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City Logistics for Sustainability

The Case of Stockholm

[Logistics και Αειφορία των πόλεων –
Η περίπτωση της Στοκχόλμης]

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Summary

Over the past decades, road freight transport has been constantly growing in volumes and in proportion to the other modes of transport. This has had grave impacts on the environment, especially regarding CO₂ emissions. Examining opportunities for taking measures in order to mitigate these impacts on urban level is a rather new concept, which emerged from the increased sensitivity of urban areas, due to the large number of people that live there and are exposed to these impacts. Green city logistics solutions are gaining importance as they focus, not only on mobility, but also to the other two 'neglected' sides of city logistics: sustainability and viability.

Stockholm is a city in the frontline of sustainability. The high sensitivity of the local government and the inhabitants is reflected in the many ambitious environmental targets that have been set, with most prominent the one to become a fossil-fuel free city by 2050. However, when it comes to freight transport, the situation is more or less on the control of private companies, with little public involvement, apart from a few notable exemptions. There are great possibilities for governmental action on the direction of sustainable urban freight transport, so that the other environmental targets can be achieved as well.

The main objective of this thesis is to present green logistics solutions as they have been or are planned to be implemented in Stockholm and to provide suggestions for future action, in accordance to the current European policy and based on experiences from other European cities. The aim is to identify and stimulate Stockholm's authorities' level of awareness on urban freight, since it is a common perception that strong governmental guidance and support can guarantee the success of most green logistics measures. Private freight transport actors can also find this thesis useful and adopt initiatives which can also be very beneficial.

Forward

This thesis is connected with some of the best memories in my life, memories from the time I spent as an exchange student in Stockholm. It would be risky to mention exactly how many those memories have been, because it might raise suspicion about the quality of this thesis, but in the end, I think it is actually a quite complete work (since I included plenty of Swedish literature, even though I do not speak Swedish) as well as an interesting one, for it is a vital subject that it is dealing with. A subject that is certain to draw more attention in the following years.

This thesis owes its existence to the inspiring guidance of both my supervising professors, Haris Koutsopoulos from the KTH and Athanasios Ballis from the NTUA. I am deeply grateful to both of them and I owe them all the knowledge I gained from my research. The choice of this subject has been in many ways ideal for me compared to other subjects.

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1. Introduction

1.1. Background

Freight transport is vital for the structure of modern societies and absolutely essential for preserving our modern way of life. It ensures the flow of goods from production points to distribution points, making them accessible to consumers. Freight transport is even more vital when it comes to cities, because cities, by definition, are places where none of the primarily essential goods is produced. On the contrary, cities present the highest demand in consumable goods, due to the large number of people that live there.

In fact, the cities' population has been increasing constantly over time, and in Europe it is expected to rise from 72% in 2006 to 84% of the total population in 2050. Therefore, considering the simultaneous increase of the global (and thus, the European) population, one can realise the increased significance of an efficient and effective freight transport system for the future societies.

The efficiency of freight transport lies on the function of **Logistics**. The term '*Logistics*' refers to the "*planning, organisation, management, execution and control of freight transport operations. It integrates individual transport acts to door-to-door supply chains*" (European Commission, 2010a). Logistics usually focuses on minimizing shipper costs, with little consideration of social costs such as congestion or pollution impacts. Taniguchi et al (2001) defined 'City logistics' as "*the process for totally optimizing the logistics and transport activities by private companies with support of advanced information systems in urban areas considering the traffic environment, the traffic congestion and energy consumption, the traffic safety and the energy savings within the framework of a market economy*".

However, the continuous growth of freight transport (and especially the road mode) aggravates its significant negative impacts on society and the environment. In cities, millions of people live and work in close vicinity with the road network, being largely exposed to the effects of road traffic. The growth of logistics activities implies an increase of their many negative effects. The U.K. Round Table on Sustainable Development has summarized these negative effects in **Table 1**.

Transport currently depends by 97% on fossil fuels. Unfortunately, diesel combustion products can cause significant negative impacts on regional level. Gaseous components of diesel exhaust include carbon dioxide (CO₂), oxygen (O₂), water vapor, nitrogen (N₂), carbon monoxide (CO), nitrogen compounds, sulfur compounds and low-molecular-weight hydrocarbons. Particulate matter (PM) released includes a

central core of elemental carbon, absorbed organic compounds, as well as small amounts of sulfate, nitrate, metals and other trace elements (Sathaye et al, 2006).

Nitrogen oxides (NO_x) and particulate matter (PM) tend to be the greatest concern, as they are related to a number of health-effects, such as irritation, neurophysiologic dysfunction, respiratory problems and even lung cancer. The combination of NO_x with volatile organic compounds (VOC) and sunlight can cause the formation of photochemical smog, which affects the air quality of many urban areas. In addition nitric acid (HNO₃) can cause paint deterioration, corrosion, degradation of buildings, and damage to agricultural crops.

CO₂ is a greenhouse gas (GHG) which has been found responsible for climate change. Global climate change is expected to severely affect the hydrological cycle, increase average temperatures, accelerate the melting of the ice in arctic areas and raise the sea level, literally changing the face of the earth. Road transport (passenger and freight) is a major contributor of CO₂ emissions (16.3% of the total CO₂ emissions in Europe in 2006). **Especially in cities, urban freight transport accounts for 21% of the CO₂ emissions, while transiting heavy goods vehicles add another 10% of the CO₂ emissions (European Commission, 2007b).**

Older heavy goods vehicles fitted with air conditioners and refrigerators may also release chloro-fluorocarbons (CFCs), which cause stratospheric O₃ depletion, thus increasing the amount of harmful ultra-violet radiation penetrating the earth's atmosphere.

Economic Impacts	<ol style="list-style-type: none"> 1. Traffic Congestion 2. Resource Waste
Ecological Impacts	<ol style="list-style-type: none"> 1. Greenhouse Gases cause Climate Change 2. The use of non-renewable fossil fuel 3. The effects of waste products such as tires and oil 4. Ecosystem destruction and species extinction
Social Impacts	<ol style="list-style-type: none"> 1. Negative Public Health Impacts of Pollution 2. Crop Destruction 3. Injuries and deaths resulting from traffic accidents 4. Noise 5. Visual intrusion 6. Congestion deterring passenger travel 7. Loss of Greenfield sites and open spaces 8. Deterioration of buildings/infrastructure

Table 1: Impacts of logistics systems (UK Roundtable on Sustainable Development, 1996)

Since the early 1990s, there has been growing interest in reducing the negative impacts of logistics and making them “greener”. However, Rodrigue et al. (2001) showed that there are basic inconsistencies between the goals and objectives of logistics and “greenness”. The cost-saving strategies followed by logistics operators are often at variance with the environment since they usually externalize the environmental costs. This means that the benefits of logistics are realised by the users, but the environment assumes a wide variety of burdens and costs. Furthermore, logistical activities do not usually pay the full costs of using the infrastructures. As a result, logistical operators use the most polluting, least energy efficient and most infrastructure-intensive transportation modes to increase the speed of distribution.

Table 2 summarizes the major characteristics of these conflicts. The “Outcomes” column lists the positive effects on the logistics companies and the “Paradox” column the negative effects on society.

Dimension	Outcome	Paradox
Costs	Reduction of costs through improvement in packaging and reduction of wastes. Benefits are derived by the distributors.	Environmental costs are often externalized.
Time/Flexibility	Integrated supply chains. JIT and DTD provide flexible and efficient physical distribution systems.	Extended production, distribution and retailing structures consuming more space, more energy, and producing more emissions.
Network	Increasing system-wide efficiency of the distribution system through network changes (Hub-and-spoke structure).	Concentration of environmental impacts next to major hubs and along corridors. Pressure on local communities.
Reliability	Reliable and on-time distribution of freight and passengers.	Modes used, trucking and air transportation are the least environmentally efficient.
Warehousing	Reducing the needs for private warehousing facilities.	Inventory shifted in part to public roads (or in containers), contributing to congestion and space consumption.
E-commerce	Increased business opportunities and diversification of the supply chains.	Changes in physical distribution systems towards higher levels of energy consumption.

Table 2: Paradoxes of Green Logistics (Rodrigue et al, 2001)

Rodrigue et al (2001) also refer to reverse logistics, as this field was the first trend to “greenness” beginning in the early 1990s. They observe that this trend was mainly

developed as a marketing opportunity and only when there were notable financial benefits for the companies involved. They even go one step further to argue that reverse logistics might even be adding further to the traffic load.

However, many countries have been urged to take measures and implement green logistics solutions which faced the problem at various levels. The European Commission also included freight transport in its Action Plans and Papers and promoted best practices through innovative projects, funded by four Framework Programmes (FP4, FP5, FP6 and FP7). The European Commission advises authorities to create the appropriate framework conditions and to keep logistics on the political agenda. Moreover, it is increasingly perceived that, although individual green logistics solutions can be very beneficial, an integrated plan resulting in a package of measures, is the recommended way to deal with such a complex issue. European cities are just starting to elaborate freight transport plans in this way, focusing not only in mobility, but also in sustainability and livability.

However, on city level, there is the following difficulty: *“cities are often too small for freight transport planning, since freight transport in one city area is only a part of a supply chain that includes line haul transport between cities or even between countries. Therefore, urban freight transport planning in a city should be harmonised with other adjacent cities (...) Such an institutional framework in a wider area for urban freight transport planning is essential for sustainable development of urban areas”* (Taniguchi et al, 2003).

1.2. Freight transport in Stockholm

Stockholm has set the ambitious goal of becoming a fossil-fuel free city by 2050. CO₂ emissions per capita have already been reduced by 25% compared to the levels of 1990. But the city has to face the same growth in freight transport demand as every European city. Åkerman and Höjer (2006) showed that if the current transport and technology trends do not change, the estimated energy use per capita will be twice as high as the target levels for 2050. The goal can only be achieved by an integrated and complete policy for freight transport, which still does not exist. However, some important steps have been made in recent years, providing knowledge and experience from different areas of freight transport, as well as improving relations and communication between stakeholders.

Stockholm has been leading the way on the field of clean vehicles since 1994. It was also one of the first cities in the world (together with two other Swedish cities) to introduce an environmental zone for heavy goods vehicles in 1996. This had a great impact on the quality of the trucks that drive in the city today, which reflects on the emissions of pollutants. Furthermore, the Congestion Charging System, which was

tested in 2006 and implemented permanently in 2007, has successfully reduced traffic congestion levels by 18%. Road pricing can be an effective tool to manage urban freight traffic, but the City has not expressed interest in this direction so far.

The city's participation in some important European programmes provided experience, cooperation with other cities, funds for innovative logistics solutions and also, enhanced the city's reputation of being truly environmentally sensitive.

However, to what freight transport is concerned, Stockholm lacks public initiatives that will promote best practices in the future and is characterized by liberalization of the freight transport sector. Private companies may be improving their environmental profile, but this is done mainly for marketing reasons, usually when it is related to some profit. On the public side, there are many authorities involved, and often serious communication problems appear. Moreover, there is significant lack of freight traffic data.

1.3. Objectives

The main objective of this thesis is to present green logistics solutions as they have been or are planned to be implemented in Stockholm and to provide suggestions for future directions, in accordance to the current European policy and based on experiences from other European cities. The aim is to identify and stimulate Stockholm's authorities' level of awareness on urban freight, since it is a common perception that strong governmental guidance and support can guarantee the success of most green logistics measures.

