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Logistics / Sea Transportation and Port Operations

Sini Sorviala

REDUCING EMISSIONS BY PRACTICAL SOLUTIONS IN PORT OF MUSSALO

Bachelor's Thesis 2013

TIIVISTELMÄ

KYMENLAAKSON AMMATTIKORKEAKOULU
Logistiikan koulutusohjelma

SORVIALA, SINI	Päästöjen vähentäminen käytännön toimilla Mussalon satamassa
Opinnäytetyö	41 sivua +10 liitesivua
Työn ohjaaja	Lehtori Juhani Heikkinen
Toimeksiantaja	North European Logistics Institute
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Avainsanat	rekkojen kääntöajat, päästöt, satama, ympäristöasiat

Opinnäytetyö oli osa Ecologically Friendly Port – projektia, jonka tavoite on kehittää itäisen Suomenlahden ympäristön tilaa. Projekti keskittyy HaminaKotkan ja venäläisen Ust-Lugan sataman ympäristöasioihin.

Tämän työn tarkoitus oli löytää käytännöllisiä tapoja vähentää päästöjä HaminaKotkan satamassa ja etenkin Mussalon satamassa. Tässä työssä rekkojen kääntöaikoja tutkittiin Mussalossa ja tavoitteena oli löytää ratkaisuja pitkiin kääntöaikoihin. Päästöjä oli tarkoitus vähentää lyhentämällä rekkojen viettämää aikaa satamassa.

Tämä tutkimus suoritettiin käymällä läpi jo olemassa olevia tutkimuksia satamien ympäristöasioista sekä rekkojen kääntöajoista. Tämän jälkeen Stevecon, tullin ja sataman edustajia haastateltiin. Yhden normaalipäivän kääntöajat otettiin sataman kulunvalvontajärjestelmästä.

Pääongelmana olivat rekankuljettajat, jotka eivät siirry suoraan satamaan saatuaan kulkuluvan. Rekkojen ajanvarausjärjestelmä voisi olla ratkaisu tähän, sillä silloin kuljettajilla olisi ennalta määrätty aika, jolloin heidän olisi ajettava satamaan. Tämä myös poistaisi jonot, jotka johtuvat rekkojen yhtäaikaisesta saapumisesta satamaan.

ABSTRACT

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SORVIALA, SINI	Reducing Emissions by Practical Solutions in Port of Mussalo
Bachelor's Thesis	41 pages + 10 pages of appendices
Supervisor	Juhani Heikkinen, Senior Lecturer
Commissioned by	North European Logistics Institute
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Keywords	truck turn times, emissions, port, environmental issues

This thesis was a part of Ecologically Friendly Port -project, which aims to improve the environmental status of the eastern Gulf of Finland. The Ecologically Friendly port- project is focused on the environmental issues relating to Ports of HaminaKotka and Ust-Luga in Russia.

The objective of this study was to find practical ways to reduce emissions in the Port of HaminaKotka and especially in the Port of Mussalo. In this thesis truck turn times were researched in Mussalo and the goal was to shorten the turn times. Emissions were to be reduced by decreasing the time that trucks spend in the port.

This research was carried out by reading through already existing studies of environmental issues in ports and truck turn times. Then Steveco, customs' personnel and the port authority were interviewed. The turn times for one usual day were taken from the port's access control system.

The main problem was the truck drivers, who do not drive to the port straight after they have gotten their access pass. Truck appointment system could be a solution to this as the drivers would have a given time slot to go to the port. This would also be a solution to the other problem, which is the queues in the port because the trucks arrive at the same time.

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1 INTRODUCTION

This thesis was a part of the Ecologically Friendly Port - project that has begun in December 2012. The project is meant to create close cooperation between citizens and public authorities. The goals are sustainable regional development, increased ecological awareness, and improved understanding of the responsibility of ports with regard to the climate change. The project also aims to improve cooperation between the port authority and port operators.

The Ecologically Friendly Port - project will be executed by analyzing the state of the region's environment and by developing compensatory measures for improving it, by researching the environmental regulations and by creating a surveillance center for the regulations.

This part of the project examined turn times of container trucks in the Port of Mussalo and its purpose was to find a solution for the long turn times. The purpose of this thesis was to reduce emissions from the trucks with practical solutions such as reducing the time spent inside the port gates by the trucks.

1.1 Research Method

This research was conducted by going through existing international material on truck turn times. First a journal database called Emerald was used to search journal articles on truck turn times and emission reductions in ports, and then the Internet was searched using the same criteria. A few articles were found in Emerald and a study of the port of Los Angeles was found in the Internet.

Interview questions were created based on the information from journal articles, and port operators were interviewed. First the production manager of Steveco’s office in Mussalo Arto Sinikannas was interviewed about the turn times of their terminal. Then Satu Tapola and Ari Holopainen from customs were interviewed to find out how their services affect the turn times. The purpose of the interviews was to find reasons for long turn times and possible improvement suggestions.

The turn times of the Port of Mussalo for one example day were taken from the ports

access control system. The chosen day was a normal day; it was neither a slow one nor a congested one. The port's traffic coordinator Markku Koskinen was also interviewed about the turn times. Finally existing research papers were reviewed in order to find solutions for the port of Mussalo.

1.2 Ecologically Friendly Port

The project is led by the Russian State Hydrometeorological University and the project consortium includes Ust-Luga Company JSC, University of Turku Centre for Maritime Studies and Kymenlaakso University of Applied Sciences. The project associates are Port of HaminaKotka, City of Kotka, Finnish Port Association and Administration of Leningrad Region Committee on Natural Resources. (Ecologically Friendly Port, 2013.)

The overall objectives of the project are:

- Improving the environmental status of the eastern part of Gulf of Finland,

- Improving the ability of the ports to develop the environmental protection and sustainable growth in ports,

- Improving the municipalities' ability to enhance environmental safety issues,

- Increasing the awareness of the citizens' green thinking. (Ecologically Friendly Port, 2013.)

The main outputs of the project regarding the port of HaminaKotka are recommendations to decrease air emissions, to improve energy effectiveness and to decrease noise level in the port, and to review the environmental status of the port. The project also aims to give a description of light and movable noise walls for ports and to give recommendations about the development of co-operation between stakeholders in the port. (Ecologically Friendly Port, 2013.)

1.3 Port Operations

The word port has three definitions; as a physical area a port consists of the dock area,

fields, quays, fairways, and land routes. The port also consists of the entire infrastructure, such as warehouses, cranes and terminals, related to the port activities. In the largest definition of port, it includes all the services provided by different organizations in the port. (Karvonen and Tikkala, 2004.)

The stakeholders of the port can be divided into four different groups; port organizations, port users, public authority and service providers (Santala, 1989). Port organizations are port authority, owner companies, and port operators also known as stevedoring enterprises. Bringing cargo alongside a ship and moving the cargo to trucks or warehouses is a part of stevedore's work. (Pöllänen et al., 2005, p.77.)

Freight forwarder represents the cargo owner in a port. They arrange the goods to be in the right place at the right time for the right price. Freight forwarding company plans transportation and arranges the necessary cargo handling and customs clearance. In addition the freight forwarder supplies information between transportation companies, insurance companies, customs and banks. (Vuoristo, 1994.)

Customs has four different tasks in a port. The tasks can be divided into surveillance, rating and collection, and statistics. Customs prevents illegal import and export and it collects tariffs for products that go through customs clearance. Customs also collects other fees that belong to the state. (Santala, 1989.)

Steveco is the main port operator in the port of HaminaKotka. It offers stevedoring, freight forwarding, transportation, and terminal services to companies that work in export, import or transit traffic. Steveco Oy is the leading port operator and market leader in the Finnish forest industry's transportation and transit traffic. Steveco group had approximately 950 employees and Steveco Oy had 816 employees in 2011. Group's turnover was 146,2 million Euros and stevedoring tonnages were 11,1 million tons that same year. (Steveco, 2013.)

The vision of Steveco:

"Steveco is a respected, competitive and profitable enterprise which provides and develops port and logistics services for the requirements of clients." (Steveco, 2013.)

The Business idea of Steveco:

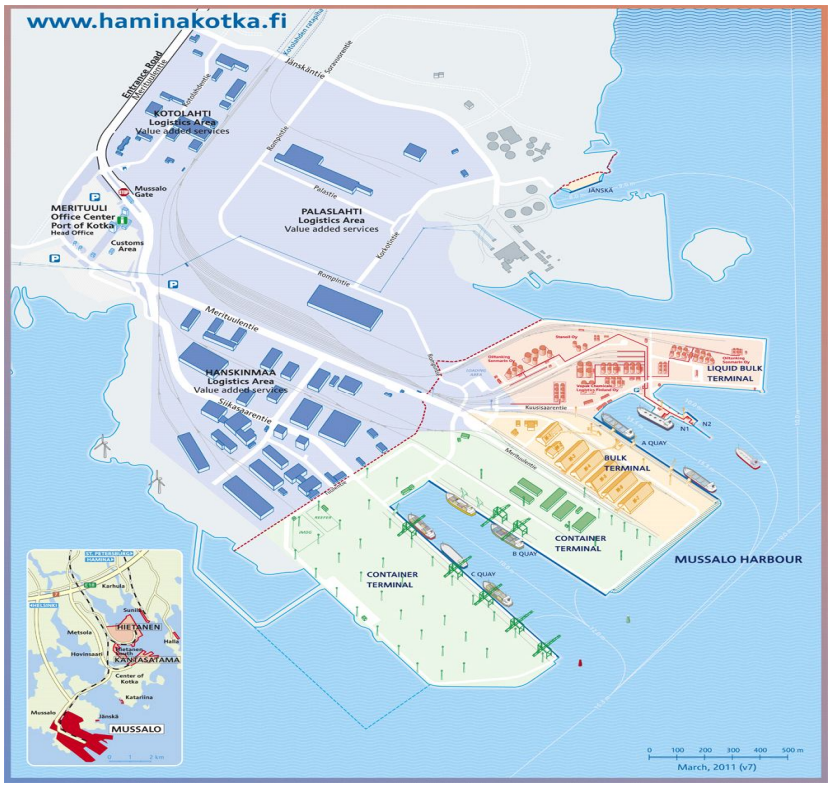
"Steveco is to solve its clients' cargo handling and logistics service requirements cost-effectively, profitably and in an environmentally sustainable manner. This is accomplished through the expertise and productive work of the entire personnel." (Steveco, 2013.)

1.4 Port of HaminaKotka

HaminaKotka is the largest universal, export and transshipment port in Finland. The port provides good connections to the Baltic Sea region and also to other European, Asian and Russian markets. It is located 35 kilometers from the Russian border. Because of its eastern location HaminaKotka is specialized in transshipment to Commonwealth of Independent States(CIS) countries. A 15-meter fairway enables connections not only to Europe but also to other parts of the world. (Port of HaminaKotka, 2013.)

Ten port operators and 170 other businesses work in the port in its 1,100 hectares of port land area. One of the most efficient container terminals in the Baltic Sea is located in HaminaKotka. The port also has liquid bulk terminals, which are specialized in providing handling and storing services for liquid bulk cargos. (Port of HaminaKotka, 2013.)

The port of Mussalo serves container, bulk and liquid bulk vessels. There are 1,792 meters of quays for container traffic and 600 meters for bulk traffic. Twelve berths are reserved for container vessels with the draught of ten to twelve meters. Seven container cranes operate the vessels with lifting capacity of 30 to 40 tons. Bulk traffic occupies four berths with the draught of 13,5 to 15,3 meters. The vessels are operated by three 40-tonne-cranes and by one eight-ton-crane. (Port of HaminaKotka, 2013.)



Picture 1Port of Mussalo (Port of HaminaKotka, 2013.)

2 ENVIRONMENTAL IMPACTS OF TRANSPORTATION

Global warming is a major problem in the present world and transportation with its emissions contributes to it. This is why the environmental impacts of transportation are covered in the following chapters. First transport related emissions are presented and then their environmental effects are explained.

