Coordinated freight logistics in existing city districts- Evaluation of methods for calculating energy and environmental effects

Samordnad varulogistik i befintliga stadsdelar - Utvärdering av metoder för att beräkna energi och miljöeffekter

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Abstract
Norra Djurgårdsstaden is the largest ongoing construction project in Sweden and is planned to be completed in 2030. The city district is situated in north-eastern Stockholm, in a former industrial area where approximately 12 000 new homes and 35 000 workplaces are planned. The city district focuses strongly on reducing energy consumption and the negative impacts on the environment. One idea for realizing this goal is to implement coordinated freight logistics. This can be accomplished by building a consolidation centre where goods from different logistics companies and freight carriers can be loaded together on the same delivery vehicles and then be delivered in the same area in Norra Djurgårdsstaden.

The purpose of this master thesis is to evaluate five earlier evaluation reports on consolidation centres. Based on these evaluation reports and other relevant literature, it is recommended how a coordinated freight logistic project should be organized in Norra Djurgårdsstaden and how the impact on the environment and energy consumption should be calculated. The evaluation reports are from the logistic centre in the Old Town of Stockholm, the pilot project Samlic in Linköping, the urban consolidation centre in Norwich, the micro-consolidation centre in London and several urban logistic practices in Utrecht. A thorough comparative analysis of the five different evaluation reports has looked at the initiators and the stakeholders, the delivery situation before and after the implementation of the consolidation centre as well as done a deeper evaluation analysis of all the evaluation reports. The comparative analysis showed that the consolidation centres have had a positive effect on decreasing the number of delivery vehicles in the city district and thereby reducing the emissions and the energy consumption from the delivery vehicles.

Based on the comparative analysis and other literature it is suggested that the initiative to build a consolidation centre in Norra Djurgårdsstaden has to come from the City of Stockholm. The stakeholders should be the City of Stockholm, logistics companies, freight companies, the different businesses in the area and the Ports of Stockholm. To encourage even more businesses to have deliveries from the consolidation centre and get more environmentally friendly delivery vehicles in the city district it might be necessary to use several management control instruments. Examples of control instruments are environmental zones, time windows and implement different restrictions on the delivery vehicles. It is essential to gather information about the delivery vehicles in the city district to estimate emissions and the energy consumption. The collection of data from the delivery vehicles can be gathered from consignment notes, driver

notes, invoice data or statistics of the number of vehicles that have delivered goods in the city centre from freight and logistics companies. Then the delivery vehicles impact on energy consumption and the environment can be estimated with the computer tool Network of transports and environment (NTM-method).

Sammanfattning

Norra Djurgårdsstaden är det största pågående byggprojektet i Sverige och är planerat att slutföras under 2030. Stadsdelen ligger i nordöstra Stockholm, i ett före detta industriområde där cirka 12 000 nya bostäder och 35 000 arbetsplatser är planerade att byggas. Stadsdelen har ett starkt fokus på att minska miljöeffekterna och påverkan av energianvändningen. En av idéerna för att uppfylla detta är att införa samordnad varulogistik. Detta kan göras genom att bygga ett logistikcenter där gods från olika logistikföretag och godstransportörer kan lastas på samma leveransfordon och sedan levereras inom samma område i Norra Djurgårdsstaden.

Syftet med detta examensarbete är att utvärdera fem tidigare utvärderingsrapporter om logistikcenter. Med hjälp av dessa utvärderingsrapporter och annan litteratur ges det förslag på hur ett projekt inom samordnad varulogistik kan organiseras i Norra Djurgårdsstaden och hur miljöpåverkan och energiförbrukning från leveransfordonen kan beräknas. Utvärderingsrapporterna kommer från logistikcentret i Gamla Stan i Stockholm, pilotprojektet Samlic i Linköping, logistikcentret i Norwich, mikro-logistikcentret i London och olika logistikmetoder i Utrecht. En noggrann jämförande analys av de fem olika utvärderingsrapporterna har undersökt initiativtagare och intressenter, leveranssituationerna före och efter uppförandet av logistikcentren samt gjort en fördjupad utvärderingsanalys av samtliga utvärderingsrapporter. Den jämförande analysen visar att införandet av logistikcenter har haft en positiv effekt för att minska antalet leveransfordon i stadsdelen och därmed inneburit minskade utsläpp och lägre energianvändning för leveransfordonen.

Baserad på den komparativa analysen och annan litteratur föreslås det att initiativet i Norra Djurgårdsstaden måste komma från Stockholms stad. Intressenterna bör vara Stockholms Stad, logistikföretag, godstransportörer, de olika företagen i området och Stockholms Hamnar. För att få fler företag att använda logistikcentret samt att få miljövänligare leveransfordon i stadsdelen kan det vara nödvändigt att använda flera styrmedel. Exempel på styrmedel är miljözoner, tidsfönster och att införa olika begränsningar på leveransfordon. Det är väsentligt att samla information om leveransfordonen i stadsdelen för att beräkna utsläpp och energianvändning. Insamlingen av data från leveransfordon kan hämtas från fraktsedlar, fakturaunderlag eller statistik över antalet fordon som har levererat varor i stadsdelen från frakt- och logistikföretag. Då kan miljö- och energieffekterna från leveransfordonen beräknas med dataverktyget Nätverket för transporter och miljö (NTM-metoden).

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This master thesis is a part of the demonstration project “Citylogistik”, a collaborative project between Sustainable Innovation AB, Division of Industrial Ecology at the Royal Institute of Technology, Posten AB and the City of Stockholm. The projects aim is to investigate the benefits of having coordinated freight logistics on goods deliveries and construction logistics in city districts, focusing on the ongoing construction project called Norra Djurgårdsstaden in Stockholm.

The master thesis is the last course in Master of Science in Energy Engineering at Umeå University and it consists of 30 credits. The supervisors are from the Division of Industrial Ecology at the Royal Institute of Technology, and the master thesis has been examined by the Department of Applied Physics and Electronics at Umeå University.

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1. Introduction

This chapter gives an overview of the background, the aims and objectives, the limitations, the definitions of important terms and the methodology of this master thesis.

1.1. Background

Urban freight transportation is very important to the life of cities. It delivers goods to all sorts of businesses, from industries and stores to offices and other businesses. This helps to sustain the life style of the inhabitants and make the different processes in the city work (Allen, Anderson, Browne, & Jones, 2000). But urban freight transport also has many bad environmental side effects. The vehicles generate a significant energy consumption, noise and emissions of CO_2, NOx and particulates, which are also dangerous for those who live in the city. So in order to create more environmentally friendly cities it is necessary to change how the urban transportation delivery system works today. One solution is to implement coordinated freight logistics, for example a consolidation centre where goods are loaded together from several freight carriers to smaller delivery vehicles that deliver the goods to a specific area of the city. This in turn often leads to fewer vehicles delivering goods in the city.

Norra Djurgårdsstaden is the largest urban project in Sweden today, it involves building a whole new city district with 12 000 new homes and 35 000 workplaces (Stockholm Stad, 2013a). The City of Stockholm has decided that the city district will be built with high environmental ambitions to create a sustainable neighborhood in world class. In order to fulfill this ambition, the city has planned to set up a consolidation centre with environmentally friendly delivery vehicles (Norra Djurgårdsstaden, 2010).

But unfortunately urban goods deliveries belong to a field that has received little attention in planning processes and as a research topic in transportation studies as well as attracting low political interest in the cities (Statens Vegvesen, 2005). There has also been little research on the urban delivery vehicles energy consumption and impact on the environment, so this master thesis aims at contributing with more knowledge on this research topic. This report seeks to understand the methods used in different evaluation reports to find out how the implementation of a consolidation centre impacts on the environment and the energy consumption, with the aim of developing this subject further to find suitable arguments for building a consolidation centre for goods in Norra Djurgårdsstaden.

This study is part of the demonstration project “Citylogistik”, focusing on Norra Djurgårdsstaden. The project is a collaboration between Sustainable Innovation, Division of Industrial Ecology at the KTH Royal Institute of technology, Stockholm City Council and Posten Meddelande AB. The project “Citylogistik” seeks to develop solutions on how to decrease the number of delivery vehicles, how to become more efficient and how to become more environmentally friendly. Citylogistik aims at analyzing the benefits of coordinated freight logistics from delivery vehicles and construction logistics and how this will affect Norra Djurgårdsstaden with respect to energy consumption and the effects on the environment.

1.2. Aims and objectives

The main objective of this report is to analyze previous evaluation reports in order to evaluate the energy consumption and the environmental impacts of coordinated freight logistics from urban consolidation centres. Based on those experiences an objective is to develop a suitable coordinated freight logistics model for Norra Djurgårdsstaden. To achieve this objective, there are four sub-targets in this report;

1. Analyze previous examples on coordinated freight transport in Europe. The examples are the logistic centre of the Old Town in Stockholm, the pilot project called Samlic in Linköping, the urban consolidation centre in Norwich, the micro-consolidation centre in London and several urban logistic practices in Utrecht. This analysis focus on the background, objectives, energy and environmental parameters, method of collecting data and the results of the impact on the environment and energy consumption used in the evaluation of the five different cities.

2. Perform a thorough comparative analysis of the five cities by evaluating the methods used and investigate how the analysis is done in the evaluations reports.

3. Take the most appropriate practices of the evaluations reports and adapting a suitable model to count the number of delivery vehicles in Norra Djurgårdsstaden with or without a consolidation center. This is done to make a basis to calculate the energy use and emissions from delivery vehicles in both scenarios. Further to gather material on the freight logistics in Hammarby Sjöstad and test the most suitable model to count the number of delivery vehicles on Hammarby Sjöstad, another newly constructed city district in Stockholm with an environmental profile like Norra Djurgårdsstaden.

4. Suggest how a coordinated urban freight logistics project can be organized and evaluated in Norra Djurgårdsstaden with focusing on reducing energy consumption and negative impacts on the environment. This should be done with a progression compared to the transportation situation of Hammarby Sjöstad and be compatible with the current and planned physical solutions in Norra Djurgårdsstaden. Also, finding a practical and efficient method for further collecting data and suggest how the project with coordinated freight logistic should continue in the case of Norra Djurgårdsstaden.

1.3. Definition of important terms

- **City logistics** is the organization of the distribution of goods in urban areas (Petterson, Nilsson, Orwén, & Berglund, 2011).
- **Coordinated freight logistics** means that goods from different logistics companies and freight carriers often are loaded in the same vehicle and are delivered to different recipients in the same city area. Hence, recipients get goods from multiple suppliers in the same delivery vehicle (Kristoffersson, Pettersson, & Eklund, 2010). This could for example happen through coordinated orders, pickup sites for home deliveries or loading goods via an urban consolidation centre (Petterson, Nilsson, Orwén, & Berglund, 2011). This master thesis will look at coordinated freight logistics from a consolidation centre. An important aspect of coordinated freight logistics is to load the vehicle with as much goods as possible for maximizing the delivery potential of the vehicle.
- **Urban freight transportation** is defined as all types of goods vehicles (from light vans to heavy goods vehicles) and other motorized road vehicles (like cars, mopeds and electric cycles) used for collection and delivery of goods in the urban area (Allen, Anderson, Browne, & Jones, 2000). Figure 17 in Appendix 1 - Truck guide presents a detailed view of the transportation vehicles.
- **Urban consolidation centre** is a common city terminal for individual suppliers, freight carriers and logistics companies that take care of the distribution of the goods to be delivered in the city centre. The vehicles first deliver the goods that are going to the city centre to the city terminal. From the city terminal the goods are distributed on delivery vehicles that are adapted to the street network and have routes that minimize the transportation and the number of vehicles in the city centre (Statens Vegvesen, 2005). The picture to the left in Figure 1 shows how a delivery system looks without a consolidation centre, where many different delivery vehicles drive around in the city district and deliver goods. While, the picture to the right in Figure 1

displays how an urban consolidation centre will decrease the number of deliveries in the city district by having coordinated freight logistics.

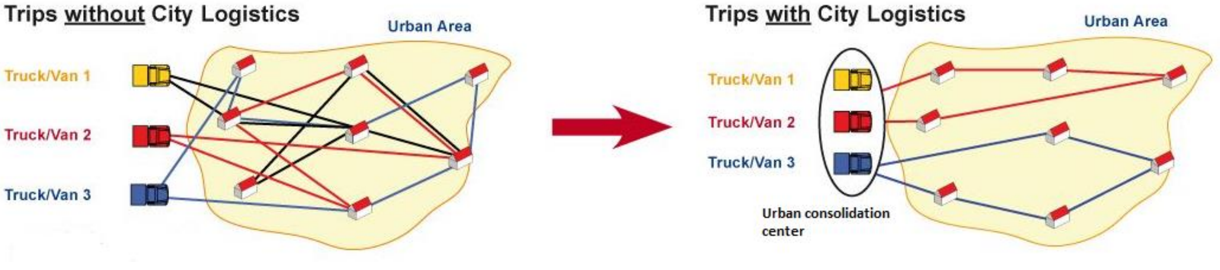

Figure 1: The difference between deliveries without or with an urban consolidation centre in an urban area (C-liege, 2013, authors editing).

Other names for a consolidation centre appearing in the different evaluation reports are logistic centre and urban distribution centre. These names will be used in the review of the evaluation reports, but urban consolidation centre will be used as the main expression in this report.

1.4. Limitations

Urban freight transport is a complex subject, and there are many factors and several participants that are important in creating effective urban freight logistics. Therefore, due to time limitations in, some boundaries have been set for this report. First and foremost the report will focus on delivery vehicles and their impact on environmental and energy consumption, not impacts caused by private cars or public transportation. As noted in section 1.3, coordinated freight logistics can be organized in different ways. But in this master thesis, coordinated freight logistics is limited to be studied only in the form of consolidation centres, because this type of terminals is considered to have the largest potential of consolidating the goods and reducing the number of delivery vehicles in Norra Djurgårdsstaden. A consolidation centre also makes it possible to consolidate goods in a large scale. The economic aspect of setting up a coordinated freight logistic system is not thoroughly investigated in this report. It costs a lot of money to invest in a coordinated freight logistic system, but this must be weighed against the potential energy and environmental benefits (Allen & Browne, 2010a).

There have been many technological inventions that can improve city logistics, for example ICT-technology and several GPS-systems. However this is not the main emphasis in the report, but the technology today is an important tool that makes it easier to create an efficient logistic system and measure the energy and environmental effects from urban freight transport. The report does not include an analysis on the potential positive social impacts of introducing a coordinated freight logistic system, for instance like safer streets and traffic congestion. It does not include an evaluation of OD-matrices, which is an important tool in estimating the traffic flow in cities.

1.5. Methodology

The information was gathered mainly from literature studies and through conversations with relevant people through e-mail or telephone.

1.5.1. Literature studies

Literature studies were the main way to gain information for this master thesis. In order to get a broad perspective of coordinated freight logistics, several articles have been investigated. The articles were either recommended from the supervisors at the Division of Industrial Ecology at the Royal Institute of Technology or found through research in scientific databases, the internet as well as studying sources from the list of references in every article. Interesting sources have been investigated more thoroughly in order to create a clear picture of the processes and applications of the subject. The sources also come from reports of different research groups, including Transport Studies Department in United Kingdom and the Swedish National Road and Transport Research Institute, as well as information from the project supported by the European Union, CIVITAS ("City-Vitality-Sustainability" or "Cleaner and Better Transport in Cities") that works for sustainable transports in cities. Usually the original source, also called the primary source, has been used as literature. But when it was impossible to find the original source a secondary source was used as the reference.

1.5.2. Other ways to gather information

Several relevant persons have been contacted to get more information about urban transportation, especially to get information about delivery vehicles in Hammarby Sjöstad, a city district with an environmentally profile in Stockholm. A webinar on urban consolidation centre, which was held by the CIVITAS Vanguard and the CIVITAS thematic group "Urban freight logistics", was attended in April 2013. In the webinar, four different cities, which included the Old Town and Utrecht, presented their experiences on urban consolidation centre. Interviews with relevant persons have also been performed. In June 2013, a workshop was held for the participants in the Citylogistik project to get a clear view of how the transportation system works in Norra Djurgårdsstaden today.

1.5.3. Selecting the five evaluation reports

A number of cities have implemented urban consolidation centres and WSP Analysis and Strategy has made a list of all known evaluation analyses on cities that have done this (Petterson, Nilsson, Orwén, & Berglund, 2011). This list is shown in Table 9 and Table 10 in Appendix 2 - Guide of cities with coordinated freight logistics. The five cities that were chosen as examples in this report are innovative in terms of the organization of the consolidation centre and they complement each other in the size and the structure of the city, as well as the various environmentally friendly vehicles that are used as delivery vehicles. The last is important because Norra Djurgårdsstaden has a goal that the city district will have no emissions from fossil fuel by the year 2030. An important aspect was also to choose cities that were involved in different projects, for example different projects supported by the European Union or different projects within the CIVITAS initiative. This is because projects within the same CIVITAS initiative very often have similar evaluation reports and look at the same parameters.

The first city district analyzed is the Old Town of Stockholm. It is interesting that it already is a logistic centre in Stockholm, which also is successful in reducing the energy consumption and emissions from the delivery vehicles. Another similar CIVITAS project that could have been investigated is the logistics centre in Graz, but the example of Stockholm was chosen because of the geographical nearness to Norra Djurgårdsstaden. There also exist a coordinating freight distributions projects among grocery stores in the south of Stockholm, but the evaluation report of this project concentrated on the economic gain, not on energy and environmental aspects (Petterson, Nilsson, Orwén, & Berglund, 2011). Therefore the evaluation report from the grocery stores in the south of Stockholm has not been considered in this master thesis.

The Samlic project in Linköping was chosen because it is important to have another Swedish initiative to serve as inspiration for setting up a consolidation centre. Other similar projects in Sweden are the Samtra-project in Uppsala and a coordinated freight project in Dalarna. But in the case of the Samlic project, there are six detailed reports that have evaluated the pilot project. Also, the idea of how this consolidation centre is organized is quite original and creative, because it divided the city into different delivery zones.

Norwich was chosen because it contained one of the most detailed evaluations on the energy consumption and the environmental impacts of a consolidation centre. Projects with resemblance are the urban consolidation centre in Bristol, the Bremen freight village or the urban consolidation centre in Toulouse. In the evaluation report of Norwich, the method on how the number of transports was counted was described systematically and was well-thought through.

The analysis of the micro-consolidation centre in London was chosen because it was interesting to use an example from the largest city in Europe. Projects that are closely related are for example the Chronopost project in Paris and the logistic centre in the inner city of Berlin. Due to the fact that the micro-consolidation centre in London is very innovative when it comes to the selection of environmentally friendly vehicles and that the delivery area largely consists of offices space, like a large part of Norra Djurgårdsstaden also will do, London became an appropriate choice.

Utrecht is a city that is famous for a cooperation between the transportation industry and city officials. In this town there have been many different initiatives with the aim of reducing transportations in the inner city. Other similar projects are the logistic centre in Njimegen, the coordinated distribution in La Rochelle and the urban distribution centre in Rotterdam, but these centres cannot be characterized to be as innovative like the one in Utrecht. Utrecht was chosen because the city also has four consolidation centres around the city, and it has innovative environmentally friendly vehicles that deliver goods in the city, which are the Cargohopper and the Beer boat (Turbolog, 2013).

The five evaluation reports from these cities are presented in a similar way to make the evaluation analysis easier. The method for collecting data on the delivery vehicles in the city districts is also described and is divided into the following chapters: the preliminary investigation of the project, the before situation without a consolidation centre and the after situation where a consolidation centre has been built. The most important results of the evaluation reports are presented in diagrams, because this is a precise and structured way to present the results of the calculations. By using diagrams it is easier to highlight important results and thereby use them as arguments for setting up a consolidation centre in a city district. The results, as they are presented in the evaluation reports are shown in the Appendix section 3 to 6. Usually, the results in the evaluation reports are presented in tables and not in diagrams.

2. Norra Djurgårdsstaden

This chapter gives a presentation of the construction project in Norra Djurgårdsstaden and the plans for the four areas in this city district. It also showcases the status of the project in September 2013 and describes two previous preliminary investigations on consolidation centre in Norra Djurgårdsstaden.

2.1. Presentation of the project

Norra Djurgårdsstaden is one of the largest ongoing construction projects in Sweden, and it takes place in the north-eastern district of Stockholm that stretches from Hjorthagen down to Loudden. The main vision for the project is to create a sustainable society and a vibrant city district. The planning of the new district started early in the 2000s and the whole area is scheduled to be finished around 2030. There are plans of constructing around 12 000 new apartments and around 35 000 workplaces in the city district. Previously some of the areas have been used for gas production, as a container harbor and for industrial activities (Stockholm Stad, 2013a). In Figure 2 the red outlined area in the picture to the left shows an overview of the plans for Norra Djurgårdsstaden and the blue outlined area in the picture to the right demonstrates where in Stockholm the four areas in the city district are located.

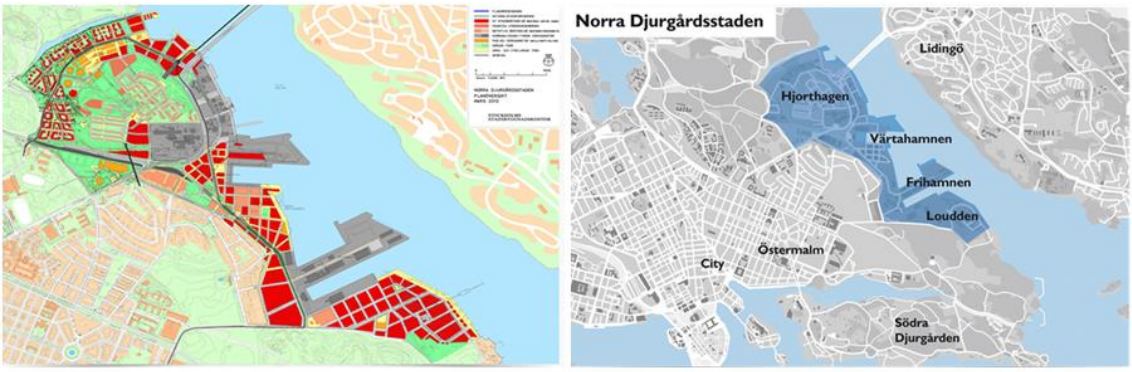

Figure 2: Map over Norra Djurgårdsstaden (Stockholm Stad, 2013c), and the location of Norra Djurgårdsstaden in Stockholm (Stockholm Stad, 2013b).

A large scale development of the infrastructure in the area is also planned. There are plans of building new pedestrian paths and bicycle paths, bicycle bridges, a new tram line and a new motorway called "Norra länken" (Stockholm Stad, 2013b).

2.2. The four areas of the city district

Norra Djurgårdsstaden consists of four districts, which are Hjorthagen, Värtahamnen, Frihamnen and Loudden.

2.2.1. Hjorthagen

Hjorthagen is an old industrial area, where the old gas works area and the electricity plant of Fortum is located. This is the first area in the project that will be built and the construction process started in

2011. It is planned that the development takes place at a rate of 500 dwellings per year. By the time the urban area is completed in 2020, Hjorthagen will contain 6000 new apartments and 15 000 new residents (Stockholm Stad, 2013d). Figure 3 shows the plans for Hjorthagen and in what stages the city district will be constructed. All the buildings in the middle of Figure 3 contain 1500 households built in the 1930s and which are a part of the old Hjorthagen (Stockholmshem, 2013).

Figure 3: The area of Hjorthagen (Stockholm Stad, 2013d).

2.2.2. Värtahamnen

One of the biggest harbors in Stockholm lies in Värtahamnen, and this area is going to be developed even further. Both the Värta Pier and the Värta Pool is planned to be expanded out into the water (Stockholm Stad, 2012). The expansion of the Värta Pier will offer new, modern and efficient port facilities and will create space for housing, offices and retail services in Södra Värtahamnen, where the harbor is situated today. This area is expected to accommodate a total of 1000 homes and 20 000 new workplaces (Stockholm Stad, 2013e). Figure 4 demonstrates what the area will look like when the construction of the Värta Pier, Värta Pool and Södra Värtahamnen are finished.