1.4. Structure of the thesis

The first step of this research (**Chapter 2.1**) was to review the current European policy on city logistics, as it has been formed during the past 10 years. As the demand for freight transport continued growing, accompanied by its various negative impacts, particularly in the sensitive urban areas, an increasing number of Papers and Communications from the European Commission have been including the urban scale of logistics into their fields of interest and action. At the same time, several projects were funded in order to promote best practices and the exchange of information between European cities, creating an expanding network of actors willing to participate in further developments and increasing awareness among city authorities. The most prominent of these projects are listed here, beginning with the most significant and recent ones.

Secondly (**Chapter 3**), this research addressed a number of interesting green city logistics solutions, as they emerge from existing literature and the various European projects which tested them. The intention was not to include all the possible measures, but to cover a wide range of action fields, namely: distribution strategies, administrative solutions, schedule management solutions, pricing strategies and technological solutions. Specific examples were provided for each of these fields, from successful (or even unsuccessful) implementations in European cities. Literature and website references are also provided for further information.

The next step (**Chapter 4**) focused on the city of Stockholm. Based on literature and web research, but also on personal interviews with people from the City of Stockholm and Sustainable Innovation (SUST), five different green logistics schemes were selected and presented here, ranging from 1996 to the present (including one study for a future scheme). They are classified by the size of the area involved into two categories: (a) strategies on city-level and (b) strategies on district-level. The first category includes two measures whose driving forces have been public initiatives: the Environmental Zone and the Congestion Charging System. The second category reviews the cases of logistic centres serving three different districts of Stockholm (Hammarby Sjöstad, Gamla Stan and Norra Djurgården), with different levels of public actor's involvement.

For each of the above cases, there is a general description, followed by details of its impact on road traffic (and particularly on commercial traffic), a discussion on economic aspects and a review of its estimated environmental impacts. Finally, each case study provides conclusions concerning the city authorities' interest and participation and other issues related to the rest of the freight transport actors.

Chapter 5 sums up the conclusions drawn from this research. There is an evaluation of the authorities' attitude concerning logistics and a comparison to the EU policy on urban freight transport, but also to the environmental targets set by the City of Stockholm. Some other interesting points for discussion that were yielded during this research are also presented here.

Finally, the recommendations for further action are presented in **Chapter 6**, based on the conclusions presented on the previous chapter, in accordance to the green logistics solutions discussed in Chapter 4 and the EU policy as presented in Chapter 3. A specific section is dedicated to Logistics Centres, due to the multiple benefits related to this measure.

This research did not include interviews with private companies that operate in the Stockholm area. This is an important field that can fill some of the existing knowledge gaps. Another issue that needs further investigation is the Swedish legislation and the implications it might cause to the implementation of various measures. One

barrier for the author has been the Swedish language. Finally, the fertile field of reverse logistics provides wide opportunities for applications and research, but has also been left out of this thesis. All the above fields are recommendable for further research.

All the statistics and charts presented in this thesis have been found in official documents (which are always mentioned) and are considered as reliable by the author. The author cannot be held responsible for possible inaccuracies that might be related to these statistics.

2. Literature Review

This thesis is based mainly on literature research from a variety of sources. The first step included extended research for scientific articles in databases such as Inspec and Compendex. A number of urban freight transport related terms were used, both Thesaurus and non-Thesaurus ones. Secondly, there was an extended research in the websites of various European projects and Freight Transport related pages. Thirdly, personal interviews were held with people from the City of Stockholm, Sustainable Innovation, Home2You and KTH.

An important research institute for city logistics has been created by Taniguchi and Thomson (Institute of City Logistics, 2010), with important contribution in literature, mainly by publishing the Proceedings of the several “International Conferences on City Logistics” (e.g. Taniguchi et al, 2003). Those publications cover various aspects of the subject, including modelling tools, logistics systems planning tools, route planning tools, organisational and administrative issues etc. The authors pointed out the three pillars that should run through city logistics activities: mobility, sustainability and viability. Another important contribution is also the widely acknowledged definition of city logistics that the authors provided (Taniguchi et al, 2001).

Most of the European Commission’s papers and communications can be found on the official website for Transport (European Commission, 2010b), as well as other information material, such as leaflets and brochures. Details about policy issues can be found at Europa (2010).

The website of BESTUFS (2010) is a great source of material related to Best Practices on city logistics in Europe. It includes references to a wide list of city logistics projects, presentations from the numerous Workshops, Conferences and Roundtables, and, above all, the updated Best Practice Handbooks for the most important fields like Freight Platforms, Road Pricing, ITS, Public Private Partnerships, etc. The “Good Practice Guide on Urban Freight Transport” (Allen et al, 2007) has also been a very useful guide for the author.

The website of the Civitas project (Civitas, 2010) is of similar significance with the above, presenting a great variety of case studies from 61 European cities that participated in 13 Civitas projects from 2002 to 2012. The various Project Reports contain valuable information for every city and measure, like for example the Trendsetter Evaluation report for the city of Stockholm (Civitas Trendsetter, 2006b).

The “Policy Notes” of the NICHES project have also been used by the author (NICHES, 2007a, 2007b), while a series of useful documents can be found at the City Transport

and Logistics Network of the Øresund Ecomobility Centre (Oresund, 2010) and at the British website “Freight Best Practice” (Freight Best Practice, 2010).

Another source for case studies that was proved to be useful is the review of Geronimis and Daganzo (2005). Russo and Comi (2010) provide an interesting way of classification of city logistics measures and their impacts. Rodrigue et al (2001) presents the “Paradoxes of Green Logistics” in a comprehensive way, while contains some useful issues for consideration. Sathaye et al (2006) provides a thorough evaluation of the “externalities” of city logistics.

Many studies and reports about logistics in Stockholm have been published by the former Swedish Road Administration (Vägverket, 2008, 2009), Transek AB (2006a, 2006b), Trafikkontoret (2008, 2010), Miljömiljarden (2006), City of Stockholm (2003). Reports concerning freight statistics in Stockholm have been issued by Trafikanalys (2010a, 2010b) and SIK Statistisk (2005, 2009).

More information on recommended literature can be found in the relative sections of the book. Very valuable contributions to the author’s sources have been made by Björn Hugosson, Jan Kristoffersson, Jonas Eliasson and Erik Freudenthal.

2.1. European Union Policy on Green City Logistics

2.1.1. Papers and communications

European transport policy has been characterized by liberalization and harmonization over the years. There has been a growing number of communications and papers issued by the European Commission on the subject of urban mobility, as the negative effects of urban transport and logistics become more and more evident.

The subsidiarity principle does not allow the European Union to use regulation as a means of imposing measures and solutions on towns and cities. The responsibility for urban transport lies mainly with the national and local authorities, confining the Commission to taking initiatives to encourage the use of diversified energy in transport, including regulatory initiatives, and to promote good practice. However, cooperation at EU level can help urban authorities in making their transport systems more sustainable. There is a range of activities and fields where the EU can set examples and continue to promote and support demonstration projects and the exchange of best practices. Moreover, the EU can provide a framework in which it will be easier for local authorities to take measures.

From a slow start, the European Union's transport policy has developed rapidly over the past 20 years. The objectives of the European transport policy, from the transport White Paper of 1992 via the White Paper of 2001 and in anticipation of the White Paper of 2010, consist in helping provide Europeans with efficient, effective transportation systems that:

- Offer a high level of mobility to people and business throughout the Union. The availability of affordable and high quality transport solutions contributes vitally to achieving the free flow of people, goods and services, to improving social and economic cohesion, and to ensuring the competitiveness of European industry.
- Protect the environment, ensure energy security, promote minimum labour standards for the sector and protect the passenger and the citizen.
- Innovate in support of the first two aims of mobility and protection by increasing the efficiency and sustainability of the growing transport sector. EU policies develop and bring to market innovative solutions that are energy efficient or use alternative energy sources or support large intelligent transport projects such as Galileo.
- Connect internationally, projecting the Union's policies to reinforce sustainable mobility, protection and innovation, by participating in the international organizations. It is aimed that the role of the EU as a world leader in sustainable transport solutions, industries, equipment and services, shall be even better recognized.

The 2001 White Paper identified as main challenges the imbalance in the development of the different transport modes, congestion on routes and cities, as well as in airspace, and the impact on the environment. The White Paper proposed policies to eliminate bottlenecks in the trans-European networks (TEN) and to reduce the number of road accidents. It called for an effective policy on infrastructure charging and it argued that the Community should strengthen its position in international organizations. It should be noticed that the White Paper expected a strong economic growth which was never materialized though.

The White Paper highlighted three main measures related to urban transport (European Commission, 2001):

- Support for pioneering towns and cities, with each Member State remaining responsible for coming up with national plans;
- Increased use of clean vehicles and of forms of public transport accessible to all users including people with reduced mobility;
- Identification and dissemination of best urban transport system practices, including urban and regional rail services, and best practice in management of the relevant infrastructure.

The market introduction of alternative motor fuels was also supported, with proposed measures such as favorable tax treatment for the use of bio-fuels, natural gas and hydrogen.

In 2006 there was a mid-term review of the White Paper, redirecting its objectives according to the contemporary evolutions in global transport. Concerning transport logistics, the review reports that “industry has taken up the challenge of using existing infrastructure and vehicles more efficiently by developing sophisticated logistics chains. Advanced information and communication technologies enable their implementation and deliver the services needed to make intelligent logistics a reality. The trend towards integrated logistics companies needs to be matched by public policies enabling the optimal use and combination (“co-modality”) of different modes of transport. This may include action to remove regulatory obstacles to co-modality, to stimulate learning and the exchange of best practices throughout the EU, to promote standardization and interoperability across modes and to invest in transshipment hubs. Adapting dimensions of containers and vehicles to meet the needs of intelligent logistics will be part of these considerations” (European Commission, 2006a). The action proposed was to develop a framework strategy for freight transport logistics in Europe, followed by broad consultation and leading to an action plan.

The mid-term review was followed by a Communication of the Commission under the title “Freight Transport Logistics in Europe - the key to sustainable mobility” (European Commission, 2006b), which recognized the need for optimization by means of advanced logistics solutions. The Communication was followed by extensive consultations with stakeholders and led to the “Freight Transport Logistics Action Plan” of 2007 (European Commission, 2007a).

The Action Plan paid separate attention to urban freight transport logistics and identified factors as land use planning, environmental considerations and traffic management to be the most significant. Three separate measures were proposed, concerning urban freight transport:

- The issue of an Urban Transport Action Plan to encourage the exchange of experiences on urban areas to establish a set of recommendations, best practice, indicators or standards for urban transport logistics, including freight deliveries and delivery vehicles. The deadline was set for 2008.
- The reinforcement of the freight part of CIVITAS towards better co-ordination or integration between passenger and freight transport, between interurban (long-distance) and urban transport logistics. The option of an integrated “CIVITAS Freight” was viewed. The deadline was set for 2010.
- To make recommendations of commonly agreed benchmarks or performance indicators to measure efficiency and sustainability of delivery and terminals

and, more generally, in urban transport logistics and planning. The deadline was set by 2011.

In September 2007 the Commission issued the Green Paper “Towards a new culture for urban mobility” (European Commission, 2007b). Among others, there was mentioned that any urban mobility policy must cover both passenger and freight transport. Efficient interfaces between long-haul transport and short distance distribution to the final destination are required. Planning and technical measures are recognized as the main instruments for reducing the negative impacts of long distance freight transport passing through urban areas.

