-in-time deliveries. The case company has an average of 39% load factor for land transportation inside Thailand. The following table shows supply frequency of 80 local suppliers:

<table>
<thead>
<tr>
<th>Days per weeks</th>
<th>No of suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
</tr>
</tbody>
</table>

Table 5 Supply frequency for local suppliers
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Some of the materials are non-stackable resulting in low filling degree and usage of many trucks. Stack ability of some materials can be improved by better packaging technique and better loading technology. But most materials are transported by Volvo standard packaging boxes which are stackable with no difficulty. Thus, a larger warehouse capacity is required to reduce truck numbers and higher filling degree. If a significant number of suppliers who deliver five or four days a week could deliver three or two days a week, a huge portion of CO2 emission could be mitigated by reducing transport demand. And this change could be proven as pivotal as this is one of the techniques, if not the only CO2 emission reduction technique which can be sustained.

After analysing the activities from Table 4 it seems reducing transport demand through capacity utilization and less air shipments have the most potential in mitigating CO2 emissions in the transport system which answers the research question 2. Table 6 shows a framework of causes and possible mitigation of CO2 in the inbound logistics for the case company. Herein, CO2 mitigation is viewed on different system levels and an interactive approach to CO2 reduction was taken.

Table 6 Framework for the causes and mitigations of CO2

<table>
<thead>
<tr>
<th>Where? Areas</th>
<th>Causes of higher CO2 emissions</th>
<th>Mitigations of CO2 emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Inbound logistics</td>
<td>Demand for short lead times, minimization of inventory size.</td>
<td>Decrease demand for just-in-time, better forecasting.</td>
</tr>
<tr>
<td>2c. LSPs</td>
<td>Lack of proactive measures from production logistics, poor warehouse management, lack of sustainability vision from LSPs and no control over fleet efficiency.</td>
<td>Improved planning of packaging and transporting material, better supplier collaboration, Green logistics purchasing, use of better IT and education.</td>
</tr>
<tr>
<td>2b. Plant logistics</td>
<td>Higher transport demand, shipment by air freight and old trucks with old engines.</td>
<td>Higher filling degree in trucks, reduce unnecessary air shipments and updated fleet.</td>
</tr>
<tr>
<td>2a. Production logistics and suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1c. Lower engine class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1b. Air transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a. Low truck utilization</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6 Discussion and Conclusions

In this chapter, the study is discussed with regards to the methods used as well as the outcomes of the research. Finally, the study is concluded and suggestions for future research are given.

6.1 Discussion of Method

This research was designed around a single case study. Single case studies have the advantage of being not too time consuming and inexpensive. This approach helps an author to have a deeper understanding of the exploring object. However, single case studies have a reputation for biased results which are difficult to generalise. In order to ensure the validity of the findings, it could be helpful to look into more companies for their transport-related sustainability activities. The internal validity and reliability were ensured with the semi-structured interviews which were very insightful. Many follow up interviews with open-ended questions were conducted to validate the findings furthermore.

As mentioned earlier, a mix method research approach was considered. Qualitative method to generate theory and quantitative method to calculate possible amount of emission reduction was the initial plan. This study was performed as a standard project in the case company. Two student interns were appointed to assist the author with data collection and other related stuff. The top management in the Bangkok branch was very enthusiastic about the study and was willing to provide any resources needed to help them with their target of reducing 30% emissions. The author’s internship experience in the case company before the study laid a good foundation for the research as the author investigated Volvo’s CO2 calculation methods and possible flaws in the system. The COVID-19 pandemic had some effect on the depth and the method of the study as many crucial supplier visits had to be cancelled and the interns had to leave the country. The case company had to be shut down and stop production for more than 6 weeks. So, in the end only a qualitative method was approached. The chosen methodical approach was successful to investigate the research questions and purpose thoroughly. High reliability and validity were achieved as expected. However, further research is required in other market settings for automotive companies as a follow up to this study.

6.2 Discussion of Findings

The purpose of this study is to explore and improve automotive manufacturer’s sustainability related activities in their transportation system. The research questions that were constructed to design the study were about automotive manufacturer’s currently planned activities related to sustainable inbound logistics and what activity/activities has the most potential to mitigate CO2 emission for the transportation system. A question could arise that why automotive manufacturers should take responsibility for their emissions in the transport system as they do not own any trucks, ships, trains, or airplanes. Should not the Logistic service providers be held accountable? The answer is manufacturers create demand and LSPs just fill the void. So, it is a responsibility for all parties involved in the operation. The case company, in all probability, will not reach their goal of 30% mitigation by 2025 with current concepts. Nevertheless, this study has been able to pinpoint some activities where automotive manufacturer should find success against the emission battle.
Most employees in the case company were not aware of the new sustainability targets which was evident during the meeting with the whole purchasing team. The initial target plan was announced several months ago but surprisingly the company failed to educate its employees about new competitive strategy. However, it was made clear during the meeting that profitability (company survival) comes before sustainability. The company plans to eliminate some of the local suppliers and replace them with foreign suppliers for cost-effectiveness. The factory is situated in a “tax-free zone” where the manufacturer does not pay tariffs for imported goods but only pay custom fees. So, the buyers are not worried about importing materials from other low-cost markets such as China. So, nearshoring or localisation of supplier bases does not seem to be an option for the case company. Also, companies with production facilities in multiple countries or continents would probably choose one reliable supplier for one specific material. It would not be logical to procure the same parts from different suppliers in different regions. It would only increase uncertainties and quality defects. Localisation manufacturing brings economic prosperity to a country as it creates new jobs and reduces risk giving shorter lead time and own currency transactions. So, in many senses, it is the duty of governments to facilitate companies with better local options. And after all, localising supplier bases does not reduce CO2 in the atmosphere but redistributes them as mentioned by Alaane and Saari (2006).