2.1 Emissions from Transportation

Carbon monoxide, nitrogen oxides, volatile organic compounds and particulate matter are the main emissions from transportation, which can cause major health and environmental problems. This chapter covers these emissions more thoroughly.

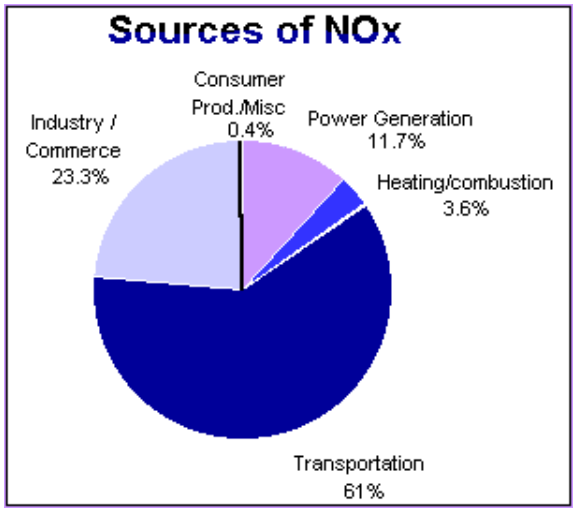
2.1.1 Carbon Monoxide

CO is a colorless, odorless gas emitted from incomplete combustion process. It can cause health effects as it prevents body's organs and tissues of getting enough oxygen. If carbon monoxide levels rise too high, it can cause death. The first air quality standards for CO were set in 1971. Unites States Environmental Protection Agency (EPA)

set an 8-hour primary standard at 9 parts per million (ppm) and a 1-hour primary standard at 35 ppm. (EPA United States Environmental Protection Agency, 2012.)

2.1.2 Nitrogen Oxides

Nitrogen oxides (NOx) consist of nitric oxide (NO), nitrogen dioxide (NO2) and nitrous oxide (N2O) and are formed when nitrogen (N2) combines with oxygen (O2). Nitric oxide and nitrogen dioxide exist in the atmosphere from one to seven days and nitrous oxide up to 170 years. The main source of nitrogen oxides is from the burning of fossil fuels. (Clean Air Strategic Alliance, 2013.)



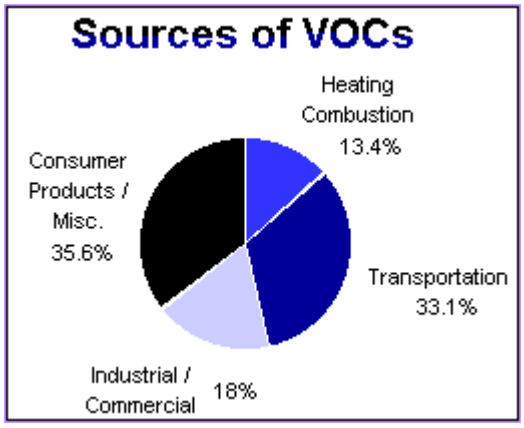
Picture 2 Sources of NOx (Environmental Journalism Canada, 2013.)

Twenty percent of the atmosphere's volume is nitrogen. Nitrogen oxides stay between one and three days in the atmosphere, which means that they can be transported up to 1,200 kilometers. (OECD, 2011.) Nitric oxide is not harmful, but it is converted into nitrogen dioxide in the air. At high levels it is potentially toxic to plants, can injure leaves and reduce growth. (Clean Air Strategic Alliance, 2013.)

As a component of smog, nitrogen dioxide irritates lungs and increases susceptibility to respiratory infections (Clean Air Strategic Alliance, 2013). Nitrogen oxides contribute to the formation of ozone, which is hazardous to health and can cause vegetation damage and crop yields. They also affect biodiversity on land and in coastal waters. (OECD, 2011.) Picture 2 shows that most of the nitrogen oxides are originated from transportation. (Environmental Journalism Canada, 2013.)

2.1.3 Volatile Organic Compounds

Volatile organic compounds (VOC's) are caused by evaporation of fuel and are another ingredient in ozone production. Many of the VOC's are harmful especially benzene, which is carcinogenic. (Gilbert and Perl, 2010, p.189) Picture shows the distribution between the sources of volatile organic compounds in Canada. (Environmental Journalism Canada, 2013.)



Picture 3 Sources of VOC's (Environmental Journalism Canada, 2013.)

One third of volatile organic compounds are originated from transport. Another third comes from consumer products and the last third comes from heating combustion and from industrial or commercial sources.

2.1.4 Particulate Matter (PM10)

Particulate matter is also known as particle pollution or PM. It is a mixture of very small particles and liquid droplets. It consists of acids, organic chemicals, metals, and soil or dust particles. Particles that are ten micrometers in diameter or smaller (PM10) pass through the throat and nose and enter the lungs. (EPA United States Environmental Protection Agency, 2013.) It can take hours or days for these particulates to settle on the ground. (OECD, 2011.)

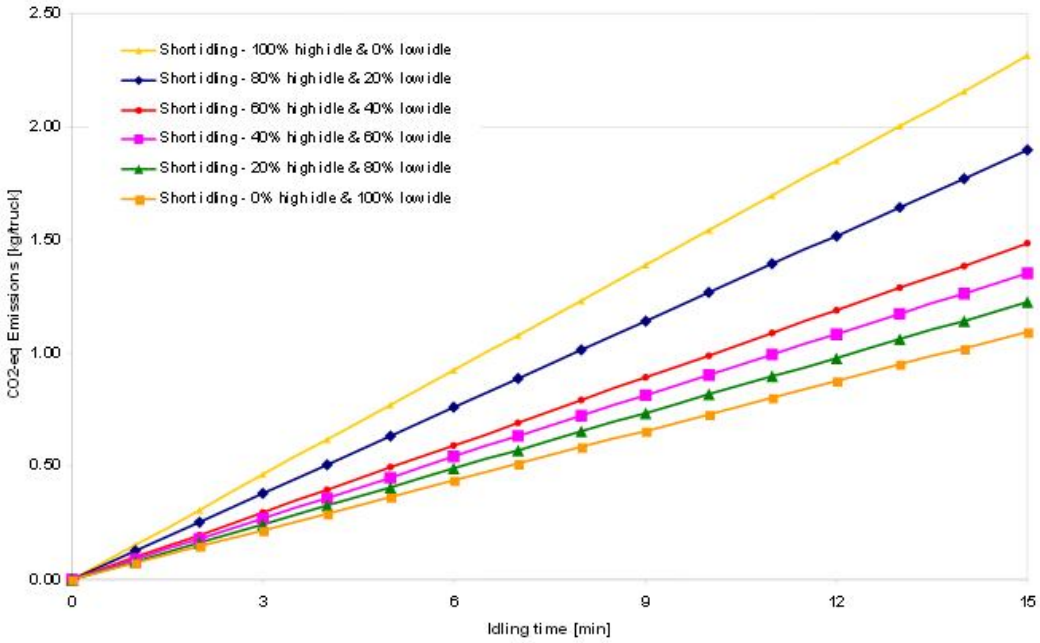
The particles can effect heart and lungs and cause serious health effects. Fine particles can form when gases from vehicles react in the air. These particles are 2.5 micrometers in diameter or smaller. (EPA United States Environmental Protection Agency, 2013.) The finest fractions of particulate matter stay in the air and can move long dis-

tances. They have climate-forcing impacts; they either contribute or offset the effects of greenhouse gases. (OECD, 2011.)

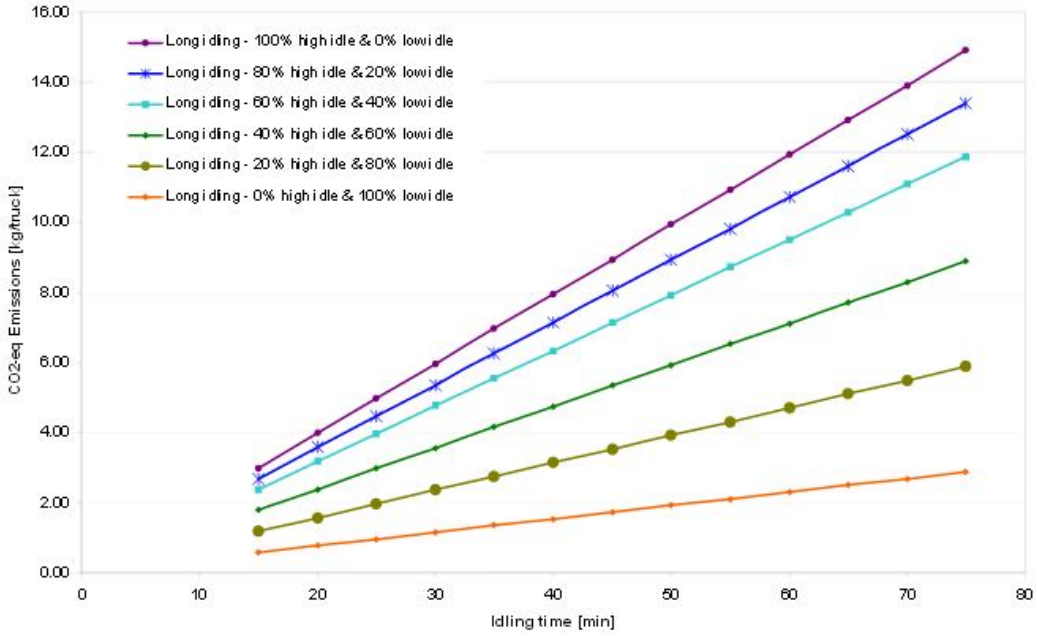
2.2 Emissions during Idling

The pictures four and five show carbon dioxide emissions created by idling. Picture four shows the effect of using appliances on emissions during short idling and picture five shows the effect of using appliances on emissions during long idling. Short idling occurs when trucks move regularly such as in traffic or gate wait. This means that the idling lasts under 15 minutes. Long idling occurs when trucks stay at one place for a long period of time, such as waiting for a load. (Morais and Lord, 2006.)

High idling means idling with the engine operating at high revolutions per minute (RPM). A high RPM runs when air conditioning, heaters, microwaves, TV and other on-board accessories are used. This happens mostly in hot or cold weather. Low idling means idling with the engine operating at low RPM. This happens in temperate climates and during short waiting. (Morais and Lord, 2006.)



Picture 4 Emissions per Truck during Short Idling (Morais and Lord, 2006)



Picture 5 Emissions per Truck during Long Idling (Morais and Lord, 2006)

As the pictures four and five show the carbon dioxide emissions during idling are quite high. For example if a truck has to wait in line for sixty minutes during winter time and the heaters are on, the carbon dioxide emissions rise up to twelve kilograms.