The Paper pointed out that urban freight distribution could be better integrated within local policy-making and institutional settings. While public passenger transport is usually supervised by the competent administrative body, freight transport distribution is normally a task for the private sector. It is necessary for local authorities to consider all urban logistics related to passenger and freight transport together, as a single logistics system.

The “Action Plan on Urban Mobility” came out on September 2009, following the consultations of stakeholders after the above Green Paper (European Commission, 2009b). Action 19 focuses on urban freight transport and consists on optimizing urban logistics efficiency by improving the links between long-distance, inter-urban and urban freight transport, aiming to ensure efficient ‘last mile’ delivery. The intention is to focus on how to better incorporate freight transport in local policies and plans and how to better manage and monitor transport flows.

The recent communication ‘A sustainable future for transport’ identifies policy options to be tested and eventually included in the next White Paper of 2010 (European Commission, 2009a). Among other policy objectives, the communication considers the improved exploitation of the transport network’s capacity and of each mode as a tool to reduce congestion, emissions, pollution and accidents. This requires the optimization and operation of the network as a single entity, whereas currently modal networks are largely separated. Even within modes there is lack of integration between countries. Particularly concerning freight transport, the goal is the realization of an intelligent and integrated logistics system, where development of ports and intermodal terminals is a key element.

Currently, the target of the European Commission is to reduce total Greenhouse Gas (GHG) emissions in the EU by 20% with respect to 1990. Transport has a key role to play in achieving this goal and an inversion of some of the current trends will be necessary. A binding target of 10% share of renewable energy sources in transport by 2020 has been adopted recently as part of the Climate and Energy package. A conference on urban freight transport and logistics is also planned for November 2010.

2.1.2. Incentives and initiatives

As mentioned above, apart from regulatory initiatives, the European Commission is aiming to promote good practice in city logistics. Three Framework Programmes (FP5, FP6 and FP7) have been the funding base for a large number of projects concerning the wider area of urban freight transport.

Within the key Action “Sustainable Mobility and Intermodality” the European Commission established the thematic network on **BEST Urban Freight Solutions (BESTUFS)** in January 2000 with a 4-year-duration (BESTUFS I). The initiative wanted to make a collection of all initiatives and projects already existing and all their results in Europe rather than starting new research activities. The initiative was followed by another 4-year thematic network (BESTUFS II) which aimed to maintain and expand an open European network between urban freight transport experts, user groups/associations, ongoing projects, the relevant European Commission Directorates and representatives of national, regional and local transport administrations and transport operators.

The main objectives of BESTUFS were (Egger & Ruesch, 2003):

- *To create a permanent and dynamic concentration activity during the period of the 5th Framework Programme (BESTUFS I) and the 6th Framework Programme (BESTUFS II);*
- *To identify and structure the various themes which build the urban freight solutions (UFS) domain and which have relations and influence to it;*
- *To present projects and best practices;*
- *To support the clustering of projects on European level and to integrate projects and clusters into the network;*
- *To collect, compare and summarize available experiences and results of projects and initiatives in the UFS domain mainly for Europe but also if easily obtainable – for the USA and other countries;*
- *To identify and describe best practices and success criteria within the UFS domain;*
- *To disseminate experiences, project relations, best practices and success criteria to a broad public of interested actors, thereby aiming at the transferability of solutions;*
- *To establish links and co-operations with relevant other thematic networks (treating different themes) on European level in order to share and integrate the results (regarding overlapping themes) and to avoid duplication of work;*
- *To establish links and co-operations with national thematic networks (treating the UFS domain) in order to share and integrate results;*

- *To support the co-operation between actors in the UFS domain by providing information and by providing contacts.*

The second edition of BESTUFS began in 2004 and ended in 2008. It increased broad geographic coverage and dissemination of guides about best practices in different languages, quantified urban freight solutions to EU policy objectives and reviewed existing urban freight transport models and data structures. From BESTUFS I it emerged that it is necessary to have tools for the design, assessment and control of urban freight transport systems, thus simulating with the use of models what the system state will be once the new scheme/practice is adopted (BESTUFS, 2010).

The **CIVITAS Initiative** (City VITAlity Sustainability) supports cities in introducing and testing bold and innovative measures to radically improve urban passenger and freight transport. CIVITAS I started in early 2002 (within the 5th Framework Research Programme – FP5) and was followed by CIVITAS II (FP6) and CIVITAS PLUS (FP7).

CIVITAS objectives are:

- *To promote and implement sustainable, clean and (energy) efficient urban transport measures;*
- *To implement integrated packages of technology and policy measures in the field of energy and transport in 8 categories of measures;*
- *To build up critical mass and markets for innovation.*

Within CIVITAS I (2002-2006) 19 cities were clustered in 4 demonstration projects, within CIVITAS II (2005-2009) 17 cities participated in 4 demonstration projects, whilst within CIVITAS PLUS (2008-2012) 25 cities took part in 5 demonstration projects. These demonstration cities all over Europe are funded by the European Commission.

A wide variety of measures has been applied, concerning both passenger and freight transport, in 61 cities all over Europe. Some of them have shown great sensitivity towards the implementation of ‘green’ measures on freight transport, while others have been much slower. Stockholm participated in the TRENDSETTER project of CIVITAS I and had the opportunity to implement green logistics schemes, such as the logistics centres in Hammarby Sjöstad and Gamla Stan. TRENDSETTER in Stockholm is presented in section 4.1 of this thesis. (Civitas, 2010)

The **SUGAR initiative** (Sustainable Urban Goods logistics Achieved by Regional and local policies) promotes the exchange, discussion and transfer of policy experiences, knowledge and good practices in the field of urban freight management, since 2009. The SUGAR approach is structured along three main strands (SUGAR, 2010):

- The refinement of policies of 4 Good Practice Sites through dialogue with other leading administration outside the project partnership.
- The development of policies in 7 Transfer Sites, supported by the development of good practice analysis thematic training, joint planning for transfer sites and the development of local transfer action plans.
- The creation of interest, knowledge, tools and exchange for new administrations from outside the SUGAR partnership through the Enlarged Transfer Programme.

Another important project that focused on urban freight transport was the **START project** (Short Term Actions to Reorganize Transport of Goods). Five European cities (Göteborg, Bristol, Ljubljana, Ravenna and Riga) joined forces to develop and implement sustainable city logistics and urban freight solutions. The START project started in February 2006 and ended in January 2009 and was funded through the Intelligent Energy Europe (STEER) programme. The START approach was based on local freight networks which established a close collaboration between the city government, transport companies and local businesses (START, 2010).

FREILOT is a pilot implemented in four European cities aiming to increase energy efficiency in road goods transport, to widely disseminate and share the pilot results with all stakeholders and to increase the involvement of fleet operators, cities and other stakeholders in the scheme. The FREILOT project will experiment with the following services:

- Energy efficient intersection control (by providing priority to trucks at intersections)
- Adaptive speed and acceleration controls
- Eco-driving support
- Real-time loading/delivery space booking

It started in April 2009 and will last for 2,5 years (FREILOT, 2010).

FIDEUS (Freight Innovative Delivery in European Urban Spaces) is a project aiming to provide a complementary set of vehicle solutions to support an innovative approach to the organization of urban freight transport, in line with political strategies to safeguard the livability of cities, while being compatible with efficient logistics. In the project participated 13 companies from 6 countries, from May 2005 to April 2008 (European Commission, 2010c, and Videolectures.net, 2010)

The **NICHES project** (2004-2007) promoted innovation in urban transport in 4 research areas, among which were “Innovative approaches in city logistics”. These approaches included:

- Space Management for Urban Delivery

- Inner-city Night Delivery
- Alternative Solutions for Home Delivery

Good quality dissemination material and policy notes were produced by the project. The project has been succeeded by **NICHES+** (2008-2011), financed by the 7th Framework Programme, which promotes further sustainable and efficient urban transport solutions. (NICHES+, 2010)

CITY PORTS (2003-2005) is a transnational co-operation project devoted to the topics of the urban goods distribution, which has been developed within the framework and under the financial assistance of the INTERREG IIIB CADSES Community Programme. Under the leadership of Regione Emilia-Romagna in Italy, the project actions have been developed by a transnational consortium joining public administrations, public utilities and consulting companies in four countries (Italy, Austria, Slovenia and Greece). CITY PORTS' overall objective is to promote concrete interventions in urban logistics for some European cities in order to reorganize their urban systems (CITY PORTS, 2005).

e-DRUL (e-Commerce Enabled, Demand Responsive Urban Logistics) was a research and innovation project in the field of e-logistics that lasted from April 2002 till October 2004. It investigated, developed and validated an innovative e-logistics platform, and supported service models, for improved management of freight distribution processes in four urban areas: Siena, Lisbon, Eindhoven and Aalborg (e-DRUL, 2010).

COST 346 (2000-2004) aimed to develop an improved methodology for estimating pollutant emissions and fuel consumption from commercial road transport operated with Heavy Duty Vehicles in Europe. It concentrated on improving the amount and quality of basic data on emissions and transport activity, as well as validating and improving existing models. (Europa, 2010a)

Project REFORM (1997) analysed and evaluated the effects of freight platforms regarding the urban traffic and provided guidelines and criteria for designing, locating and organising freight platforms in urban areas with the view of optimizing their benefits and reducing their negative effects. (Europa, 2010b)

COST 321 (1994-1998) studied the design and operation of innovative measures to improve the environmental performance of freight transport in urban areas. The project analysed how the air pollution, noise and energy consumption are reduced by optimizing the use of trucks in the city traffic through the application of modern logistical devices and appropriate administrative measures. (Europa, 2010c)

3. City Logistics Solutions from European cities

3.1. Introduction

The BESTUFS Initiative (see section 3.2) attempted to develop a common framework for best urban freight solutions, considering as many as possible relevant aspects which might have an impact on urban freight transport. The term '*Best Practice Solutions*' has been used to identify different 'types' of actions, research and activities which might affect urban freight transport directly or indirectly. The BESTUFS Best Practice Handbooks give the following definition of *Best Practices*:

"Best Practices are planned or implemented private only, public only or Public Private Partnership (PPP) strategies, measures or activities which have an essential contribution to urban goods transport and ideally lead to benefits for all actors involved. Best Practices will be identified on the fulfillment degree regarding the following requirements:

1. Best Practices have to fit to a defined theme or address a relevant problem with respect to the movement of goods in urban areas.
2. Best Practices should be based on real experiences (real world implementations, pilot projects) or analysis in studies.
3. Best Practices should have considerable and measurable positive effects (qualitative, quantitative) or relevant indicators of urban goods transport.
4. In some cases it can also be important to take project activities into account which have not been successful. We can also learn from bad experiences and improve solutions by describing and analyzing failure factors" (Ruesch & Patz, 2008).

A classification of solutions (measures) that concern city logistics and their possible results has been proposed by Russo and Comi (2010). The proposed classification is the following:

- Measures related to **material infrastructure**:
 - Linear measures (referring to the links of the urban transport network);
 - Surface measures (referring to areas reserved for freight operations);
- Measures related to **immaterial infrastructure** (telematics) or Intelligent Transport Systems (e.g. systems for traffic information, freight capacity exchange systems, route optimization services, vehicle maintenance management systems, other information services, and centralized route planning);
- Measures related to **equipment**, including measures on:
 - Loading units;

- Transport units (e.g. use of alternative fuel vehicles, rail and trams);
- Measures related to **governance of the traffic network** (e.g. access regulations, road pricing etc.).