Figure 4: A vision for the new Värtahamnen (Stockholm Stad, 2012), and a map over the new Värtahamnen (Stockholm Stad, 2013e)

The area marked by a red color in the picture to the right in Figure 4, Valparaiso, is described to be a multifunctional hub and the centre of Norra Djurgårdsstaden. There are also plans for a number of apartments in the area (NCC, 2013). Värtahamnen is probably the part of Norra Djurgårdsstaden where most of the goods deliveries will happen. This is because of the quantity of offices, malls and harbor activity that will be situated in this part of the city district.

2.2.3. Frihamnen and Loudden

Currently there is a harbor for oil handling and container space at Frihamnen and Loudden. In year 2025 there is planned for approximately 5000 apartments to be completed at Loudden, and there are plans to build office spaces and service activities closer to Frihamnen. The City of Stockholm has decided that all oil handling at Loudden shall move to an alternative location, which is not yet determined. Further, the container space at Frihamnen is going to move to Nynäshamn and this will decrease the heavy truck traffic through downtown Stockholm (Stockholm Stad, 2013f).

2.3. Status of the project in September 2013

The construction of the Hjorthagen area has started and a construction logistic centre close to this area was opened on May 15th in 2013. Almost all construction materials are supposed to go through this logistic centre, and then be delivered by environmentally friendly vehicles to construction sites in the area (Stockholm Stad, 2013g). The construction logistic centre lies between stage 9 and stage 10 of apartments in Hjorthagen, which can be seen in Figure 3. Production of 140 students housing are underway in stage number 2 in Hjorthagen. The construction of the office building "The Riga Quarter" in Värtahamnen is completed and the construction of more offices and retail businesses is scheduled to start in Södra Värtahamnen in 2013. Also, the construction of the new Värta Pier is also planned to begin in the autumn the same year (Stockholm Stad, 2013h). The solar cell system on the roof of Tray 6 at Frihamnen was opened in September 2013. 919 solar panels are covering an area of 1500 square meters and will provide the building with 15 percent of the annual electricity need. The plant will supply approximately 180 000 kWh per year (Stockholms hamnar, 2013).

2.4. Preliminary investigations of delivery vehicles in Norra Djurgårdsstaden

Two different preliminary investigations have estimated the energy and environmental impacts of the coming goods delivery transportation in Norra Djurgårdsstaden. Both studies have calculated two scenarios, which is scenario A without a consolidation centre and scenario B with a consolidation centre. Also, both of the studies used reference areas to find the impacts on energy consumption and emission of dangerous substances. Since the construction of the city district has just started, the calculations have taken several assumptions. One study was performed by students from the Institution of Economic and Industrial Development at Linköping University in cooperation with the Swedish postal service Posten AB. The other study is called TransOpt and was done by Sustainable Innovation in cooperation with WSP Strategy and Analysis as well as Logica.

2.4.1. The preliminary investigation made by TransOpt

TransOpt has studied the areas that will be built first, which are Hjorthagen and Värtahamnen. To find the number of transports from delivery vehicles, statistics from two reference areas in Gothenburg that are similar to Norra Djurgårdsstaden have been used. The reference areas are the office centres in Lindholmen and Nordstan as well as the shopping centre in Nordstan. At the reference areas, the number of transports per day has been counted. Then the numbers of transports per square meter in the reference area have been estimated by dividing the number of transports per day in the reference area with the number of square meters of the office and retail trade surface area in the reference area. This gives the number of transports that one square meter of surface area generates per day, see Table 1 (Kristoffersson, Pettersson, & Eklund, 2010).

Table 1: The calculations of the transports generated by business materials (Kristoffersson, Pettersson, & Eklund, 2010).

Area	Type of area	Square meter of surface	Transports/square meter per day	Transports per day
Lindholmen	Office	90 000	0.0027	285
Nordstan	Retail trade	65 000	0.0032	500
Nordstan	Office	90 000		
Norra Djurgårdsstaden	Office and retail trade	378 500	0.0030	1100

In order to calculate the transports per day in Norra Djurgårdsstaden, the total average transport per square meter per day from the reference areas is multiplied by the total office and retail trade surface in Norra Djurgårdsstaden. In scenario B, when it comes to setting up a consolidation centre the preliminary investigation has made an assumption, based on the experience from other projects, that the number of delivery vehicles can be reduced by 40 percent if a consolidation centre is built (Kristoffersson, Pettersson, & Eklund, 2010). The results are demonstrated in Table 2 under section 2.4.3.

2.4.2. The preliminary investigation made by Linköping University

In this study, Norra Djurgårdsstaden was split up into sub areas by character and by the available data. It was predicted that the area Hjorthagen will have the same type of structure and inhabitants as Hammarby Sjöstad in Stockholm. Värtahamnen and Frihamnen will contain office buildings and other workplaces and it was assumed that these districts will be similar to Kista Industrial area in Stockholm. A starting point of the study, in scenario A without a consolidation centre, was to estimate the amount of goods delivered by the delivery vehicles in Norra Djurgårdsstaden. The study used information from Posten AB, for example the average weight of the parcels and pallets from the reference areas, and then it was scaled linearly to represent the entire market of Norra Djurgårdsstaden. To calculate the number of transports the weight of the vehicle was divided by the total weight of the parcels and pallets that was estimated for Norra Djurgårdsstaden, and the study assumed that 65 percent of the deliveries will take place in the morning and 35 percent of the deliveries will take place in the afternoon. It has also been corrected for trends such as the growing e-commerce trade in the final results (Back, Högström, Kronander, Ljungberg, & Överfors, 2012).

In scenario B, the starting point is that Norra Djurgårdsstaden aims to be an environmentally innovative district. Therefore, the study has been inspired by the electrically-assisted cargo tricycles used in La Petite Reine and the micro-consolidation centre in London to deliver goods. In scenario B it is proposed that the consolidation centre will make deliveries by these electric vehicles and a biogas vehicle from the traffic place called Värtan, located next to Norra Länken and the ferry terminals in Värtahamnen (Back, Högström, Kronander, Ljungberg, & Överfors, 2012). A more detailed description and the results are shown in Table 2 in section 2.4.3.

2.4.3. A comparison of the two preliminary investigations

Table 2 summarizes the differences in methodology, calculation methods and the results of the two preliminary investigations.

Table 2: A comparative evaluation of the two preliminary investigations on delivery vehicles in Norra Djurgårdsstaden.

	Linköping University and Posten AB	**TransOpt**
The initiators of the study	Posten AB and Sustainable Innovation	Sustainable Innovation, Logica, Riksbyggen, JM and the Stockholm City Council
Who has done the evaluation analysis	Five students at Linköping University, at the Institution of Economic and Industrial development, under the course TETS38 "Logistic project"in cooperation with Posten	Sustainable Innovation Logica WSP
Research field	Logistic Systems	Transportation analysis
Interest to bring out of the survey	-To calculate the energy consumption and environmental impacts of coordinated freight logistics in NDS -To evaluate the traffic situation	-The effects of implementing a consolidation centre in NDS and calculate the number of delivery vehicles per day and per year
Time period	October 2011 to September 2012	2010
Method used in scenario A	-Used reference areas in Stockholm with similar structure as NDS (Hammarby Sjöstad and inhabitants, Kista Science City and workplaces) -Information from Posten AB on the number and the weight of parcels and pallets -Finds the number and weight of the parcels and pallets in NDS by scaling the inhabitants and workplaces linearly and taking account of the marked share to Posten AB - To find the number of transports in one day in NDS is the total weight of the parcels and packages divided with the max load of the vehicles that is assumed to be used -Approximates the average delivery distance -Calculates the energy and environmental effect with the NTM-method	-Used reference areas in Gothenburg with similar functions as NDS (Lindholmen and office space, Nordstan, office space and retail trade) -The transports is based on number of transports per square meter office per day in the reference areas in Gothenburg -The transports per day in NDS is calculated by multiplying the transports per square meter office per day in the reference areas in Gothenburg with the total square meter of office surface in NDS -Calculates the energy and environmental effect with the NTM-method
Method used in Scenario B	-Assumes that 25 % of the transports that scenario A generates still will happen -The remaining 75 % will be replaced with environmentally friendly vehicles that has zero emissions (electric and biogas vehicles) -The energy consumption of the electric vehicles is calculated by using a full loaded battery multiplied by the number of electric vehicles -The NTM-method was also used here	-Assumes, with results from previous studies, that a consolidation centre will reduce the transports in NDS with 40 percent of what is calculated in scenario A -Calculates the energy and environmental effect with the NTM-method
Results	<u>Scenario A:</u> 46 transports per day, which in turn generates 10 300 kg of CO_2 per year, 0.440 kg particulates per year and 152 000 MJ in energy use of the vehicles per year <u>Scenario B:</u> 8 electric cargo tricycles and one biogas vehicle in peak period, which generates 2600 kg CO_2 per year, 0.11 kg particulates per year and 107 000 MJ in energy consumption of the vehicles per year	<u>Scenario A:</u> 1100 transports per day 350 000 transports per year <u>Scenario B:</u> 680 transports per day 205 000 transports per year, which generates a decrease in 1400 tonnes CO_2 per year, 65 kg particulates per year, 4900 kg NO_x per year and 270 kg CO per year

From Table 2 it is interesting to notice that the students from Linköping University have estimated that the number of transports per day will be 46 in scenario A, while the TransOpt study estimated it to be 1100 per day. This is a significant difference and it is discussed more in section 7.2.

3. Theory

This chapter explains the relationship between the energy system, the energy sources, the delivery vehicles impact on the environmental and the strong focus on energy consumption and environmental issues in Norra Djurgårdsstaden. It also gives an example of a data tool that estimates the energy and environmental effects from the delivery vehicles. Further, a theory on how to estimate the number of vehicles in a city district is specified.

3.1. The energy system of the delivery vehicles

An energy system is the relationship between the production and distribution of energy as well as the energy consumption. What the system consist of is different from case to case. When it comes to consolidation centres the delivery vehicles are the main components of the energy system. As noted in section 1.3, the different types of delivery vehicles are displayed in Figure 17 in Appendix 1 - Truck guide. The delivery vehicles use energy, and the number of delivery vehicles in a city district as well as the types of delivery vehicles decide how much energy and what kind of energy source that is used in this energy system. What kind of energy source a vehicle uses also determines how much and what kind of emissions that is released by the delivery vehicles, or if no emission is released by the delivery vehicles. In the case of Norra Djurgårdsstaden, the city district will be the geographical unit of the energy system, because this is where the delivery vehicles will deliver goods. Further on in this chapter, the energy sources of the delivery vehicles, the emissions from the delivery vehicles and a method for calculating energy and environmental effects from the delivery vehicles will be presented. At the end of this chapter a theory on how the number of deliveries can be estimated by using key numbers will be demonstrated. This is to obtain knowledge of one of the theories behind the energy and environmental impact of the delivery vehicles and one of the theories on estimating the number of delivery vehicles in a city district.

3.2. Energy sources

Vehicles need some kind of energy source to get the engine working and for the most part the energy comes from fossil fuel, like gasoline and diesel, or from batteries and biogas.

3.2.1. Fossil fuel

Fossil fuel is a generic term for a mixture of various hydrocarbons which constitutes an easy volatile, colorless and flammable liquid (Store Norske leksikon, 2013). What mainly distinguishes gasoline and diesel is that the gasoline is distilled crude oil while diesel fuel is refined from crude oil. Diesel fuel contains more energy and more carbon than gasoline (MiljöfordonSyd, 2013). Burning of fossil fuels leads to emission of dangerous substances into the atmosphere. Gasoline and diesel release different types of emissions because the combustion processes are different. Furthermore, the emission factors and the energy use are dependent on the type of vehicle used, like motor type, weight, technology and age as well as driving patterns (Statistics Norway, 2008). For example with a modern diesel vehicle emissions from carbon dioxide can be reduced by around 20 percent compared to a gasoline vehicle of similar size and power due the greater fuel efficiency of the diesel engine. Compared to a gasoline vehicle, diesel vehicles have slightly higher emissions of nitrogen oxides and particulates, but most new diesel vehicles have particulate filters, which reduces these problems (Konsumentverket, 2011) .

3.2.2. Batteries

The electric motor with batteries is completely emission free. There are zero emissions of greenhouse gases and no local pollution from particulates or other harmful emissions from the electric car. If the electricity is produced from various forms of renewable energy, whether it comes from wind, water, waves or biomass, then the whole energy chain is emission free. The electric car is powered by batteries and it varies from vehicle to vehicle how long and how often the charging of the batteries takes. Battery life is still the biggest limitation of electric vehicles, but there is a lot of research in the area. The range of electric vehicles is also affected by weather, temperature and driving style (Klimabiler.no, 2013a).

3.2.3. Biofuel

Biofuels are fuels produced of renewable materials, such as food, vegetable oils, sugar or waste. It comes mostly in the form of biogas or biodiesel. When biofuels burn, there are emissions of CO_2 just like from gasoline and diesel, but this emission of CO_2 is part of the natural carbon cycle into the atmosphere and are therefore considered to be a more environment-friendly fuel than fossil fuel. Biofuels behave much like fossil fuel in a car engine. Therefore, ordinary vehicles using biofuels requires usually only small changes of the engine and in some cases no changes at all (Klimabiler.no, 2013b).

3.2.4. Other types of energy sources

Other types of vehicles are for example ethanol fuelled vehicle (E85) and electric hybrid vehicles, which are also more environmentally friendly than fossil fuelled vehicles (Konsumentverket, 2011). These are also an alternative to use as delivery vehicles from a consolidation centre, but these are not mentioned in the evaluation reports that are analyzed and thus not considered in this report.

3.3. The environmental effects

Emissions of exhaust gases derive from the combustion of fossil fuels in the engines of the delivery vehicles. The formation of certain emissions is either linked directly to the elementary composition of the fuel or it comes from the combustion conditions. Some emissions also derive from both of the processes (IVL Swedish Environmental Research Institute Ltd., 2003). A lot of different substances are released from fossil fuel vehicles, but only the substances with the highest emissions are discussed in this chapter. These substances are also likely to be released in Norra Djurgårdsstaden.

3.3.1. Carbon Dioxide - CO_2

Carbon Dioxide is a gas that is formed directly from the carbon in the fossil fuel. The burning of fossil fuel converts fossil carbon into CO_2 and it releases carbon that has been stored underground for millions of years and therefore is not part of the natural carbon cycle. An increased concentration of CO_2 in the atmosphere is the biggest contributor to the greenhouse effect (Klimabiler.no, 2013b). If the combustion process is incomplete and other organic compounds are created, a small portion of the carbon can form carbon monoxide (CO). An important parameter for the formation of CO_2 from fossil fuel is the C/H-ratio (carbon/hydrogen) and a high C/H ratio provides a high CO_2 emission per unit of energy (IVL Swedish Environmental Research Institute Ltd., 2003). CO_2 contributes to increase global warming and CO contributes to local air pollution and is dangerous for people with illness. On the other hand CO_2-equivalents are emission of the greenhouse gases CO_2, CH_4 and N_2O that is weighted together and is equivalent to the emission of CO_2 (Statistics Norway, 2008).

3.3.2. Nitrogen Oxide - NO_x

NO_x is a common term for Nitrogen dioxide (NO_2) and Nitric oxide (NO). NO_x is formed during the combustion in the motor by a series of chemical reactions in the flame and flue gases and by oxidizing the nitrogen contained in the fuel (IVL Swedish Environmental Research Institute Ltd., 2003). The gas can give respiratory disease (particularly NO_2) and contributes to the formation of tropospheric ozone and acidification (Statistics Norway, 2008).

3.3.3. Particulates (PM_{10})

Particulates are small organic compounds that come from the exhaust gases. This substance increases the risk of respiratory disease in conjunction with other components and contributes to local air pollution (Statistics Norway, 2008). Diesel vehicles have commonly higher emissions of particulates than gasoline and biogas.

3.3.4. Noise levels

The delivery vehicles engine creates a lot of noise when the vehicle is in driving mode. Noise levels are often measured in decibel (dB). It is a logarithmic scale, so whenever the sound effect doubles the decibel level increases by three dB. Noise is an unwanted sound that can cause widespread environmental problems and health problems for human beings. Physically, there is no difference between sound and noise. But what is seen as an unwanted sound varies greatly between individuals and even with the time of day. Traffic noise is actually the environmental disturbance that affects most people in Sweden (Naturvårdsverket, 2012). So decreasing the number of delivery vehicles in Norra Djurgårdsstaden could help reduce the noise levels from traffic.

3.3.5. Other types of emissions from delivery vehicles

Other greenhouse gases that come from transport vehicles are for example ozon (O_3), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydroflourocarbons (HFCs), sulphur hexafluoride (SF_6), non-methane-hydrocarbons (NMHC) and hydrocarbon gas (HC). Emissions of other acid gases from transport vehicles are for instance sulfur oxide (SO_2) and ammonia (NH_3).

3.4. The strong environmental and energy focus of Norra Djurgårdsstaden

Norra Djurgårdsstaden has one of the strongest energy and environmental profiles of urban planning in Sweden. The comprehensive environmental tradition was established in Hammarby Sjöstad in the early 2000, where environmental issues were integrated with urban planning, and will be passed on to the sustainable urban planning in Norra Djurgårdsstaden. Three ambitious environmental goals have been set out for Norra Djurgårdsstaden. This includes that the city district has to be well prepared for climate changes, that the CO_2 emissions will be less than 1.5 tonnes per person and year before year 2020 (the average CO_2 emission per person and year in Stockholm was 4.5 tonnes in 2008) and that the city district only will use energy from renewable energy resources before year 2030 (Norra Djurgårdsstaden, 2010).

To achieve these ambitious goals several initiatives have been proposed. The district will have a climate-friendly outdoor environment that can handle climate changes. Further, the buildings constructed in the area are energy efficient buildings that are low energy houses or energy plus houses with installations displaying the daily energy consumption, and the buildings are designed to generate their own solar and wind energy. Waste is also going to be disposed of via an underground vacuum system and there will be three different options for drops like packaging, paper and residual waste. On top of that, there will also be general recycling houses in the area. The area will support an environmentally efficient transportation by targeting pedestrians and cyclists. To develop an efficient coordinated freight logistics system is a part of the efficient transportation strategy. Freight and goods transport in Norra Djurgårdsstaden will be done in an environmentally efficient manner using consolidation centre and environmentally friendly vehicles (Norra Djurgårdsstaden, 2010).

3.5. The NTM-method

There are many methods for calculating the environmental and energy effects of transports. The most common in Sweden is the NTM-method (the Network for transport and environment), which is set together by the NTM working group for freight transport and logistics with their member organizations that represents different transport types. They have established methods and data, which calculate the energy and environmental performance of cargo transport systems in a computer tool. 10 different vehicles can be chosen, see Figure 17 in Appendix 1 - Truck guide. Each vehicle engine type can be classified by the Euro standard, according to the European emission standards that define tolerable limits for exhaust emissions in European Union member states. At the moment there are six classes where Euro 6 is the latest classification and also has the toughest emission requirements (Road transport Europe, 2010). This means that vehicles classified as Euro 1 releases the most amount of emissions and Euro 6 vehicles release the least amount of emissions. It is worth noting that the two previous preliminary investigations of Norra Djurgårdsstaden used the NTM-method to calculate the environmental and energy effects of the delivery vehicles.

3.5.1. The fuel consumption data

The general calculation strategy behind the fuel consumption data in the NTM-method begins with collecting information on the fuel type of the vehicle and what type of road it is. These are the first factors that are entered into the computer tool. Then the emission factors, the Euro standard the vehicle is classified as and the average slope of the road are typed in. After this the shipment weight of the vehicle, the maximum weight load of the vehicle as well as the cargo load factor in percent are typed into the computer tool. Next, the difference in fuel consumption per kilometer for a vehicle with 0 % loading factor and a vehicle with 100 % loading factor is calculated. This is also dependent upon the type of road the vehicle is driving on, whether it is a motorway, rural roads or urban roads. The final digits to be entered is the distance the vehicles have travelled and the fuel consumption of the vehicles, which is higher if the vehicle has a heavier load because of an increased rolling resistance and more dynamic weight. Then the fuel consumption of the vehicles can be approximated to be a linear equation shown in Equation 1.

$$FC_{LCU} = FC_{empty} + \left(FC_{full} - FC_{empty}\right) * LCU_{weight(phys)}$$ **Equation 1**

Where $LCU_{weight(phys)}$ is the load capacity utilization, which is defined as cargo physical weight/max weight capacity, FC_{LCU} is the fuel consumption at load capacity utilization LCU, FC_{empty} is the fuel consumption of the vehicle when it has 0 percent loading factor and FC_{full} is the fuel consumption of the vehicle when it has 100 percent loading factor. From the fuel consumption data, the energy consumption and the emission factors of the vehicles are estimated (Road transport Europe, 2010).

3.5.2. The emission factors data

From the NTM-methods fuel consumption data it is possible to obtain information of nine different types of emissions from dangerous substances. The emission factors are mainly data that is extracted from ARTEMIS, which is the common emission model used by the European Union and the fuel consumption data from the NTM-method. These data are based on emissions per liter fuel consumption and what type of fuel that is used in the truck. The total emission of a substance is calculated by Equation 2.

$$Em_{i,x,y}^{Tot} = EF_{i,x,y} * FC_{i,x,y} * Travel\ Distance$$ **Equation 2**

Where $Em_{i,x,y}^{Tot}$ is the total emission of substance i, driving on road x with vehicle y, $EF_{i,x,y}$ are the emission factor that comes from ARTEMIS and $FC_{i,x,y}$ are the fuel consumption (Road transport Europe, 2010). The emissions that are estimated in the computer tool from vehicles are CO, CO_2, HC, CH_4, N_2O, NMHC, NO_X, PM and SO_2.

3.6. Key figures to count number of deliveries in a city district

The Norwegian Public Roads Administration controls the planning, construction and operating of the national and county road networks in Norway (Statens vegvesen, 2013) and they have published a guidance book for goods transports in the city centre. This guidance book contains a table with key numbers on how much deliveries that are generated for businesses based on the industry and sector (Statens Vegvesen, 2005). The key numbers are taken from an article written by Jørgen Rødseth from SINTEF in 2004, which is called “Generated numbers on deliveries and other business-oriented transport”. SINTEF is the largest independent research organization in Scandinavia and is a broad, multidisciplinary research group with international expertise in technology, science, medicine and social science (SINTEF, 2013). Table 3 indicates the average number of deliveries for stores in different industries and sectors, based on experience numbers.

Table 3: Key numbers on goods deliveries (Statens Vegvesen, 2005).

Industry / Sector	Number of deliveries	Comments
Goods deliveries to businesses within		
Grocery	5-10 per day per store in the city centre 5-15 per day per store outside the city centre	
Clothes, textiles, shoes and sport	0.5-1 per day per store	
Wholesale and retail in general	1-2 per day per store (in average)	There are many different businesses
Shopping mall	1.2-1.5 per day per store for shopping malls in the city centre 1.2-2.0 per day per store for shopping malls outside the city centre	
Service visits to companies within		
Wholesale	0.2-0.5 per day per store	Includes visits from craftsmen, and a wide range of services and service businesses
Goods deliveries and service visits to		
Service and enterprises providing businesses	1-5 per day per business	
Department Stores	2-5 per day per 100 m^2	Industry department stores, furniture stores, electrical stores, building warehouses, office equipment, data warehousing, "everything" store. For example: Clas Ohlson, Biltema, Rusta, Ikea and Mio.