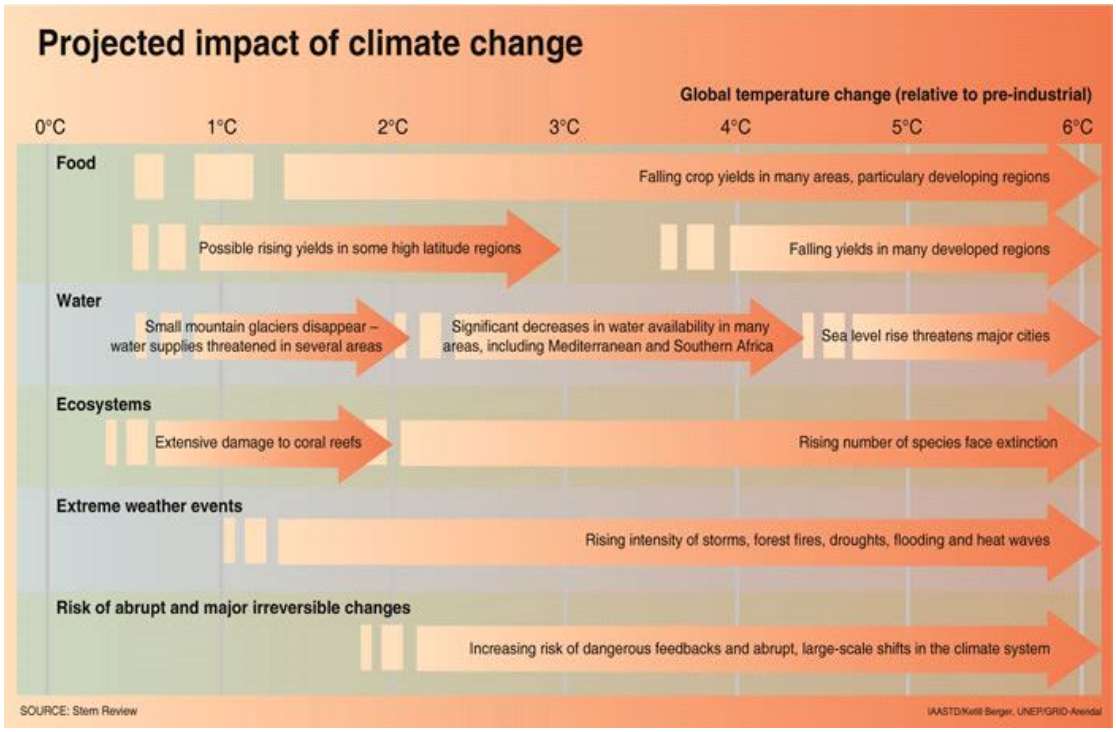
2.3 Climate Change

The average temperature of the planet's surface has been rising and it is believed that greenhouse gases (GHGs) are the reason for it. Even a few degrees' increase in the temperature can cause serious consequences, which include an increase in extreme weather events, changes in land and marine growing seasons and species composition, sea level rise and consequent flooding, changes in water availability, infrastructure damage and health effects from heat stress, and changes in disease patterns. (Gilbert & Perl, 2010, 171-173.)

Global warming causes disintegration of polar ice, thawing of permafrost, dying coral reefs, rising sea levels and fatal heat waves. If the temperature rises even by 2°C, millions of people are threatened by an increased risk of hunger, malaria, and water shortages. The risk of total rainfalls has increased in Northern Europe, which can result in devastating floods. Global warming could be stopped by reducing the emission of GHG's into the atmosphere. (Isover, 2008.)

Picture 6 shows the effects of global temperature change. Even a-two-degree change can affect crops, in developing regions the crop yields start falling, and in some high latitude regions the yields might rise. Over a-four-degree rise in temperature could cause falling yields in many developed regions. A-one-degree change would cause small mountain glaciers to disappear and water supplies would be threatened in several areas. A-three-degree change would mean significant decreases in water availability in many areas, including Mediterranean and South Africa. An-over-four-degree change would make the sea level rise threaten major cities. (Isover, 2008.)

A one-degree change in global temperature would damage coral reefs extensively and over a-two-degree change would mean that a rising number of species would face extinction. Even a slight change would mean rising intensity of storms, forest fires, droughts, flooding and heat waves. A two-degree change would increase the risk of dangerous feedbacks and abrupt, large-scale shifts in the climate system. (Isover, 2008.)

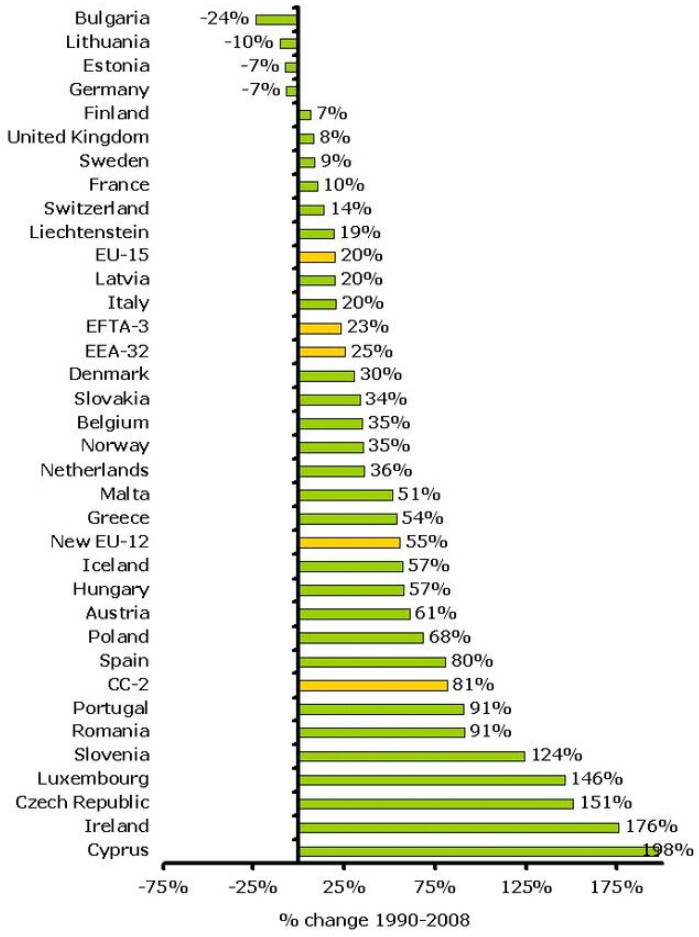


Picture 6 Projected Impact of Climate Change (Isover, 2008.)

2.4 Other Global Effects

Chlorofluorocarbons (CFCs) and similar compounds cause ozone depletion as they rise to the stratosphere where they dissociate into elements that combine with and deplete ozone. This allows more medium-wavelength ultraviolet light, which is harmful to life in big amounts, to passage trough. (Gilbert & Perl, 2010, 184.)

Transport related persistent organic pollutants (POP's) are a by-product of the combustion of petroleum fuels. POP's can appear far away from their original source. This is of great significance since they may cause adverse effects to human health or environment. (Gilbert & Perl, 2010, 185.)



Picture 7 Change in total GHG emissions from transport (European Environment Agency, 2013.)

In the picture 7 EU-15 refers to 15 old EU Member States prior to May 2004 (Austria,

Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom), EFTA-3 to the three EFTA countries (Liechtenstein, Norway and Switzerland), New EU-12 to 12 new EU Member States as of January 2007 (Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia) and CC-2 to the two candidate countries Turkey and Iceland. (European Environment Agency, 2012.)

As picture 7 shows emissions have risen by 20% in the EU-15 countries, in which Finland is included, between 1990 and 2008. This is a fifth of the total GHG emissions in 2008. The main source of emissions from transportation is CO2 (99%) and road transport is the greatest contributor to these emissions (93%). Road and air transport are the two fastest growing sources of transport GHG emissions between 1990 and 2008. (European Environmental Agency, 2012.)

3 OTHER ENVIRONMENTAL ISSUES

This chapter discusses other environment-related issues such as requirements for heavy-duty engines and fuel quality. It also presents the ISO quality management system.

3.1 Russian Vehicles and Their Emissions

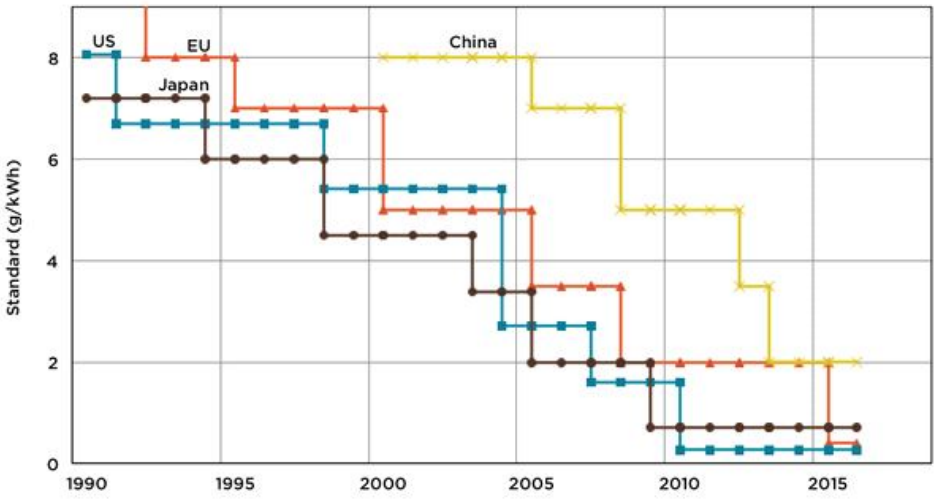
As most of the foreign trucks at the port of HaminaKotka come from Russia, the next chapter is about Russian vehicles and their emissions. Engines of Russian heavy duty trucks are required to meet European emission standards. The implementation schedule is shown on Table 1. All new trucks sold must meet these regulations. (DieselNet, 2013.) Table 2 shows the emission standards for heavy duty trucks. For example the average standard value for nitrogen oxides in 2013 is 0.2-1.0 grams per kilowatt-hour and for particulate matter 0.01-0.02 g/kWh. (Transport Policy, 2013.)

Table 1 Emission Requirements for Heavy-Duty Engines (Transport Policy, 2013.)

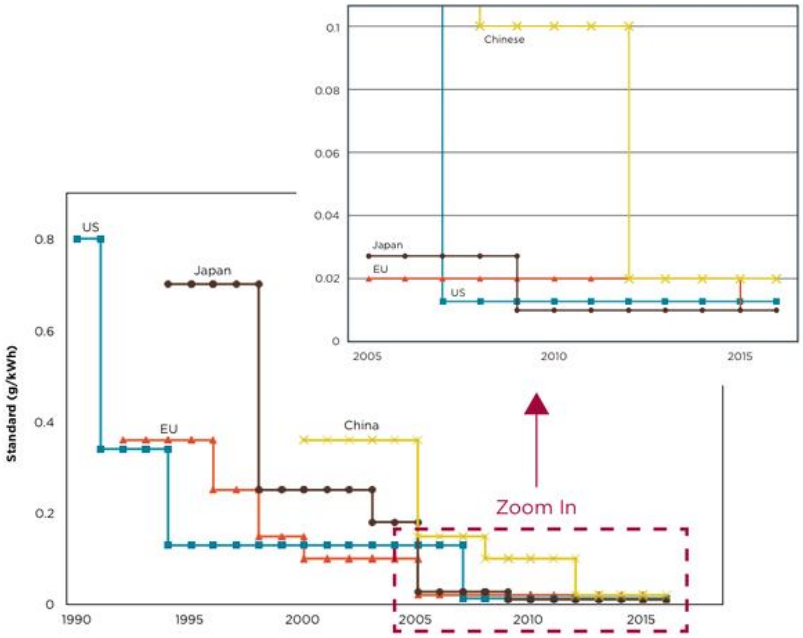
DATE	REQUIREMENT
1999.01	Euro I / Ecological Class 1 (ECE R49.02)
2006.01	Euro II / Ecological Class 2 (ECE R49.02 Stage 2
2008.01	Euro III / Ecological Class 3 (ECE R49.04-A)
2014.01	Euro IV / Ecological Class 4 (ECE R49.04-B1)
2016.01	Euro V / Ecological Class 5 (ECE R49.04-B2 C)

Table 2Heavy Duty Emission Standards (Transport Policy, 2013.)

REGION	REGULATION AND YEAR	AVERAGE STANDARD VALUES (g/kWh)	
		NOx	PM
United States	2002–2004	2.7	0.13
	2007	1.6	0.013
	2010	0.27	0.013
European Union	Euro III (2000)	5	0.1
	Euro IV (2005)	3.5	0.02
	Euro V (2008)	2	0.02
	Euro VI (2013)	0.2-1.0	0.01-0.02
Japan	2003–2004	3.38	0.18
	2005	2	0.027
	2009–2010	0.7	0.01



Picture 8 NOx Standards for Heavy-Duty Engines (Transport Policy, 2013.)



Picture 9 Particulate Matter Standards for Heavy-Duty Engines (Transport Policy, 2013.)