The BESTUFS Good Practice Guide presents a number of available approaches in relation to the aimed objectives and they are shown in the following table:

Objectives	Approaches available
Gaining freight industry support for freight strategies and initiatives	<ul style="list-style-type: none"> • Freight transport partnerships
Improving journey time reliability of goods vehicles	<ul style="list-style-type: none"> • Telematics for urban goods transport • Signing • Urban freight information and maps • Road pricing • Allowing night deliveries • Lorry lanes or no car lanes
Assisting the journey of goods vehicle drivers and reducing goods vehicle trips and kilometres	<ul style="list-style-type: none"> • Telematics for urban goods transport • Signing • Lorry routes • Simplification & harmonization of vehicle weight, size and construction regulations • Urban freight information and maps • Urban consolidation centres
Assisting freight transport companies at the point of delivering and collection	<ul style="list-style-type: none"> • Providing on-street loading bays • Nearby Delivery Area (ELP) • Urban consolidation centres
Reducing environmental impacts and the risk of accidents involving goods vehicles	<ul style="list-style-type: none"> • Vehicle weight, size and emissions standards regulations • Time regulations for goods vehicle access and loading • Allowing night deliveries • Environmental zones • Lorry lanes • Infrastructure improvements • Encourage use of environmentally-friendly vehicles • Enforcement

Table 3: Objectives and approaches for urban freight transport (Allen et al, 2007)

The fields presented in this thesis have been selected by the following criteria:

- They are commonly accepted as effective (under certain conditions)
- They are widely tested and recommended by a number of sources
- They cover a wide range of action fields and levels (see **Table** below)
- There is great availability of relevant literature

The green logistics solutions presented below can be classified to the following action fields:

Action Field	Measure
Distribution strategies	<i>Freight Platforms – Urban Consolidation Centres (UCCs)</i> Examples: <ul style="list-style-type: none"> – London Construction Consolidation Centre – City Logistik in Kassel
Institutional solutions	<i>Public Private Partnerships</i> Examples: <ul style="list-style-type: none"> – Freight Quality Partnerships in the UK – Nearby Delivery Area (ELP) in Bordeaux
Schedule management solutions	<i>Night Deliveries</i> Examples: <ul style="list-style-type: none"> – Night-time deliveries in Barcelona – The PIEK Project in the Netherlands
Pricing Strategies	<i>Road Pricing Systems</i> Examples: <ul style="list-style-type: none"> – Congestion Charging in London
Technological solutions	<i>Technological Solutions</i> Examples: <ul style="list-style-type: none"> – Intelligent Transport Systems (ITS) – Environmentally-Friendly Vehicles (EFV)

Table 4: Classification of Measures in Action Fields used in this thesis (by author)

It is beyond the purposes of this work to make a complete record of all possible measures that have been used to reduce the negative impacts of urban freight transport. However the following examples are interesting and can be seen as an introduction to the broader subject of Green City Logistics, rather than a thorough analysis. The cities that are mentioned are not the only ones that have implemented these measures of course, but they were chosen on the basis of the success of the implementation and the availability of related data. A failed project ('City Logistik in Kassel', see 4.5.2) has also been presented as an additional source of knowledge that can be derived from bad experiences.

3.2. Freight Platforms – Urban Consolidation Centres (UCCs)

3.2.1 Solution Description

Freight platforms were developed to reduce urban freight traffic and to shift long distance freight traffic from road to rail. The first freight centres in Europe were established in Paris in the mid 1960s in response to urban congestion. Many countries followed and Italy was the first to include the development of freight centres in their national policy, in 1990, followed by Germany in 1992 and France in 1993. Today, this trend has slowed down after the inability of a number of projects “to fulfill their optimistic expectations” (Karrer & Ruesch, 2007). However it is beyond doubt that urban consolidation and distribution centres can be very effective when planned appropriately and realistically.

Freight platforms can be found in a great variety of forms and names, because they don’t obey the rule: ‘one size fits all’. Instead every different freight platform is intended to cover the needs of a different area with different stakeholders and aims. Therefore, there are many different names that refer to similar but not identical kinds of centres. The boundaries between them are not clear (Allen et al, 2008):

- Freight platform
- Urban consolidation centre
- Public distribution depot
- Central goods sorting point
- Urban transshipment centre
- Shared-user urban transshipment depot
- Co-operative delivery system
- Specific consolidation centre (e.g. retail, construction)
- Urban distribution centre
- City logistics (or logistik) scheme
- Logistics centre
- Pick-up/drop-off location
- Freight village

The REFORM (see p.25) definition for freight platforms describes them as “areas in which different transport related companies such as forwarders, logistic service providers etc. are established. They are transshipment areas where, ideally, at least two transport modes are connected (usually road and rail, but also waterborne and air)” (Karrer & Ruesch, 2007).

A term more dedicated to urban freight is an *Urban Consolidation Centre (UCC)*. The BESTUFS definition describes it as “a logistics facility situated in relatively close proximity to the geographical area that it serves (be that a city centre, an entire town or a specific site such as a shopping centre), to which many logistics companies deliver goods destined for the area, from which consolidated deliveries are carried out within that area, in which a range of other value-added logistics and retail services can be provided” (Allen et al, 2008).

Logistics companies with deliveries scheduled for the urban area or site are able to transfer their loads at the UCC and thereby avoid entering the congested area. The UCC operator sorts and consolidates the loads from a number of logistics companies and delivers them, sometimes using environmentally friendly vehicles, to an agreed delivery pattern.

A classification of UCCs can be as follows:

- Area UCCs – serving a town/city (e.g. German city logistics schemes, La Rochelle in France, etc).
- UCCs on single sites with one landlord (e.g. airports or shopping centres).
- Special project UCCs (e.g. construction material UCCs)

Further classification may concern: company structure, spatial orientation (urban, regional, national, international), transport modes and access, Institutional solution (private or Public Private Partnership), main aims. The following **Figure** shows two examples of different company structure.

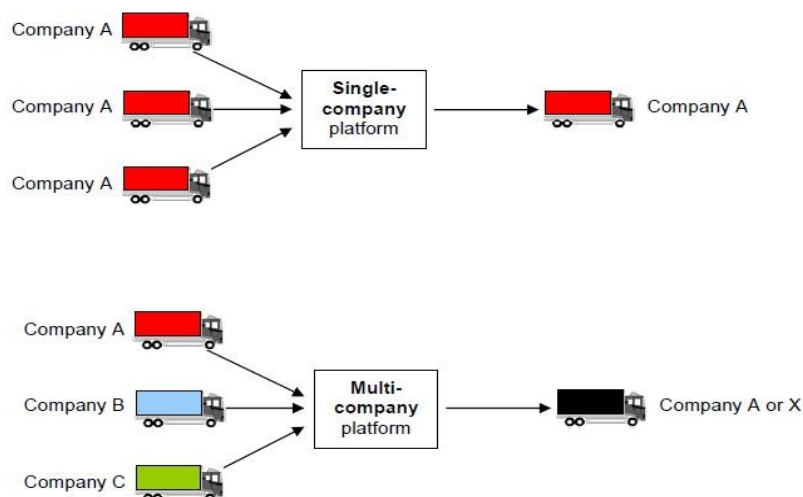


Figure 1: Single-company and multi-company platform (Karrer & Ruesch, 2007)

The UCCs are a solution that has been widely tried and applied all over Europe, because it can offer a number of advantages (Huschebeck & Allen, 2005):

- environmental and social benefits resulting from more efficient and less intrusive transport operations within urban areas
- better planning and implementation of logistics operation, opportunity to introduce new information systems at the same time as consolidation centre
- better inventory control, product availability and customer service
- can facilitate a switch from push to pull logistics through better control and visibility of the supply chain
- potential to link in with wider policy and regulatory initiatives
- theoretical cost benefits from contracting out “last mile”
- public relations benefits for participants
- potential to allow better use of resources at delivery locations
- specific transport advantages
- opportunity for carrying out value-added activities

However, not all these advantages appear in every UCC. In fact there are a number of disadvantages linked to their implementation (Huschebeck & Allen, 2005):

- potentially high set up costs (and sometimes high operating costs)
- much urban freight is already consolidated at the intra-company level or by parcels carriers, so limited benefits (or even negative consequences) for trying to channel these flows through a consolidation centre. The potential scope for UCCs may therefore be limited
- difficult for a single centre to be able to handle the wide variety of goods moving in and out of an urban area, for example due to different handling and storage requirements
- most studies report an increase in delivery costs due to an additional stage in the supply chain which imposes a cost (and often a time) penalty though this clearly depends on how well the centre is integrated into the supply chain and the extent to which all costs and benefits are considered
- a single consolidation centre for an urban area is unlikely to be attractive for many suppliers’ flows due to the degree of diversion required from their normal route (and may therefore negate transport savings for onward distribution)
- lack of enforcement of regulations for vehicles not included in the consolidation scheme
- organizational and contractual problems often limit effectiveness
- potential to create monopolistic situations, thus eliminating competition and perhaps leading to legal issues
- loss of the direct interface between suppliers and customers

More about the impacts of UCCs on the supply chain, the carriers and the environment, but also the key issues in planning and operating them, can be found in Browne et al (2005b).

3.2.2. London Construction Consolidation Centre (LCCC) – Construction Logistics Plans (CLPs)

Following the success of the acclaimed Heathrow Consolidation Centre and the DTI supported study of the project, a large-scale Construction Consolidation Centre opened in the area of South Bermondsey in South London, in 2005. The LCCC was established for the supply of construction materials to major construction sites on a just-in-time basis of material from suppliers to site. It was intended to reduce the number of deliveries going directly to the construction sites and thereby reducing traffic congestion and vehicle emissions.



Figure 2: The London Construction Consolidation Centre (TfL, 2009)

The mission statement of the LCCC was “to deliver in the safest and most efficient manner possible the right materials to the right site at the required time in active partnership with trade contractors and project managers” (TfL, 2009).

Funded by Transport for London (£1.85m), Stanhope and Bovis Lend Lease (£1.35m) and managed by Wilson James, the LCCC covers an area of 5.000m² and can process in excess of 200,000 pallets of construction project material per annum. 16 people were employed at the LCCC

By the end of the two-year pilot project, encouraging findings were provided (TfL, 2009):

- The reduction in the number of vehicles delivering materials to four construction sites was estimated from 60 to 70 per cent, when the deliveries were made via the LCCC
- The total amount of deliveries was reduced by approximately 40 per cent in the case of Unilever House
- The vast majority of deliveries from the LCCC were made in rigid goods vehicles, thus eliminating the use of vans
- Two hours average reduction in supplier journey times by going directly to the LCCC than driving into and out the City of London (including loading/unloading time)
- Deliveries from the LCCC to sites achieved 97 per cent reliability (i.e. 97 per cent materials of the correct type and quantity were delivered within 15 minutes of the scheduled time). The standard achieved without the use of a consolidation centre is 39%
- It increased the productivity of the labour force on the construction sites by up to 25 minutes per person per day, as a result of the delivery reliability from the LCCC
- Work scheduling problems appeared because of the LCCC, including an increase in the order lead time of up to six days. Some incorrect components were sent by the LCCC and some items were misplaced at the LCCC
- There were some liability issues due to the use of the LCCC, where trade contractors had no longer control of their materials, while the sign-off process for goods deliveries from the LCCC to the site was not as good as possible
- The estimated reduction of CO2 emission from vehicle movements was up to 70-80 per cent (referring to the short journey from the LCCC to the construction sites)
- Approximately 3000 goods vehicles did not enter the London Congestion Charging Zone during the two-year pilot, as a result of the LCCC
- It is likely that noise pollution and traffic accidents have also been reduced
- It proved difficult to measure reductions in the material waste as a result of the use of the LCCC. However, the improved reliability and secured storage at the LCCC reduced the quantity of materials damaged, lost, stolen and over-ordered, and thus reduced the total quantity of the required materials
- LCCC vehicles brought recyclable packaging and unused materials back to the LCCC for recycling, re-use, or disposal thereby improving vehicle utilization and reducing waste transport journeys.
- The interest shown by other construction sites to make use of the LCCC was lower than expected.