Table 3 make evident that the number of deliveries to individual stores generally shows great variation. The Norwegian Public Roads Administration states that the numbers must be treated with great caution. Some industries have less data than wanted from a research perspective and the numbers are intervals where most stores will be within the ranges specified. For most shops and businesses in the service industry, there is less variation in numbers measured per store than the numbers measured per area. A big store tends to get larger volumes delivered, but not necessarily more deliveries. The Norwegian Public Roads Administration emphasize that deliveries per store therefore provide a better measurement than deliveries per 100 square meter, but is an exception when it comes to warehouses (Statens Vegvesen, 2005). These key figures can be used to calculate the number of transports in the areas in Norra Djurgårdsstaden with the most businesses and department stores, which are Värtahamnen and Frihamnen.

4. Review of previous studies

This chapter reviews previous studies that have evaluated consolidation centres. The studies are from the Old Town of Stockholm, a part of the city center of Linköping, the city center of Norwich, the financial district in London and the city center of Utrecht.

4.1. The logistic centre in the Old Town of Stockholm in Sweden

The chapter below presents the background, the objectives, the energy and environmental parameters, the method of collecting data, the calculation methods and the results of the evaluation report from the logistic centre in the Old Town of Stockholm.

4.1.1. Background

The Old Town of Stockholm is situated on an island in the middle of the capital of Sweden. About 3000 people live in the Old Town and approximately 9000 people are working in the area. In this part of Stockholm most of the buildings originate from the medieval time dating back to the 16th century. Because of this the streets are narrow and small, and most of the Old Town contains pedestrian areas with goods delivery hours in the morning since no entry is allowed for distribution vehicles after 11am. The area contains tourism based businesses, the Royal Castle, the Parliament, churches, museums, hotels, restaurants, shops and other businesses. Usually, the restaurants and shops are small and requires frequent deliveries of goods. Consequently, the delivering of goods into the Old Town was quite complicated and many local stakeholders in the area were seeking more efficient logistic solutions before the decision to implement the logistic centre. Local NGO`s like parents groups and Agenda 21-groups collaborated with local politicians of Stockholm and the delivery company Home2you to develop a logistic centre near the Old Town, see Figure 5 (CIVITAS Trendsetter, 2005).

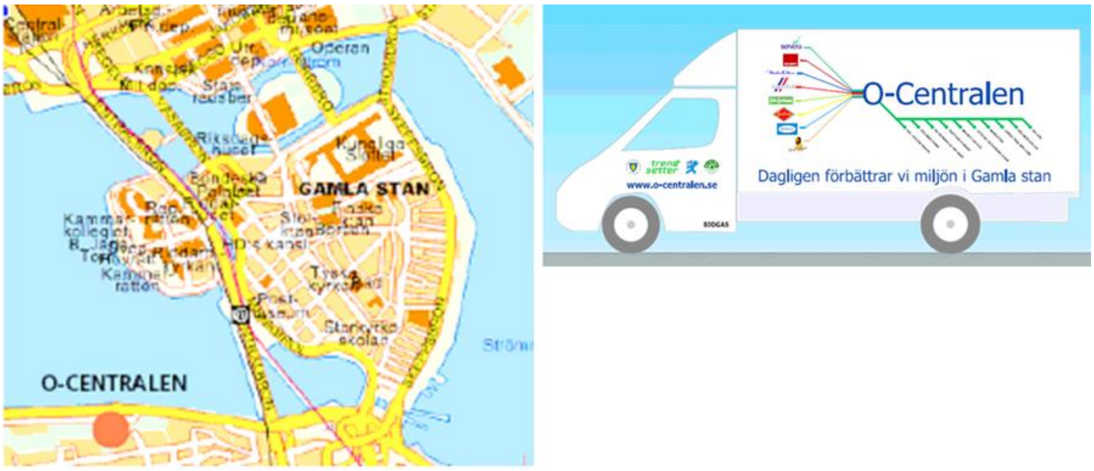

Figure 5: The logistic centre is located at the point called O-centralen near the Old Town (Gamla Stan on Swedish) and a picture of the the biogas fuelled vehicle that delivers goods from the O-central (CIVITAS Trendsetter, 2005).

The logistic centre opened in 2004 and provides goods deliveries to the restaurants in the area by co-transporting goods from several delivery companies, and the number of customers reached 35 during the test period, of potentially 85 customers (CIVITAS Trendsetter, 2005).

The first plan of Home2you, the company that operates the logistic centre, was to use an electric truck to deliver the goods. But this truck was destroyed in a garage fire so instead a new biogas fuelled vehicle with a loading capacity for 15 rolling containers was purchased for delivering the goods, see the picture to the right in Figure 5. Because of a long delivery time of the biogas fuelled vehicle an ordinary diesel truck was used as a substitute in the meantime. The evaluation report of the logistic centre is done by CIVITAS Trendsetter, which was a part of the CIVITAS 1 project that lasted from 2002 to 2006 (CIVITAS, 2013a). Two almost identical evaluation reports investigates the effects of setting up the logistic centre.

4.1.2. Objectives of the project

The objectives for implementing the logistic centre were (CIVITAS Trendsetter, 2005):

1. Setting up the logistic centre for coordinated freight deliveries to the Old Town.
2. Decreasing the number of small direct deliveries to shops and restaurants in the area and to get less traffic congestion during the delivery hours.
3. Improving the environment for people working in the area, inhabitants and visitors in the area.
4. Minimizing the energy use and reduce the emissions from environmentally dangerous substances, by saving 30 000 km of driving of diesel lorries (CIVITAS Trendsetter, 2006).

4.1.3. Energy and environmental parameters

The energy and environmental parameters used in the evaluation report are (CIVITAS Trendsetter, 2005):

- The total and renewable energy use
- Emissions of CO_2
- Emissions of particulates
- Emissions of NO_x
- Noise levels

Other related parameters in the evaluation report are number of trips, vehicle kilometer, vehicle load factor and number of small deliveries (CIVITAS Trendsetter, 2005).

4.1.4. Method of collecting data

Preliminary investigation

Gradient AB performed a preliminary investigation of the delivery situation in the Old Town in 2003 and studied the actual number of deliveries and the value of the goods delivered. This investigation also studied the structure of the businesses with respect to the quantity, number of employees and the percent share the particular business had in the Old Town as well as what type of deliveries these businesses had. The reason for this was to get an idea of what businesses that had most deliveries per day. There were 85 restaurants in the Old Town with a 44 % share of the businesses, which was the biggest share of all of the different businesses. Further, the structures of the suppliers were also studied and two types of suppliers of the businesses were found. The two types are businesses with their own distribution solution and businesses that use logistics companies like Posten AB, Schenker and DHL to get their goods delivered (CIVITAS Trendsetter, 2005).

Before

The before situation is unfortunately not so well described in neither of the two evaluation reports from CIVITAS Trendsetter. It is assumed that this situation was studied as a part of the preliminary investigation in the evaluation reports done by CIVITAS Trendsetter. In the thorough investigation of the businesses in the area it was estimated that the 85 restaurants in the area had 120 000 deliveries per year. It was assumed that each restaurant approximately had six different deliveries per day and that the goods were delivered by diesel vehicles (CIVITAS Trendsetter, 2005).

After

The Trendsetter evaluation report claims that the calculation of the results from the logistic centre is based on invoice data from the "O-centralen" registered from December 2004 to the end of February 2005. Further the report says that the numbers from the invoice data are multiplied by 4 in order to get a result on an annual basis, since the data only comes from a three month period. In this period 30 restaurants received deliveries with the biogas vehicle from the logistic centre (CIVITAS Trendsetter, 2005).

4.1.5. Calculation methods

Standard values from the delivery vehicles were used to calculate the energy and environmental effects of the diesel vehicle and the biogas vehicle. The standard values were for example diesel consumption per kilometer and the emission of CO_2, NO_x per kilometer. It is noted in the report that the values for the NO_x and particulates for the diesel vehicle are too high compared to normal emissions, but the authors still choose to continue to use these values (CIVITAS Trendsetter, 2005). Table 11 in

Appendix 3 - The logistic centre in the Old Town of Stockholm in Sweden shows the standard values of the diesel vehicle and the biogas vehicle. The standard values are converted to energy use and emission of fossil CO_2, NO_x and particulates with help from the number of transports, the number of trips and the distance travelled (CIVITAS Trendsetter, 2006). In the before situation all of the 85 restaurants were assumed to get deliveries from the diesel vehicle. Thus in the before situation, the calculations were based on the standard values from the diesel vehicle. While in the after situation the total energy and environmental impacts of setting up a logistic centre are calculated by adding the results from 30 restaurants getting deliveries with the biogas vehicle from the logistic centre and the 55 restaurants that did not get deliveries from the logistic centre, together. These 55 restaurants received deliveries from the diesel vehicle from other types of suppliers instead. This means that in the after situation the calculations were based on both the standard values from the biogas vehicle and the diesel vehicle (CIVITAS Trendsetter, 2006).

4.1.6. Results

Figure 6 demonstrate the results from the evaluation reports of CIVITAS Trendsetter.

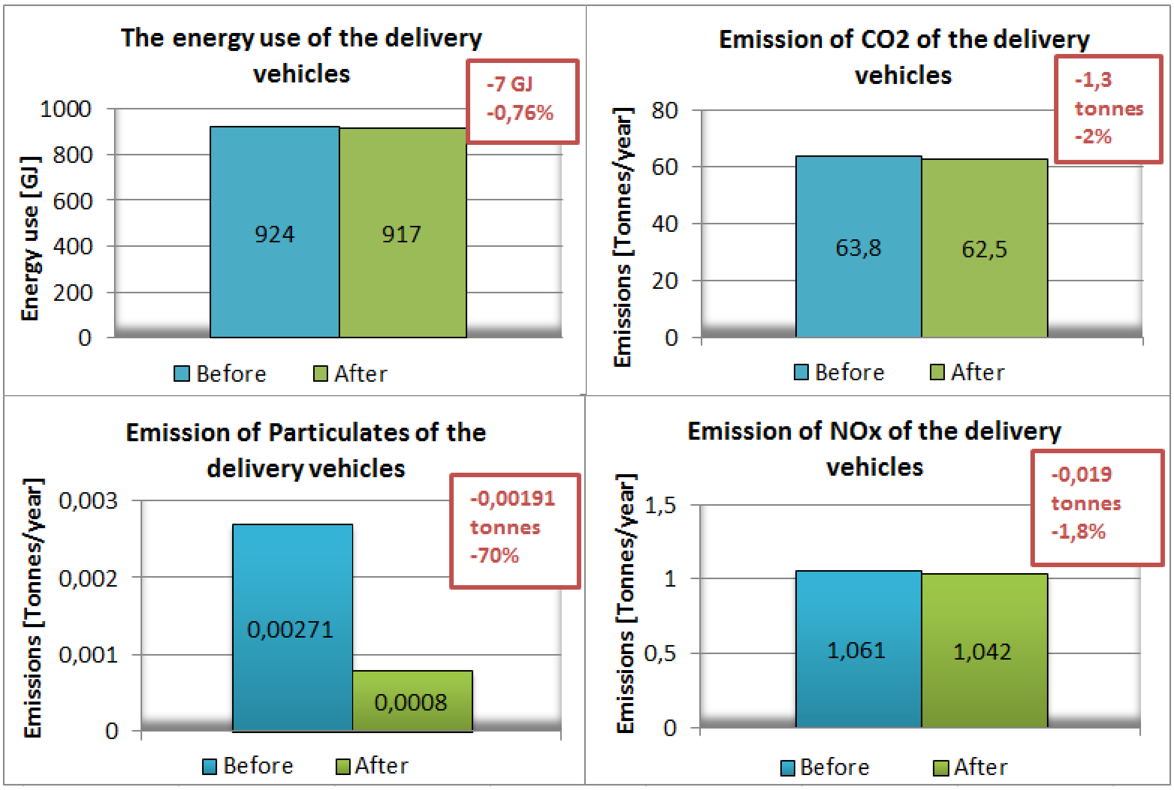

Figure 6: The energy and emissions calculated from before and after the logistic centre.

The results in Figure 6 indicate that the energy use as well as the emissions from CO_2, NO_x and particulates of the vehicles has decreased after setting up the logistic centre. Further results are presented in Table 12 in Appendix 3 - The logistic centre in the Old Town of Stockholm in Sweden.

Table 12 also shows that the noise levels were estimated to be 122 dB both in the before and after context (CIVITAS Trendsetter, 2005).

4.2. The Samlic project in Linköping in Sweden

The chapter below presents the background, the objectives, the logistics parameters, the method of collecting data, the calculation methods and the results of the evaluation report from the Samlic project in Linköping, Sweden.

4.2.1. Background

Linköping is the fifth largest city in Sweden with a population of approximately 150 000 people and is situated in the south-east of Sweden (Linköpings kommun, 2010). By the end of the 1990`s central Linköping experienced an increase in congestion as well as delays in traffic and at loading sites for delivery vehicles. As a consequence this led to higher costs for the distribution of goods in the city and the retail businesses searched for a change. Therefore, a group called "The Local Network for Transporters" in Linköping initiated the project SAMLIC - coordinated goods distribution in Linköping City (In Swedish: SAMordnad varudistribution i LInköpings City). The initiative developed in many steps, but this was the most important group in the process. This group consisted of representatives from the municipality, the logistics companies, the commercial properties in Linköping, the retail business industry and shopping malls (Eriksson, Lundgren, & Svensson, 2006).

A pilot project was carried out in the spring of 2004 to obtain a solid base of data on how well a coordinated freight logistic project like Samlic could operate. The pilot project lasted for nine weeks, from 29th of March to 28th May in 2004, and the direct participants were the logistics companies DHL, Posten and Schenker. It was also intended that DFDS would participate in the project, but the company pulled out of the pilot trial because of restructuring in the business organization during the same time (Eriksson, Lundgren, & Svensson, 2006). Only one part of the inner city was part of the Samlic pilot project, and the participants divided this part of the city into three zones called west, central and east, see Figure 7.

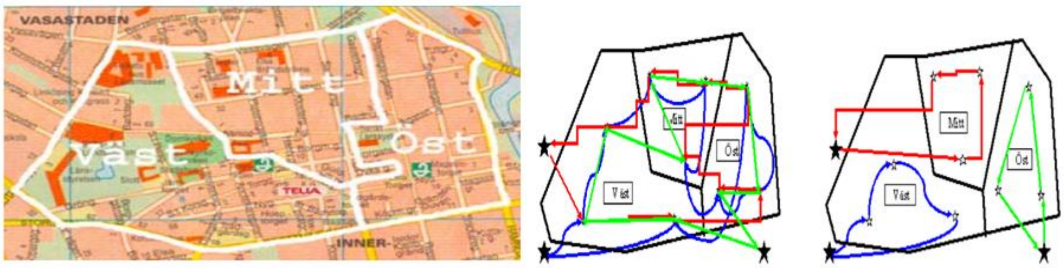

Figure 7: Linköping was divided into three zones, and the delivery system without or with the consolidation centre (Eriksson, Lundgren, & Svensson, 2006).

The different zones were based on freight measurements during week 6 in 2004, just before the pilot project started. In the picture to the left in Figure 7, a map of the city centre in Linköping is shown. In the picture to the middle of Figure 7, all three logistics companies make deliveries at every load site in the zones. The blue, red and green colors represent the logistics routes of different delivery vehicles in the inner city. But, in the right of the picture, which shows the case of coordinated freight logistics, the goods are first transported to the urban consolidation centre run by Schenker and here the goods are sorted by the zones (west, central and east). Each of the logistics company participating in the project delivers goods from all logistics companies to one determined zone in the city centre. The idea is that it creates a efficient distribution system and less traffic in the city (Svensson, et al., 2006). The Swedish National Road and Transport Research Institute have published six different articles about this pilot project. The articles "The Pilot project" and "Implementation of Samlic - the proposal and the process" are the most appropriate articles to this master thesis (VTI, 2013).

4.2.2. Objectives of the project

The objectives of the experiment were to measure:

1. The potential benefits of coordinated freight logistics, and also gaining practical experience on how coordinated goods distribution can act as an alternative to regulate and control the truck traffic in the inner cities (Eriksson, Lundgren, & Svensson, 2006).
2. How to make the coordinated freight logistics project lucrative for every stakeholder in the project, like the municipally, the logistics companies, the retail industry and the drivers at the logistics companies (Svensson, et al., 2006).

None of the reports published on the Samlic project mention that the objectives were to decrease the energy consumption or reduce the environmental effects of the urban transportation.

4.2.3. Logistics parameters

The Swedish National Road and Transport Research Institute measured logistical and transport parameters, not any energy or environmental parameters. The parameters used for evaluation are:

- Run times in the city centre
- Mileage in the city centre
- Number of stops in the city centre
- Total number of stops
- Average time per stop
- Total time of the distribution
- Total weight of the goods

The first three can be used to describe the effects on traffic and the last four measures the efficiency of the transport systems. The number of stops is also used as an indicator of how the loading sites interfere the stores (Svensson, et al., 2006). These parameters are related to energy and environmental effects because they can be converted, with for example the NTM-method, to calculate the energy and environmental effects of the delivery vehicles.

4.2.4. Method of collecting data

Preliminary investigation

The logistician Catarina Nilsson performed the preliminary investigation, with financial support from the employment services, in the city centre during three weeks in May and June 2001, in order to get an overview of the trends in freight transports in Linköping (Eriksson, Lundgren, & Svensson, 2006). The deliveries on three different berths in Linköping were mapped, representatives of the biggest logistics companies were interviewed and questionnaires were sent out to the retail businesses in the city centre (Svensson, et al., 2006).

Before

Almost the same type of data was collected before and after the pilot study. This was to compare the situation of coordinated freight logistics against the "normal" traffic mode. Two types of data were collected, information about the routes and the consignment notes of the delivery vehicles. The examination of the normal situation was actually done after the trial of the Samlic-terminal. This was carried out in two stages after the pilot study, partly during two weeks in June with Schenker and partly during a week in September at Posten AB. Information from DHL was received about certain trips but they were of minor value. What made the collecting of data difficult was that the trips were often not limited to the survey area that followed the zone section (Svensson, et al., 2006). How the data was gained is explained more thoroughly under the *After* heading.

After

During the nine weeks the experiment lasted, data was collected from the drivers of the delivery vehicles from the consolidation centre. Several vehicle types were used during the project, but the average type of vehicle had a load capacity of 8738 kg (Svensson, et al., 2006). The logistics companies took turns on delivering goods to the three zones with a three-week interval, so that the results do not depend on which of the logistics companies that delivers goods to one of the zones (Eriksson, Lundgren, & Svensson, 2006). Driving to and from the consolidation centre the drivers of the vehicles had to fill out notes with information of the trips. The forms were delivered with the consignment notes from the goods, examples of the consignment notes and driver notes are seen in Figure 18 in Appendix 4 – The Samlic project in Linköping. In the note, the driver had to write down the date, vehicle number, which zone the driver travels to, arrival time at the terminal and the number of pallets the truck had at the arrival at the terminal. Further the driver had to write down the departure time from the Samlic-terminal and the number of pallets included in the truck in the departure. Information about the trips length from the meter indication of the vehicle and at which time the driver had lunch break (Svensson, et al., 2006).

The consignment note is a document that accompanies the goods throughout the transportation and usually includes information on the weight, length and width of the packages as well as both the the recipients and the senders address. Each consignment note must have a label tacked on stating which logistics company sent the goods. A dispatcher at the consolidation centre copied the notes from the drivers and the consignment notes, and entered the data to a database. The variables from the consignment notes and the notes from the drivers are seen in a database structure in Table 13 and Table 14 in Appendix 4 – The Samlic project in Linköping in Sweden. They are divided into variables from the trips made by the delivery vehicles and variables from the goods taken from the consignment notes (Svensson, et al., 2006).

4.2.5. Calculation methods

All of the collected data material is gathered in an excel sheet. The researchers found it useful to complement the original database with a number of auxiliary variables and also tried to account for drop-out cases and minimize the errors in the data. Statistical regressions models were also performed, but these are not explained in this master thesis. To calculate the load ratio of the vehicle, the total weight of the shipment of a vehicle is divided by the number of pallets of the same vehicle. The average load ratios for all the vehicles is then calculated. The mileage in the city centre per day is calculated with the meter indication in a vehicle. For each route the driver of the vehicle specified the meter indication for the first and last stop on the route. The mileage is calculated as the difference between the starts and the stops. All of the routes in one particular zone are added together and then the average mileage for one vehicle in one day in each zone is calculated (Svensson, et al., 2006).

Further, the total number of stops for one vehicle per day can be calculated by counting the number of arrivals at one delivery trip. By adding the delivery trips per day the total number of stops can be calculated for one vehicle per day. All of the arrivals of all of the delivery trips are added together and then divided by the number of days the data was calculated to get the average total number of stops.

The driving time per day can be calculated by taking the vehicles time out of the Samlic-terminal and take the difference between the stop times at a delivery address (Svensson, et al., 2006).

4.2.6. Results

In Figure 8 the results from the evaluation reports from the Samlic project are presented.

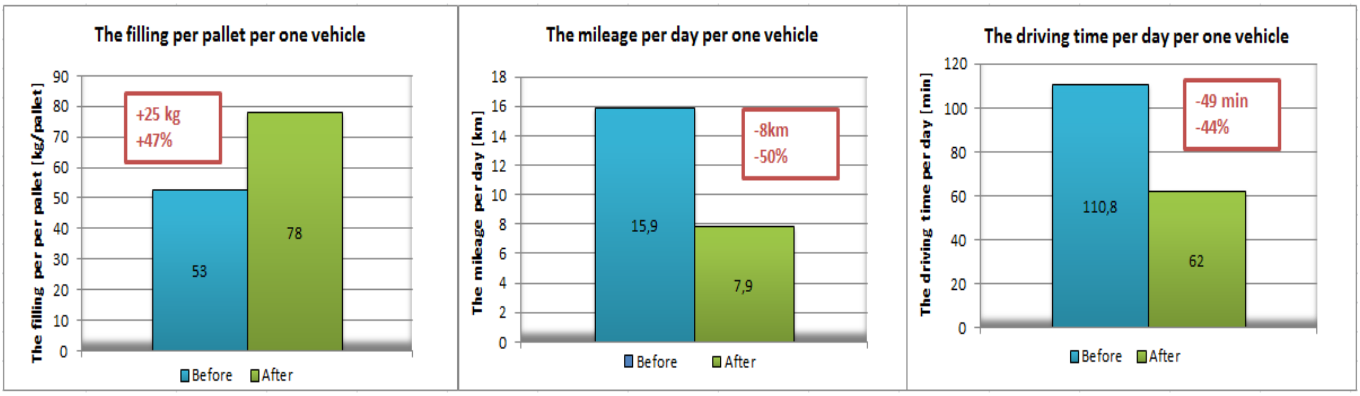

Figure 8: The filling per pallet, the mileage and driving time per day from before and after the consolidation centre.

Figure 8 makes it evident that it has been a reduction in the mileage and the driving time for one delivery vehicle per day and an increase in the filling per pallet of one delivery vehicle (Svensson, et al., 2006). For more results see Table 15 and Table 16 in Appendix 4 – The Samlic project in Linköping. Furthermore, Svensson et al. (2006) states that this in turn creates consequential effects for noise and that the emissions from CO_2, HC, NO_x and particulates are more than halved. Unfortunately, this is the only thing that is written about environmental effects from the Samlic project. The evaluation report does not present any calculations to show that the emissions were halved.

4.3. The urban consolidation centre in Norwich in United Kingdom

The chapter below presents the background, the objectives, the energy and environmental parameters, the method of collecting data, the calculation methods and the results of the evaluation report from the consolidation centre in Norwich, United Kingdom

4.3.1. Background

The city of Norwich is an old mediaeval city is situated in the east of England. About 120 000 people live in the city and it is the administrative centre in the County of Norfolk (CIVITAS, 2013b). Norwich is relatively compact as a city, and it has a radial pattern surrounded by motorways entering the city. The city centre is situated within the Inner Ring Road, and most of the commercial and retail activities are located here. In Figure 9, the inner red line formed as a circle shows the city centre of Norwich. All motor vehicle access is prohibited in the pedestrian areas within the Inner Ring Road, except for loading or unloading of goods that can happen between 6pm and 10am. The exterior ring highlighted by a green color around Norwich city in Figure 9 is called the Outer Ring Road (CIVITAS Smile, 2009).