Pictures 8 and 9 describe the NOx and particulate matter standards during the years in different countries and areas. The pictures show the same information as table 2, but it shows the figures from a longer time period. For example the standard value for nitrogen oxides in the United States in 1990 was 8 g/kWh and the standard value for particulate matter was 0.8 g/kWh.

The following table 3 will show the requirements for Russian fuel for the next few

years. The maximum sulfur amount allowed in the Russian trucks in 2013 is 350 parts per million (ppm) and by the year 2016 the maximum sulfur amount will be only 10 ppm.

Table 3 Russian Diesel Fuel Sulfur Limits and Implementation Dates (Transport Policy, 2013.)

FUEL	MAX. SULFUR	NATIONAL IMPLEMENTATION DATE	
		Actual	First Proposed
Type I (Euro 3)	350 ppm	2013.01	2009.01
Type II (Euro 4)	50 ppm	2015.01	2010.01
Type III (Euro 5)	10 ppm	2016.01	2013.01

3.2 ISO 14001

Port of HaminaKotka Oy's managing system consists of certified environment and quality management standards ISO 14001 and ISO 9001. The port aims to continuously improve and develop the level of operations, quality and environmental protection to better serve their customers and promote the competitiveness of business in their area of operations. (Port of HaminaKotka, 2013.)

The environmental management system of the port of HaminaKotka realizes and assesses environmental impacts, plans and implements improvements, prepares for emergencies, and ensures that environmental impacts are monitored and communication lines are open. (Port of HaminaKotka, 2013.)

The negative environmental impacts can be reduced by managing environmental issues. By managing the issues environmental awareness can be raised and interaction between the stake holders in the port can be increased. The entire staff must be dedicated to the environmental managing system to ensure its functioning and environmental issues must be taken into account in every operation. (Port of HaminaKotka, 2013.)

When a company agrees to the environmental certificates, it is therefore committing to improving the level of environmental protection, and it acknowledges the environmental effects of its products, operations and services. The company ensures the fulfill-

ment of its legal responsibilities. It also maintains the knowhow of its personnel and directs processes and operations. The company is required to prepare for environmental risks and accidents, supervise and follow the environmental effects, and prevent environmental hazards and their renewal. The certificate also requires the company to maintain good environmental practice, evaluate the results, and improve its operations. (Suomen Standardisoimisliitto SFS, 2013.)

The organization benefits in various ways from the environmental management system. The certificate combines environmental issues as part of management and the planning of operations. It increases the cost effectiveness by enhancing the use of raw materials and energy and also by reducing the amount of waste. The environmental management system improves the environmental knowledge and involvement of the personnel. It also ensures the company to follow the environmental legislation and helps to predict future changes. (Suomen Standardisoimisliitto, 2013.)

It promotes the consideration of environmental issues in different stages of product and service chains. The environmental management system improves the management of environmental risks and guarantees the continuity of operations. It shows stakeholders responsibility of environmental issues, and supports the organization’s environmental communication and building of the company's image and marketing. (Suomen Standardisoimisliitto, 2013.)

4 TRUCK APPOINTMENT SYSTEMS

This chapter covers theory for one possible solution for shortening the truck turn times in the port of HaminaKotka. First previous studies are discussed, then a vehicle booking system is presented and finally some examples of the advantages of a vehicle booking system are given.

4.1 Previous Studies

Some studies of truck turn times in ports already have been conducted and main findings of those studies are presented in the following three chapters. First the importance of information systems related to port truck turn times is explained, then the problem

of empty truck trips is presented and finally the advantages of truck appointment systems are covered.

4.1.1 Information Systems

The challenge at ports is that the arrival times of trucks are left for truck operators to be decided. Without coordination between truck operators and terminals fluctuations in traffic volumes occur, which lead to under- or overutilization of terminal capacity. Overload on gates and terminals lead to longer waiting times and congestion, lost revenues for drivers, decreased throughput, wasted fuel, and increased air pollution in ports. (EPA United States Environmental Protection Agency, 2013.)

According to the case studies conducted by Morais and Lord (2006) extended gate hours and gate reservation systems are effective in reducing truck emissions in the port of Vancouver. Truck idling can be decreased by integrating the truck appointment systems and extending gate hours. U.S. Environmental Protection Agency suggests that implementing an automated terminal appointment system can decrease the time a truck spends waiting outside the terminal gates. They have found out that by doing so turn times can be reduced by 30%.

Port information systems can offer advanced freight scheduling, and appointment and container tracking information to trucking companies and container terminals. Benefits of these information systems can be alleviation of congestion and delays at the terminal gate, fuel savings and reduction of vehicle greenhouse gas (GHG) emissions.

Many ports have implemented truck appointment systems, vehicle booking systems, and truck licensing systems to reduce container truck volumes and congestion. A concern is how to improve or adjust the functions to enhance capacity and reduce carbon emissions. (Islam, Olsen and Ahmed, 2013.)

If truck arrival rates are not pre-determined, the demand and supply of capacity cannot be met, which creates long waiting times and increased turn times for trucks (Islam, Olsen and Ahmed, 2013.). Turn time is one of the most important performance measures of port efficiency (Lubulwa, Malarz and Wang, 2011).

The Gate Entry Management System (GEM) has been implemented in the Port of New Orleans. GEM is a web based application that integrates the terminal management systems of multiple operators. It allows dispatchers to schedule appointments and provide information for pre-clearance prior the trucks arrival at the terminal gates, which reduces paperwork and provides early identification of problem transactions. (EPA United States Environmental Protection Agency, 2013.)

As a result, traffic flows have improved, terminal throughput has increased and productivity of terminal operators and trucking companies has improved. The Georgia Ports Authority's Web Access system provides real-time access to online data on container shipments. The result has been a decrease in waiting times at the gates and savings of approximately 11,430 liters on fuel, a half ton of nitrogen oxide and 33 tons of carbon dioxide on a peak day. (EPA United States Environmental Protection Agency, 2013.)

4.1.2 Empty Truck Trips

Islam, Olsen and Ahmed (2013) address the problem of empty container truck hauling process in their research. The problem arises in ports because of the lack of information exchange between exporters and haulers. Trips could be matched to and from warehouses, seaports, and truck companies. The problem with empty trucks can cause additional vehicle miles travelled, truck-related emissions, and a deficit in potential transport capacity.

The problem of an empty truck occurs often in export. Unutilized slot transportation happens when a truck leaves to pick up an empty container from the port. Then a partially unutilized truck delivers the container, which is often a twenty foot equivalent unit (TEU), to a warehouse although it could be transporting two TEUs. This creates congestion and increases carbon emissions in a port. Another unutilized trip is created when a truck moves the loaded container from the warehouse to the port and leaves empty from the port territory. (Islam, Olsen and Ahmed, 2013.)

4.1.3 Truck Appointment Systems

The case study port in Islam, Olsen and Ahmed's (2013) research has developed its

transport process from a conventional truck transport process to basic truck appointment system (BTAS) and then to advanced truck appointment system (ATAS) at the port gates. The result has been a reduction in truck turn times from almost four hours to approximately 25 minutes. The application of computing, communication and controlling (CCCT) can increase the container throughput by 4 percent and lower operating costs by 14.78 percent (Zhong and Yin, 2010).

Implementation of the BTAS in the case study port has helped importers and exporters with inventory planning, labor utilization and space management. It provides arrival or delivery timetables for containers and assists trucking companies to increase truck utilization. Dramatic changes were acquired to achieve the turn time reduction of almost three and a half hours but then on the other hand they enable further continuous improvement for the port. (Islam, Olsen and Ahmed, 2013.)

The basic truck appointment system has limitations, for example it can be misused by the truckers. The system allows truck operators to book an appointment without cross-checking the container information. The advanced truck appointment system does not have the same problem as it will not allow a time slot reservation unless all the container information is matched with the container announcement message. Once the provided information (vessel and voyage information, cargo type, and number and type of containers) is validated against the container, an appointment can be made. (Islam, Olsen and Ahmed 2013.)

BTAS is also limited by the manual gate process, which ATAS is not. In ATAS a gate card can be obtained online and the truck driver can scan his driving license and enter a personal identification number (PIN) and then drive to the designated area of the terminal. BTAS also fails to cross-check booked timeslots by other stakeholders, such as exporters and importers, which is not a problem in the ATAS. (Islam, Olsen and Ahmed, 2013.)

4.2 Vehicle Booking System VBS

In this chapter an example of a vehicle booking system is presented. This VBS is used in the port of Southampton.

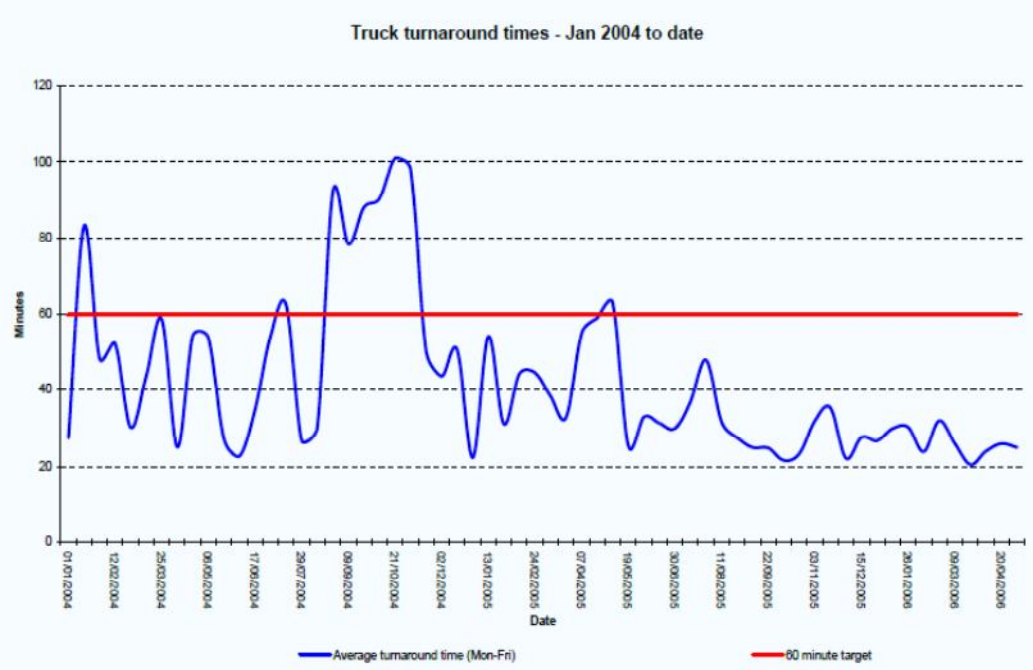
Vehicle booking system is designed to achieve a constant flow of vehicles at the port's gate. It is also meant to improve truck turn times and provide a simplified system which is fair, flexible and easy to use for all users. The system can be mandatory so if no appointment is made, the truck cannot arrive at the port. In the port of Southampton charges apply for peak slots and if the truck does not arrive at the right time. (McCrindle, 2013.)

In the system at Southampton all information and user interaction is web-based. The booking can be amended as many times as haulers wish prior entry to the terminal. Haulers can also change the booking time but there are a limited number of bookings allowed per hauler. A 24-hour Help Desk exists to assist drivers with any queries. In Southampton the simplified vehicle booking system was introduced at the same time as a reorganization of gate processes and systems. (McCrindle, 2013.)

The terminal benefits from the VBS as the trucks arrive as a consistent flow. This reduces the amount of trucks at peak hours and decreases traffic in ports. The haulers can be informed of issues that affect the terminal such as high winds or fog, and this allows the haulers to allocate trucks alternative work. (McCrindle, 2013.)

VBS improves security in ports as a VBS security number, which the trucks get at booking, is required for entry to terminal. The booking is also linked to registration. The haulers must be registered before booking, which eliminates 'rogue' haulers. The system also requires banking details for successful registration as all charges are collected through direct debit. (McCrindle, 2013.)