One goal connected to the LCCC is the creation of a centre of excellence for vocational training and professional learning for businesses, local authorities and people in London. There is also the intention of the facility serving as a model for logistics delivery of the major construction programme for the London Olympics 2012 or the Thames Gateway Regeneration project.

One of the four main projects described in the *London Freight Plan* are **Construction Logistics Plans**. They will be applied to the design and construction phases of premises to improve construction freight efficiency by reducing CO₂ emissions, congestion and collisions. The aim will be for TfL and the GLA Group to take a lead in implementing such plans for their construction projects (TfL, 2007a).

Construction Logistics Plans have a number of benefits for all stakeholders (TfL, 2007b):

1. Benefits for local authorities and residents:
 - Less congestion on local roads
 - Reduced emissions to limit the impact of freight transport to the environment
 - Fewer goods vehicle journeys lowering the risk of collisions
 - Opportunity to reduce parking enforcement activity costs
 - Improved quality of life for local residents (reduced noise, intrusion and accidents)
2. Benefits for building developers and contractors:
 - Reduced delivery costs and improved security
 - More reliable deliveries, which means less disruption to the normal business practices
 - Time saved from identification of unnecessary deliveries
 - Less noise and intrusion
 - Opportunity to feed into a corporate social responsibility programme and ensure your operations comply with health and safety legislation
3. Benefits for freight operators:
 - Legal loading areas mean less risk of receiving penalty charge notices
 - Fuel savings through consolidated deliveries
 - More certainty over delivery times will increase fleet productivity
 - Less journeys mean less risk of collisions

Transport for London estimates an increase in demand for freight transport by 15 percent by 2025.

3.2.3. City Logistik in Kassel, Germany – An abandoned project

The project started in 1993 in Kassel, a medium sized city of about 200.000 inhabitants. It was located in Northern Hessen on the crossing of the A7 (North-South Autobahn) and A44 (connection to the Ruhr area).

The aim was to reduce the constantly rising traffic volume in Kassel, especially industrial and individual traffic. From August 1994, ten forwarding agencies participated in the co-operative system. A neutral carrier was employed to collect and distribute the bundled goods in the centre of Kassel, an area which included the pedestrian zone and adjacent roads.

The neutral operator started the collection tour at 6.00 a.m. with about 5 vehicles. The goods were delivered during the night to the forwarding agencies. At the urban distribution centre the consignments were bundled according to the address of the consignees as well as to specific street corridors. At about 10.00 a.m. the urban delivery started, with two or three 7,5 tons vehicles. Usually two tours were carried out per day (depending on the transport volumes). An average of about 5 to 6 tons was transported via the urban distribution centre.

Köhler's (2003) study for the University of Kassel showed a 40% reduction of the annual mileage towards the inner city, a 60% reduction of mileage within the inner city, a 60% reduction of the distance between stops and a great increase in vehicle utilization (+100% per volume or +140% per weight), as a result of the City-Logistik.

Even though it was initially successful, the partners involved gradually lost their interest in the continuation of the project and soon three agents left the partnership, before it was totally stopped in 2003. There were a number of reasons that led to that outcome (Köhler, 2003):

- There were no regular meetings between the partners
- There was no specific form of organization for the centre
- There was lack of information between the partners involved
- Some profitable deliveries were not carried out via the logistics centre, but by the forwarding agencies themselves
- There was no freight traffic centre, although some studies found it necessary
- The local authorities showed little support and did not use restrictive measures to promote the use of the centre (e.g. prohibiting other transporters from certain areas of the city)
- Little interest for the project was shown by local retailers
- The cost savings through the use of the centre were negligible

The City-Logistik in Kassel was just one among over 100 projects related to consolidation centres that were abandoned in Germany in the late 90's. The main reason is

found at the extra time and cost of the cooperation and pre-delivery consolidation. A number of changes in the German market that contributed to these results (Klaus, 2005):

- The structure of the inner city shopping environment was altered due to:
 - a new trend of shopping at shopping centres at the periphery in most cities
 - the continuing replacement of “traditional” stores by standardized “optimized” chain stores
- The structure of the inner city merchandise changed also
- Cities and retailers faced severe budgetary problems
- Reverse of municipal politics: keeping private cars away from the city was no longer a target, and neither was commercial vehicle traffic
- There were significant changes in retail industry logistics which showed that urban consolidation should be based on “commercial pressures” rather than urban planning and politics
- A new approach of urban consolidation has appeared and is very popular: Consolidation close to the final customer (e.g. delivery boxes)

Klaus (2005) concludes that the potential of the “first generation” urban consolidation centre concepts is limited. Instead, more attention must be placed on the “commercial” developments of the industry sector logistics and “new supply chain architectures, such as consolidated mail-papers-mail-orders-home-services and technologies for self-service “consolidated” pick-ups as the Post-Box”.

3.2.4. Discussion

Urban consolidation centres for several companies have been implemented for improving the efficiency of urban distribution and for reducing urban truck traffic. There was a boom in UCC projects in the 90s mainly in Central Europe. Since then, many of these projects have been abandoned due to significant problems. Today the situation is quite heterogeneous among European countries, some being very skeptical after the disillusioning experiences, while others are awaiting a second wave of successful UCCs that will have learned from the failures of the past.

BESTUFS recommends to be ensured that UCC trials have sufficient support and funding to run for a suitable period of time over which to measure and analyse the results. Public funding is necessary for any chance of success.

For UCCs there is no ‘one size fits all’ rule. Every city has its own peculiarities and different characteristics that need to be taken into account. Some valuable recommendations for stakeholders related to UCCs are mentioned in Karrer and Ruesch (2007):

- Urban Consolidation Centres can contribute to solving urban freight problems. However, they are just one among many tools. In order to see if they are of use, a community needs to identify what problems or opportunities it has, and then consider a UCC as one of several possible options.
- An in-depth knowledge of the urban mobility system (offer, demand, logistics chain organization, stakeholders, etc.) is necessary for understanding what kind of UCC can be realised.
- Different tools, regulations etc. must be attentively applied together and harmonised in order to identify “integrated solutions”.
- Once the solution is identified, it must be implemented step by step, trying to generate consensus among retailers, transport and logistics operators, citizens.
- The system must be open to new participants at any time (no monopoly or oligopoly).
- Vehicle usage and efficiency can be increased even more by additional activities like collecting mail, reverse logistics, etc.
- An integrated approach taking into account access regulations, PPP, vehicle technology etc. is generally more promising.

Browne et al (2005b) made an in-depth analysis of this logistics solution and identified some parameters that can increase the potential of success of UCCs:

- Availability of funding – there is no strong evidence that any truly self-financing schemes yet exist.
- Strong public sector involvement in encouraging (or forcing) their use through regulatory framework (e.g. relaxing access time restrictions for vehicles operating from the centre).
- Significant existing problems in the area to be served (e.g. poor vehicle access, significant traffic congestion, constrained loading/unloading facilities).
- Bottom-up pressure from local interests.
- Resolving logistics problems associated with a site that has a single manager/landlord (e.g. shopping centre).

3.3. Public Private Partnerships (PPP)

3.3.1. Solution Description

In international literature there is no general definition for Public Private Partnerships. Some speakers can mean the simple informal communication between members of the public administration and private enterprises. Others consider PPPs as exclusively contractual arrangements between government and a private party for the provision of assets and the delivery of services that have been traditionally provided by the public sector (a notion close to that of privatization). Thus, PPP is a blanket term covering many forms of co-operation between government institutions and private sector entities. Yet all these different forms of PPP have one main idea in common: that public and private actors are different. Each of them disposes of comparative advantages in certain aspects whether it is information, material know-how, financial resources, etc. Within the partnership (which can be seen as a sort of institutional division of labour) each partner fulfils the tasks he is better at – resulting in a win-win situation.

With respect to their degree of formalization, PPPs can be classified in three categories, although the differences are rather gradual than discrete (Ruesch & Patz, 2008):

- Informal co-operations (also called “handshake partnerships”)
- Contractual co-operations / agreements
- Joint venture companies with public and private shareholders / partners

Various examples of PPPs exist in urban freight transport in recent years. They have been used for financing, building and operation of infrastructure projects, as well as for the negotiation and setting of framework conditions and agreements between the public and private sectors. Such partnerships were used in the city logistics schemes that were heavily promoted by the public sector in some countries in the early 1990s.

However, most of these city logistic schemes have since failed (see 3.2.3 and the City Logistik in Kassel example). The main reasons for these “failures” were that the profitability of such approaches was overestimated and the critical mass on consignments to be bundled for city distribution was never reached. Hence, most projects vanished or the activities were taken over by one private operator. The lesson learned from these city logistics experiences was that PPPs which do not provide sufficient commercial benefits are not sustainable over time. More recent efforts to establish working relationships between the public and private sector to address urban freight issues have proved more successful – the example of Freight Quality Partnerships in the UK is provided below.

The initiation and maintenance of a PPP is a complex task. However, bringing both sides together can result in mutual benefits, large synergy effects and efficiency gains especially for tasks which are not core duties of the public sector.

Public Private Partnerships offer opportunities and benefits for all partners:

- Synergy effects such as the mutual exchange of information and know-how
- Effects of reciprocal learning such as a mutual understanding of the partner's mindset and action constraints
- Acceleration effects in developing and implementing a project (efficient division of labour and mutual reduction of resistance through integration of the opposite sector from the beginning)

For the public shareholder the following benefits can be taken as an example:

- Access to corporate funding
- Utilization of private management expertise
- Ability to concentrate on core competences and
- Increase efficiency

For private participation there are also important benefits that can be assumed like:

- PR and image gains
- Motivated and committed employees
- Improved access to public information channels and acceleration of planning procedures and project implementation
- Possibility to influence external factors that play a significant role in the development of the company, e.g. economical and social issues

Presently, national governments and urban authorities do not have a good track record in involving urban freight transport actors in decision-making. Participation in policy making has been often kept to a limited consultation exercise. A good review on Public-Private Partnerships in urban freight can be found at Browne et al (2004). Many examples of PPPs have also been used during the Civitas project and can be found at Civitas (2010).

3.3.2. Freight Quality Partnerships (FQP) in the United Kingdom

A more inclusive approach to PPP has been developed in the UK. It has included the publication of documents that outline the government's determination to recognize problems caused by and faced by urban freight transport. Urban authorities have been encouraged by the national government to focus greater attention on freight

transport and to include consideration of urban distribution and sustainability in Local Transport Plans (LTPs) and to establish Freight Quality Partnerships.