Fleet renewal and engine class improvement is essential for reliable transport and pollution problems. But this solution does not have a great impact on CO2 reduction. Using LNG as a fuel source would be helpful but the regular drop in fossil fuel prices in the last decade has not helped the cause. Thailand has good resources and vehicle readiness for LNG implementation but in business, cost will always be the first issue for influencing decisions. Considering the reputation and the operation size globally, it was surprising to find out how detached Company X Thailand is from their global sustainability targets. Apart from GHG emissions, Thailand has a big pollution problem. Every winter the big cities get covered with toxic smog and the air becomes unbreatheable. Pollution from automotive vehicles is hugely responsible for this among other reasons. But it appears Company X Thailand is doing less than ideal with emissions as they have little control over their sub-contractors. Effective change is possible through electro mobility only as it seems. The heavy vehicle industry is catching up quickly in the segment. In Sweden, some companies are already using electric trucks inside urban area transportation. Electric trucks have a range of less than 100 km between charges at the moment, but the technology is improving at a fast pace. In Thailand, it is far from reality, but the government is targeting to make Thailand as the centre of electro mobility in Asia by 2025. Historically Thai government has not been very effective against the pollution battle but hopefully the situation changes sooner rather than later.

Capacity utilisation would be the first big step for automotive manufacturers to focus on. The motivation factor should be high as it could reduce costs for transportation. Collaboration with suppliers is crucial for reaching a higher load factor. In practice, companies ignore the capacity utilisation process giving the loading complexity and low transportation prices. More resources such as dedicated manpower should be deployed to work with suppliers for this issue. Manufacturers could also work with suppliers to invest in loading technologies which will be beneficial for both parties. A lot of these sustainability proposals should be communicated during the sourcing or contract renewal process. All transport professionals in the case company agree that just-in-time manufacturing process is the root cause of low capacity utilisation for trucks and containers. For automotive manufacturers production volume always
fluctuates because of fluctuating demands in the market. Fuel prices, economic recessions, carbon taxes, interest rates are a few key drivers for these market instabilities. With lower production volume comes lower load factors as lean production system only allows transportation of immediately needed materials. But time has come to re-evaluate just-in-time practices for manufacturers. Warehouse costs and tied-up capital are the biggest concerns when stepping away from lean. However, the suggestion is not to purchase goods for a quarter in advance but possibly for a week or two. The case company has a few suppliers who send trucks five days a week. If warehouse capacity were to be increased these transport demands could be cut by one-third. These ideas in practice will increase some operating costs for companies but some trade-offs need to be made to reduce CO2 emissions.

Reducing air shipment and introducing 3D printing technology could help greatly in mitigating transport emissions further. These two ideas could complement each other in reality. As the findings suggest lead times are the biggest culprit behind increased air shipments. Automotive manufacturers need to re-evaluate their forecast strategies. Sales teams need to minimize forecast deviations. In the production floor forecasting needs more accuracy as well. Sometimes parts are brought with air freights without realizing the actual lead time. Additive manufacturing technologies such as 3D printing has revolutionised manufacturing for airplane building and medical instrument industry. The technology is not quite ready for automotive industries yet, but they are not far behind. Automotive companies should invest in the technology already as they could learn early about the changes in the machine design which could be made. The case company uses air shipment for a few small, low quantity parts. Once 3D printing becomes operational this demand transportation could go away permanently. Most manufacturers must value air freights because of natural calamities or other unexpected events but the regular shipments must be minimised. Above all stakeholders including customers should be informed about their CO2 footprint from using air shipments shown earlier in figure 14.