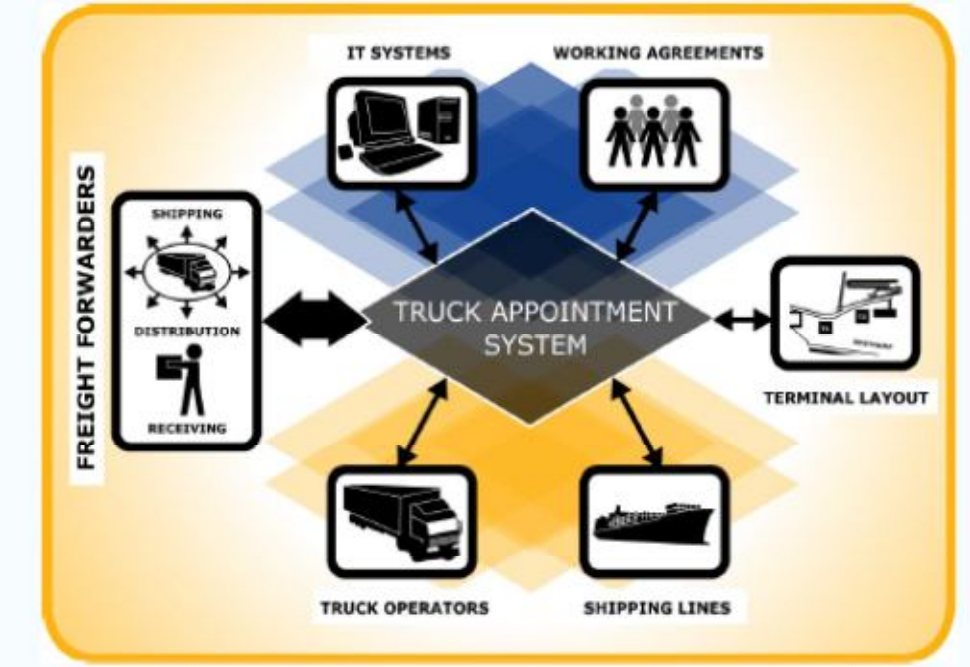
As the picture 10 shows the turn times have decreased from around 50 minutes to twenty to forty minutes after the implementation of the vehicle booking system in the port of Southampton. (McCrindle, 2013)



Picture 10 Truck Turn Times in the Port of Southampton (McCrindle, 2013.)

Also stakeholders benefit from the booking system. Shipping lines and freight forwarders get consistent high level of service. The system allows cessation of import errors such as no wasted truck journeys due to import container not being available. The VBS also improves the reliability of service as on time deliveries of goods have increased. (McCrindle, 2013.)

Many parties benefit from a truck appointment system as seen on picture 11. The haulers benefit as the operating costs have reduced significantly, and they have the ability to manage truck fleet effectively due to predictability of service, and ability to view live information. The haulers have also confidence in the terminal to service their truck at whatever time. Local communities get the benefit of reduced congestion on local roads and reduced air pollution in local area as there are no idling trucks in the port and no wasted journeys. (McCrindle, 2013.)



Picture 11 Practicalities of Implementation of Vehicle Booking System (McCrindle, 2013.)

4.3 Examples of Advantages of VBS

Port of Los Angeles has implemented a vehicle booking system and this chapter explains the study conducted in the port after the implementation. This chapter also presents the changes in the turn times after the implementation of the truck appointment system.

4.3.1 Port of Los Angeles

The Port of Los Angeles Long Beach uses a truck appointment system in all of its terminals except for Total Terminals Inc., where the system is mandatory. According to Philip Davies, principal at Davies and Associates Transportation Consulting in Vancouver, British Columbia, the appointments have improved terminal productivity significantly and the trucking companies can experience good turn times. (The Journal of Commerce, 2009.)

PierPass Inc. and Ability/Tri-Modal Transportation Services conducted a study of turn times at the Port of Los Angeles and Long Beach. The study evaluated three time periods, queue time spent before entering the port, terminal visit time and the total visit

time, which is the sum of queue and terminal time. (PierPass, 2013.)

In October the total median visit time was 51 minutes, with 20 minutes queue time and 31 minutes terminal time. Most of the visits take less than two hours, 27% are under 30 minutes, 58% are under an hour, 7 % take under one and a half hours, and 86% take under two hours. Approximately 91% of queue times are under an hour. Cargo volumes rose in the spring and summer of 2010 and the terminal operators added their service hours. This resulted in a visit time decrease of 13%, even though the cargo volumes increased by 6%. (PierPass, 2013.)

4.3.2 Emission Reductions

According to the research conducted by Morais and Lord (2006) emissions were reduced by 84 % in TraPac Terminal in Los Angeles and by 92 % in STS Terminal in Oakland. As shown on the picture 12, emissions per truck reduced from 35.53 to 9.6 kilograms at TraPac Terminal and from 39.08 to 2.2 kilograms at STS Terminal. (Morais and Lord, 2006.)

	Past			Current			% Reduction
	Emissions per Truck [kg/truck]	Gate Moves /day	GHG Emissions [tons/day]	Emissions per Truck [kg/truck]	Gate Moves /day	GHG Emissions [tons/day]	
TRAPAC	35.53	1650	58.6	2.67	3600	9.6	84%
STS	39.08	700	27.4	2.41	900	2.2	92%

Picture 12 Comparison of Past and Current Waiting Times and Gate Moves (Morais and Lord, 2006.)

TraPac suffered from operation problems at the gate and in-yard and as a result the terminal authorities decided to implement automation technologies. The average waiting time before the implementation of the technologies was five hours consisting of a two-hour wait outside the terminal and a three-hour wait inside the terminal. Picture 13 shows that after the implementation the waiting time decreased to 31 minutes, which means the reduction of 89 %. (Morais and Lord, 2006.)

	Past Waiting Time Average (min)	Current Waiting Time Average (min)	Δ (%)
TraPac, LA	300	31	-868

Picture 13 Current and Past Waiting Time at TraPac Terminal (Morais and Lord, 2006.)

STS terminal adopted a different approach. They integrated a few automation technologies but primarily complied container truck drivers to use an appointment system. Picture 14 shows that they managed to reduce waiting times from five hours to 28 minutes, which means a reduction of 92 %. (Morais and Lord, 2006.)

	Past Waiting Time Average (min)	Current Waiting Time Average (min)	Δ (%)
STS, Oak	330	28	-1079

Picture 14 Current and Past Waiting Time at STS Terminal(Morais and Lord, 2006.)

5 TRUCK OPERATIONS IN THE PORT OF HAMINAKOTKA

This chapter explains the trucks' routes and actions in the port of HaminaKotka. First the total truck turn times are presented, then the operations at Steveco and at customs are explained.

5.1 Truck Turn Times in the Port of Mussalo

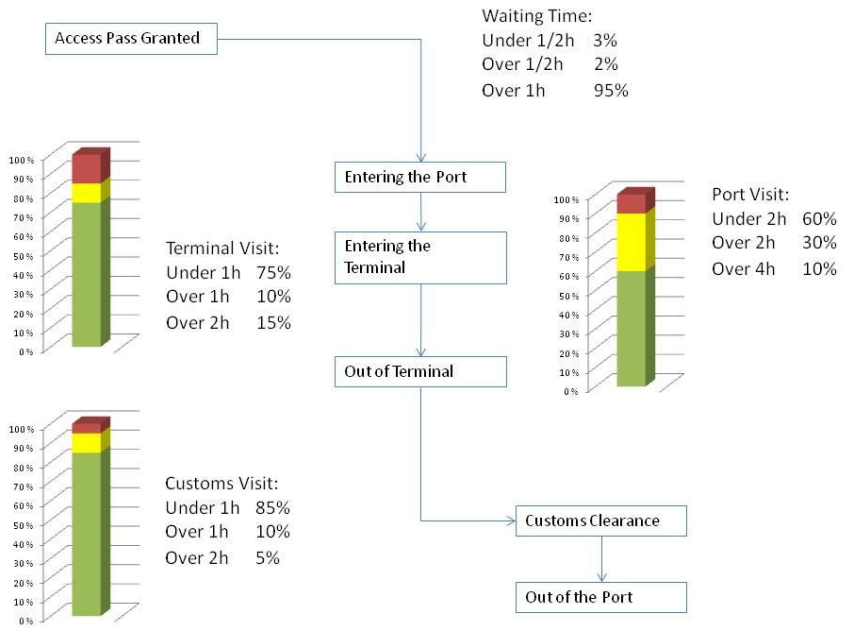
The following information is taken from the port's access control system during one normal day and is shown in pictures 15 and 16. The day was neither a slow one nor a congested one. The time is checked at multiple points in the port area, the first check point after the truck gets a pass is at the port gate. Then the time is taken when the truck arrives and leaves the operator's terminal. The last two points for taking the time are at customs, when they clear the truck and at the port gate, when the truck leaves the port. (Koskinen, 2013.)

When the driver is granted a pass to enter the port it means that the container is ready to be picked up and the truck is allowed to enter the port. This should take only a few minutes as the information and port gates are only approximately 200 meters apart. However, it took 95 percent of the trucks over an hour to enter the port. Only three

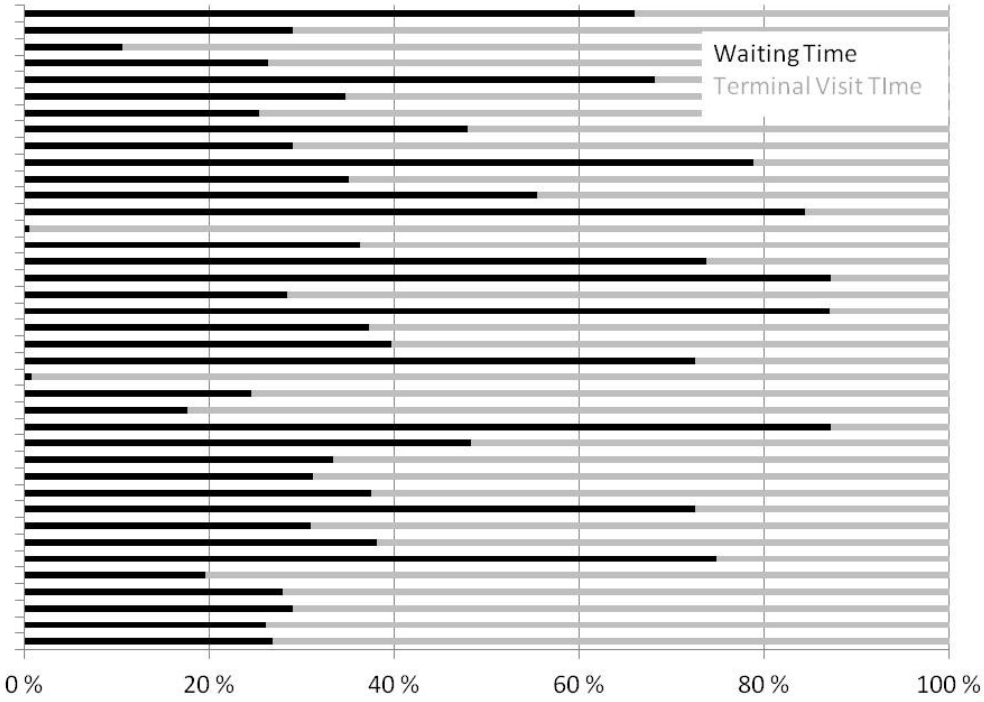
percent entered the port in less than thirty minutes and two percent between thirty and sixty minutes from the moment they got the pass. (Koskinen, 2013.)

After the truck enters the port, it drives to the terminal. During this example day 75 percent of the terminal visits lasted under an hour, ten percent lasted over an hour and 15 percent lasted over two hours. After the terminal, most of the trucks go to customs as most trucks are foreign. Eighty five percent of the stops at customs took under an hour. Ten percent of the service times were over an hour and five percent were over two hours.(Koskinen, 2013.)