Figure 9: A map of the radial pattern of Norwich and where the consolidation centre is situated (Mayes, 2008).

In order to encourage the use of environment-friendly and energy efficient goods vehicles in the urban area, the Norfolk County Council decided to build an urban consolidation centre outside the city next to the main road A11, approximately 30 kilometers outside Norwich, see Figure 9. The urban consolidation centre was opened in October 2007. Foulger transport is the logistics company that operates the consolidation centre. At the same time as the urban consolidation centre opened, the Freight Stakeholders Club was also established to encourage more freight companies to participate in the process. Besides that, there was also a project that involved introducing a priority access for environmental friendly goods vehicles in bus lanes into the city centre. These two initiatives were also measured in the evaluation report. The effect of driving in bus lanes was measured in the same way as the usual transport, but it did not have a big impact on the energy and environment compared to the usual transport and is therefore not investigated further in this report (CIVITAS Smile, 2009).The evaluation report is a partnership between Norfolk County Council and Foulger Transport with CIVITAS SMILE, which is a part of the CIVITAS 2 project that lasted from 2005 to 2009 (CIVITAS, 2013a).

4.3.2. Objectives of the project

The overall objectives for all three initiatives were to encourage freight operators to use more environmentally friendly vehicles, to reduce the number and size of delivery vehicles into Norwich and to reduce freight emissions in Norwich. Specific objectives of the urban consolidation centre were (CIVITAS Smile, 2009):

1. Creating a demonstration site where goods from outside Norwich could be consolidated, and then be delivered together into the city by using fewer delivery vehicles.
2. Optimizing the use and payloads of the delivery vehicles moving into the city centre.
3. Lowering the congestion and reducing the emissions in the city centre.
4. Reducing the systematic damage to roads in Norwich.

4.3.3. Energy and environmental parameters

Five different indicators were selected to evaluate how the urban consolidation centre has affected the energy consumption and the environment in the city, these are presented below (CIVITAS Smile, 2009):

- Vehicle fuel efficiency (energy use)
- CO_2 emissions
- CO emissions
- NO_x emissions
- Small particulate emissions

Other parameters that were evaluated in the report were the transport effects and how the society reacted to the consolidation centre. Most of the transport effects were used as a base for calculating the energy and environmental effects. The energy indicator is built on an assumption that the consolidation of goods in an urban consolidation centre will reduce the consumption of energy because the number of vehicle trips into the city centre will decrease (CIVITAS Smile, 2009).

4.3.4. Method of collecting data

Preliminary investigation

Between 2005 and 2007 a preliminary investigation for the evaluation report was performed. The investigation focused on traffic flow on the main radial routes that goes into the city centre. To get an overview of what types of Heavy goods vehicles, for now on shortened to HGV, that was using the route, a manual counting of the delivery vehicles on the A11 highway into Norwich was done. The survey also recorded vehicle registration plates from the HGVs, which gave information about the age of the vehicles. An approximation of the proportion of the European emission standards to the delivery vehicles was presented in the survey and was later used in the calculations of the environmental impacts from the urban consolidation centre (CIVITAS Smile, 2009).

Before

The recording of data from the urban consolidation centre in Norwich, both before and after, was done in the same time period. In the before situation it was assumed that all the vehicles delivering goods to the urban consolidation centre otherwise would have delivered the goods into the city centre. The vehicles that delivered goods to the urban consolidation centre was articulated heavy goods vehicles with 6 axles, for now on called HGV 6A (CIVITAS Smile, 2009). This is one of the biggest truck types in the United Kingdom and it has an average max weight limit of 44 000 kg (Department for transport, 2010). HGV 6A is truck number 9 in Figure 17 in Appendix 1 - Truck guide.

After

The after situation was the delivering of goods from the urban consolidation centre into the city centre. It is assumed that the trucks delivering the goods from the consolidation centre to the city centre are the smallest trucks classified in United Kingdom, called rigid heavy goods vehicle with 2 axles, which are named HGV 2R from now on (CIVITAS Smile, 2009). These trucks have an average max weight of 18 000 kg and is characterized as a small truck (Department for transport, 2010). HGV 2R is truck number 4 in Figure 17 in Appendix 1 - Truck guide.

Recording of data

During the first year after the opening of the consolidation centre, the vehicles was recorded on a monthly basis, from November 2007 to October 2008. It was recorded how many HGV 6A vehicles delivering goods into the consolidation centre and also the number of HGV 2R vehicles delivering goods from the consolidation centre into the city centre. As shown in Table 17 in Appendix 5 – The urban consolidation centre in Norwich, only 88 vehicles stopped at the consolidation centre during its first year of operation. This was because only a few retailers in Norwich participated in the project. Since 88 vehicles delivered goods to the consolidation centre and 88 vehicles that delivered the goods into the city during the first year, there was no actual consolidation of goods in the consolidation centre (CIVITAS Smile, 2009).

To measure the energy and environmental impacts a vehicle journey time survey on the motorway was performed from the urban consolidation centre to the city centre. This was done by measuring the average speed in two different corridors on the motorway A11 where the delivery vehicles are driving into Norwich. The first section goes from the consolidation centre to just outside the Outer Ring Road, the distance is 26.92 km and the average speed is measured to 72.3 km/h. Section number two is the distance from the Outer Ring Road to Inner Ring Road, which is a distance on 2.95 km and the average speed is measured to 25.3 km/h, see the results from the measurements in Table 18 in Appendix 5 – The urban consolidation centre in Norwich (CIVITAS Smile, 2009).

4.3.5. Calculation methods

The estimated effects on fuel efficiency have been calculated by using the vehicle speed information taken from the Department of Transport`s "Transport Analysis Guidance (TAG) Unit 3.5.6 - Values of time and Operating Cost" from February 2007. When the average speed to the vehicles is known, the fuel consumption per kilometers of the vehicles can be estimated by Equation 3:

$$L = a + bv + cv^2 + dv^3$$ **Equation 3**

Here L is the fuel consumption in liters/km and v is the average speed in km/h. Further are a, b, c and d parameters that comes from AEA Technology`s Environment Technology Centre and are derived from laboratory testing of different types of vehicles. These values are shown in Table 19 in Appendix 5 – The urban consolidation centre in Norwich in United Kingdom (CIVITAS Smile, 2009). The average fuel consumption can be estimated using Equation 3 by calculating the fuel consumption of both of the two corridors and then adding the results from the two corridors together. Then the total fuel consumption of the 88 vehicles is calculated by Equation 4:

$$V = L * n * x$$ **Equation 4**

Here V is the total fuel consumption in liters, L is the fuel consumption in liters/km, n is the numbers of vehicles and x is the distance one vehicle is driving in kilometers.

Similar assumptions have been used to measure the environmental effects of setting up the urban consolidation centre. The emissions from the HGVs have been calculated with help from the Appendix E of the NERA document "Lorry track and environmental Costs" from august 2000 and in this document there are detailed unit emission figures from selected vehicles of Euro emission standard. By using the traffic flow information and the approximated European emission standards for vehicles, the current emissions released by the HGVs were calculated. What type of Euro emission standard the delivery vehicles is characterized as is based on studies from the preliminary investigation. Both the HGV 6A delivers goods into the consolidation centre and the HGV 2R delivers goods into the city centre are assumed to be of Euro 3 vehicles, because this group had the highest proportions of vehicles in the preliminary investigation (CIVITAS Smile, 2009).

4.3.6. Results

Regarding the total fuel consumption and environmental effects like CO_2, CO, NO_x and particulates, the results of opening the consolidation centre are displayed in Figure 10.

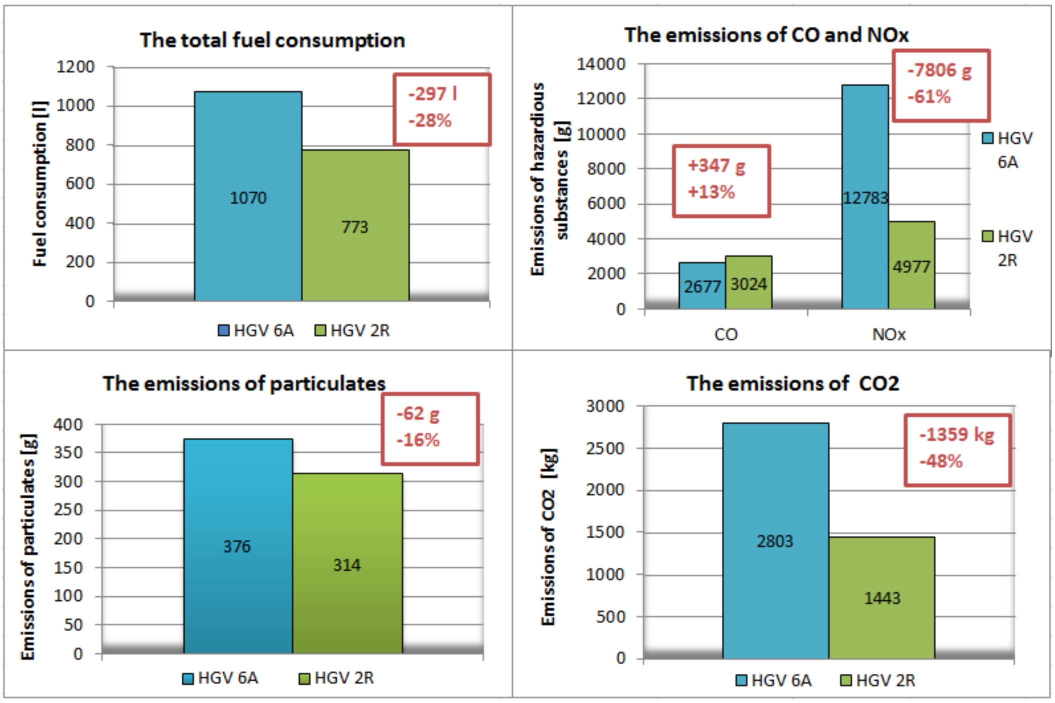

Figure 10: The total fuel consumption and the emissions of CO, particulates, NO_x and CO_2 from before and after the consolidation centre.

Figure 10 show that the implementation of the consolidation centre had a positive effect on the fuel consumption and the emission of CO_2, particulates and NO_x. The HGV 2R vehicles released more emissions of CO than the HGV 6A vehicle. Even though it was limited consolidation of goods at the consolidation center, the change of the vehicle type into the city centre had a positive effect on the fuel consumption and the environment (CIVITAS Smile, 2009). More results are displayed in Table 20 and Table 21 in Appendix 5 – The urban consolidation centre in Norwich.

4.4. The urban micro- consolidation centre in central London in United Kingdom

The chapter below presents the background, the objectives, the energy and environmental parameters, the method of collecting data, the calculation methods and the results of the evaluation report from the micro- consolidation centre in London, United Kingdom.

4.4.1. Background

London is the biggest city in United Kingdom with a population of approximately 8 million people (London Higher, 2013). In 2009, Office Depot, a huge international logistics company, decided to trial a new urban delivery system in the City of London. The reason was partly because of corporate responsibilities the company had made and partly for reducing the environmental impact on their delivery system. Consequently, a small consolidation centre was built near the Tower of London, which was used as an overnight transshipment centre for the transfer of parcels from a suburban depot to new electric vehicles that delivered the goods to the offices nearby. Since the size of the centre was only 20 meters by 8 meters it was referred to an “urban micro-consolidation centre”. It is Gnewt Cargo, which specializes in green urban freight transportation, that operates the micro-consolidation centre on behalf of Office Depot (Allen, Browne, & Leornardi, 2011).

The delivery situation before the trial involved using seven diesel vans that were delivering parcels from a suburban depot located in the London suburbs, 29 km from the city of London directly to the City of London, see the left side of Figure 11. In the new logistic system one diesel truck is used to transport goods from the suburban depot to the micro-consolidation centre, and then the goods are delivered by electrically-assisted cargo tricycles and electric vans that use energy from renewable sources to the offices in the City of London. The trial situation is also portrayed on the right side of Figure 11 (Allen, Browne, & Leornardi, 2011).

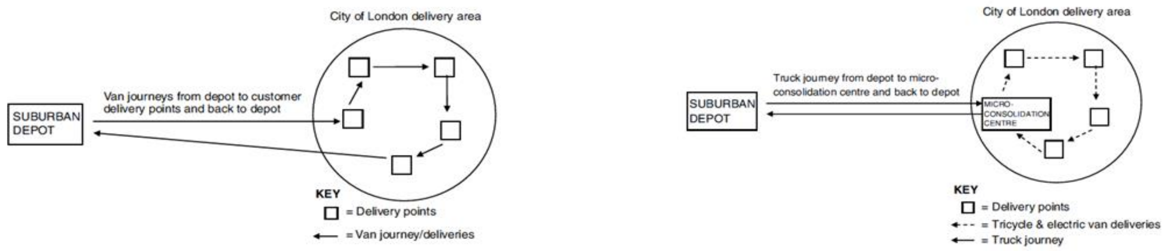

Figure 11: The delivery system before and after the trial of the micro-consolidation centre (Allen, Browne, & Leornardi, 2011).

Moreover, the delivery area is City of London which contains the business and the financial centre in London, where all the customers are located within an area of 2.9 square kilometers. This also lies within the Clear Zone Partnership, which is used as a testing ground for new transport technologies and innovations. Since 1999 the London Borough of Camden, The City of London and The City of Westminster have collaborated to achieve this partnership. Therefore, the trial is partly financed by the London Borough of Camden and partly by the office supplies company (Allen, Browne, & Leornardi, 2011). The evaluation report of the micro-consolidation centre is written by researchers from the Transport Studies Department at the University of Westminster in London (Allen, Browne, & Leonardi, 2010b).

4.4.2. Objectives of the project

The objectives of the report are (Allen, Browne, & Leonardi, 2010b):

1. Evaluate the existing Office Depot deliveries from the suburban depot to the postcodes EC 1-4 in City of London using diesel vans.
2. Comparing the situation in objective number 1 with the new micro-consolidation centre and the use of the electrically-assisted cargo tricycles and electric vans for final delivery.
3. Evaluate the impacts on:
   - The total driving distance in London and in the delivery area of City of London
   - Energy use and greenhouse gas emissions
   - Road space occupancy during parking when the deliveries are made

4.4.3. Energy and environmental parameters

The parameters used in this evaluation report are (Allen, Browne, & Leornardi, 2011):

- Kilometers per parcel (distance travelled inside the City of London, distance travelled outside the City of London and the distance travelled in London total)
- CO_2–equivalents per parcel (inside the City of London, outside the City of London and in London total)
- Fuel use in litres per journey and the fuel use per parcel delivered for the diesel van

Other parameters that are used in the evaluation report are the daytime road space and time occupied by the vehicles per parcel, the kerbside loading space and different cost components (Allen, Browne, & Leornardi, 2011).

4.4.4. Method of collecting data

Preliminary investigation

Transport for London studied the potential of introducing cycle freight in London. In the study they have evaluated several different logistics companies in the London region, which are anonymous in the case study, with the potential to have cycle freight as a part of the delivery structure. There is reason to believe that Office Depot was one of the companies that was studied, especially since one of the company profiles matches the one of Office Depot. The study was performed with face-to face interviews with representatives from the logistics companies and desk-based reviews of the current operations of freight transport. Also, the study gives an example of a successful cycle freight model, which is La Petite Reine in France, and base a potential large-scale cycle model in London on this particular model (Transport for London, 2009).

Before

The original diesel van delivery system was first studied in February to March in 2009 and then it was updated with information from October 2009 before the trial went live (Allen, Browne, & Leonardi, 2010b). The diesel vans had a size of 3.5 tonnes and carried out multi-drop delivery journeys with a payload capacity of 1.2 to 1.6 tonnes. Collection of data before the trial was gathered from one delivery journey from the suburban depot to the City of London in October 2009. Here the surveyor accompanied the driver and noted the parameters shown in Table 22 in Appendix 6 - The urban micro-consolidation centre in London. The time and distance between each stop and start was measured, and the driving speed in different parts of London was also noticed. Observations of the fuel consumption of the diesel vans as well as the time use in percent of total journal time were done. Managers and drivers from the office supplies company were interviewed to get at full overview of the before situation (Allen, Browne, & Leornardi, 2011).

After

The trial started in November 2009 and continued until July 2010. The new delivery system was implemented gradually in stages and the trial had the same amount of customers and same volumes of products as before the trial. From November 2009 to March 2010 an intermediate system was used which involved electrically-assisted cargo tricycles, electric and diesel vans. The researchers from the Transport Studies Department also did surveys during this period, but the results are not presented in this report. The new system, using only electrically–assisted cargo tricycles and electric vans, was fully implemented in May 2010, and at this point 6 tricycles and 3 electric vans were in operation each day. The deliveries with the diesel vans directly from the suburban depot to the customers had ended, but one diesel truck still transported parcels from the suburban depot to the micro-consolidation centre (Allen, Browne, & Leornardi, 2011).

The collection of data from the tricycle and electric van journeys was based on detailed surveys and observations from Gnewt Cargo. In total, fourteen delivery journeys of the tricycle and three delivery journeys of the electric van were studied. The observed data are measured by the surveyor during deliveries and then the average results for each vehicle have been calculated. Almost the same type of data were collected during the trial as before the trial, see more data observations in Table 22 in Appendix 6 - The urban micro-consolidation centre in London. The data collected was the distance travelled on journey, deliveries on journey, time use as a percentage of the total journey time, the driving speed and fuel use of the diesel van. These data were accounted for one average trip. For that reason the results are based on one average delivery trip from before the trial and one average trip from after the trial (Allen, Browne, & Leornardi, 2011). A picture of the electrically-assisted cargo tricycle and the electric van are presented in Figure 12.

Figure 12: The electrically-assisted cargo tricycle and the electric van (Allen, Browne, & Leornardi, 2011).

The electric tricycle used in the trial is complemented with two batteries and the max load capacity is 180 kg. It also requires recharging of the batteries for four hours during the night. The electric vans that were used in the trial have a load capacity of 445 kg and needs to be recharged during the nighttime (Allen, Browne, & Leornardi, 2011).

4.4.5. Calculation methods

To calculate the kilometer per parcel, the distance travelled on one particular journey was divided by the number of parcels delivered during a journey. In turn this was calculated for the distance travelled inside the City of London, the distance travelled outside the City of London and the distance travelled in London total. For all of the three distances the change in percent is also calculated in the evaluation report. The fuel use in litres per journey is calculated by multiplying the total distance and the fuel use in litres per kilometer. Further, the fuel use per parcel is then calculated by dividing the fuel use in litre per journey with number of parcels delivered during journey. There is no mention of how the CO_2-equivalents were calculated in the evaluation report, but this is most likely done with a computer tool that is similar to the NTM-method.

4.4.6. Results

Figure 13 shows the change in CO_2-equivalent per parcel and the distance travelled in the case of outside of the City of London, inside the City of London and in London total.

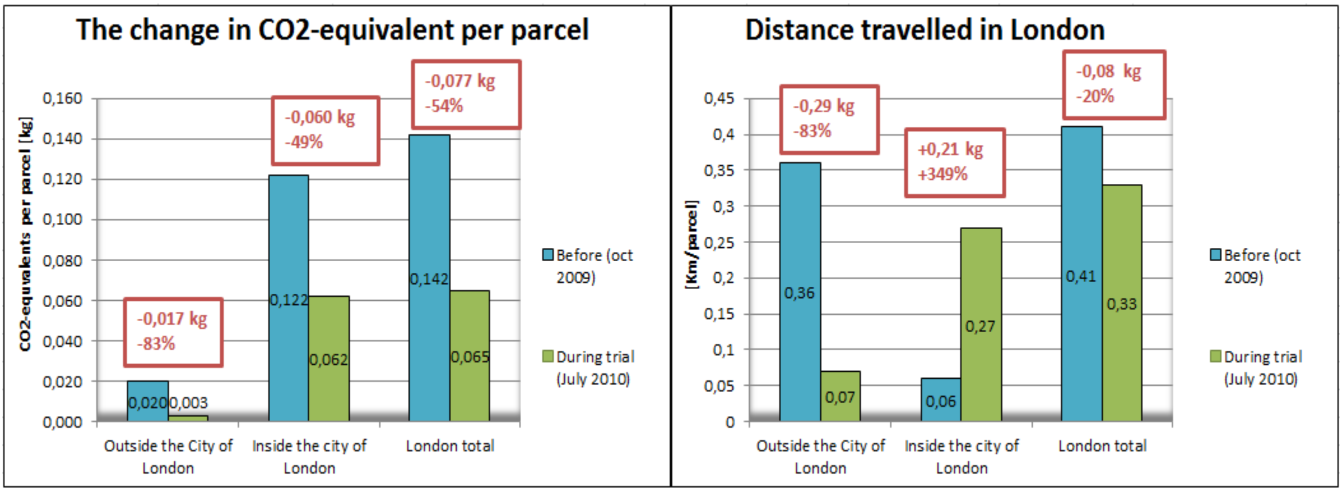

Figure 13: The change in CO_2-equvalent per parcel and the distance travelled in London for the delivery vehicles before and after the consolidation centre.

Moreover, Figure 13 underline that the total CO_2-equivalent emissions per parcel have decreased in all of the three geographical areas investigated in London. All of the results are shown in Table 23 in Appendix 6 - The urban micro-consolidation centre in London. Gnewt Cargo was so satisfied with the results from the trial and decided to continue to use the new delivery system (Allen, Browne, & Leonardi, 2010b). Unfortunately there is no comparison available between the energy consumption of the different vehicles before and after the test.

4.5. Urban logistic practices in Utrecht in The Netherlands

The chapter below presents the background, the objectives, the energy and environmental parameters, the method of collecting data, the calculation methods and the results of the evaluation report from the urban logistic practices in Utrecht.

4.5.1. Background

Utrecht has a population of approximately 316 000 inhabitants and is the fourth largest city in the Netherlands (The municipality of Utrecht, 2012). The city is a hub for the national rail network, motorways and inland waterway systems, so the city is experiencing major transport flows on a daily basis. A railway surrounds Utrecht and the city contains many canals, historical buildings and narrow streets from the medieval time, see Figure 14. This in turn causes several problems for freight deliveries, like congestion as well as environmental and livability problems (Turbolog, 2011).

Figure 14: The location of Utrecht in the Netherlands, in point A and a map of the city of Utrecht (Turbolog, 2011).

Utrecht is famous for its collaboration on freight transport between the freight industry and the authorities. There are four different urban distribution centres, for now on shortened to UDC, in Utrecht and these are run by well-known logistics companies like GLS Netherlands, Stadsvracht BV by DHL, Hoek Transport and TNT. The first city distribution centre has existed since 1994 and provides deliveries to households or businesses in the city. Further, the collaboration has also resulted in several initiatives to solve the transportation problems in the city and different measures have been implemented to form a so called Integrated Policy Package. This includes vehicle restrictions, the use of time windows, the introduction of the Beer Boat and the Cargohopper, two delivery profiles for Utrecht, specific logistic routes for freight transports, and an environmental zone in the city centre. All of the efforts are made to stimulate freight companies to use environmental friendly vehicles and silent trucks as well as having deliveries from the city distributions centres. The policy package is called a multi-stakeholder model where the municipality of Utrecht cooperates with all the relevant stakeholders in the implementation of all the measures (Turbolog, 2011).