Freight Quality Partnerships (FQPs) are partnerships between the freight industry, local government, local businesses, the local community, environmental groups and other interested stakeholders which allow them to work together and address specific freight transport problems. Their aim is to develop an understanding of those problems and then promote constructive solutions which reconcile the need for access to goods and services with local environmental and social concerns (TfL, 2007a).

FQPs provide a forum to achieve best practices in environmentally sensitive, economic, safe and efficient freight transport. FQP partners exchange information, experiences and initiate projects regarding urban freight transport.

In addition FQPs (Steele, 2008):

- help reduce Penalty Charge Notice (PCN) hotspots to improve congestion and help reduce CO2 emissions
- develop freight mapping and signing
- promote London's Freight Operator's Recognition Scheme (FORS)
- help design-out freight-crime and tackle fly-tipping (illegal dumping of waste material in public places)
- integrate freight in the planning process
- enhance Transport for London (TfL)/ Borough communication and collaboration

The real value of an FQP is that it brings together stakeholders to look for the best practical answers to specific freight problems. This approach increases the likelihood of finding solutions beneficial to all partners involved.

Being a key of TfL's London Freight Plan, London's FQPs are organised at 4 different levels:

- Pan-Regional
- Sub-Regional
- Local
- Single Issue

FQPs develop a programme of works that reflect the views of their members and the aims of the London Freight Plan and then it is submitted for assessment by TfL. Examples of work undertaken by London's Sub-Regional FQPs are presented in the following table:

FQP	Objective	Outputs
West London FQP	Park Royal signage and mapping	<ul style="list-style-type: none"> • Improved directional signage • Freight delivery map
South London FQP	Night Time Deliveries	<ul style="list-style-type: none"> • Develop a pilot project in South London • Freight lessons and disseminate best practice
Central London FQP	Loading, unloading and parking	<ul style="list-style-type: none"> • Code of Practice • Cancelled PCNs • Hotspot reduction

Table 5: Examples of work undertaken by London's FQPs (TfL, 2007a)

3.3.3. Nearby delivery area (ELP) in Bordeaux

In Bordeaux, a system was established to ease the delivery of goods in the city centre, which involved the creation of 'nearby delivery areas' (Espaces de livraison de proximité – ELP). The ELP approach includes the installation of an urban transshipment platform on which dedicated personnel provides assistance for the dispatching of consignments for the last mile (inner city). Goods are unloaded from incoming vehicles and can be loaded onto trolleys, carts, electric vehicles and bicycles for the final distribution leg. This approach can also be used to provide additional services, such as home delivery, short-term storage etc. (Ruesch and Patz, 2008).



Figure 3: Equipment used at the ELP (Niches, 2007c)

The need for the creation of the ELP appeared during the construction of the tramway lines in the inner city area. Deliveries were nearly impossible because of the public works in the city centre. As a result, a PPP started as a general collaboration between freight organizations, the Chamber of Commerce (CCI) of Bordeaux and the Bordeaux metropolitan authority to design solutions for delivering the goods during the building of the new tramway lines. The first main achievement of the PPP process was to involve the three main truck organizations.

For one year there was one meeting every three months with a private consultant who was hired to organize and manage the meetings and set up the ELP experiment project itself. Employing a private consultant was one of the success factors because he could manage and take care of the PPP more neutrally compared with a city official.



Figure 4: Espaces de livraison de proximité (ELP) Bordeaux (Ruesch & Patz, 2008)

The solution reached was the ELP with contractual commitments between parties involved to set up and co-finance specific delivery areas. The project aimed not only at the easier delivery of goods to the city centre, but also to reduce traffic congestion, noise and pollution associated with deliveries.

The space is reserved and controlled by up to two members of staff who can also help goods vehicle drivers to deliver their goods to the shops using trolleys. It can accommodate 3 to 5 delivery vehicles at once (it is about 30 meters wide). The ELP operates from Monday to Friday between 09.00 and 17.00 and on Saturday between 09.00 and 11.00.

The costs for the two permanent employees are rather high. During the second year of test, one third of the financing was paid by the operators (TNT), one third by the chamber of commerce and one third by the city of Bordeaux.

Initial results show that the ELP system is very popular with freight transport companies because it offers the guarantee of an available and secure unloading area close to the commercial area in the city centre. A second ELP was set-up in Bordeaux on 2005 and a third on in 2006. ELPs are also being established in other French cities, e.g. Rouen (Allen et al, 2008).

3.3.4. Discussion

The framework conditions that favor the building of a PPP can be found in Ruesch and Petz (2008):

- Less public budgets
- Public interest and acceptance among users
- Complex projects
- Lack of information
- Problems in efficiency

The same BESTUFS Handbook identifies that the main fields for establishing a PPP is on the optimization of urban distribution, road pricing and the construction of logistics and distribution centres. Other application areas for PPPs can include: the usage of ITS in urban freight, city access management, the development of environmentally-friendly vehicles for goods distribution, loading zone management, etc.

The most PPPs in the field involve only partners from the freight transport business. Because of the complexity of environmental and congestion problems in urban areas it would be advantageous to also integrate other interest groups like public transport services. It should be aimed to find a comprehensive approach which affects all kinds and all modes of transport. Communication between different stakeholders with different interests and objectives is otherwise very difficult.

Given the wide range of stakeholders involved in freight transport considerations in urban areas (including retailers, wholesalers, carriers, warehousing, residents, shoppers and workers) it will undoubtedly prove difficult to both engage and please everyone. However, if the focus remains on ensuring that the delivery and collection of goods in urban areas takes place as in an efficient manner, while imposing as few social and environmental impacts as possible, there are clearly benefits to be achieved through the use of a broad PPP approach.

3.4. Night Deliveries

3.4.1. Solution Description

Inner-city night delivery is the delivery to retailers and shops in the inner city area during the night hours when the city usually is quiet and inactive. Typical times are between 22:00 and 06:00. In several cities, such as Barcelona or Dublin, successful experiences with trials on night delivery are made replacing a (higher) number of vehicles operating during day time by a (fewer) number of vehicles operating during night time.

In most European cities there are night time regulations with some notable exceptions such as Paris. Two types of night-time regulations may be introduced (Allen et al, 2008):

- Time regulations on deliveries and collections to and from a particular building (e.g. a retail outlet, office or factory)
- Regulations on goods vehicles movement in a part or the whole of an urban area.

There may be a number of consequences for freight transport companies due to not allowing night time activities:

- More vehicles may be required to make deliveries in a shorter delivery window
- Deliveries may have to be made in periods of greater congestion (reducing vehicle & driver productivity and increasing fuel consumption)
- Journey times may be slower and less reliable
- The supply chain may be less efficient
- Total supply costs may be increased

On the opposite side, inner-city night delivery:

- Reduces delays for the logistics service providers by using the free road capacities at night
- Reduces emissions and energy consumption (less congestion during night time, direct access to the shops)
- Increases logistics efficiencies in terms of the deployment of HGVs and manpower
- Enhances road safety

Restrictive night-time regulations can result in an increase in total costs within the supply chain. By being allowed to make night-time deliveries, some companies can

improve the efficiency of their operations and improve sales. Unrestricted access to loading/ unloading facilities without traffic interference ensures faster delivery service and minimizes the impact of freight on congestion. Night delivery schemes also promote the use of cleaner and quieter goods vehicles, e.g. compressed natural gas (CNG) engines.

The most important issue raised by night-time deliveries is the noise created by the vehicles operations, the vehicles' engines, the handling of goods (loading/ unloading process), the opening/ closing gates etc. Well defined noise standards for night-time operations could bring significant benefits to local residents increasing the acceptance of night-time transport operations. There needs to be a balance between vehicle noise, equipment noise and driver behavior. Operators need to train and educate their staff for this sensitive issue.

Another important problem connected to night deliveries is exposure to theft and lack of security for both the drivers and goods. The lack of flexibility in the personnel's working hours is also a difficulty that is costly to overcome. In addition, it is more difficult to locate and correct mistakes in deliveries during the night.

Sathaye et al (2009) also showed that nighttime delivery policies might actually deteriorate a city's environment on terms of particulate matter and other emissions, since the atmospheric boundary layer is usually more stable during the night. The actual impact depends on the local climate, but in general inland areas are more affected than coastal settings, especially during the summer. The paper highlights the importance of conducting comprehensive assessments of logistics policies, before introducing them.

Several European programmes dealt with night deliveries, such as the Civitas MIRACLES project, NICHES, FIDEUS and SILENCE. NICHES (2004-2007), for example, addressed the following aspects (NICHES, 2007b):

- The delivery during night-time with specially equipped low noise vehicles (low noise equipment, CNG engines etc)
- Allowance for larger trucks to enter the city centre which are restricted during the day time.

An Interesting review on night-time delivery restrictions and their impacts in the UK has been made by Browne et al (2005a)

3.4.2. Quiet Night-time Deliveries in Barcelona

As part of the Civitas MIRACLES project, the goods operator Mercadona adopted quiet night-time deliveries in the inner city of Barcelona in 2003. The objectives addressed were (MIRACLES, 2006):

- Improving Municipal management of vehicle circulation on the main and local road networks
- Reducing delivery times and costs
- Developing mechanisms to self-finance the successful scheme elements

The Municipality introduced experimental traffic regulations. The delivery processes were concentrated between 23:00 and 24:00 in the night and between 5:00 and 6:00 in the morning. Traffic police collaborated with the Municipality to measure noise levels in residences close to the supermarket sites. In this innovative collaboration, operators have become active in introducing quieter and more ecological vehicles. In addition to the adaptations to the vehicles, staff were trained to realize the unloading operations using a set of procedures aimed at minimizing verbal communication and other noise.



Figure 5: Quiet night-time unloading using adapted 40T truck at Mercadona's Valencia St. outlet (MIRACLES, 2006)

Operator Mercadona has demonstrated that quiet delivery is possible with a 40T lorry serving supermarkets with a rather large capacity and with substantial refrigeration facilities. The result is quantified in terms of noise measures compared to ambient noise levels on nights when the delivery was not being made. The average of the minimum values recorded during unloading inside buildings (23.5 dB(A)) was 0.3

dB(A) greater than those recorded before loading started. For maximum values, no difference was recorded inside buildings (33.4 dB(A)), while in the street they varied by only 0.1 dB(A), average with unloading of 52.2 dB(A). This was achieved by the use of special carpets inside the vehicle and electric lift and carry elements.

The delivery characteristics of this trial indicate that 2 trips/week at night can save 7 trips using smaller lorries during day-time traffic. Operator Mercadona estimated that full investment in vehicle adaptation was recovered within 2-3 years (from the 7 points delivered at the moment a cost saving of about 6,000 € per month can be seen).

The Municipality and operators realized further trials with the FIDEUS project and noise measurements through the SILENCE project. The trials with small trucks show that the combination is possible but in this case only biodiesel was used and no hybrid, fuel cell or CNG technology. The combination of low noise equipment and alternatively driven vehicles is seen as very important in the future, but at the moment the availability of alternatively fuelled vehicles is not given especially for long distance trucks. For the 16T and 40T trucks, the financial rate of return ranges from 18 to 36 months.