During this day, sixty percent of the truck turn times took under two hours, thirty percent took over two hours and ten percent took over four hours. As seen on picture 16, most of the total time was spent waiting to enter the port and most of the waiting times were from forty to seventy percent of the total time spent in the port.(Koskinen, 2013.)



Picture 15 Truck Turn Times in the Port of Mussalo on an Example Day



Picture 16 Comparison between Time Spent Waiting to Enter the Port and Time Spent in the Port

5.2 Operations of Steveco

When a truck is coming to Steveco's terminal, the driver visits a service desk or a self-service station. Approximately 80 - 90 % of the Russian and 60 % of the Finnish drivers use the self-service stations. The Russians like to use the self service stations because there they can choose the Russian language. After this point they drive to the terminal gate, where the truck's registration number is read automatically and if everything is in order, they are allowed to drive through to the terminal area. (Sinikannas, 2013.)

If a truck is bringing an empty container, it drives to the depot area, where an independent contractor takes care of the collection of empty containers. Then the truck drives out of the terminal, or as most of them do, move on to the container exchange area. The driver identifies the truck electronically and a straddle carrier receives the information about the waiting truck and the container it is supposed to deliver. (Sinikannas, 2013.)

The straddle carriers deliver containers so that they drive the shortest distance which means that the trucks are not served in the same order as they have arrived. If the straddle carrier has delivered a container to the container area and it is possible to pick up a container nearby and take it to a waiting truck, that truck will be served next. It is taken care of, though, that a single truck will not have to wait much longer than the other trucks. After receiving a container the truck drives out of the terminal gate. (Sinikannas, 2013.)

If a truck is bringing a full container it drives straight to the container exchange area to wait for a straddle carrier to get the container. Then the truck can drive to the container depot to get an empty container or to the terminal gate. (Sinikannas, 2013.)

5.2.1 Information Technology at Steveco

There is no truck appointment system at work in the terminal but all information is transferred electronically. When the driver arrives at the port they will make an appointment either at the service desk or at the self-service station. Then they will drive to the terminal gate, where the license plate of the truck is read automatically, and if everything is fine the truck can move on to the terminal area. (Sinikannas, 2013.)

The next time the driver identifies himself is when he is picking up or leaving a full container. The straddle carrier receives the information of the truck and the container it is meant to pick up or leave. The next time the truck is identified is at the terminal gate, when it leaves the terminal. (Sinikannas, 2013.)

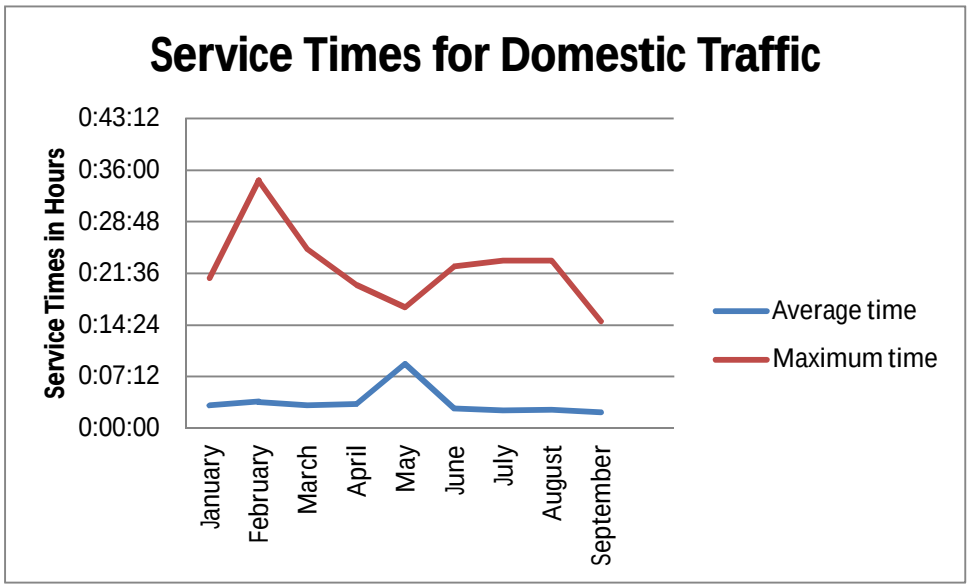
5.2.2 Factors that Cause Congestion

The average turn time for a truck at Steveco's terminal is thirty minutes on a normal day. The waiting times might prolong at some specific times of day when most of the trucks arrive simultaneously. There is the same amount of staff at the terminal from six in the morning till ten in the evening but the trucks' peak hours are around noon. This creates queues in the terminal area as more trucks wait to be served at the same time. Other reasons for queues are extreme weather conditions and broken equipment. (Sinikannas, 2013.)

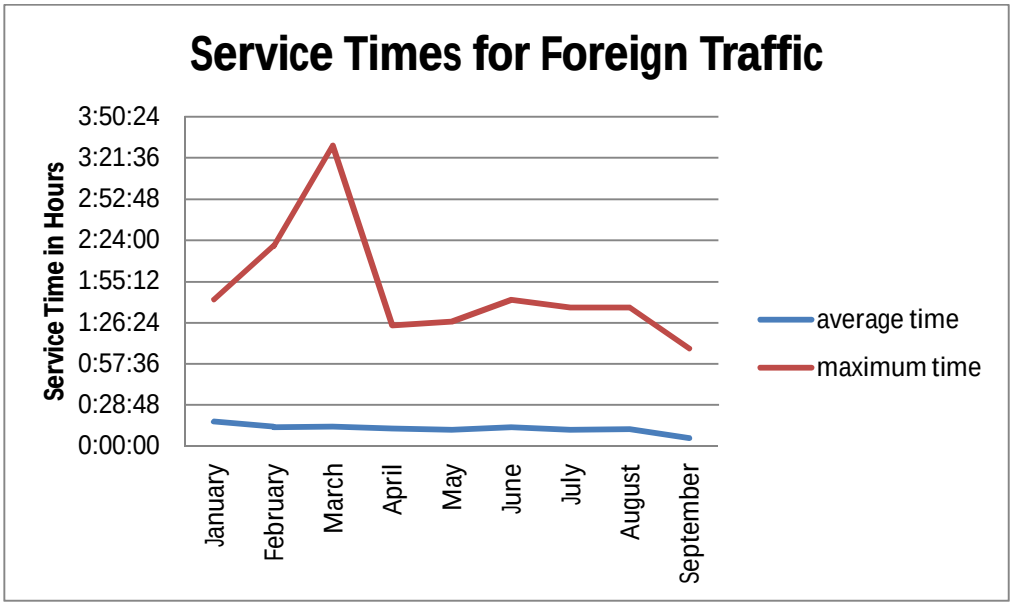
5.3 Customs

When a container truck arrives at the port it goes from the main gate to the terminal to pick up a container. After this it drives to the back parking area of customs to wait to get to an inspection where the condition of the truck is checked and the truck is sealed. In the inspection a customs inspector also checks that the truck has the right container. This takes from five to ten minutes, during which the engine must be turned off. When the truck passes the examination it is sealed with the customs' seal and the inspector writes a sealing certificate to the driver. (Holopainen and Tapola, 2013.)

Next the driver parks the truck and does business in the customs building. The service times varies from ten to fifteen minutes. In August 2013 the longest waiting time was 1 h 37 min and the average was 12 minutes. In week 38 in 2013 the longest waiting time was 46 minutes and the average was six minutes. Pictures 17 and 18 show the maximum and average service times at customs. When all the documents of the truck are in order customs clears the truck and lets it leave the port. (Holopainen and Tapola, 2013.)



Picture 17 Customs Service Times for Domestic Traffic



Picture 18 Customs Service Times for Foreign Traffic

During the week 38 in 2013 there were 78 domestic customers and 2148 trucks from foreign traffic. In August 2013 the corresponding figures were 277 and 8845. Customs serves on average approximately 10 000 heavy traffic trucks monthly. The figures are based on electronic queue number system. (Holopainen and Tapola, 2013.)

All documents are created electronically apart from the sealing certificate made by the inspector. When all the documents are as they should, the truck is let out of the port via electronic access control system. (Holopainen and Tapola, 2013.)

Customs is congested every once in a while if many foreign trucks arrive at the same time. This occurs because port operators primarily serve domestic customers, in which case the foreign traffic backs up. When the trucks arrive irregularly in waves at customs their services get congested. A parking space is reserved for approximately 200 trucks, which wait to get to customs inspection. This parking area is full at times, which means that a truck might have to wait over 24 hours to be inspected. (Holopainen and Tapola, 2013.)

Congestion might be avoided by prolonging the opening hours, which would mean that queues would not accumulate at night. However this would not affect on the congestion created by the trucks arriving simultaneously. The truck flows could be evened by the port operators. Traffic flows would stabilize if foreign trucks would be served simultaneously with the domestic trucks at the terminals. The exhaustion fumes could

be reduced by creating a warm waiting area for the truck drivers. During winter time the trucks are parked with engines on waiting to get to customs. If the drivers would have a warm place to wait, the trucks' engines would not have to be turned on. (Holopainen and Tapola, 2013.)

6 DISCUSSION AND CONCLUSION

The objective of the study was to find practical solutions to reducing emissions in the port of HaminaKotka. Truck turn times and the factors that affect them were studied in the Port of Mussalo. Interviews were made to establish the trucks' movements in the port area.

The research problem was approached by researching existing studies on turn times and emission reductions in ports. Then representatives from Steveco, customs and the port of HaminaKotka were interviewed.

As the port of HaminaKotka is the largest universal, export and transshipment port in Finland it is important for it to work effectively. Truck turn times should be fast as it is one of the key performance measures in port efficiency. Shorter turn times also mean less emissions emitting from the port, which is one of the goals of the Ecologically Friendly Port - project.

During this research it was found out that the main problems in the port of HaminaKotka considering the long turn times are the fact that trucks do not enter the port as soon as they get their access passes, and the possible long queues at customs. A truck appointment system could be a solution to these problems as it would make the drivers enter the port faster and then they would arrive at the customs at a more stable flow. However, the implementation of such a system requires extensive changes in the port.

As Morais and Lord (2006) suggest extended gate hours integrated with a truck appointment system would reduce queues and thus truck idling, which reduces emissions. The problem in Mussalo is long and high idling, which creates approximately ten to twelve kilograms of emissions per hour per truck. It would also help if the drivers would have a warm area to go to when waiting to get to customs, and then the en-

gines would not have to be turned on.

Another way to reduce congestion and emissions from the customs point of view is to create a feeding line for foreign trucks as the customs sees that the terminals serve primarily domestic customers and the foreign customers have to wait. This then again creates pressure at customs when the trucks arrive simultaneously.

As TraPac and STS terminals, also the terminals in the Port of HaminaKotka could achieve great reductions in their daily carbon dioxide emissions by the implementation of a truck appointment system. As TraPac and STS reduced emissions by 89 % and 92 %, some level of reductions could be expected from the Port of HaminaKotka.

The turn times of the Port of Mussalo might not be truthful as the figures are only from one day. They should give a picture of the situation though, as they are from a normal day, which is not congested or a slow one. Customs service times give a better picture of their situation as they are for a longer time period.

As an implementation of a truck appointment system is an expensive acquisition, it might not be a suitable solution for the Port of HaminaKotka. This study concentrates on truck appointment systems as the best solution, but as it might not be suitable for HaminaKotka, other solutions should maybe have been considered more thoroughly.

The goal of this thesis was to find practical solutions for long turn times for the Port of Mussalo. This was not completely achieved as only few suggestions were made. However, this thesis can work as a good basis for further research.

Further topics for research could be the possibility of implementing a truck appointment system. The implementation could require extensive changes in the port and the requirements could be researched.