In the early 1990s the UDC-concept was promoted by the Dutch government to many cities in the country, but Utrecht is the only city that continuously has had UDCs in operation. In Utrecht the municipality has made strict rules on how the UDC shall be run. First of all the logistics companies must have deliveries to a minimum of 100 addresses per day in the inner city and the UDC must be located within 5 km of the motorway and 10 km from the city centre of Utrecht. A vehicle delivering goods to the city centre must at least be Euro 5 vehicles and the delivery vehicles are obligated to accept goods from third parties for delivery to or pick up from the city centre. The logistics companies that run the UDC are also obliged to fill in a monitoring form two times a year for the municipality (Degenkamp, 2013).

In return the delivery vehicles from the UDCs gets access to the bus lanes and the time restrictions in the pedestrian area do not apply to the delivery vehicles (Turbolog, 2011). It also gives the companies higher efficiency in the existing logistics and a unique selling point to find new customers (Degenkamp, 2013). The evaluation report is written by Turbulog, a European Union supported project within the Seventh framework programme (Turbolog, 2013). However, much of Turbolog´s calculations and results come from the municipality of Utrecht written in Dutch as well as the European Union project BESTUFS and other sources. To get an overview on what is referred to as the before situation in this paper, something called the delivery profiles is described. The delivery profiles from 2003 and 2009 were developed by several private parties and included a standardized method for analyzing urban distribution in a city (Turbolog, 2011). The first delivery profile from 2003 was done by Buck Consultants and the standardized model are described and evaluated by Vleugel (2004). Since the methods used are standardized it is assumed that the two delivery profiles gather data in the same way.

4.5.2. Objectives of the project

The main objectives of the municipality of Utrecht by introducing the different transport initiatives are (Turbolog, 2011):

1. Reducing the traffic in the city centre and thereby the congestion problem, to make the life quality of the inhabitants and the visitors better as well as improving the air quality, the accessibility and traffic safety in the city centre.
2. Introducing more sustainable approaches to transports with an Integrated Policy Package.
3. Look at the transferability of the initiatives taken in Utrecht and compare it to other cities.

4.5.3. Energy and environmental parameters

The most evident environmental parameters used in this report are (Turbolog, 2011):

- Emissions of CO_2 and particulates from the Cargohopper and the Beer boat
- Saved liter diesel fuel per year by using the Cargohopper
- The reduction of truck and lorries based on Euro standards in the city centre
- The number of deliveries in the city centre

Another parameter that is measured is the number of vehicle kilometers (Turbolog, 2011). The delivery profiles measured the economic viability and attractiveness, traffic safety, liveability, accessability and quality of delivery (Vleugel, 2004).

4.5.4. Method of collecting data

Preliminary investigation/Before

Since Utrecht has had urban distributions centres since the beginning of the 1990`s, it is quite hard to find documentation of the before situation. But besides introducing the policy package the municipality of Utrecht has produced many documents about urban distribution that investigate different elements of the issue. The most important documents involve the Air Quality Action Plan, the Municipal Traffic and Transportation plan 2005-2020, VERDER, Accessible Utrecht and the Action plan freight transport from 2010 (Turbolog, 2011).

One of the most interesting documents in this perspective is the Delivery profile model, which was done with empirical research and modeling and simulation-oriented research. This was to find the different parameters that have impacts on the delivery situation. The parameters were for example the vitality and attractiveness of the city centre, the livability in the city centre, the road safety, the accessibility and the quality of the deliveries. A set of variables for each of the parameters was defined and a set of questionnaires was made to do surveys of the delivery vehicle drivers, goods receivers, people living in the selected shopping areas and local government officials. The data was put in a database and by using statistical analysis the causality between the data in the database was determined (Vleugel, 2004).

After

The municipality of Utrecht collects different kinds of data in order to evaluate all of the transport initiatives. In Utrecht, the most common way to get the data is through surveys and desk research at the involved logistics companies. For example, Utrecht has investigated the impacts of the environmental zone by estimating the changes in the vehicle fleet and measuring the compliance rate of the environmental zone. To do this, Utrecht has developed a system that counts how many vehicles that is allowed to enter the environmental zone based on license plate investigation. From the license plate number it is possible to get information on the Euro emission standard of the vehicles and from this standard the emissions from each vehicle can be estimated (Turbolog, 2011).

Additionally the municipality of Utrecht has observed the numbers of establishments that is supplied by the city distribution centres as well as by the Beer Boat and by the Cargohopper. The Beer boat and the Cargohopper can be classified as very innovative vehicles, see the pictures in Figure 15.

Figure 15: The Cargohopper (Cargohopper Stadsdistributie Utrecht, 2013) and the beer boat (The City Council of Utrecht, 2013).

The Beer boat has been delivering drinks and food to over 70 catering industries located along the canals of Utrecht since 1996. From 2010 it was changed from a diesel fuelled boat to an electric driven boat where one charge can last for 8 to 9 hours. It can also transport 50 tonnes of goods or 30 roll containers at once. In the medieval inner city the Cargohopper, which is characterized as a small road train, has been delivering parcels from 2009. It is driven on batteries and is able to tow 3 metric tonnes in a 16 meter long line. The maximum speed of the Cargohopper is very low, so the Hoek transport company that runs the vehicle had to build an extra transfer point near the city centre, where the vehicle can pick up its parcels. Three solar panels with the size of 9 square meters are placed on the roof of the Cargohopper. It is run on solar power for 7 to 8 months of the year and the batteries are charged only during the winter or on days with bad weather. The municipality of Utrecht has estimated that the Cargohopper reduces the emissions of CO_2 with almost 34 tonnes per year and saves the city with the diesel fuel consumption with up to 24 000 liters per year (Turbolog, 2011). Unfortunately the report says nothing about how these results have been estimated.

4.5.5. Calculation methods

Before

In the delivery profiles the number of delivery trips in the city was calculated by dividing the number of deliveries per week by the average number of stop per trip (Vleugel, 2004).

After

What type of vehicles that were driving in the inner city before and after the implementation of the environmental zone, was calculated as the percent share by the type of vehicle.

4.5.6. Results

The delivery profile from 2009 counted 350 catering companies (restaurants, cafés and hotels) and 750 shops, where 3700 trips and 7500 deliveries were made each week to deliver goods to the businesses (Turbolog, 2011). There are no specific results on how the city distributions centre has affected the energy consumption and environment in Utrecht, but some of the results can be seen as a synergy effect of the city distribution centres. For example the introduction of environmental zones in the inner city has led to a shift to a more environmentally friendly vehicle fleet from the city distribution centres, see Figure 16.

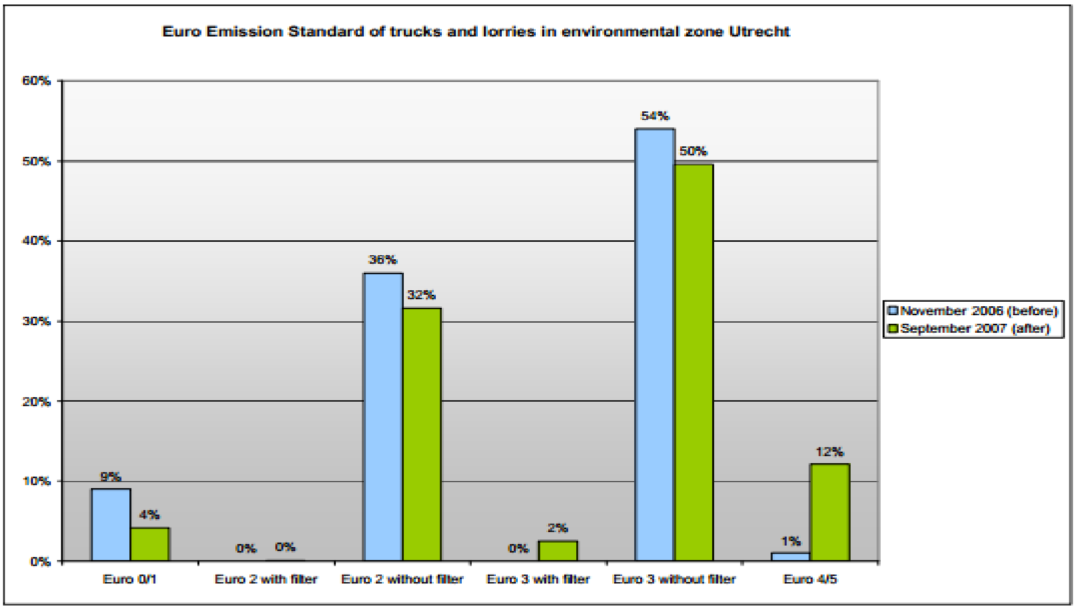

Figure 16: The trucks and lorries in the inner city of Utrecht before and after introduction of the environmental zone (BESTUFS, 2008).

Figure 16 shows an increase in environmentally friendly vehicles based on Euro emission standards after the implementation of the environmental zone. This in turn has led to a reduction of particulates with 0.2-2.6 mg/m^3 in the border of the centre zone and a reduction of particulates with 0.1-1.1 mg/m^3 within the city border (BESTUFS, 2008, Turbolog, 2011).

5. Evaluation analysis

This chapter gives a definition of evaluation analysis and describes important aspects of this analysis. The chapter further provides an evaluation analysis of the initiators and stakeholders, the ex-ante situation and the ex-post situation and lastly a deeper evaluation analysis of the five case studies.

5.1. Definition of evaluation analysis

The primary purpose of evaluation research is to provide general knowledge about the achievement of predefined objectives in a process. It should be possible to answer the purpose with a general method, thus the evaluation results should in principle be testable (Nilstun, 1984). There are many approaches to evaluation analysis. An evaluation analysis can first and foremost be divided into quantitative or qualitative methods based on how the data material is collected. A quantitative method is a systematic investigation of statistical data with mathematical models that often contains large samples. On the other hand a qualitative method is used to investigate smaller samples more deeply, through understanding a phenomena and questions (Stern, 2004). Further, the methodological positions, the ex-ante evaluation and ex-post evaluation as well as survey techniques are described in order to get an overview of evaluation analysis.

5.1.1. Methodological positions

In short there are three different methodological positions in evaluation analysis. The first is called the criteria or standard based position. This position is concerned with judging performance and success by using standards and established norms. Number two, the formative or change oriented position seeks to understand improvements both for innovations and those who take part in them. The last is titled causal inference position and this is broadly defined as an analysis of the causes and effects from implementing a new innovation (Stern, 2004). It is especially the causal inference position approach that is used in the evaluation of the case studies in this master thesis. The reason for this is that this master thesis is interested in the causal effects of setting up an urban consolidation centre.

5.1.2. Ex-ante evaluation and ex-post evaluation

In evaluation studies it is important to distinguish between the evaluations made before and those made after the implementation of a new innovation. The before situation is often referred to as the "ex-ante evaluations" that is the existing situation without any new innovations (Nilstun, 1984). In this master thesis, the ex-ante situation is defined as the situation where no urban consolidation centre exist. In the after situation, which are called "ex-post evaluations", the new innovation is implemented and the actual effects of the innovation are evaluated (Nilstun, 1984). The ex-post situation in this master thesis is defined as the situation where an urban consolidation centre has been implemented.

5.1.3. Survey techniques

In a comparative research of survey techniques of the urban freight transport, Allen, Browne, & Cherret (2012) have discovered that the survey techniques can be divided into 12 different types. The study has analyzed 162 studies in 18 countries during a time period from the 1960s to 2008. This is interesting to analyze among the evaluation reports, but only the survey techniques relevant to the evaluation reports will be described here. Freight operator survey is a survey technique that is used to collect wide ranging data on how the pattern of the goods from a freight company influences delivery vehicles in an urban area. With this technique, it is possible to collect data from the entire fleet and not just a single vehicle or trip. This is usually done by gathering data from the involved freight company and can also consist of qualitative interviews with employers. An establishment survey collects data from the total delivery vehicle trips to and from the establishments surveyed. Driver survey is where the driver of the delivery vehicle gathers detailed data about the overall trip pattern of one particular delivery round. This makes it possible to get information about the loading and unloading activity of the vehicles at the different delivery points (Allen, Browne, & Cherrett, 2012).

Further, vehicle trip diaries are where a researcher attends a delivery vehicle trip and collects detailed information about the activities of one single vehicle trip. It often provides data about the exact served locations, routes, arrival and departure times and the time it takes for the delivery or collection of goods. Supplier survey is used to collect knowledge about the goods from suppliers that are dispatched to urban establishments and the vehicle activity that comes with the goods flow. This is not a survey technique that is used so much, but sometimes it is used in addition to an establishment survey. It is also common that the studies also do qualitative interviews to get a better understanding of the transport process (Allen, Browne, & Cherrett, 2012).

5.2. Evaluation analysis of the initiators

To get an overview of the initiators, the stakeholders and who has done the evaluation analysis of the urban consolidation centres a comparative analysis has been performed in Table 4. In this chapter the urban consolidation centres are shortened to UCC in the tables. Important questions to be asked in this aspect are: who are the stakeholders of the project and what is the focus of the evaluation (Stern, 2004).

Table 4: A comparative analysis of the initiators and stakeholders in the projects.

	The Old Town	**Linköping SAMLIC**	**Norwich**	**London**	**Utrecht**
The initiators of the project	-Home2you -Local Agenda 21-group -Parent groups	-The local network for transporters in Linköping	-Norfolk County Council	-Office Depot	UCC: -The Dutch Government The Beer boat: -The municipality of Utrecht The Cargohopper: -Hoek Transport
The stakeholders of the project	-Home2you -Local Agenda 21-group -The Environment and Health administration of the City Council	-The City Council -Logistics companies -Retail trade businesses and shopping malls -Swedish biogas -VTI	-Foulger transport company -Norfolk County Council -Norwich City Council	-Office Depot -Gnewt company -The Clear Zone Partnership	-The municipality, a facilitator (UCC) or steering/guiding (EZ) -Businesses -Logistics companies
Financing of the project	-Home2you -CIVITAS Trendsetter	-VTI was financed by Vinnova, -The other stakeholders financed their own participation	-Foulger transport company -Norfolk County Council -CIVITAS Smile	-Office Depot -Gnewt company -The Clear Zone Partnership (mostly London Borough of Camden)	UCC and Carghopper: -No subsidies from the municipality The Beer boat: -The municipality
Who runs the UCC	-Home2you	-Schenker, DHL and Posten AB	-Foulger transport company	-Gnewt company on behalf of Office Depot	-Private logistics companies
Why was the UCC set up	-Reduce the number of small vehicles -Reduce traffic congestion -To be innovative and find new methods to consolidate goods	-To measure the traffic effects -Gain practical experience on UCC -To reduce the number of vehicles in the city	-To facilitate the use of clean and energy efficient goods vehicles in the urban area -Create a demonstration site to consolidate goods	-Reduce the impact on the environment -Create a more cost-effective service -Pilot trial of using small electric vehicles	-Prompted by the Dutch government -Bundling goods together -Reducing delivery trips and traffic in the city centre
Who has done the evaluation analysis	-CIVITAS Trendsetter	-The Swedish National Road and Transport Research Institute (VTI)	-CIVITAS Smile -Norfolk City Council -Foulger transport company	-Transport Studies Department at University of Westminster in London	-Turbolog
Research field	-Energy, environment and transports	-Transport and logistics studies	-Energy, environment, transports and society	-Sustainable freight transports and logistics	-Urban logistics case studies and transferability to other cities
Focus of the evaluation report	-The impacts from delivery vehicles on energy use, environment and transports	-Traffic effects -Efficiency of the transport system	-The impacts from delivery vehicles on energy use, environment, transports and society	-Sustainable urban freight transports and logistics (University of Westminster, 2013)	-The transferability of logistic concepts in Utrecht to other cities
Geography in the evaluation report	-The total delivery vehicles to the restaurants in the Old Town	-Only the vehicles from the three involved freight companies	-Only the vehicles from the UCC	-Only the vehicles from the UCC	-The inner city of Utrecht

Table 4 demonstrates that the initiative of the urban consolidation centre either comes from a logistics company that has a sustainable profile or from some kind of authority. Often the logistics company that run the consolidation centre receives some financial support from the city council, but this is not always the case. When it comes to the stakeholders in a consolidation centre, there is often a cooperation between a municipality, the involved logistics company and some other relevant organization. It is most common that one single logistics company runs the consolidation centre. The urban consolidation centres were set up for a number of different reasons, often to reduce the number of deliveries in the city district. In three of the cases, the Old Town in Stockholm, Norwich and Utrecht, the evaluation report was written by European Union funded projects. In the other two cases a transport institute wrote the evaluation report.

5.3. Evaluation analysis of the ex-ante situation

As described earlier in section 5.1.2 the definition of the ex-ante situation is the before situation, where no consolidation centre exists in the city area. One important question to consider is what the main approaches and methods in the different evaluation reports are (Stern, 2004). Table 5 compares how the ex-ante situation was evaluated among the five cities. The preliminary investigation is not the same as the ex-ante research. This is the investigation that is done before the important decisions about the urban consolidation centre are taken. The preliminary investigation is also considered in the evaluation analysis of the ex-ante situation, because in some of the cases the difference is quite blurry between what is the preliminary investigation and the before situation.

Table 5: A comparative analysis of the ex-ante situation to the projects.

	The Old Town	**Linköping SAMLIC**	**Norwich**	**London**	**Utrecht**
Preliminary investigation	-Gradient AB	-The logistician Catarina Nilsson with support from the employment services	-CIVITAS Smile	-Transport for London	-The municipality of Utrecht has produced many documents on urban distribution
The focus of the preliminary investigation	-Identified all businesses and their goods delivery habits -Counted the number of deliveries	-Mapped deliveries on berths -Interviews with logistics companies -Questionnaires to the retail trade businesses	-Survey on the traffic flow into the city centre -Measuring the proportion of the HGVs and their Euro emission standards	-A case study of the potential to introduce cycle freight deliveries in London -Based a possible pilot trial on the La Petite Rein concept	Investigated: -The vitality, livability and attractiveness of the city centre, -The road safety -The accessibility and the quality of the deliveries
Has an accurate ex-ante research been done?	-No, it is assumed to be the same as the preliminary study	-Yes	-Yes	-Yes	-No, but many documents on urban distribution have been published
Situation before the urban consolidation centre	-Every business has an own distribution solution -Freight companies that distributes goods for others	-The deliveries are done all over the city centre, where all logistics companies are delivering goods in the same areas	-Deliveries with HGV 6A vehicles directly into the city centre	-Deliveries with 7 diesel vans from a suburban depot 30 km to the inner city centre	-Not described in the evaluation report -No deliveries from the Cargohopper and Beer boat
Survey techniques	-Supplier survey -Establishment survey	-Freight operator survey -Driver survey	-Freight operator survey -Vehicle trip diary	-Vehicle trip diaries survey -Qualitative interviews	-Supplier survey -Qualitative interviews
Method of collecting data of the delivery vehicles	-The number of deliveries and vehicle kilometer were estimated for the 85 restaurants -Based on assumptions that one restaurant receives six deliveries per day	-It was done after the trial -Information about the normal routes was extracted from the driver notes and consignment notes, then the data was put in a database	-Recording the number of vehicles coming into the consolidation centre -Assumed that these vehicles, HGV 6A, would have delivered the goods into the city centre instead	-The surveyor accompanied a driver in one delivery journey -Wrote down the time, speed, distance, fuel consumption -Interviews with managers and drivers from the office supplies company	-The Delivery profiles came in 2003 and 2009 -In the 2003 delivery profile it was defined a set of variables and then formed a questionnaire to involved parties
Time period of the research	-Not clearly expressed, but preliminary investigation was published in 2003	-Two weeks in June 2004 at Schenker -One week in September 2004 at Posten AB	-1 year, from November 2007 to October 2008	-October 2009	-2003 and 2009
Delivery vehicles	-Diesel vans	-Diesel vans and trucks	-HGV 6A	-Diesel vans	-Diesel vans

In Table 5 the preliminary investigation of the projects was mentioned in four of the evaluation reports. Regarding those reports, the preliminary investigation was often done with the objective to get a broad view of the transportation of goods in the city centre, by counting vehicles alongside a road or at a berth. The survey techniques and the methods used for collecting data are very different in the evaluation reports. Further, the time period for the ex-ante research period in three of the cases was done before the implementation of the consolidation centre, otherwise for Norwich, the collection of data in the before and after situation was done in the same time period, and in the Samlic project the data collection of the ex-ante situation was done after the pilot project. The delivery vehicles in the city districts were usually a diesel vehicle.

5.4. Evaluation analysis of the ex-post situation

The definition of the ex-post situation is the after situation, where a consolidation centre has been implemented in the city area. Also, important questions to be answered here are, what the main approaches and methods are in the different evaluation reports (Stern, 2004). In Table 6 it is examined how the ex-post situation was evaluated among the five cities.

Table 6: A comparative analysis of the ex-post situation to the projects.

	The Old Town	Linköping SAMLIC	Norwich	London	Utrecht
Situation after setting up the urban consolidation centre	-Logistic centre near the Old Town that serves 30 out of 85 restaurants -The restaurants gets one delivery instead of six deliveries on a daily basis	-Consolidation centre with coordinated freight logistics -Three different logistics companies delivers goods from an UCC into three zones	-Urban consolidation centre where HGV 2R vehicles delivers goods in the city centre	-Micro-consolidation centre with electric vehicles that delivers parcels from UCC to the nearby business district -1 diesel truck that brings the parcels from a suburban depot to the UCC	-4 urban distribution centres are in operation and the transfer point of the Cargohopper is also built -Introduction of the environmental zone (EZ)
Delivery vehicles	-Small biogas fuelled truck	-Diesel truck with a load capacity of 43 m^3 and 8738 kg	-Rigid heavy goods vehicle with 2 axles, HGV 2R	-6 Electrically-assisted cargo tricycles -3 Electric vans	-Cargohopper -Beer boat
Survey techniques of the ex-post research	-Freight operator survey -Supplier survey	-Freight operator survey -Driver survey -Supplier survey	-Freight operator survey -Vehicle trip diary	-Vehicle trip diaries	-Freight operator survey -Establishment survey
Method for collecting data of the delivery vehicles	-Calculates both the impacts from the 30 customers of the O-central and the 55 other restaurants -Gathered invoice data from UCC in 3 months, multiplied by 4, to get a yearly result	-Information on the routes made by the logistics companies -Consignment notes and notes from the drivers with relevant information about a the trips that were put in a database	-Recording the number of vehicles that delivers goods from the consolidation centre to the city centre	-Detailed survey and observation of the delivery vehicles -The researches attended 14 delivery journeys of the electric tricycle and 3 delivery journeys of the electric van	-Surveys and desk research at the involved logistics companies -Logistics companies must fill out forms 2 times a year -Observed what type of vehicles going into the inner city after the introduction of EZ
Time period for the research	-3 months, December 2004 to February 2005	-Week 14-24 (23/3-11/6) in 2004	-1 year, from November 2007 to October 2008	-June 2010	-November 2006 -September 2007
Is the UCC still running?	-Yes	-No	-Yes	-Yes	-Yes
Special features about the location	-Mediaeval city district with narrow streets -Popular place to visit among tourists	-Medium sized city -Splitting the delivery area in three zones	-Mediaeval city -Medium sized city -Radial pattern of motorways around the city	-High office density in the delivery area	-Mediaeval city district with narrow streets -Canals

Table 6 shows that the after situation for all the five cities are quite similar, an urban consolidation centre has been implemented. But these consolidation centres are organized in different ways. There is a range between having a consolidation centre some kilometers away from the delivery area to more niche oriented consolidation centres that has innovative electric vehicles and serves a particular market. The survey technique called freight operator survey was used in four of the cities and it was often complemented with other survey techniques. The method of collecting data and the time period of the ex-post research was very different in all of the five cities. In four out of five cities, the consolidation centres are still running. The only project that is still not running is the Samlic project in Linköping. When it comes to transferability to other cities some special features can be seen in each case. Three of the cities have a delivery area that can be described as a mediaeval city area with narrow streets, where it is difficult to deliver goods. Utrecht has also a lot of canals with many water ways and in London the delivery area consists of a high density office space.