Now, apart from Mercadona, Condis and Lidl have also come to be exempt from time delivery regulations and benefit from night time deliveries. The following noise-abatement measures are used (Hayes, 2008):

- Plastified roll-containers, soundproofing, wedges controlling roll-trainer movement
- Adapted refrigeration equipment
- Kerb adaptations for access
- Staff training to minimize verbal communication

This measure is cost-effective – both from the local authority and the operators' points of view. The SILENCE programme has generated improved knowledge; it shows that operators are only partially successful (in 45% of the cases) in unloading within the ambient noise conditions; it also identifies which are the most important noise sources (truck arrival in 62% of cases, goods unloading in 15% of cases) (SILENCE, 2008).

3.4.3. The PIEK project in the Netherlands

At the end of 1998 the Dutch Government put into effect the renewed "Decree Retail Trade Environmental Protection", which set out that the noise emission level must remain within noise emission standards set. It particularly defines that the

noise emission generated during loading and unloading goods between 19.00 – 23.00 hours must not exceed the peak noise standards of 65 dB(A) and between 23.00 – 07.00 hours the peak noise standard is 60 dB(A). The measurements were made at a distance of 7,5 meters away from the truck.

The Ministry of Housing, Spatial Planning and Environment, the Ministry for Economic Affairs and the Ministry for Transport, Public Works and Water Management introduced a long-term PIEK (PEAK, meaning peak noise levels, in contrast to continuous noise levels) programme in 1999 in order to bring about the necessary technical adjustments, by tackling the source, to the means of transport, the materials used when loading/unloading goods and the loading/unloading locations.

The long-term PIEK programme comprises of 10 main projects. With the exception of the truck and the shopping trolley (<65 dB(A)) all solutions meet the 60 dB(A) requirement (NICHES, 2007b).

- Transfer of knowledge to the companies involved on a general level;
- Stimulate quiet behavior;
- Create the optimal loading and unloading bay;
- Low noise trucks (up to 7,5 tons);
- Low noise trucks (over 7,5 tons);
- Low noise transport refrigeration system;
- Low noise take along forklift truck;
- Reduce noise of roll containers, pallet-trucks and hand pallet-trucks;
- Quiet shopping trolleys;
- Electric propulsion or a combination of electric and diesel or gas propulsion

The PIEK MAP (Multi-Annual Program) has resulted in many innovations. It has shown that meeting the standards of the Detam order in council is technically possible. It can be concluded that the PIEK MAP has largely fulfilled expectations in terms of developing 'quiet' products. The goal of introducing these products to the market has also been achieved (fifty 'quiet' products available in 2004).

In 2007 Senter Novem and Albert Heijn carried out 5 trials in 9 cities using PIEK-Certified technology. During a period of 3 months, they performed 1,000 morning (05:00 – 07:00) and evening (19:00 – 02:00) deliveries and received only one complaint concerning the noise emitted.

The results of these trials were very positive with great noise and air emission reductions and important cost-savings. For example, in one location the average delivery time before the trial was 1 hour and a half, while during the trial it was reduced to only half an hour. Fuel consumption, CO₂ emissions, NO_x emissions and PM₁₀ emissions were also greatly reduced (Goevaers, 2008).

Another profit that came out of the trials was the upgrade from rigid to Euro-trailer. Three rigid 10 m trucks were replaced by one 17 m tractor trailer saving 75% of the total costs, with similar reductions to the above mentioned pollutants.

Albert Heijn aims to use 1000 PIEK-Certified trucks for 2010, while many other companies are also heading towards the same direction. The PIEK-Certificate has been adopted in many European countries as an important tool for night-time deliveries.

3.4.4. Other cities

Apart from the examples mentioned above, night-time delivery schemes have been successfully implemented in Dublin, London, Rome, Vicenza, Torino and many other cities. In France they are strongly encouraged by the authorities of some cities (Dijon, Marseille, Orléans, Paris) while in other cities they are banned at night at all vehicles due to noise emissions (Lille, Rennes).

3.4.5. Discussion

Night-time deliveries can provide (Browne et al, 2005a):

- i. In-store benefits (increased turnover and greater staff efficiency)
- ii. Efficiency gains in distribution vehicle operations
- iii. Efficiency gains in distribution centre operations

Identification and quantification of the environmental and social costs and benefits of relaxing or removing delivery restrictions (in terms of vehicle operations, distribution centre operations and store delivery operations) would also be necessary. Identification and costing of the approaches that retailers could take to reduce delivery-related noise would also be required, together with the potential noise reduction benefits of these approaches.

Before the implementation of the inner-city night delivery concept, the following key aspects should be considered (NICHES, 2007b):

- The acceptance of night delivery can differ from country to country (for example southern cities are seen as more noisy than northern cities);
- Technical solutions for low noise equipment are available;
- Public financial supports/subsidies can encourage buyers/users to make use of the low noise equipment;
- Existing noise limits have to be respected (on the local, national and international level);

- Local access regulations (for example no access for trucks during night time) have to be considered and adopted;
- Urban space for deliveries has to be available (competition with parking vehicles of the inhabitants);
- Infrastructure (for example paving) around the ramps may cause additional noise and has to be mitigated;
- Organisation (and/or technical solutions) of the receiving of the goods during night times or in the morning at the receiver's side is needed.

The initiatives should come from the logistics operators and retailers which are subject to complaints by residents because of night deliveries. The authorities should then respond positively to the operators' initiatives and promote the development of innovative solutions by means of special permitting arrangements and privileges.

It can be difficult to implement inner-city night delivery as a stand-alone solution. It is then recommendable to implement this solution together with additional measures related to city logistics (e.g. a zone access control scheme which foresees no or only limited access for delivery vehicles during daytime) and to consider public subsidies which make the solution more attractive for the transport operators.

3.5. Road Pricing Systems

3.5.1. Solution Description

BESTUFS defines *road pricing and urban freight transport* as “all measures imposing direct fees for the use of (urban) roads that might be able to influence the urban freight system. This includes all road pricing measures on urban roads, whether they concern freight transport or passenger transport. On the other hand it excludes all (so called “inter-urban”) road pricing on non-urban roads (e.g. motorway tolls, etc.) as well as other pricing measures such as fuel taxes, vehicle taxes or parking fees” (Karrer & Ruesch, 2007).

Road pricing may have two main purposes: financing or managing the traffic. The need for financing is the most common incentive for implementing road pricing. The money can be used in improving infrastructure, public transport or other areas of the transport system.

Fees with managing purposes can then in turn have the purpose to improve the environment or accessibility. They can be used to reduce emissions and noise by reducing the total traffic load, or to protect a certain area, for example a city center. The only congestion charging scheme that has mainly environmental purposes is the one implemented in Stockholm in 2006 (see section 4.2.2.).

Charges can be used to reduce congestion on certain roads or at certain hours, and thus to increase accessibility in the road network. In this case, the design should be to charge just where and when the traffic load is high, thereby achieving a maximum redistribution of traffic to other times, places and mode of transportation.

Existing road pricing schemes can be classified in the following categories (Egger & Ruesch, 2003):

- Single road or single lane pricing, often used for financing new roads.
- Network pricing, which in the urban context is limited to the network outside the city or to major roads leading to the city.
- Area pricing, which does not have the drawback of cars switching to alternative routes, unlike the previous categories.
- Cordon pricing, where charges are collected on entry or exits around a whole area (e.g. inner city)
- Complex area pricing, which denotes a distance based area pricing scheme with charges ideally set equal to social marginal costs. However, this is not a scheme to start with, as major preconditions (acceptance, standardization of electronic collecting techniques, etc.) are not fulfilled.

Although most urban road pricing projects focus mainly on passenger transport, freight transport is equally affected in a collateral way. By potentially reducing passenger and overall traffic it might also increase the transport business' efficiency by improving

- Reliability
- Punctuality
- Duration of the trip
- Security

In the medium and long run, road pricing could eventually contribute to more sustainable urban freight transport. Freight transport is likely to react differently to road pricing, than passenger transport due to a number of reasons:

- Commercial transport has a higher trip value, thus a lower elasticity of demand
- Commercial transport operators tend to take their decisions based on rational economic considerations (no cost illusion)
- For freight transport there is no efficient alternative available. Yet, pricing sets an incentive for optimizing the freight business processes.

Urban freight is quoted as one of the beneficiaries of urban road pricing, because, apart from increasing its efficiency, due to reduced congestion, road pricing harmonises competition as all transport operators participate on the cost of road usage including foreign vehicles or vehicles from other regions.

Nevertheless, freight transport professionals are rather skeptical against road pricing, mainly because it imposes new costs on their business. However their attitude varies from complete rejection to the expectation of benefits.

It is also interesting to notice that the majority of the BESTUFS partners participating in the material collection, when asked about the importance of road pricing in their countries, answered that is of little or no importance (Egger & Ruesch, 2003). As far as urban freight transport is concerned, the importance of road pricing was estimated even lower. An explanation for this can be that there was hardly any *urban* road pricing scheme implemented till then (2002). Also the existing urban road pricing schemes focused on passenger transport and on financing rather than demand management. However, their prediction for the future was that road pricing would substantially gain importance, both in general and urban freight transport.

The European Conference of Transport Ministers identified cost-effectiveness and public acceptance being the key issues for road pricing, instead of technical feasibility. A factor critical to the measure's success is the clarity of the policy objectives tar-

geted and the complete and unambiguous specification of functions required of the system.

Interesting policy parameters can be found in UoL (2009) and more briefly on the NICHS notes on road pricing schemes (NICHS, 2007a). An interesting study about how the impacts of road pricing on the behavior of freight carriers can be found in Holguín-Veras et al (2006).

3.5.2. Congestion Charging in London

A congestion charging scheme was introduced in central London, covering 22 km², in February 2003 (TfL, 2008). In February 2007 the original central London congestion charging zone was extended westwards, creating a single enlarged congestion charging zone. The priority of the scheme is to reduce traffic congestion in and around the charging zone, to improve the bus services, journey time reliability for car users and to make the distribution of goods and services more reliable, sustainable and efficient. In addition, all revenues generated are to be invested in transport in London for at least ten years.

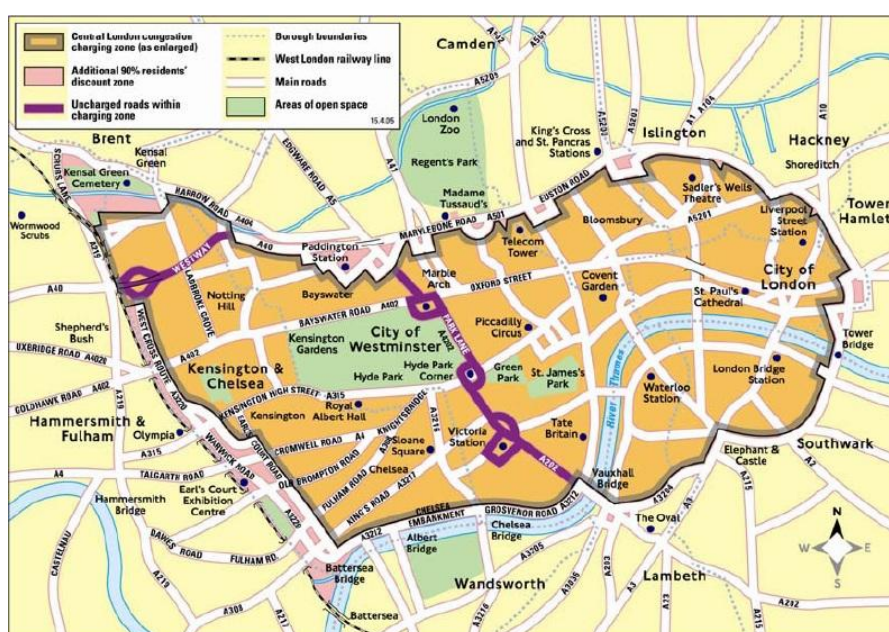


Figure 6: The extended central London congestion charging zone (TfL, 2008)

The initial charge was £5 for driving and parking a vehicle on public roads within the congestion charging zone from 07:00 to 18:30, Monday to Friday. This was increased to £8 in 2005 and the charging hours were revised to end at 18:00 in 2007. Goods

vehicles pay the same daily charge as other vehicles. A range of discounts and exemptions are available for certain groups and in respect of certain vehicles, such as alternative-fuelled and electrically-powered vehicles that attain strict emission standards.