Strategic consensus will play a vital role in attaining operations sustainability. If all the departments or organisations in a company are not on the same page, the slope will only get steeper. Most people know about the dangers of climate change but only a handful realises the emergence. Manufacturers must educate employees about climate actions and country-specific goals which should raise awareness. Working with sustainability requires a cultural change in an organisation which demands for necessary resources. Change management must be performed efficiently. Manufacturers could look for outside help such as consultancy firms who are experienced in these matters.
Discussion and Conclusions

6.3 Conclusions
The aim of this study was to explore and develop automotive manufacturer’s sustainability-related activities to reduce CO2 emissions for inbound logistics. The study examines the case company’s proposed key activities to mitigate transport CO2 emissions and their effectiveness for the Thailand operations. The results resonate closely with published literature in the topic. The outcome eliminates a few proposals and accentuates activities where concrete results could be achieved to mitigate CO2 emissions. Collaborating with external partners will be necessary but manufacturers should not rely on them more than they need to. Collaboration with internal partners will be more decisive as the strategic agreement among all internal stakeholders should be the first crucial step. Manufacturers should not commit towards dependency on biofuels or improved engine classes as they have little to no control over these factors. On the other hand, reducing transport demand, through capacity utilisation, less air shipments, 3D printing technology should be explored robustly. Controversial idea like ‘Increased inventory size’ should also be looked up by manufacturers to reduce daily shipments. But most importantly, manufacturers need to ensure their commitment towards environmental sustainability which will require a change in the company culture. Until electro mobility becomes the new standard it appears, reducing transport demand would be the most influential approach to reduce CO2 emission in the inbound logistics.

6.4 Further Research
The results from this study could be used as base for further research in transport CO2 emissions reduction. It would be interesting to observe and compare how these reduction methods would work in other countries or regions for the automotive industry. By gaining more input and feedback from industry the width of the results could be developed even further. Another aspect where more input from academia is required is to have a better model for CO2 emission calculation by minimizing the variables. A multiple case study for the same problem area could turn out to be very helpful. It could help with the generalisability of the results.
7 References


(PDF) Logistics Decisions in Descriptive Freight Transportation Models: A Review.


References

Hills: Sage Publications. Pages: 41-42


Lumsden, K. (2007). Fundamentals of Logistics, compendium, Chalmers University of Technology, Department of Technology Management and Economics, Division of Logistics and Transportation


Rizet Christophe, Cruz Cecilia & Mbacke Mariame (2012). Reducing freight transport CO2 emissions by increasing the load factor.


Schramm W. (1971), Notes on Case Studies of Instructional Media Projects.

References


Wewerinke Margreet and Vicente Paolo Yu III, (2010). Addressing Climate Change
Through Sustainable Development and the Promotion of Human Rights. South Center.


### 8 Appendices

#### 8.1 Appendix 1: Questionnaires

<table>
<thead>
<tr>
<th>Departments</th>
<th>Questions</th>
</tr>
</thead>
</table>
| **1. Material purchasing** | 1. Is your department aware of Volvo’s 2025 sustainability targets?  
2. How do you work with sustainability currently?  
3. What sustainability requirement do you enforce for material suppliers?  
4. How do you follow up with these requirements?  
5. Would your department consider procuring more locally or regionally for upcoming sourcing projects? |
| **2. Logistics purchasing** | 1. Is your department aware of Volvo’s 2025 sustainability targets?  
2. Has your department started green purchasing at this moment?  
3. How do you calculate CO2 emissions currently?  
4. What requirement do you enforce while negotiating with LSPs currently?  
5. Where do you see the future of green purchasing in Thailand? |
| **3. Production logistics** | 1. Is your department aware of Volvo’s 2025 sustainability targets?  
2. What can you tell us about upcoming truck utilization project?  
3. What is the current average load factor for domestic transport? |
| **4. Plant logistics** | 1. Is your department aware of Volvo’s 2025 sustainability targets?  
2. What can you tell us about the current plant logistics setup?  
3. Who makes decisions regarding air shipments?  
4. What is your department doing currently on reducing air shipments?  
5. Are you aware of any transportation wastes such as poor routing or planning in the local road transport? |
## Appendices

| 5. Transport optimization | 1. What software are you currently using for calculating CO2 emissions?  
2. Are you happy with the performance or the usability of this software?  
3. Are you working on further consolidation and milk runs for higher filling degree in trucks?  
4. Do you see co-loading or load sharing an option here in Thailand?  
5. From your experience in the company do you see the possibility to cut emission by 30% by 2025? |
|--------------------------|------------------------------------------------------------------------------------------------|
| 6. Sustainable manager   | 1. Could you elaborate more about the three key activities to mitigate transport CO2 emissions?  
2. What does Carbon pricing mean for the Volvo group at this moment?  
3. Do all the countries in the Volvo group has to cut emissions by 30% or there are different target levels for different countries?  
4. What happens if one country in the region cannot cut emissions by 30% by 2025?  
5. Can another country of Volvo operations makeup for emission reduction in Thailand? |
| 7. Vice president of Transport operations APAC | 1. Is building new warehouses a possibility for Volvo operations Thailand?  
2. How important just-in-time is for local manufacturing?  
3. Is the company willing to adapt if sustainability targets increase production costs?  
4. What are your thoughts about air shipments? There has been a plenty for Bangkok in the past year.  
5. How important part sharing is for Volvo group? |
8.2 Appendix 2: CO2 emission in the transportation system reduction target for some major companies around the world.

Source: International webpage of each company
Appendices