5.5. Evaluation analysis of energy and environmental impacts

In the analysis of the energy and environmental impacts in Table 7, the preliminary investigations of Norra Djurgårdsstaden are also included. This is to get a full perspective on what these types of studies look at when it comes to energy use and the emission of dangerous substances from freight transport in cities.

Table 7: A comparison of the energy and environment parameters.

	The Old Town	Linköping SAMLIC	Norwich	London	Utrecht	Linköping University	TransOPt
Energy (quantity)	-Energy	-Not calculated in the report	-Fuel consumption	-Fuel consumption	-Fuel consumption	-Energy	-Fuel consumption
Energy (unit of measure)	-GJ/year	-Not calculated in the report	-l/km	-l/km	-l/year	-MJ/year	- l/year
Environment (quantity)	-CO_2 -NO_x -Particulates -Noise	-CO_2 -NO_x -Particulates -HC -Noise	-CO_2 -NO_x -Particulates -CO	-CO_2-equivalents	-CO_2 -Particulates	-CO_2 -Particulates -Noise	-CO_2 -NO_x -CO
Environment (unit of measure)	-Tonnes/year -Db	-No	-g/vkm and -g/year	-kg/parcel	-mg/m^3 -Tonnes/year	-kg/year -db	-kg/year
Other relevant parameters that was calculated	-Vehicle load factor -Number of small deliveries	-Mileage stops -Number of stops and unloading -Driving time -The load factor	-The same measurements was done with delivery vehicles using bus lanes -Distance and journey travelled	-Distance travelled in by the delivery vehicles	-Number of delivery trips -Type of vehicle in percent	-Number of delivery vehicles	-Estimation of waste in tonnes /year
The most important data collected in order to calculate the parameters	-Standard values of emissions and fuel -Number of deliveries -Vehicle kilometer	-Meter indication -Number of pallets -Arrival and departure time -Weight of the parcels	-The number of vehicles going in and out of the UCC -The average speed of the vehicles	-Distance travelled and deliveries on journey -Time use in percent -Driving speed	-Number of stop on a delivery trip -Deliveries on a week -Number of vehicles by Euro standard	-Number of parcels and pallets from Posten AB -Assumed vehicle route	-Key figures of transports per square meter office space
Calculation method	-Based on standard values from the delivery vehicles -The standard values are converted to energy use and emissions with help from the number of transports, number of trips and distance travelled	-The number and weight of the pallets turned into load ratio of the vehicle -The arrival time and departure time from the UCC as well as the meter indication in the vehicle turned into mileage and driving time	By using the average speed of the vehicle -The fuel consumption can be found with help from the TAG unit -The emissions can be found with help from the Appendix E in the Nera document	Based on one average journey -To calculate the kilometer per parcel, the distance travelled on one journey has been divided with the number of parcels delivered during a journey	The delivery vehicles after the EZ, were calculated as the percent share by the type of vehicle -The delivery trips were calculated by the number of deliveries per week divided by the average number of stop per trip	-Used the weight and number of the parcels and pallets to the reference areas and linearly scaled them to NDS -Divides the weight with the max load of the vehicles -The NTM-method was used	-The number of transports in NDS is found by multiplying the transports per square meter office from the reference areas with the total office space in NDS -The NTM-method was used

Table 7 shows that two of the reports looked at energy in terms of Joule and as fuel consumption. All of the evaluation reports have looked at the impact that the consolidation centre has on emissions from the delivery vehicles. Several other relevant parameters are calculated in the projects, but there is no consistency among the projects in the chosen parameters.

6. A deeper evaluation analysis

This chapter gives a further evaluation analysis of the five evaluation reports. The chapter describes six different types of evaluation analysis and compares the evaluation reports based on these types.

6.1. Six different types of evaluation analysis

Nilstuns (1984) article about evaluation analysis is used in order to perform a deeper analysis of the five different projects. In this article the evaluation analysis is divided into six different types. The first type is effort analysis, which is to identify and assess the implemented measures. In order for improvement to be achieved, an effort must be made by someone. The main efforts made are sanctioning, regulatory, supervisory, informative, supportive or agreement-making actions. Effect analysis is to identify and evaluate the changed impacts in selected areas. In this aspect, two difficult methodological problems arise. The first concern is the choice of effect variables: In what areas should the impact be searched for and in terms of what should they be described? The second problem arises in trying to map the causal connection, in what way is it possible to verify that the studied changes are a result of the implementations that has been done? (Nilstun, 1984).

Process analysis is to identify and analyze the process, and to investigate if the efforts may have had an effect in the selected areas. The effects in the selected areas are in many cases often not directly driven by the decisions and the actions undertaken, but rather they are mediated by different processes of change. Goal achievement analysis is to identify and analyze the idealized, comprehensive, intermediate and immediate objectives to a project, and compare the three latter with the effects in the target area. Cause analysis is to identify the types of external factors that can have affected the projects and to assess their relative causal importance for the progress. Efficiency analysis is to identify weaknesses in the implementation of the projects and recommend improvements. Alternative approaches to achieve the goals may also be suggested (Nilstun, 1984). The six different types are edited to fit the evaluation reports and are summarized in Table 8, with some helpful questions that could be asked to facilitate the answers.

Table 8: Summary of the different types in evaluation analysis (Nilstun, 1984).

Type of analysis	Question formulation
Effort analysis	Were there any efforts made to realize the objectives while implementing the consolidation centre?
Effect analysis	Have these efforts had any effects on the energy consumption and environment?
Process analysis	Through the series of what events are the efforts related to the effects?
Goal achievement analysis	What are the objectives of the reform and have the objectives been achieved?
Cause analysis	What external factors favored, respectively prevented the achievements of the objectives?
Efficiency analysis	Could an acceptable degree of goal achievement have been realized in a more efficient manner?

6.2. Comparison of the evaluation reports

The questions in Table 8 are analyzed further in this chapter by pointing out the most interesting aspects of the evaluation reports. A summary and a comparative research of the evaluation analysis in order to answer the different questions in Table 8 is presented in Table 24 and Table 25 in Appendix 7 – Evaluation analysis.

6.2.1. Effort analysis

The efforts made in the process are often initiated by the same people and organizations that are the initiators or the stakeholders of the consolidation centre. The development of the pilot project Samlic especially highlights the many efforts made in implementing a consolidation centre. In the spring of 2000 the development of the Samlic process started. The municipality of Linköping and the Employment Service started the project "Business Contact" where small and medium businesses were visited. One of these was a freight company with the name "Östgötafrakt AB", where one of the managers expressed the idea of coordinated freight logistics in order to reduce the heavy traffic load from delivery vehicles in the city centre of Linköping. An environmental coordinator in Linköping was linked to the project and the idea was presented to "the City Coordinated Group", a group of politicians, municipal officials and business representatives. The idea was further processed and in December 2000 “the City Transport Group” was formed, which consisted of the above-mentioned site manager from Östgötafrakt and the environmental coordinator as well as a project manager in a real estate group in the city centre, a leader of the businesses in the city centre and leader of a mall in the city centre. The next step was to study the Samtra project in Uppsala and further the preliminary investigation by the logistician Catarina Nilsson took place in 2001. That same year the Local Network for Transporters in Linköping was formed. The activities in 2002 consisted of further meetings and discussions in the group, including discussions on economy, finance and project managers. The Swedish National Road and Transport Research Institute were linked to the project in 2003 and received support to do the evaluation reports from Vinnova the same year. In 2004, the pilot project Samlic was conducted (Svensson, et al., 2006). This is an example of how a consolidation centre can be implemented. There are a lot of different stakeholders and people that have to make an effort in order to implement the process.

6.2.2. Effect analysis

When it comes to the energy and environmental effects of the consolidation centres, the five evaluation reports had different results. The results from the Old Town show a slight difference in the energy and environmental effects, before and after setting up the logistic centre. This is especially the case for the energy consumption and the emission of CO_2 and NO_x, which all had a change between 2 to 0.8

percent. The only significant change in the Old Town was the emission of particulates, which was reduced by 70 percent and was probably caused by the change from diesel vehicles to biogas vehicles. These results probably depend on the fact that the evaluation report looked at all of the delivery vehicles that deliver goods to the restaurants in the Old Town and not only on the vehicles that deliver goods from the logistic centre (CIVITAS Trendsetter, 2005). The Samlic project focused on the efficiency of the delivery system. These parameters showed that the pilot project increased the efficiency of the system. The filling per pallet increased by 47 percent, the mileage decreased by 50 percent and the driving time decreased by 44 percent. In fact the pilot project was so effective that the delivery vehicle fleet could be reduced by 2 out of 9 vehicles (Eriksson, Lundgren, & Svensson, 2006).

Norwich experienced a great difference in the energy and environmental effects from setting up a consolidation centre. The fuel consumption decreased by 28 percent, the emissions of NO_x decreased by 61 percent, the emissions of CO_2 decreased by 48 percent and the emission of particulates decreased by 16 percent. These results demonstrate the effect of changing from large delivery vehicles to smaller delivery vehicles for deliver goods in the city centre. But the data material consisted only of 88 vehicles in one year, and this does probably not cover a large percent share of the trucks that drives into the city centre. Further, the emissions of CO increased by 13 percent after setting up the consolidation centre. This was because the HGV 2R vehicles released more emissions of CO than the HGV 6A vehicle (CIVITAS Smile, 2009). For London in total, the emission of CO_2-equivalents per package decreased by 54 percent. The distance travelled in the City of London per parcel increased by 359 percent during the trial of the micro-consolidation centre. This result is mainly because of the smaller carrying capacity of the electric tricycles and electric vans compared to the diesel vans. Another reason is that the electric tricycles and vans had to meet guaranteed delivery times that resulted in the need for more deliveries per day. Outside of London, the distance travelled for the diesel van from the suburban depot to the City of London decreased by 83 percent after implementing the micro-consolidation centre, which led to the total delivery trips in London dropped by 20 percent (Allen, Browne, & Leornardi, 2011). For Utrecht, the introduction of the environmental zone led to a higher share of more environmentally friendly vehicles in the city center. For example the share of Euro 0/1 delivery vehicles decreased from 9 percent to 4 percent, and the share of Euro 4/5 delivery vehicles increased from 1 percent to 12 percent (Turbolog, 2011).

6.2.3. Process analysis

Two different situations stand out when it comes to the process analysis. During the first year of operation, the consolidation centre in Norwich struggled to attract customers while Utrecht has been considered to be successful in cooperating with businesses. Norwich tried hard to attract more customers by having a marketing campaign and develop the Freight Stakeholders Club. But it was hard to encourage the retailers to use the consolidation centre because many retailers would not change their delivery situation. Another factor was that other freight companies than Foulger Transport, who operates the consolidation centre, were concerned that the consolidation centre would take the customers from their companies (CIVITAS Smile, 2009). Utrecht, on the other hand, experienced great success with the Integrated Policy Package. Mark Degenkamp, representing the municipality of Utrecht, was interviewed in the evaluation report written by Turbolog. Degenkamp summed up a number of success factors of the Utrecht policy. First and foremost, two people work with freight transportation measures in the administration of the municipality of Utrecht. The businesses in Utrecht have influence on the freight transportation system in the city centre. Degenkamp emphasize the importance of involving the businesses as stakeholders early on in the process. The municipality of Utrecht also cooperates with other regional freight organizations, the government and other municipalities in the Netherlands. Further, the municipality of Utrecht started with a practical approach that was not ambitious and showed the businesses that they had a serious approach to freight transports (Turbolog, 2011).

6.2.4. Goal achievement analysis

The goal achievement analysis of the evaluation reports underline that some objectives were achieved and some objectives were partly or not achieved. Most of the objectives were not that ambitious and this was especially the case of the micro-consolidation centre in London. The evaluation report from London only looked at the impacts of the driving distance and the greenhouse gases. However, the most common goal between the evaluation reports was to gain experience from coordinated freight logistics and to establish a consolidation centre. The last goal was achieved in all of the case studies except for the Samlic project. One of the other most common objectives was to reduce the number of delivery vehicles as well as the trips and traffic into the city district. This was achieved by Utrecht and the Old Town, but it was not achieved in Norwich. The Old Town and Norwich aimed at reducing the fuel consumption and emissions from the delivery vehicles. The Old Town partly achieved this goal, while Norwich achieved this goal. Other objectives in the evaluation reports were to reduce the traffic congestion in the city district and to get better accessibility for the delivery vehicles and improve the traffic safety. Utrecht had a goal to introduce more sustainable approaches to transports and facilitate the use of more environmentally friendly and energy efficient vehicles in the city district. The Samlic project wanted to show that a consolidation centre was lucrative for all involved stakeholders. This shows that the objectives set in the evaluation reports was not that ambitious and involved many aspects about running a consolidation centre. When the objectives are not ambitious it is easier to fulfill them and makes it easier to marketing the consolidation to attract custmers. This was also pointed out by Mark Degenkamp from the municipality of Utrecht in the evaluation report from Turbolog (Turbolog, 2011).

6.2.5. Cause analysis

Certain external factors prevented or worked in favor of reaching some of the objectives set in the evaluation analysis. Especially the cases of the Old Town and London stand out, the Old Town met many external obstacles in the process while the external factors for London worked in favor of the consolidation centre. The Old Town should have had an electric vehicle to deliver goods from the logistic centre in the beginning. But the electric vehicle was destroyed in a fire in a garage so a new vehicle had to be purchased. A new biogas vehicle was bought to replace the electric vehicle, but the waiting time on the biogas vehicle was so long that a regular diesel vehicle had to be used to deliver goods in the meantime. After a period of having deliveries from the logistic centre, it became clear that the normal delivery time in the area were not satisfactory (from 6am to 11am). Therefore the logistic centre applied for exemption of the delivery time in the Old Town. In the waiting process for this application the logistic centre was put in a so called limbo situation. This situation made it difficult to promote the logistic centre and attract more customers because the capacity was full. It was too expensive to have one employee when the logistic centre at that time only had two customers. During this time the goods were delivered from the supplier’s warehouse. These deliveries were not consolidated with other customers, but the delivery vehicle was still fully loaded. In January 2005, the permission for the exemption of delivery time was granted to the logistic centre and the number of restaurants as customers of the logistic centre increased to 35 (CIVITAS Trendsetter, 2005).

The micro-consolidation centre in London experienced the opposite. External factors affected the delivery situation of the consolidation centre positively. First of all, the types of businesses in the delivery area are suitable for the small electric delivery vehicles. In the delivery area, the financial district of London, there are a high density of office buildings that usually have the deliveries in parcels instead of pallets. The size and the weight of the parcels are often small and there is room for many parcels in the electric delivery vehicles. These electric vehicles has a smaller carrying capacity, compared to regular delivery trucks. But it is easy to navigate the electric vehicles in the delivery area because the consolidation center lies close to the financial district (Allen, Browne, & Leornardi, 2011). All of these factors make it easier to have small environmentally friendly delivery vehicles and make the delivery system effective.

6.2.6. Efficiency analysis

In the efficiency analysis, the most interesting example to analyze is the Samlic project, because this is the only consolidation centre not running today. As mentioned in section 4.2.6, the Samlic project experienced several positive results during the trial with the consolidation centre. There are different reasons why this project stopped and why it has not been implemented nine years after the pilot trial. One of the evaluation reports mentions four important factors of why this project did not continue. First of all the project lacked funding from Vinnova for the immediate continuation of the development of a coordinated IT-system for the four logistic companies. Especially Posten AB could not see how the project could be coordinated and satisfy all the different information systems to the logistics companies. There were also problems with the various logistics companies profiling brand and how this would translate to a consolidation centre. For example there were discussions about what kind of brand the vehicles should have and what the outfits of the drivers should look like. The involved logistics companies feared that the project would threaten the marketing of the individual company and that they eventually would lose customers. Furthermore, the actual process of the project went wrong. During the process, the project was raised by the freight forwarders from being a Linköping project to be a national project. When this happened the project should have involved a higher level of the Swedish National Road and Transport Research Institute and the senior officials at the transport sectors authorities in Sweden (Eriksson, Lundgren, & Svensson, 2006).

7. Discussion of the transferability to Norra Djurgårdsstaden

This chapter discusses the methods used in this report, the preliminary studies of the delivery vehicles in Norra Djurgårdsstaden, the evaluation reports, the initiators, the stakeholders, the financing, management control instruments, a development compared to Hammarby Sjöstad, a method of collecting data of the delivery vehicles, planning purposes, the delivery vehicles from consolidation centers, the calculation methods, the energy effects, the environmental effects and other important parameters.

7.1. Methods used in this report

Several difficulties occurred during the literature study of this report. Unfortunately, only a few evaluation reports looked at energy and environmental impacts of urban consolidation centres. This made it quite difficult to find evaluation reports that contained precisely the information this report was looking for. In some of the evaluation reports, especially in the case of the Old Town and London, a problem occurred when the data material and the calculation methods from the evaluation reports were not available to the public because it was confidential. For all of the evaluation reports often no explanation was given of why particular parameters and the associated units of measures were chosen. These kinds of evaluation reports were sometimes written in the national language and needs to be translated. This was especially evident in the case of Utrecht were the public documents on the official website of the City of Utrecht was written in Dutch.

In order to get the best possible scientific results in an evaluation report the same amount of data needs to be gathered before and after setting up a consolidation centre. A comparison of the before and after situation survey periods can be seen in Table 5 and Table 6. This shows that the research period was much greater in the after situation of the projects. It is also normal to have a preliminary investigation, but Table 5 demonstrates that the line between the preliminary investigation and the before situation can be blurry in these evaluation reports. This can cause problems in comparing the before and after situation. Many of the evaluation reports were also quite old, especially the reports from the Old Town, the Samlic project and Norwich. This makes it evident that it is necessary to follow up the evaluation reports after a while, to understand how the development of the consolidation centre has been and to get more updated results.

7.2. Preliminary investigations of delivery vehicles in Norra Djurgårdsstaden

Table 2 make underline that the two previous preliminary investigations from the students of Linköping University and the Transopt study were performed in different ways and ended up with different results in calculating the future amount of delivery vehicles in Norra Djurgårdsstaden. The students from Linköping University predicted that it would be 46 delivery vehicles per day and the Transopt study predicted that it would be 1100 delivery vehicles per day. Hence, the different results of the number of deliveries are one reason as to why there is need for a further investigation on goods transportation in Norra Djurgårdsstaden. Since the construction of the city district has just started it is difficult to predict which study that is correct. But, because the city district is going to consist of 12 000 new residents and 35 000 new workplaces, 46 delivery vehicles per day will probably be a quite small amount. The small amount of delivery vehicles is probably because the students from Linköping University did not take home delivery vehicles, letter delivery vehicles, service vehicles, food transport vehicles, goods delivery vehicles to and from Valparaiso, goods delivery vehicles to and from the Värta Pier into account in the survey (Back, Högström, Kronander, Ljungberg, & Överfors, 2012). This means that the survey may have missed many delivery vehicles. The only delivery vehicles the survey looks at are the parcels and pallets delivered by Posten AB. Although the study is limited in terms of delivery vehicles, it offers some good ideas for the organization of a consolidation centre in Norra Djurgårdsstaden.

7.3. Evaluation reports

Table 4 presents an analysis of who performed the evaluation reports, and it shows a variation among the studies. The evaluation reports and the preliminary investigation focuses mainly on energy and environmental impacts are the ones that were written by CIVITAS and by students from Linköping University. Two of the other reports were done by a transport research programme and focuses mainly on freight transport and logistics. The transport studies in London had a slightly more sustainable approach than the Samlic project, focusing on logistics and efficiency. The evaluation report in Utrecht was done by a European Union funded project called Turbolog, which focused on the transferability of the urban logistic practices to other cities.

7.4. Initiators

Table 4 shows that the initiators of building a consolidation centre usually is a logistics company, an authority or an organization that is connected to the city district. If a logistics company took the initiative, it was usually because they had a genuine interest in environmental issues or a social responsibility, like the case of Home2you or Office Depot. The initiative from the logistics company or a corporate group is often driven by some kind of problem with deliveries in the city district. Inefficient delivery systems are often caused by the geographic situation in the city district, like narrow streets, crowding of vehicles or that the logistics company has an ineffective delivery system. It is hard to predict how the traffic situation will be for the delivery vehicles in Norra Djurgårdsstaden so early in the construction process. It is also not clear how many restaurants, shops, shopping malls and other businesses and services that are going to open in Norra Djurgårdsstaden. Additionally, this is probably also the reason why a logistics company is not going to take the initiative of a coordinated freight logistics in Norra Djurgårdsstaden in this stage of the process.

For Norwich and Utrecht an authority took the initiative, like the county council or the government and the municipality. The Dutch government promoted the urban distribution concept to Dutch cities in the 1990s. The logistics policies are implemented in all kinds of levels in the Dutch institutional framework, much because of the demography and the major ports that distribute goods from the Netherlands to the rest of Europe (Turbolog, 2011). It is the municipality in Utrecht that sets the rules for how the consolidation centres are organized and this method has proved to be successful. When it comes to logistics, Sweden does not have the same strategic position as the Netherlands, so it is hard to see that the Swedish government would take an initiative like this in the current situation. In Norwich it was the Norfolk County Council that took the initiative of the consolidation centre, because the city centre faced poor air quality and emissions from of all of the delivery vehicles.

Since the construction of Norra Djurgårdsstaden is in the beginning phase, the initiative to implement a consolidation centre has to come from the City of Stockholm in this stage of the process. First and foremost, the City of Stockholm controls the planning process of the whole city district and also owns the property in Norra Djurgårdsstaden. The City of Stockholm also has high environmental ambitions for Norra Djurgårdsstaden, and secondly a specific objective of the City of Stockholm is that freight transport in the city district shall occur in an environmentally efficient manner using consolidation centres, mixed with environmentally efficient vehicles (Norra Djurgårdsstaden, 2010). So based on the five evaluation studies and the documents written by the City of Stockholm it is proposed that the City of Stockholm should take the initiative of implementing a consolidation centre in Norra Djurgårdsstaden.

7.5. Stakeholders

Many stakeholders are often involved in the implementation and operating of the consolidation centre, which also is shown in Table 4. As mentioned in section 7.4, a municipality and logistics company is always involved in the organization of a consolidation centre. In all of the cases where the consolidation centre is still running, one logistics company is in charge of operating the centre. Three logistics companies collaborated on deliveries from the Samlic terminal and as mentioned before it was hard to get a coordinated IT-system to function and the project was cancelled. Therefore the best alternative is probably to have one logistics company as an operator of the consolidation centre, to prevent problems on collaboration and discussions about the brand of the companies.

In almost none of the five evaluation reports the potential customers, the businesses that receive the goods, were involved in the process of implementing a consolidation centre. This was actually pointed out in the evaluation report of the Old Town, because the restaurants and their suppliers had not been a part of the discussion about the O-central. This led to some of the restaurants being negative to changes in their supply system and in turn it created problems when the consolidation centre was looking for new customers (CIVITAS Trendsetter, 2005). The question of setting up a consolidation centre was actually brought up in many instances and groups in Linköping before the trial started. As discussed earlier in section 6.2.6 different representative groups and organizations were involved the pilot project. The retailers were also positive that the number of deliveries decreased during the pilot trial (Eriksson, Lundgren, & Svensson, 2006).

A process like the one in the Samlic project is also emphasized by the Norwegian Public Roads Administration. Their opinion is that it is possible to acquire the best overview of the distribution market by talking to logistics companies, freight forwarders, wholesalers and their organizations of interest. The Norwegian Public Roads Administration also highlight that a cooperation between all parties involved in the planning phase, based on experience, in general gives better solutions on transportation questions (Statens Vegvesen, 2005). Therefore, this means that it is important to include all potential involved parties in the planning process of the consolidation centre in Norra Djurgårdsstaden. This should start as early as possible in the process to get as many stakeholders as possible involved. A potential way to get the stakeholders interested is to organize meetings and send out information about the consolidation center. It is also important to establish contact with the different stakeholders and to keep it up during the process. A similar process was also emphasized by the municipality of Utrecht (Turbolog, 2011). Another interesting stakeholder was proposed on a workshop with the Citylogistik group, the Ports of Stockholm. They handle most of the goods in an efficient manner in Värtahamnen today and have a lot of experience in handling goods in this city district (Workshop, 2013). The different stakeholders in Norra Djurgårdsstaden should be the City of Stockholm, logistics companies, freight companies, the different businesses and Ports of Stockholm.