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APPENDIX 1

SUOMENKIELINEN TIIVISTELMÄ

1 JOHDANTO

Tutkimus on osa Ecologically Friendly Port -projektia, joka on aloitettu joulukuussa 2012. Projektia johtaa Venäjän hydrometeorologinen yliopisto, ja projektiyhtymään kuuluvat Ust-Luga Company JSC, Turun yliopiston merenkulkualan koulutus- ja tutkimuskeskus sekä Kymenlaakson ammattikorkeakoulu. Yhteistyökumppaneita ovat HaminaKotkan satama, Kotkan kaupunki, Suomen Satamaliitto sekä Leningradin alueen luonnonvarojen lautakunnan johto.

Projektin tavoitteena on parantaa itäisen Suomenlahden ympäristön tilaa, parantaa satamien kykyä kehittää ympäristön suojelua ja kestävää kehitystä satamissa, parantaa kuntien kykyä ratkaista ympäristön turvallisuusongelmia sekä lisätä asukkaiden tietoutta vihreästä ajattelutavasta.

Projektin tarkoitus on luoda läheistä kahdenkeskistä yhteistyötä kansalaisten ja viranomaisten välille liittyen vihreisiin arvoihin, vihreään talouteen ja ekologiseen mentaliteettiin. Tavoitteena on kestävä alueellinen kehitys, lisääntynyt ekologinen tietous ja käsitys suomalaisten ja venäläisten satamien vastuusta liittyen ilmastonmuutokseen sekä lisääntynyt tietous ja yhteistyö satamaviranomaisten ja satamatoimijoiden välillä. Tämän tutkimuksen tarkoitus on löytää tapoja vähentää autojen päästöjen määrää satamassa käytännön toimilla.

Projekti toteutetaan analysoimalla alueen ympäristön tilaa ja kehittämällä tarvittavia korvaavia toimenpiteitä, tutkimalla ympäristömääräyksiä ja kehittämällä niiden valvontakeskus yhteistyöllä osakkaiden ja projektin "Port in the City" -osan välillä.

Tämän projektin osan eli opinnäytetyön on tarkoitus tutkia konttirekkojen kääntöaikoja Mussalon satamassa ja löytää ratkaisu pitkiksi venyneisiin aikoihin. Työn tarkoitus on vähentää rekkojen päästöjä satamassa käytännön ratkaisuilla eli vähentämällä rekkojen oloaikaa sataman porttien sisäpuolella.

1.1 Tutkimukseen liittyvät tahot

HaminaKotkan satama on Suomen suurin yleis-, vienti- ja transitosatama. Satama tarjoaa hyvät yhteydet Baltian maihin sekä Eurooppaan, Aasian ja Venäjän markkinoille. HaminaKotka sijaitsee 35 kilometrin päässä Venäjän rajasta. Itäisen sijaintinsa takia satama on erikoistunut transitokuljetuksiin CIS-maihin. 15 metrin syväys mahdollistaa yhteydet Euroopan lisäksi muuallekin maailmaan. (HaminaKotka satama 2013)

Steveco on HaminaKotkan sataman pääoperaattori. Se tarjoaa ahtaus-, huolinta-, kuljetus- sekä terminaalipalveluja tuonti-, vienti- ja transitoliikenteelle. Steveco Oy on Suomen metsäteollisuuden kuljetuksien johtava satamaoperaattori sekä markkinajohtaja. Steveco-konserni työllisti vuonna 2011 noin 950 henkeä ja Steveco Oy 816 henkeä. Konsernin liikevaihto oli 146,2 miljoonaa euroa ja ahtausmäärä oli 11,1 miljoonaa tonnia. (Steveco 2013)

Ecologically Friendly Port -projektia johtaa Venäjän hydrometeorologinen yliopisto, ja projektiyhtymään kuuluu Ust-Luga Company JSC, Turun yliopiston merenkulkualan koulutus- ja tutkimuskeskus sekä Kymenlaakson ammattikorkeakoulu. Projektin yhteistyökumppaneita ovat HaminaKotkan satama, Kotkan kaupunki, Suomen satamaliitto sekä Leningradin alueen luonnonvarojen lautakunnan johto. (Ecologically Friendly Port 2013)

2 LIIKENTEEN YMPÄRISTÖVAIKUTUKSET

2.1 Liikenteen päästöt

Häkä (CO) on väritön ja hajuton kaasu, jota syntyy epäpuhtaasta polttoaineen palamisesta. Se on terveydelle haitallinen kaasu, sillä se estää elimiä ja kudoksia saamasta happea. Suuret häkämäärät voivat johtaa kuolemaan. (EPA United States Environmental Protection Agency 2013)

Typen oksidit, joita ovat typpioksidi (NO), typpidioksidi (NO2) sekä typpioksiduuli (N2O), syntyvät fossiilisten polttoaineiden poltosta (Clean Air Strategic Alliance 2013). 20 % ilmakehästä on typpeä, ja typpioksidit pysyvät ilmassa yhdestä kolmeen päivää, mikä tarkoittaa sitä, että ne voivat kulkeutua jopa 1 200 kilometrin päähän. (OECD 2011)

Typpioksidi itsessään ei ole haitallista, mutta muuttuessaan typpidioksidiksi se voi korkeina pitoisuuksina olla myrkyllistä kasveille, se vahingoittaa lehtiä ja vähentää kasvua. Savusumun osana typpidioksidi ärsyttää keuhkoja ja lisää hengitysteiden tautien riskiä. (Clean Air Strategic Alliance 2013) Suurin osa typen oksideista on peräisin kuljetuksista. (Environmental Journalism Canada 2013)

Haihtuvia orgaanisia yhdisteitä haihtuu polttoaineesta, ja ne aiheuttavat otsonikerroksen kasvua. Monet haihtuvista orgaanisista yhdistelmistä ovat haitallisia, etenkin bentseeni, joka aiheuttaa syöpää. (Gilbert ja Perl 2010, 189). Hiukkaset, jotka ovat alle kymmenen mikrometriä halkaisijaltaan, ovat haitallisia, sillä ne kulkeutuvat nenän ja kurkun kautta keuhkoihin sekä sydämeen ja voivat aiheuttaa vakavia terveydellisiä vahinkoja. Hienot hiukkaset syntyvät, kun autojen pakokaasut reagoivat ilman kanssa. (EPA United States Environmental Protection Agency 2012)

2.2 Ilmastonmuutos

Maapallon keskilämpötila on kohonnut ja kasvihuonekaasujen uskotaan olevan syy siihen. Jopa muutaman asteen nousu voi aiheuttaa vakavia seuraamuksia, joita ovat muun muassa äärimmäiset sääolosuhteet, muutokset maa- ja merikasvukausissa sekä lajikokoonpanoissa, merenpinnan nousu sekä jatkuvat tulvat, muutokset veden saatavuudessa, infrastruktuurin vahingot, terveysvaikutukset lämpöjännityksestä ja muutokset tautikannoissa. (Gilbert ja Perl 2010, 173)

2.3 Venäläiset ajoneuvot ja niiden päästöt

Venäläisten raskaan liikenteen rekkojen on noudatettava eurooppalaisia päästöstandardeja. Kaikkien uusien rekkojen on noudatettava näitä säännöksiä. (DieselNet 2013)

Taulukko 1. Päästövaatimukset raskaanliikenteen moottoreille (DieselNet 2013)

PÄIVÄYS	VAATIMUS
1999.01	Euro I / Ecological Class 1 (ECE R49.02)
2006.01	Euro II / Ecological Class 2 (ECE R49.02 Stage 2)
2008.01	Euro III / Ecological Class 3 (ECE R49.04-A)
2014.01	Euro IV / Ecological Class 4 (ECE R49.04-B1)
2016.01	Euro V / Ecological Class 5 (ECE R49.04-B2 C)

Taulukko 2. Päästövaatimukset raskaanliikenteen ajoneuvoille (Transport Policy 2013)

ALUE	SÄÄDÖS JA VUOSI	KESKIARVOT (g/kWh)	
		NOx	PM
USA	2002–2004	2.7	0.13
	2007	1.6	0.013
	2010	0.27	0.013
Eurooppa	Euro III (2000)	5	0.1
	Euro IV (2005)	3.5	0.02
	Euro V (2008)	2	0.02
	Euro VI (2013)	0.2-	0.01-0.02
Japani	2003–2004		0.18
	2005	3.38	0.027
	2009–2010	2	0.01
		0.7	

Taulukko 3. Venäläisen dieselin rikkirajat sekä käyttöönottopäivät

POLTTOAINE	MAX. RIKKI	KANSALLINEN KÄYT-TÖÖNOTTOPÄIVÄ	
		Todellinen	Ehdotettu
Type I (Euro 3)	350 ppm	2013.01	2009.01
Type II (Euro 4)	50 ppm	2015.01	2010.01
Type III (Euro 5)	10 ppm	2016.01	2013.01

2.4 Ympäristöstandardi ISO 14001

Kun yritys hankkii ympäristösertifikaatin, se sitoutuu kehittämään ympäristönsuojelua sekä tiedostaa tuotteidensa, toimintojensa ja palveluidensa vaikutukset ympäristölle. Se myös vakuuttaa huolehtivansa lainopillisten vastuidensa täytäntöönpanosta sekä ylläpitävänsä työntekijöiden tietotaitoa. (Suomen Standardisoimisliitto 2013)

Yritys hyötyy monin tavoin ympäristöjärjestelmästä. Sertifikaatti yhdistää ympäristöasiat osaksi toimintojen hallintaa ja suunnittelua. Se lisää yrityksen kustannustehokkuutta parantamalla raaka-aineiden ja energian käyttöä sekä vähentämällä jätteiden määrää. Ympäristöjärjestelmä näyttää osakkaille vastuuta ympäristöasioista sekä tukee organisaation ympäristöviestintää kohentaen yrityksen imagoa ja markkinointia. (Suomen Standardisoimisliitto 2013)

3 REKKOJEN AJANVARAUSJÄRJESTELMÄT

3.1 Aiemmat tutkimukset

Satamien haasteena on se, että rekkojen saapumisaika on kuljetusyritysten päätettävissä. Tämä johtaa vaihteluihin rekkojen määrissä eri vuorokaudenaikoina, mikä ruuhkauttaa satamaa. Jonot portilla ja satamassa johtavat kuljettajien ansionmenetyksiin sekä lisääntyneisiin ilmansaasteisiin. (EPA United States Environmental Protection Agency 2013)

Vancouverin satamassa pidennetyt porttien aukioloajat sekä ajanvarausjärjestelmät ovat vähentäneet päästöjä (Morais ja Lord 2005). USA:n ympäristönsuojeluviraston mukaan rekkojen ajanvarausjärjestelmä voi vähentää rekkojen kääntöaikoja noin 30 prosenttia. Muita etuja ovat vähentyneet viivästykset terminaalin portilla, polttoainesäästöt sekä ajoneuvoista aiheutuvien kaasuhuonekaasujen väheneminen.

New Orleansin satamassa on otettu käyttöön Gate Entry Management System (GEM). Tämä järjestelmä yhdistää useiden eri operaattoreiden terminaalien hallintajärjestelmät. Tämän johdosta liikennevirrat ovat parantuneet, terminaalin tuotto on parantunut, ja operaattoreiden sekä kuljetusyritysten tuottavuudet ovat parantuneet.

Islam, Olsen ja Ahmed (2013) tutkivat satamaa, joka muutti kuljetusprosessiaan tavanomaisesta prosessista rekkojen ajanvarausta käyttävään järjestelmään ja siitä vielä kehit-

tyneeseen ajanvarausjärjestelmään. Tuloksena rekkojen kääntöajat lyhenivät neljästä tunnista noin 25 minuuttiin. Suuria muutoksia vaadittiin satamassa järjestelmän käyttöönottamiseksi, mutta toisaalta muutokset mahdollistavat lisää muutoksia tulevaisuudessa.