7.6. Financing

This topic is not investigated thoroughly in this report, but according to Petterson, Nilson, Orwén, & Berglund (2011) the economy and financing of a consolidation centre is a critical factor for a continued existence of the project. The projects are often terminated when the authority withdraws their economic support and there is no money to cover more costs (Petterson, Nilsson, Orwén, & Berglund, 2011). Two different trends can be pointed out in Table 4 about the finances to the evaluated cities. In London and Norwich, the logistics companies received financial support from authorities. However, for Utrecht and the Old Town, the logistics companies running the consolidation centre also finances it. This means that it is possible to run a consolidation centre without financial support from an authority. It was emphasized on the workshop with the Citylogistik group that it is important that the consolidation centre in Norra Djurgårdsstaden is self-financing and paid by the customers who use it (Workshop, 2013). But this also requires a stable customer base and this was hard to achieve in the beginning phase for some of the projects, especially for Norwich and the Old Town. Thus this is also an aspect to consider carefully and a consolidation centre in Norra Djurgårdsstaden should focus on attracting customers in the beginning.

7.7. Management control instruments

Several management control instruments are often implemented at the same time as a consolidation centre is set up. This is especially helpful if there is little support for coordinated freight logistics among businesses or if there is a lack of interest from the logistics companies and freight companies in the city district. Through control instruments, the municipality can force the businesses to have deliveries from a consolidation centre (Petterson, Nilsson, Orwén, & Berglund, 2011). One of the most common incentives are environmental zones, where the aim is to encourage the use of less polluting vehicles in established zones in the city, like electric vehicles or biogas fuelled vehicles (Allen & Browne, 2010a). As mentioned earlier in this report, Utrecht has implemented many management control instruments including environmental zones and innovative electric delivery vehicles, within the Integrated Policy Package and is also considered as a success story when it comes to coordinated freight logistics (Turbolog, 2011). The City of Stockholm can learn something from the Utrecht experience regarding control instruments and the cooperation between the logistic companies, the entrepreneurs in the inner city and other business organizations.

Another example on control instruments is time windows, which are rules that decide when a delivery vehicle can enter the city, for example at night time or off-peak-delivery hours (Allen & Browne, 2010a). In the Old Town it is forbidden to deliver goods for any vehicle after 11am, but the delivery vehicles from the O-central got exemption for delivering after that time, which made it easier to run the consolidation centre. Norwich lacked customers in the beginning, mostly because there were no incentives to encourage or force participation of customers to the consolidation centre. A potential to get more customers is to form increased access for the delivery vehicles from the consolidation centre in the city centre (CIVITAS Smile, 2009). Other control instruments in Norra Djurgårdsstaden could be restrictions of the weight, length and loading capacity of the delivery vehicles (Allen & Browne, 2010a). Economic incentives are also an option as control instruments. For example environmental taxes on certain delivery vehicles or a type of road pricing system for delivery vehicles. The City of Stockholm has many alternatives in implementing control instruments in Norra Djurgårdsstaden. This could help increase a larger customer base, get more environmentally friendly delivery vehicles and make freight companies cooperate on coordinated freight logistics in the city district.

7.8. A development compared to Hammarby Sjöstad

An objective in this report is to gather data on the number of delivery vehicles in Hammarby Sjöstad and test the number of vehicles with the most suitable calculation model from the evaluation reports or the preliminary investigations on Norra Djurgårdsstaden. Based on this the aim is to demonstrate a clear improvement in Norra Djurgårdsstaden compared to the situation in Hammarby Sjöstad, especially in terms of the energy and environmental impacts of the vehicles. Therefore, contact with different people that have worked with the transportation situation in Hammarby Sjöstad was taken. It turned out that many of these persons had worked with the construction logistic centre during the construction of the city district, and they had no information on measurements of delivery vehicles in the area. A thorough research on the internet was carried out. Unfortunately, no data on the number of delivery vehicles was found there either. A clear development for Norra Djurgårdsstaden compared to Hammarby Sjöstad is the focus on delivery vehicles in the two previous preliminary investigations on Norra Djurgårdsstaden and the attention on delivery vehicles in Norra Djurgårdsstaden from the Citylogistik group.

7.9. Method of collecting data of the delivery vehicles

As Table 7 shows, the method of collecting data from the delivery vehicles is completely different among the five evaluation reports and the preliminary investigations on Norra Djurgårdsstaden. The collection of data in the evaluation reports is often limited to include only the delivery vehicles from the consolidation centre, through the survey technique called freight operator survey, not the total delivery vehicles in the whole city district. This type of data collection is often done in city districts that consist of businesses like stores, restaurants and offices and it is usually not done in residential areas. This means that the studies carried out in the evaluation reports are better suited to areas like Värtahamnen and Frihamnen in Norra Djurgårdsstaden.

All of the studied evaluation reports used quite simple methods to collect data and could be used in an evaluation report for Norra Djurgårdsstaden. In the case of the Samlic project, the Old Town and Norwich the data are collected by the logistics company that operates the consolidation centre. The data collection was done through information from consignment notes, driver notes, invoice data or statistics of number of vehicles that has entered and left the consolidation centre. These methods require that a consolidation centre is built in Norra Djurgårdsstaden and are more appropriate to use in a future evaluation report of a consolidation centre. Freight operator survey is problematic to use if a new preliminary investigation of the city district is sought. In this context it is more interesting to investigate the total number of goods delivery vehicles in the whole city district of Norra Djurgårdsstaden. This means that all freight and logistics companies in the city district have to be studied. Since many freight and logistics companies deliver goods to a city district it would be resource consuming to get an overview over all of the companies and to collect data from them.

If the energy and environmental effects are going to be measured, it is most convenient to collect data from consignment notes and complementary driver notes, and to put the required data in a computer tool like the NTM-method. The only thing that could be difficult to get from the consignment notes is the type of Euro standard to the vehicle, but this is for example available in an information book from the vehicle.

Other ways to find the number of delivery vehicles in Norra Djurgårdsstaden before it is finished is by traffic measurements, for example by counting the number of delivery vehicles on key road sections in Norra Djurgårdsstaden during relevant time frames. Similar traffic measurements have been done in the preliminary investigation of Norwich, Utrecht and Linköping. This method could for example be used in the residential areas Hjorthagen and Loudden. Another option to get data of the delivery vehicles is to use the key numbers that is developed by SINTEF and recommended by the Norwegian Public Roads Administration. To do that it is required to count the number of stores and businesses in Norra Djurgårdsstaden and study what kind of businesses they are. With help from Table 3 the number of deliveries can be estimated. This method could be carried out in the businesses areas Värtahamnen and Frihamnen. A similar method was also used before setting up the consolidation centre in the Old Town.

7.10. Planning purposes

Table 6 shows that the consolidation centres among the evaluated projects are organized and operated in different ways. Since Norra Djurgårdsstaden is situated in such a large area and will be built in stages in 17 years forward, an idea is to test a consolidation centre in one part of the city district first, for example in Hjorthagen. When the construction of the city district is finished around 2020 it is a possibility to use the location of the construction logistics centre in Hjorthagen as a trial of a consolidation centre in the area. But it is not often a consolidation centre serves a residential area. On the other hand, Värtahamnen will have a high density of office space just like the delivery area of the micro-consolidation centre in London. As mentioned earlier in this report, this is also the area where most goods deliveries are likely to happen in Norra Djurgårdsstaden. Therefore, another option is to try out a consolidation centre that focuses on office supplies to the offices in Värtahamnen. This could for example be based on the delivery system of the micro-consolidation centre in London. A similar idea was also presented in the preliminary investigation performed by the students from Linköping University (Back, Högström, Kronander, Ljungberg, & Överfors, 2012). Another alternative is that the consolidation centre is placed outside the city district, like in the case of Norwich. But it is ultimately the type of goods and the land use planning in Norra Djurgårdsstaden that decides where the consolidation centre would be situated.

7.11. Delivery vehicles from the consolidation centre

Table 5 underline that diesel vehicles usually delivered goods before the consolidation centre was implemented. After the consolidation centre was implemented, Table 6 shows that the delivery vehicles changed to more environmentally friendly vehicles, like biogas or electric vehicles. The vehicles were also often innovative, like the Cargohopper, the Beer boat and the electrically-assisted cargo tricycle. Especially the evaluation report from Utrecht emphasized that these innovative vehicles could be used in marketing campaigns and attracts more customers to the consolidation centre. Another important aspect that should be considered is how the delivery vehicles before and after the implementation of the consolidation centre will affect the delivery situation. For example in the case of London, where diesel vehicles were changed to smaller delivery vehicles, the electrically-assisted cargo tricycles and electric vans, the deliveries became more environmentally friendly but it required more delivery trips. In the Samlic project the consolidation centre increased the efficiency in the delivery system. The most common delivery vehicle used in the Samlic project is classified in Figure 17 in Appendix 1 - Truck guide as a number 3, a small to medium-small truck that is a diesel fuelled truck. A biogas fuelled vehicle also comes in this size and this is more environmental friendly than a diesel vehicle. When it comes to delivery vehicles in a consolidation centre in Norra Djurgårdsstaden this master thesis does support the suggestion from the students from Linköping University in, that the delivery vehicles should be small biogas fuelled truck mixed with small electric vans and electrically assisted vehicles (Back, Högström, Kronander, Ljungberg, & Överfors, 2012). This report also recommends testing the Cargohopper as a delivery vehicle from the consolidation centre in Norra Djurgårdsstaden. The Cargohopper is especially useful if the consolidation centre lies close to the city district and the vehicle is driven by solar panels on sunny days.

7.12. Calculation methods

Usually simple calculations are used in evaluations analysis, for example in Table 7. The calculations are simple when a computer tool like the NTM-method is used, it only requires keeping track of the collected data. The most challenging part is to handle a large data sample, like in the case of the Samlic project. Also, there are a lot of statistical issues to consider, this should not create a significant problem as long as reasonable assumptions are made and the issues are recognized.

7.13. Energy effects

The limited focus on the energy consumption of the delivery vehicles was common between the evaluation reports and the two preliminary investigations of Norra Djurgårdsstaden. From the energy point of view this is disappointing. The reasons for this could be many, but Table 4 made it evident that the main research fields of the authors for the evaluation reports are not energy technology. The Old Town and the preliminary investigation from Linköping University measured the energy consumption in the SI unit Joule/year. These studies are also the only studies that expressed energy consumption in pure energy terms. The other evaluation reports calculating the energy consumption of the delivery vehicles expressed the results in fuel consumption. But the measurement units are different, Norwich and London stated the units in l/km, and Transopt and Utrecht expressed the units in liter/year.

An advice for a new preliminary investigation or an evaluation report of a consolidation centre in Norra Djurgårdsstaden is to calculate the energy consumption of the delivery vehicles and use the measurement unit Watt hour/year. If the energy consumption is estimated by the NTM-method, the measurement unit is Joule, but it is easy to convert Joule into Watt hour, which is a unit equal to 3600 Joule. Watt hour is also the measurement unit the Swedish Energy Agency uses when the energy consumption of the transport sector and all other sectors is estimated, for example in the hand book "The energy consumption of the transport sector" from 2012 (Statens energimyndighet, 2013). This would make it easier to compare the total energy consumption of the delivery vehicles in Norra Djurgårdsstaden with the national transport sector and other sectors in Sweden.

7.14. Environment effects

The evaluation reports of the five cities and the preliminary investigations on Norra Djurgårdsstaden focused more on environmental effects than on energy consumption. Table 7 documents a slight variation in the type of emissions estimated. Almost all of the studies have chosen to estimate the quantity CO_2, except for London that instead estimates CO_2-equivalents per parcel. CO_2 is thereby the most common quantity to measure when it comes to delivery vehicles. This is probably due to the fact CO_2 has higher amounts of emissions compared to other substances. Another reason could be that CO_2 is the most important contributor to global warming and this has also a great public focus. According to Table 7 the most common quantity to estimate in addition to CO_2 are NO_x, particulates and CO. Hence, particulates were calculated in four of the studies, NO_x was calculated in three of the studies and CO was calculated in two of the studies. Furthermore, the reason of the focus on these quantities is probably the same as for CO_2, the delivery vehicles have significant emissions of these substances. All of the emissions also have serious local health impacts. For that reason, CO_2, NO_x, particulates and CO should at least be calculated in a preliminary study or a potential evaluation report of a consolidation centre in Norra Djurgårdsstaden.

All of the studies calculating the environmental effects used the measurement units tonnes/year, kilogram/year or gram/year. Depending on the amount of emissions of each substance, it is suitable to measure the emissions in tonnes, kilogram or gram per year in an evaluation report or a preliminary investigation of a consolidation center in Norra Djurgårdsstaden. This is also the measurement units the NTM-method uses in their computer tool and it is easy to relate to these measurement units. Norwich also measured the emissions in g/vkm, where vkm is vehicle kilometer, and Utrecht in mg/m^3, but these measurement units can be harder relating to and therefore it is not recommended to use these units. Almost all of the studied evaluation reports had a significant reduction in emission of CO_2, CO, NO_x and particulates. This means it is a huge probability for a reduction of emissions by implementing a consolidation centre in Norra Djurgårdsstaden.

None of the studies have explained why it is important to calculate the environmental effects caused by the delivery vehicles. It is suggested that the consequences each particular emission has for the environment is explained accurately in an evaluation report or a preliminary investigation of a consolidation centre in Norra Djurgårdsstaden. This could be especially important if the emissions from the delivery vehicles are going to be used as an argument for building a consolidation centre in Norra Djurgårdsstaden. Before the decision about an urban consolidation centre is made, it is necessary to discuss whether the benefits for the society including the environmental impacts can justify the financing of the consolidation centre. It is also possible that other ways of coordinated freight logistics can provide greater benefits to the society than the consolidation centre.

The engines of the diesel and biogas fuelled delivery vehicles also create a lot of noise. It is interesting to measure how much noise that comes from delivery vehicles, but Table 7 shows that noise is briefly mentioned in three of the studies. This is measured in the Old Town, and the preliminary investigation by the Linköping students briefly mentioned another study that investigated noise in Norra Djurgårdsstaden. The Samlic study mentions noise in one sentence. One reason could be it is difficult to measure noise, because it is difficult to distinguish the noise of cars and public transportation to the noise that the delivery vehicles create. It is evident is that electrically assisted vehicles create less noise compared to other vehicles. If the delivery vehicles from a consolidation centre in Norra Djurgårdsstaden are powered by electricity, the noise will be lower compared to diesel or biogas fuelled vehicles. But noise might not be the highest priority to measure in an evaluation report for Norra Djurgårdsstaden.

7.15. Other important parameters

To develop more arguments for implementing a consolidation centre in Norra Djurgårdsstaden it would be smart to measure other parameters than the mentioned energy and environmental parameters in section 7.13 and 7.14. Logistics companies might need more arguments in order to change the delivery situation, for example measures that can help lowering the economic costs. In this case some of the parameters that were measured in the Samlic project and in London are suitable for this task. The measures in these projects was the filling per pallet per vehicle, the mileage per day per vehicle, the driving time per one vehicle and the total number of stops in the city centre. These parameters measure the efficiency of the delivery vehicles and the consolidation centre and can be related to the cost.

8. Conclusion

The objectives of this report were to analyze previous examples on coordinated freight logistics in Europe focusing on the energy and environmental effects, to do a thorough comparative evaluation analysis of the five example cities, to find a suitable model to test on Hammarby Sjöstad and to propose how a consolidation centre project could be organized in Norra Djurgårdsstaden. The thorough analysis of the evaluation reports shows that the reports focused on different parameters and there were lots of variation in the projects. Despite that, some common practices among the studies were found. Based on this information several advices and suggestions on how a consolidation centre project should be implemented in Norra Djurgårdsstaden were made.

The initiative should come from the City of Stockholm in this stage of the process in Norra Djurgårdsstaden. Further, the stakeholders of the project could for example be the City of Stockholm, logistics companies, freight companies, the different businesses in the area and the Ports of Stockholm. It is important to contact the potential businesses in Norras Djurgårdsstaden and explain all the benefits of having deliveries from a consolidation centre. In connection to this, it is also important to involve businesses from the start of the process and keep regular contact further in the process. When it comes to the organization of a consolidation centre, the lessons learned from the evaluation reports is that it is easier to have one logistic company operating the consolidation centre. A consolidation centre in Norra Djurgårdsstaden should try to follow this example.

The consolidation centre in Norra Djurgårdsstaden should focus on being self-financing and creating a stable customer base. But it is important for the consolidation centre to have enough customers in order to be self-financing. To attract more customers the City of Stockholm can also implement different management control instruments like environmental zones, time-windows for deliveries, different restrictions on the delivery vehicles or economic restrictions. For a planning purpose it is appropriate to first test a consolidation centre in Hjorthagen or Värtahamnen. The Hjorthagen district will be completed first, and it is possible to use the location of the construction logistic centre for a trial of a consolidation centre. On the other hand, most of the office buildings are situated in Värtahamnen and it would be interesting to test a consolidation centre for offices supplies or other types of goods in this area. The objective regarding Hammarby Sjöstad was unfortunately not reached, because there is not enough information about the delivery vehicles in the city district. Two preliminary studies of the delivery vehicles in Norra Djurgårdsstaden has already been performed in the city district. This shows that it is a greater focus on delivery vehicles in Norra Djurgårdsstaden than in Hammarby Sjöstad.

Regarding the methods for collecting data, the most common survey technique in the evaluation studies has been freight operator survey. This means that the evaluation reports focused only on the delivery vehicles from the consolidation centre, not on the total amount of delivery vehicles in the city district. Further studies of the delivery vehicles in Norra Djurgårdsstaden should focus on the whole city district since a consolidation centre not has been built there yet. In the evaluation reports, quite simple methods were used to collect data about the delivery vehicles. The data collection occurred through consignment notes, driver notes, invoice data or statistics of number of vehicles that have entered or left the consolidation centre. All of the methods could be used to collect data in Norra Djurgårdsstaden. Since the results from the two earlier preliminary investigations were completely different a new preliminary investigation in Norra Djurgårdsstaden should be done. It is more convenient to use most of these methods in the office districts of Värtahamnen and Frihamnen. For the residential areas, Hjortagen and Loudden, it is probably more useful to count the number of delivery vehicles. When it comes to the delivery vehicles from a consolidation centre in Norra Djurgårdsstaden, it is suggested that the delivery vehicles should be an innovative delivery vehicle like the Cargohopper as well as small biogas fuelled trucks mixed with small electric vans and electrically-assisted vehicles.

All of the evaluation reports showed that the consolidation centres had a positive effect on decreasing the number of deliveries and thereby increasing the load factor of the delivery vehicles. This in turn had positive effect on reducing the impact on the environment and the energy consumption. The implementation of a consolidation centre caused a reduction of emissions and the fuel consumption from the delivery vehicles decreased. But the evaluation analysis shows that there are room for improvements when it comes to the energy effects in an evaluation report of a consolidation centre. The energy effects for a consolidation centre in Norra Djurgårdsstaden should be measured in Watt hour per year. This makes it easier to compare the energy consumption with other sectors. Further, the effects on the environment should be estimated in tonnes, kilogram or gram depending on the amount of emissions. CO_2, CO, NO_x and particulates are the most important to measure since these are considered to affect the environment the most. An interesting topic is the noise caused by the delivery vehicles, but this should not be the highest priority to measure in Norra Djurgårdsstaden. The energy and environmental effects can be estimated by the NTM-method. Other parameters useful to measure when it comes to the efficiency and lowering the economic costs of a consolidation centre are the filling per pallet per vehicle, the mileage per day per vehicle, the driving time per one vehicle and the total number of stops in the city centre.

9. Recommendations

This chapter gives further recommendation of the preliminary investigations and the future evaluation report for Norra Djurgårdsstaden.

9.1. Preliminary investigations

The preliminary investigation should preferably be performed in Norra Djurgårdsstaden. This investigation could take place when the first part of the city district is starting to be completed, for example in Hjorthagen or Värtahamnen. Another alternative is to use Hammarby Sjöstad as a reference area for the collection of data, since the completion of these city district will take a long time. Hammarby Sjöstad is the city district that is most similar to Norra Djurgårdsstaden when it comes to the ambitious energy and environmental focus. The collecting of data from the delivery vehicles could be gathered through:

- Consignments notes or driver notes
- Statistics of delivery vehicles driving in and out of Norra Djurgårdsstaden
- Use the key numbers from the Norwegian Public Roads Administration and investigate all of the businesses in Norra Djurgårdsstaden
- Use the NTM-method for estimating the energy and environmental effects

This master thesis suggests that a preliminary investigation of a consolidation centre in Norra Djurgårdsstaden should focus primarily on energy and environmental effects by reducing the number of delivery vehicles in the city district. Especially the information from the consignment notes and driver notes can be used in the NTM-method to estimate the energy and environmental effects.

9.2. A future evaluation report

In a future evaluation report the information could be gathered at the consolidation centre by:

- Consignment notes and driver notes
- Statistics of vehicles going in and out of the consolidation centre
- Using the NTM-method for estimating the energy and environmental effects
- Perform the same type and amount of survey before and after setting up a consolidation centre

It is suggested that an evaluation report in the future of a consolidation centre in Norra Djurgårdsstaden should be similar to the method overview in this report, but be more extensive and more detailed in each sub-chapter. This means that the chapters that at least should be included are the background of the project, the objectives of the report, the energy and environmental parameters studied, the method of collecting data, the calculation methods and the results.

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Appendix 1 - Truck guide

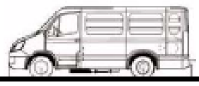
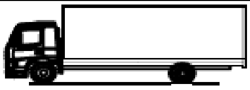
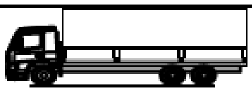
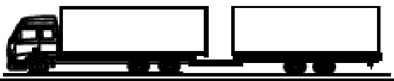
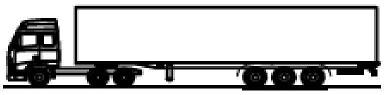
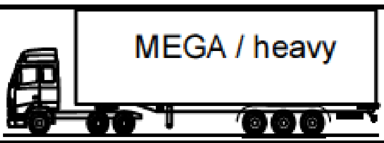
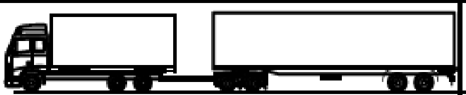
No	Illustration	Max weight[1]	Vehicle length (approx.)	Load capacity (typical values, inner dimensions)				
		[tonne]	[m]	[tonne]	pallets	[m]	[m3]	TEU
1	(no picture)	< 2.5	5	0.6	1	1.8	3 - 6	0
2		< 3.5	7	1.5	3 - 5	3 - 4	10	0
3		3.5–7	8	5	14	4 - 6	35	0
4		7.5-14	12	7	24	7.7	44	0
5		14–26	12	15	24	7.7	44	1
6		14 - 28	12 - 15	15 - 16.5	20-28	8 - 12	50-64	1
7		28 - 40	18.75	22	36	7.75 + 7.75	104	2
8		28 - 40	16.5	26	33	13.6	92	2
9		40 - 50	16.5	33	33	13.6	110	2
10		50 - 60	24 - 25.25	40	51	7.7 + 13.6	140	3

Figure 17: The different vehicles and their max weight and load capacity (Road transport Europe, 2010).

Appendix 2 - Guide of cities with coordinated freight logistics

Table 9: A list of the known examples on coordinated freight logistics in Swedish cities (Petterson, Nilsson, Orwén, & Berglund, 2011).

Project name	City	Time period/Start year
Freight Collaboration in Lundby-coordinated ordering	Gothenburg	2001-2006
The O-central in the Old Town	Stockholm	2004- now
Logistic function in Hammarby Sjöstad	Stockholm	2003
Coordinated distribution in south of Stockholm	Stockholm	
Coordinated ordering / distribution	Stockholm	2006-2008
SAMTRA- Coordination of freight transports	Uppsala	1999-2001
SAMLIC-Pilot trial	Linköping	2004, nine weeks
Coordinated freight transport in Karlstad	Karlstad	1997
Coordinated freight distribution in Borlänge, Gagnef and Säter	Dalarna	1999
Coordinated food distribution in Piteå	Piteå	1999-2005
Coordinated distribution in Halland	Halland	2001-2002
Coordinated food distribution in Linné	Gothenburg	1996-1998
Coordinated food distribution in Katrineholm	Katrineholm	2003-2006
The Five clover County council in Uppsala, Västmanland, Dalarna, Sörmland and Örebro county	Several cities	1999
Coordinated freight distribution in Malmö	Malmö	1998-2005
Coordinated freight distribution in Umeå	Umeå	1999
Coordinated freight distribution in Trollhättan	Trollhättan	1998
Coordinated freight distribution in Gothenburg	Gothenburg	
IDIOMA - Innovative intermodal distribution in urban environment - Project 1	Helsingborg	1998-2001
IDIOMA - Innovative intermodal distribution in urban environment - Project 2- Distribution of mixed goods	Malmö	1998-2001
IDIOMA -Innovative intermodal distribution in urban environment - Project 3 -Coordination of public procurement and related transport	Malmö	1998-2001
Collaboration in Östnor	Mora	
USTRA- The Universities coordination of goods transports	Uppsala	2001
Coordination of freight transports in Örebro	Örebro	1999, 6 months
Coordination of freight transports in Södertörn	Several municipalities in Södertörn	It shall soon beginning

Table 10: A list of the known examples on coordinated freight logistics in international cities (Petterson, Nilsson, Orwén, & Berglund, 2011), (Beittoei, 2012).

Project name	**City**	**Country**	**Time period/Start year**
Coordinated distribution in Bristol	Bristol	United Kingdom	2005
Coordinated distribution in Leiden	Leiden	The Netherlands	Ended 2010
PICK-UP Centre/delivery point	Winchester	United Kingdom	-
Cityplus	Milan	Italy	-
LOGurb	Lisbon	Portugal	-
Packstation	Several places	Germany	-
Binnenstadservice.nl	Njimegen	The Netherlands	2008
Logistic centre	Graz	Austria	2003
ReLog	Regensburg	Germany	2007
spediTHUN	Thun	Schweiz	2007
Urban consolidation centre	Norwich	United Kingdom	2004
Chronopost	Paris	France	2004
Nearby distribution area (ELP)	Bordeaux	France	2003
Cityporto	Padua	Italy	2004
Motomatchi	Yokohama	Japan	
Coordinated distribution in La Rochelle	La Rochelle	France	
Floating water distribution	Amsterdam	The Netherlands	
La Petite Reine	Paris	France	2003
Inner City logistic centre	Berlin	Germany	2003
Forum for City logistic	Aalborg	Denmark	2003
e-Drul	Siena	Italy	2002-2004
Coordinated distribution in Monaco	Monaco	Monaco	
Urban distribution centres	Utrecht	The Netherlands	1994
Micro-consolidation centre	London	United Kingdom	2010
Urban distribution centre	Rotterdam	The Netherlands	
Urban distribution centre	Lucca	Italy	
Urban consolidation centres	Several cities	Poland	
Urban distribution centre	Osaka	Japan	

Appendix 3 - The logistic centre in the Old Town of Stockholm in Sweden

Collection of data

Table 11: Standard values from the diesel vehicle and the biogas vehicle (CIVITAS Trendsetter, 2005).

	Diesel vehicle	Biogas vehicle
CO_2	0.44 kg/km	0 kg/km
NO_x	7.32 g/km	1.2 g/km
Particles	0.226 g/km	0.012 g/km
Fuel consumption	0.17 l diesel/km	7.2 MJ biogas/km
Vehicle km	1 km/cage	0,33 km/cage

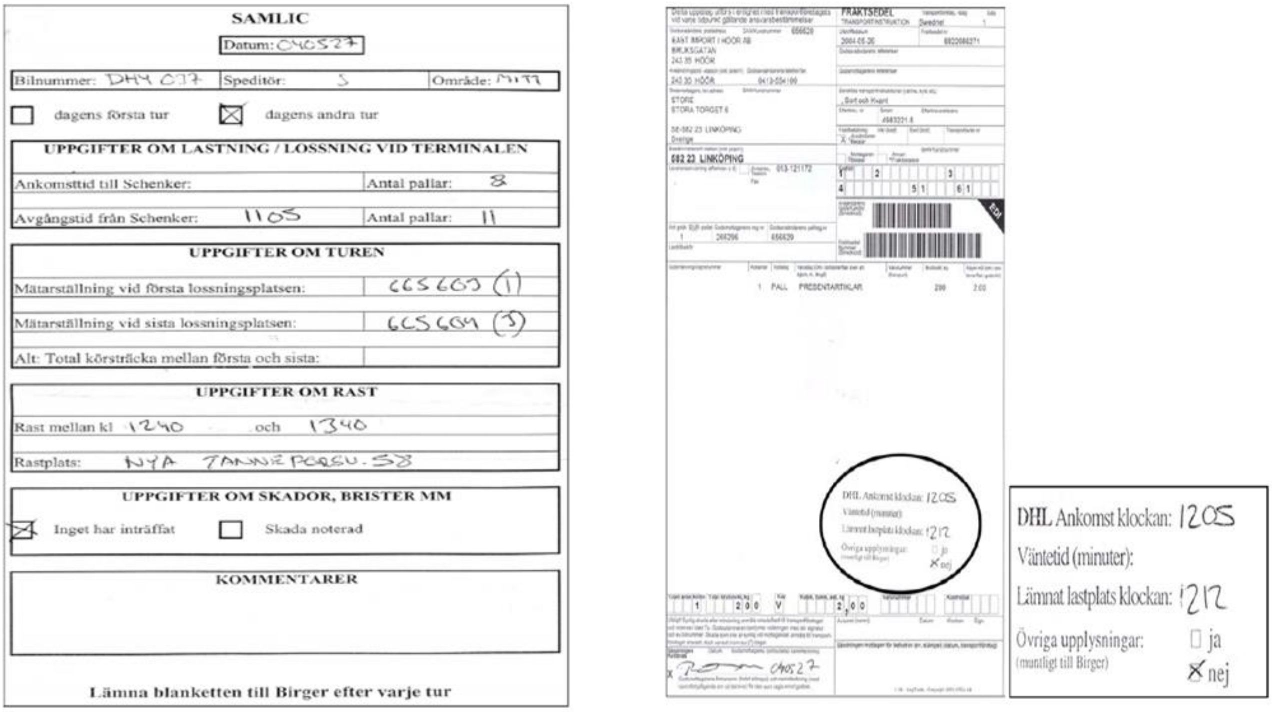
Results

Table 12: The results from before and after setting up the "O-centralen" in the Old Town (CIVITAS Trendsetter, 2005).

Indicator	Before	After
Energy use (total and Renewable)	924 GJ/year	917 GJ/year
Emission of CO_2	63.8 Tonnes/year	62.5 Tonnes/year
Emissions of NO_x	1.061Tonnes/year	1.042 Tonnes/year
Emissions of particles	2.71 kg/year	0.8 kg/year
Noise levels	122 dB(A)	122 dB(A)
Vehicle km by vehicle type (peak/off peak or total)	480 Vkm per day	474 Vkm per day
Vehicle load factor	67 %	80 %
Small deliveries	329 Vehicles/day	324 Vehicles/day
Number of deliveries	120 000 /year	117 268 /year (Total)

Appendix 4 – The Samlic project in Linköping in Sweden

Collection of data



SAMLIC

Datum: 040527

Bilnummer:	Speditör: S	Område: MITT

☐ dagens första tur ☒ dagens andra tur

UPPGIFTER OM LASTNING / LOSSNING VID TERMINALEN

Ankomsttid till Schenker:	Antal pallar: 8
Avgångstid från Schenker: 1105	Antal pallar: 11

UPPGIFTER OM TUREN

Mätarställning vid första lossningsplatsen:	665663 (1)
Mätarställning vid sista lossningsplatsen:	665669 (5)
Alt: Total körsträcka mellan första och sista:	

UPPGIFTER OM RAST

Rast mellan kl 1240 och 1340

Rastplats: NYA TANNEFORSV. 58

UPPGIFTER OM SKADOR, BRISTER MM

☒ Inget har inträffat ☐ Skada noterad

KOMMENTARER

Lämna blanketten till Birger efter varje tur

FRAKTSEDEL

DHL Ankomst klockan: 1205

Väntetid (minuter):

Lämnat lastplats klockan: 1212

Övriga upplysningar: ☐ ja ☒ nej

(muntligt till Birger)

Figure 18: The consignment notes the drivers must fill out (Svensson, et al., 2006).

Table 13: Variables from the delivery trips from the SAMLIC-terminal (Svensson, et al., 2006).

Date	Date for the ride
Area	Zone distribution area (east, west, central or the whole city)
Trip number	Numbering of daily trips within a certain area
Transport company	The provider of the trucking route
Car number	Car number of the car that deliver goods on one route
Km out	Meter indication of the departure from the terminal
Km in	Meter indication of the return to the terminal
Driving distance	The total mileage of the driving distance
Time in	Arrival time at the SAMLIC-terminal
Pallet in	Number of incoming pallets to the SAMLIC-terminal
Time out	Departure time from the SAMLIC- terminal
Pallet out	Number of outgoing pallets from the SAMLIC-terminal
Note	Any particular note made by the driver or transport manager

Table 14: Variables from the goods on the consignments notes from the SAMLIC-terminal (Svensson, et al., 2006).

Date	The date on which the consignment is delivered to the recipient
Area	The zone to which the receiver belongs (east, west, central or the whole city)
Trip number	The route where the consignment was delivered to the recipient
Waiting time	The waiting time on arrival at the address to the receiver
Arrival time	Arrival time to the stop when goods are delivered to the recipient
Departure time	The departure time from the stop where the goods are delivered
Transport company	The consignments "owner"
Recipients	Name
Unloading address	Street
Number	Street number
Parcel	Number of parcels that the consignment consists of
Weight	The consignments total weight in kilograms
Break address	For example the address to the lunch break

Results

Table 15: The result of nine weeks without modeling (Svensson, et al., 2006).

Parameter	**With coordinated freight transport**				**Without**	**Change with the coordinated freight transport**
	Central	**West**	**East**	**Total city**	**Total City**	
Mileage per day	1.9 km	3.7 km	2.5 km	7.9 km	15.9 km	50 % reduction
Number of stops per day	9.5	7.9	8.2	25.5	41.4	38 % reduction
Driving time per day	20.7 min	20.7 min	20.7 min	62.0 min	110.8 min	44 % reduction

Table 16: Numbers of the unloading with or without coordinated freight logistics (Svensson, et al., 2006).

Parameter	**Without coordinated freight logistics (estimated from the pilot project)**	**Without coordinated freight logistics (from survey after the pilot project)**	**With coordinated freight logistics**	**Savings**
The total number of unloading	3520		2879	18.2 %
Number of unloading per day	83.8	87.4	68.5	18.2 % and 21.6 %

Appendix 5 – The urban consolidation centre in Norwich in United Kingdom

Collection of data

Table 17: Collected data on how many deliveries that comes in and out of the urban consolidation centre (CIVITAS Smile, 2009).

	Deliveries into the consolidation centre by various vehicles						**Deliveries from the consolidation centre into Norwich**					
	HGV 2R	**HGV 3R**	**HGV 4R**	**HGV 3/4A**	**HGV 5A**	**HGV 6A**	**HGV 2R**	**HGV 3R**	**HGV 4R**	**HGV 3/4A**	**HGV 5A**	**HGV 6A**
November 2007	0	0	0	0	0	4	4	NA	NA	NA	NA	NA
December 2007	0	0	0	0	0	4	4	NA	NA	NA	NA	NA
January 2008	0	0	0	0	0	4	4	NA	NA	NA	NA	NA
February 2008	0	0	0	0	0	4	4	NA	NA	NA	NA	NA
March 2008	0	0	0	0	0	8	8	NA	NA	NA	NA	NA
April 2008	0	0	0	0	0	10	10	NA	NA	NA	NA	NA
May 2008	0	0	0	0	0	8	8	NA	NA	NA	NA	NA
June 2008	0	0	0	0	0	8	8	NA	NA	NA	NA	NA
July 2008	0	0	0	0	0	11	11	NA	NA	NA	NA	NA
August 2008	0	0	0	0	0	8	8	NA	NA	NA	NA	NA
September 2008	0	0	0	0	0	9	9	NA	NA	NA	NA	NA
October 2008	0	0	0	0	0	10	10	NA	NA	NA	NA	NA
Total	0	0	0	0	0	88	88	NA	NA	NA	NA	NA

Table 18: The vehicles journey time (CIVITAS Smile, 2009).

	Distance	**AM Peak average journey time (min:secs)**	**AM Peak average speed**
Consolidation centre to Unthank road	26.92 km	22:20	72.3 km/h
Unthank road to Inner ring road	2.95 km	6:59	25.3 km/h

Table 19: The values of the parameters from AEA Technology`s Environment Technology Centre (CIVITAS Smile, 2009).

Parameter	**A**	**B**	**C**	**D**
Rigid vehicles over 3.5 tonnes with 2 or 3 axles (HGV 2R and HGV 3R)	0.76833752	-0.02257303	0.00031766	- 0.0000013544
Rigid vehicles with 4 or more axles and all articulated HGVs (HGV 4R, HGV 3/4A, HGV 5A and HGV 6A)	1.02443156	-0.03021812	0.00044285	-0.00000200959

Results

Table 20: Fuel consumption per vehicle that delivers goods from the consolidation centre (CIVITAS Smile, 2009).

	HGV 6A	HGV 2R	The change
Fuel consumption per vehicle at 72,3 km/h from consolidation centre to Unthank Road (corridor 1)	0,396 l/vkm	0,285 l/vkm	0,111 l/vkm
88 vehicles fuel consumption at 72,3 km/h from consolidation centre to Unthank Road	938,1 l	675,2 l	262,9 l
Fuel consumption per vehicle at 25,3 km/ from Unthank Road to Inner Ring Road (without using any bus lanes)	0,511 l/vkm	0,379 l/vkm	0,132 l/vkm
88 vehicles fuel consumption at 25,3 km/h from Unthank Road to Inner Ring road (without using any bus lanes)	132,7 l	98,4 l	34,3 l
Total fuel consumption for 88 vehicles from consolidation centre to Inner Ring road	1070,8 l	773,6 l	297,2 l
Fuel consumption per vehicle from consolidation centre to Inner Ring road	0,907 l/vkm	0,664 l/vkm	0,243 l/vkm

Table 21: The effects on the emissions by setting up the consolidation centre (CIVITAS Smile, 2009).

	HGV 6A	HGV 2R	The Change
CO_2 emissions per vehicle from consolidation centre to Unthank road	1026.6 g/vkm	528.9 g/vkm	497.7 g/vkm
CO_2 emissons per vehicle at 25.3 km/h from Unthank road to Inner Ring road	1430.1 g/vkm	734.4 g/vkm	695.7 g/vkm
Total CO_2 emissions from 88 vehicles from consolidation centre to Inner Ring road	2803228.3 g	1443593.1 g	1359635.2 g
CO emission per vehicle at 72.3 km/h from consolidation centre to Unthank road	0.964 g/vkm	1.107 g/vkm	0.143 g/vkm
CO emissions per vehicle at 25.3 km/h from Unthank road to Inner Ring road	1.513 g/vkm	1.546 g/vkm	0,033 g/vkm
Total CO emissions from 88 vehicles from consolidation centre to Inner Ring road	2676.5 g	3023.7 g	347.2 g
Particulate emissions per vehicle at 72.3 km/h from consolidation centre to Unthank road	0.126 g/vkm	0.110 g/vkm	0.016 g/vkm
Particulate emissions per vehicle at 25.3 km/h from Unthank road to Inner Ring road	0.299 g/vkm	0.207 g/vkm	0,092 g/vkm
Total particulate emissions from 88 vehicles from consolidation centre to Inner Ring road	376.1 g	314.3 g	61.8 g
NO_x emissions per vehicle at 72.3 km/h from consolidation centre to Unthank road	4.513 g/vkm	1.773 g/vkm	2.74 g/vkm
NO_x emissions per vehicle at 25.3 km/h from Unthank road to Inner Ring road	8.057 g/vkm	2.993 g/vkm	5.064 g/vkm
Total NO_x emissions from 88 vehicles from consolidation centre to Inner Ring road	12782.7 g	4977.2 g	7805.5 g

Appendix 6 - The urban micro-consolidation centre in London

Collection of data

Table 22: Data from before the trial in 2009 and during the trials in 2010 (Allen, Browne, & Leornardi, 2011).

Operational features	**Diesel van**	**Electrically-assisted tricycle**	**Electric van**
Distance travelled on journey			
Distance from suburban depot to City of London (each-way)	29 km		
Distance travelled by van in City of London	10 km	8.9 km	12.4 km
Total distance travelled by van on delivery journey	68 km		
Deliveries on journey			
Number of stops to make deliveries	20	17	14
Parcels delivered per establishment during journey		17	19
Number of parcels delivered during journey	168	33	42
Parcels delivered per stop	8.4	2.0	3.0
Parcels delivered per establishment		1.7	2.5
Establishments delivered to per stop		1.2	1.2
Time use (as % of total journey time)			
"Stem" driving time from depot to first stop	21 %	10%	12%
Time running on the road between first and last stop	21%	28%	26%
Time unloading between first and last stop	48%	54%	52%
"Stem" driving time from last stop to depot	10%	9%	10%
Total journey time (hours and minutes)	05:24	02:42	02:15
Driving speed			
Driving speed from depot to City of London	26 km/h	8 km/h	8 km/h
Driving speed from City of London to depot	48 km/h		
Driving speed in the City of London	8 km/h		
Fuel use	12.8 l/100 km		

Results

Table 23: Comparison of the results from before and during the trials (Allen, Browne, & Leornardi, 2011).

	Before trial (October 2009)	**During trial (July 2010)**
Fleet mix used	**No micro-consolidation centre – 7 diesel vans only**	**Micro-consolidation centre – 6 tricycles, 3 electric vans and 1 diesel truck**
Distance travelled in the City of London		
Kilometres per parcel	0.06 km	0.27 km
Change compared with before trial	-	349%
Distance travelled rest of London		
Kilometres per parcel	0.36 km	0.07 km
Change compared with before trial	-	-82%
Distance travelled in all of London		
Kilometres per parcel	0.41 km	0.33 km
Change compared with before trial	-	-20%
CO_2 - equivalents emissions in City of London		
CO_2 - equivalents per parcel	0.020 kg	0.003 kg
Change compared with before trial	-	-83%
CO_2 - equivalents emissions in rest of London		
CO_2 - equivalents per parcel	0.122 kg	0.062 kg
Change compared with before trial	-	-49%
CO_2 - equivalents emissions in entire system		
CO_2 - equivalents per parcel	0.142 kg	0.065 kg
Change compared with before trial	-	-54%
Fuel use		
Fuel use in litres per journey	8.7 l	
Fuel use per parcel delivered	0.052 l	

Appendix 7 – Evaluation analysis

Table 24: The first part of the comparative analysis of the different types of evaluation analysis.

	The Old Town	**Linköping SAMLIC**	**Norwich**	**London**	**Utrecht**
Effort analysis	-Local Agenda 21-groups, parenting groups and Home2you took initiative to build the UCC	-The City Council, the businesses in the urban district and the freight companies cooperated in doing the trial	-Norfolk City Council with support from the CIVITAS SMILE project implemented the UCC	-Office Depot wanted to try out a new sustainable delivery system with sustainable freight company, GNewt operating it	-Integrated Policy Package implemented by the Municipally of Utrecht that contains many initiatives to reduce deliveries in the inner city
Effect analysis	-The UCC had positive effect on reducing the energy consumption and the environmental impcts because of fewer small deliveries and increase in the load per pallet	-Increase of the load ratio to the delivery vehicles -Fewer deliveries, less traffic and less vehicles in the city centre	-The UCC had a positive effect on the energy use and the environment because of the change from HGV 6A to HGV 2R vehicles	-The UCC had a positive effect on the environment because of the change from diesel vehicles to the electric vehicles	-No specific analysis of the impacts from the UCCs -But the EZ, Cargohopper and the Beer boat had positive effect on the environment
Process analysis	-The delivery vehicles from the UCC got exemption for delivering after 11am -Home2you specializes in sustainable freight deliveries	-The classification of three zones in the inner city, where one freight company delivered goods from all three logistics companies in the trial	-More environmental friendly vehicles -The marketing campaign to attract more customers -The development of the Freight Stakeholders Club	-More environmentally friendly vehicles -GNewt specializes in sustainable freight deliveries	-The environmental zone and the Utrecht UDC concept makes the vehicle fleet more environmentally friendly -The introduction of all of the initiatives from the Integrated Policy Package

Table 25: The second part of the comparative analysis of the different types of evaluation analysis.

	The Old Town	**Linköping SAMLIC**	**Norwich**	**London**	**Utrecht**
Goal achievement analysis	Achieved goals: -Established an UCC -Decreased the small deliveries -Improved the environment for inhabitants and people that are staying in the area Partly achieved goals: -Reduced the fuel consumption and emissions	Achieved goals: -Gaining experience from coordinated freight distribution -It was lucrative for the involved stakeholders Not achieved goals: -It has not been implemented an UCC almost 10 years after the trial	Achieved goals: -Established an UCC -Reduced the fuel consumption and emissions -Maximizing the payloads by using smaller vehicles Not achieved goals: -Reduce the number of HGV trips into Norwich	Achieved goals: -Established an UCC Evaluating the: -The driving distance in London -The energy use and greenhouse gas emissions	Achieved goals: -Decreased traffic in the inner city -New sustainable transportation with the Cargohopper and the Beer boat
Cause analysis	Not in favor: -The electric vehicle was destroyed in a fire -Long waiting time on the new biogas vehicle -Little flexibility from the City Council when it comes to permits and exemptions -Relatively few customers -The UCC cannot mix deliveries to shops and restaurants	Not in favor: -It was not a uniform system -Statistical issues in the data material -Use biogas as delivery vehicles instead -To have a more softer classification of the zones	In favor: -Change of vehicle delivery type from HGV 6A to HGV 2R Not in favor: -Few customers -No actual consolidation of goods in the UCC -Long time perspective of choosing logistic company -Participation is optional for the customers -No incentives or restrictions to use	In favor: -The type of businesses are suitable for electric tricycles (parcels instead of pallets) -Size and weight of parcels are often small -The delivery area has a high density of customers -The UCC is near the customers (Allen, Browne, & Leonardi, Cargocycle trial evaluation, 2010b)	In favor: -The municipality of Utrecht has an open scheme and distinctive requirements to form UCCs. -The Cargohopper receives no subsidy from the municipality -The municipality is the facilitator and the transport companies run the UCCs. -The Integrated Policy Package
Efficiency analysis	-More involvement from the City Council -More marketing campaigns	-No economic support from Vinnova -Difficult to organize the computer systems together -Certain logistic companies feared the brand would not have enough marketing space -Posten AB pulled out early from the project	-Have greater incentive to encourage the use of UCC to customers -Continue with publicity and promotion of UCC -Have more freight companies involved	-Not considered in the evaluation report	-Finding other types of markets that suits the UCC -Have other requirements like number of goods instead of number of addresses