3.2 Rekkojen ajanvarausjärjestelmä

Rekkojen varausjärjestelmän tarkoitus on saada rekat saapumaan satamaan tasaisin aikavälein. Sen tarkoitus on myös parantaa kääntöaikoja ja tarjota järjestelmä, jota on joustava ja helppo käyttää. Järjestelmä voi olla pakollinen, eli jos varausta ei ole tehty etukäteen, rekka ei pääse satamaan sisään. Southamptonin satamassa kiireisinä aikoina tai myöhästymisistä rekkojen on maksettava maksu. (McCrindle 2013)

Southamptonissa ajanvarausjärjestelmä on käytettävissä Internetissä. Ajanvarausta voi tarvittaessa muuttaa, mutta jokaista kuljettajaa kohden on olemassa rajattu määrä varauksia. Kuljettajia varten on olemassa Help Desk, joka on auki vuorokauden ympäri. Terminaali hyötyy järjestelmästä, sillä rekat saapuvat tasaisesti, mikä vähentää painetta aiemmin kiireisinä aikoina sekä ruuhkaa portilla. (McCrindle 2013)

Kääntöajat ovat vähentyneet Southamptonin satamassa 50 minuutista 20 - 40 minuuttiin. Myös laivayhtiöt sekä huolitsijat hyötyvät, sillä heille voidaan tarjota tasainen palveluiden taso. Ajanvarausjärjestelmä parantaa palveluiden luotettavuutta, kun ajallaan olevat toimitukset lisääntyvät. Paikalliset yhteisöt taas hyötyvät siitä, että ruuhkat vähenevät maanteillä, mikä puolestaan vähentää ilmansaasteiden määrää. (McCrindle 2013)

3.3 Los Angelesin satama

Los Angelesin satama käyttää ajanvarausjärjestelmää kaikissa paitsi yhdessä terminaaleistaan. PierPass Inc. ja Ability/Tri-Modal Transportation Services tekivät tutkimuksen sataman kääntöajoista. Tutkimuksessa otettiin huomioon kolme eri aikajaksoa, odotusaika ennen satamaa, terminaalissa käytetty aika sekä satamakäynnin kokonaisaika eli odotus- ja terminaaliajat yhteensä. (The Journal of Commerce 2009)

Tutkimuksessa selvisi, että jonotusaikojen mediaani oli 20 minuuttia, terminaalikäynnin 31 minuuttia ja kokonaisajan 51 minuuttia. Suurin osa käynneistä kesti alle kaksi tuntia,

27 5 kesti alle 30 minuuttia, 58 % alle tunnin, 75 % alle puolitoista tuntia ja 86 % alle kaksi tuntia. Noin 91 prosenttia odotusajoista oli alle tunnin, tässä on otettu huomioon rekat, jotka saapuivat ennen aamukuutta odottamaan satamaan pääsyä. (PierPass 2013)

3.3.1 Päästöjen vähennykset

Morais ja Lordin (2006) tekemän tutkimuksen mukaan päästöt vähenivät 84 % TraPacin terminaalissa Los Angelesissa ja 92 % STS:n terminaalissa Oaklandissa. Päästöt laskivat rekkaa kohti TraPacissa 35,53 kilogrammasta 9,6 kilogrammaan ja STS:ssä 39,08 kilogrammasta 2,2 kilogrammaan.

TraPac kärsi toiminnallisista ongelmista portilla ja kentällä, joten terminaalissa päätettiin ottaa käyttöön automaatioteknologiaa. Keskimääräinen odotusaika ennen järjestelmää oli viisi tuntia ja järjestelmän käyttöönoton jälkeen 31 minuuttia, mikä tarkoittaa 89 prosentin laskua. STS otti käyttöön toisenlaisen toimintatavan, seedellytti rekkakuljettajilta ajanvarauksen käyttöönottoa. seonnistui laskemaan odotusajat viidestä tunnista 28 minuuttiin, mikä tarkoittaa 92 prosentin laskua. (Morais ja Lord 2006)

4 HAMINAKOTKA SATAMAN REKKALIIKENNE

4.1 Rekkojen kääntöajat Mussalon satamassa

Seuraavat tiedot on otettu sataman kulunvalvontajärjestelmästä yhden normaalipäivän aikana. Kun kuljettaja saa kulkuluvan, kontti on valmiina otettavaksi kyytiin, eli rekalla on lupa ajaa sisään sataman porteista. Tässä pitäisi mennä vain muutama minuutti, sillä neuvonta ja sataman portit ovat vain muutaman sadan metrin päässä toisistaan. Kuitenkin 95 prosentilla rekoista kesti yli tunti ajaa sisään satamaan. Vain kolme prosenttia siirtyi satamaan alle puolessa tunnissa ja kaksi prosenttia alle tunnissa. (Koskinen 2013)

Seuraavaksi rekka siirtyy terminaaliin. Esimerkkipäivänä 75 prosenttia käynneistä kesti alle tunnin, kymmenen prosenttia yli tunnin ja 15 prosenttia yli kaksi tuntia. Tullissa 85 prosenttia pysähdyksistä kesti alle tunnin, kymmenen prosenttia yli tunnin ja viisi prosenttia yli kaksi tuntia. Kokonaiskääntöajoista 60 prosenttia kesti alle kaksi tuntia, 30 prosenttia yli kaksi tuntia ja kymmenen prosenttia yli neljä tuntia. Suurin osa kokonaisajasta kului sataman porttien ulkopuolella ennen satamaan ajoa. Suurin osa odotusajoista oli 40 - 70 prosenttia kokonaisajasta. (Koskinen 2013)

4.2 Stevecon toiminnot

Kun rekka tulee asioimaan Stevecolla, kuljettaja luo työtapahtuman palvelutiskillä tai itsepalvelukioskilla, minkä jälkeen hän ajaa terminaaliin. Terminaalin portilla rekan rekisterikilpi luetaan automaattisesti, ja jos kaikki on kunnossa, rekka pääsee ajamaan terminaaliin. Rekka saattaa ajaa konttikentälle jättämään tyhjää konttia pois kyydistä tai suoraan konttien vaihtoalueelle, jossa se jättää tai saa täyden kontin. Konttien vaihtoalueella kuljettaja kirjautuu tunnistuspäätteelle, jolloin lukit saavat tiedon rekasta ja siihen kuuluvasta kontista. Tämän jälkeen rekka ajaa ulos terminaalista tulliin tai ulos satamasta. (Sinikannas 2013)

4.2.1 Ruuhkaa aiheuttavat tekijät

Keskimääräinen rekan kääntöaika terminaalissa tavallisena päivänä on 30 minuuttia. Odotusajat voivat pitkittyä tiettyyn kellonaikaan, jos suurin osa rekoista saapuu samaan aikaan. Terminaalissa työskentelee sama määrä työntekijöitä aamukuudesta iltakymmeneen, mutta eniten rekkoja saapuu keskipäivän aikaan. Tämä aiheuttaa jonoja terminaalissa. Muita syitä voivat olla äärimmäiset sääolosuhteet sekä rikkoutuneet välineet. (Sinikannas 2013)

4.3 Tulli

Terminaalin jälkeen ulkomaalainen rekka ajaa tullin takapysäköintialueelle, jossa se odottaa vuoroaan tullitarkastukseen. Tarkastuksessa katsotaan rekan kunto ja kontti sinetöidään. Tarkastaja tarkistaa myös, että rekalla on oikea kontti kyydissä. Tämä kestää viidestä kymmeneen minuuttia, mutta moottori on oltava sammutettuna, eli tässä pisteessä ei synny päästöjä. (Holopainen ja Tapola 2013)

Seuraavaksi kuljettaja asioi tullin palvelutiskillä, jossa kuluu kymmenestä viiteentoista minuuttia. Kun kaikki asiakirjat ovat kunnossa, rekka saa luvan poistua satamasta. Tulli ruuhkautuu, kun useita ulkomaalaisia rekkoja saapuu yhtä aikaa asioimaan tullissa. Tämä johtuu siitä, että terminaalit palvelevat ensisijaisesti kotimaan liikennettä, jolloin ulkomaanliikenne kulkee aalloittain. Pysäköintialueella on tilaa noin 200 rekalle, ja jos tämä alue on täynnä, rekka voi joutua odottamaan tarkastukseen pääsyä jopa vuorokauden. (Holopainen ja Tapola 2013)

5 YHTEENVETO

Tutkimuksen tarkoitus oli tutkia rekkojen kääntöaikoja ja niitä hidastavia tekijöitä. Rekkojen kääntöaikoja ja niihin vaikuttavia tekijöitä selvitettiin ja haastatteluiden perusteella kuvattiin rekan liikkeitä satamassa.

Tutkimusongelmaa lähestyttiin tutkimalla jo olemassa olevia tutkimuksia kääntöajoista ja päästöjen vähentämisestä satamissa. Tämän jälkeen Stevecon, tullin ja sataman edustajia haastateltiin.

Koska HaminaKotka on Suomen suurin yleis-, vienti- ja transitosatama, on tärkeää, että se toimii tehokkaasti. Kääntöaikojen tulisi olla lyhyitä, sillä ne ovat yksi tärkeimmistä suoritustehon mittareista satamissa. Lyhyet kääntöajat myös tarkoittavat vähemmän päästöjä, mikä on Ecologically Friendly Port - projektin tarkoitus.

Tämän tutkimuksen aikana selvisi, että sataman suurimmat ongelmat syntyvät rekoista, jotka eivät aja suoraan satamaan saatuaan kulkuluvan, sekä tullin mahdollisista pitkistä jonoista. Rekkojen ajanvarausjärjestelmä voisi olla ratkaisu näihin ongelmiin, sillä rekkojen olisi ajettava satamaan tiettynä aikana, jolloin rekat saapuisivat myös tulliin tasaisempaan tahtiin. Tällaisen järjestelmän käyttöönotto vaatii kuitenkin suuria muutoksia satamalta.

Kuten Morais ja Lord (2006) ehdottavat, pidennetyt portin aukioloajat yhdistettynä ajanvarausjärjestelmään vähentäisivät jonoja ja siten rekkojen tyhjäkäyntiä. Mussalon sataman ongelma on pitkäaikainen ja korkea tyhjäkäynti, joka tuottaa kymmenestä 12 kilogrammaan hiilidioksidia tunnissa. Kuljettajille tarkoitetusta lämpimästä odotustilasta olisi myös hyötyä; kun kuljettajat pääsisivät pois autoista odottamaan tulliin pääsyä, moottorien ei tällöin tarvitsisi olla käynnissä.

Eräs tapa vähentää ruuhkaa ja päästöjä tullin näkökulmasta on ulkomaan liikenteen syöttölinjan luominen terminaaleissa, sillä tullin mukaan terminaalit palvelevat ensisijaisesti kotimaan asiakkaita, jolloin ulkomaalaiset rekat joutuvat odottamaan. Tämä taas luo painetta tulliin, kun rekat saapuvat samanaikaisesti.

Kuten TraPacin ja STS:n terminaalit, myös HaminaKotkan sataman terminaalit voivat saavuttaa suuria vähennyksiä päivittäisissä hiilidioksidipäästöissään ottamalla käyttöön

ajanvarausjärjestelmän. Koska nämä kaksi terminaalia saavuttivat 89 %:n sekä 92 %:n vähennyksiä päästöissä, vähennyksiä voidaan odottaa myös HaminaKotkan satamalta.

Mussalon sataman kääntöajat eivät välttämättä ole täysin todenmukaiset, sillä ne ovat kaikki yhdeltä päivältä. Niiden pitäisi kuitenkin kuvata sataman tilannetta, sillä luvut on otettu normaalina päivänä, jolloin ei ole ollut ruuhkaa, muttei myöskään hiljaista. Tullin palveluajat antavat paremman kuvan, sillä ne ovat pidemmältä aikaväliltä.

Jatkotutkimuksen aiheena voisi olla mahdollinen ajoneuvojen ajanvarausjärjestelmän käyttöönotto ja sen edellyttämät vaatimukset.