Vehicles are identified using automatic number plate recognition cameras and are checked against a database of those who have paid the charge and those who do not have to pay, as they are exempted for some reason. Once a vehicle for which a charge has been paid has been successfully matched, the photographic images are automatically deleted from the database. For those vehicles observed within the zone for which a charge has not been paid, the photographic images are kept for enforcement purposes. Failure to pay the charge results in a penalty charge.

It is important to underline the attention given to vehicle fleet owners (including goods vehicles). Organisations with 10 or more vehicles can use Fleet Auto Pay and enjoy a number of benefits:

- £7 daily charge per vehicle, instead of £8
- Less time spent on administration
- Convenient Direct Debit payments
- Online account management and telephone helpline
- No Penalty Charge Notices (PCNs) for registered vehicles
- Possibility to register extra vehicles on the same account
- Possibility to add vehicles eligible for a discount (e.g. alternative fuel vehicles), but not vehicles that are exempt from the congestion charge.

However the project's CITY PORTS Interim report (CITY PORTS, 2005) mentions that the majority of transport operators assert that the road pricing system is not well designed because of the limitations imposed on their work. They ask the same exemption from paying as applied to buses, on the grounds that they are also a public utility service, as well. The access fee is considered as an unfair tax as transport operators cannot avoid it, in the way that other users can.

According to the Sixth Annual Report (TfL, 2008) the congestion charge has reduced traffic entering the zone by 21% (compared to pre-charging levels), which equals to some 70,000 fewer cars a day. There is a six percent increase in bus passengers during charging hours. The estimated reduction of Light Goods Vehicles and Heavy Goods Vehicles vehicle kilometres in the zone was -11% in 2005, resulting in a decrease in pollutants emissions (Beevers & Carslaw, 2005).

However there has been a recent increase in congestion, back to pre-charging levels, due to numerous water and gas works, which have greatly reduced the road capaci-

ty, in addition to traffic management measures to help pedestrians and other road users. Of course the congestion problem would be much worse without the charges.

The congestion charging scheme was estimated to be responsible for 8% reduction in the emissions of NO_x, 6% to emissions of PM₁₀ and a reduction of 16% in emissions of CO₂. All these figures were for emissions from all road traffic sources, on an annual total basis. However the trends in measured air pollution remain broadly static. This confirms the important role of non-charging related 'background' factors in determining overall air quality in London. Also, the charge has been a great financing source for improving the transport in London. In the year 2007/08, 137 million pounds were raised from the charges. (TfL, 2010)

3.5.3. Other Cities

Other cities with different road pricing systems have been: Singapore (1975), Bergen (1986) and Oslo (1990) in Norway and Durham City (2002) in the UK. An interesting form of road pricing which focused on heavy goods vehicles and charged them by the distance they travelled was introduced in Switzerland (2001), Germany (2003) and Austria (2004). More information can be found in Ubbels & de Jong (2009), Karrer & Ruesch (2007), Eliasson & Lundberg (2003).

3.5.4. Discussion

Policy makers have multiple choices as road pricing can take different forms. Charges can be differentiated in various ways (e.g. time of day or location) and revenues can be used in different ways. So there are many decisions to take for a policy maker who considers the implementation of road pricing. It is clear that the specific objective of road pricing will often be a decisive factor in making such decisions. With efficiency as primary objective, the differentiation of charges will be important, as is the careful determination of charging levels.

Urban freight transport is facing an efficiency problem which is getting increasingly prominent due to decreasing consignment sizes and more frequent deliveries. Road pricing can contribute to improve the efficiency of urban freight transport and provide solutions for problems such as noise, pollution and congestion. In the medium and in the long run, road pricing could eventually contribute to more sustainable logistics and distribution strategies and to a more sustainable urban freight transport.

The BESTUFS Best Practice Handbook on road pricing gives the following recommendations concerning the design and operation of a road pricing scheme (Karrer and Ruesch, 2007):

1. The concept design should follow the problems
2. The technical solution should follow the concept design – not the other way round
3. It is not the majority of ordinary users, but the handling of the few non-equipped, uniformed or handicapped that is crucial for success
4. The design of the road side equipment can be delicate as it is often installed in sensitive historic areas (town centres)
5. Include all actors of the transport system, including freight transport, into the designing process
6. Political and administrative consensus is vital
7. Involve opposing interest groups and build coalitions between them. Get agreements about how to use the money, give something to both sides
8. Present the project as a compromise, a balanced solution
9. Define and treat the scheme as a technical, environmental, financial problem, not as an extra tax
10. Illustrate the benefits: the project must be accompanied by advantages clearly visible to the users, both motorists and environmentalists
11. Something is better than nothing: incremental approach, demonstration projects, pricing for improved capacity is more acceptable than pricing for demand management; first simple, then complex
12. Find your own way: there is much to be learned from existing projects, but general recommendations must be adjusted to suit local conditions (traffic conditions, political system, public opinion, etc.)

Freight transport has so far been sadly neglected by urban road pricing research. It is strongly advised that freight transport should be considered integrally in future road pricing projects.

3.6. Technological Solutions

3.6.1. Intelligent Transportation Systems (ITS)

The *Intelligent Transportation Systems (ITS)* is a term generally used to refer to the combined application of *Information and Communication Technologies – ICT*, its related infrastructure, and the necessary legislative/ policy framework, in order to optimize transport efficiency and operational sustainability in the future. The freight operations area of ITS can be defined as “advanced ICT systems aimed at simplifying and automating freight operations at both the operational efficiency level as well as the institutional level” (Giannopoulos, 2009).

The BESTUFS Best Practice Handbook on ITS (also called “transport telematics”) identifies three core features on which ITS tools are based (Karrer et al, 2007):

- Information
- Communications
- Integration

Freight ITS developments (as opposed to *Passenger ITS*) have been up to now largely “technology-driven” with emphasis on the introduction of many sophisticated (although mainly stand-alone) systems and technologies that can collect enormous amounts of data about current status as well as the various planning parameters concerning the operation of freight transportation systems, and to transmit these data in one form or another to transportation control centres and databases (impeded in ‘virtual transport platforms’) held at authorities, carriers or various intermediaries. Little progress has been made however towards the achievement of integrated and truly ‘intelligent’ systems which are required for the transformation of these ‘raw’ data into useful information according to the needs of each ‘player’ along the transport chain.

By the early 2000s the research focused more towards the creation of integrated web based applications able to be shared by many, over the internet. Original Freight ITS research produced mainly stand-alone applications that can largely be classified in the following two broad areas (Giannopoulos, 2009):

1. *Commercial Operations*, i.e. applications mainly related to the vehicle, the cargo, or the company (operator) and related in their great majority to systems for the better monitoring of the transport (e.g. collection and sending of tracking and tracing data or route choice information, etc.)
2. *Fleet Management Systems*, i.e. dedicated to the fleet management operations of a particular operator (or group of operators), including transport planning.

The core of the technological drivers in the freight sector was developed in the nine-ties and early 2000s and is presented by Giannopoulos (2009):

- *Mobile transmission technologies* such as GSM, allowing transmission of messages (voice and data) between home-base and vehicles.
- *GPS (Global Positioning System) technology*, enabling for example, Automatic Vehicle Location (AVL) and Computer-Aided Dispatch (CAD) applications.
- Availability of more affordable *positioning information* via these GPS or GSM transmission networks.
- '*Mobile Internet*' made available via wireless broadband communications for document exchange and access to ICT services
- *The XML standard*, offering a meta-language for the definition of simple and non-proprietary data exchange standards.
- The various *route guidance and navigation systems*, i.e. packages of algorithms, electronic networks and software to combine this useful information to the driver's assistance.
- *Onboard sensors* performing a variety of functions such as: tracking the vehicle's mechanical condition, monitoring speed or the state of loading goods, automatic toll payment, etc.
- Systems and hardware for vehicle or load unit identification, e.g. the RFID card (transponder).
- *Smart cards* enabling new applications such as the electronic tachograph, electronic driver license or the storage of load-related information.

The BESTUFS Handbook on ITS identifies a number of applications related to urban freight transport (Karrer et al, 2007):

- Freight and fleet management systems, automatically monitoring of vehicles and loading, tracking and tracing and proof of delivery, route planning tools;
- Electronic management of zones for delivery
- Electronic access control
- Trucking route signalization
- Automatic fee control system in connection with road pricing
- Traffic monitoring and traffic control (enforcement)
- Electronic operational management of terminals
- ITS for the management of dangerous goods transports
- On-board computers for delivery vehicles
- Electronic freight exchange systems for urban freight transport/ virtual freight distribution centres e.g. the virtual freight distribution centre (VGVZ) in Berlin (see **Figure 6**).

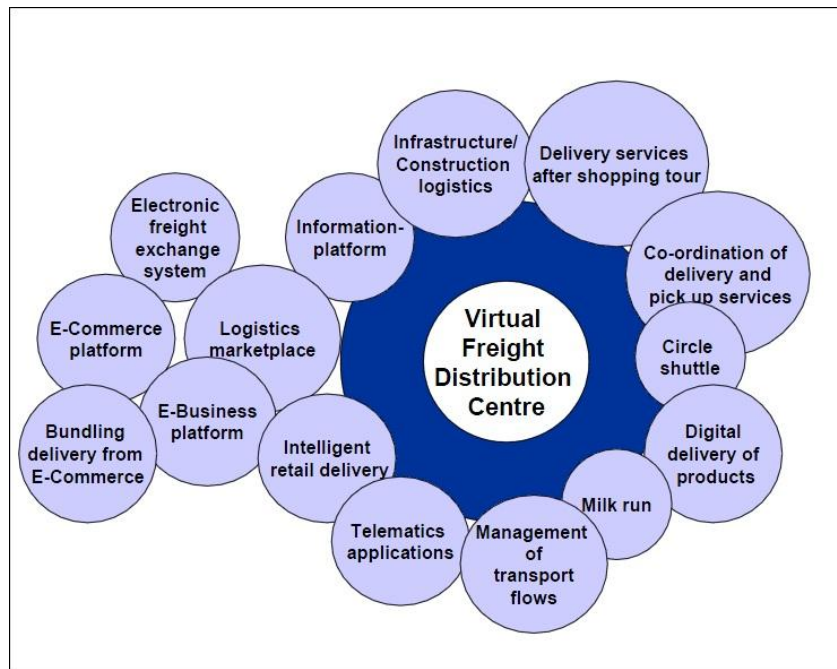


Figure 7: Concept for a virtual distribution centre with single projects (Karrer et al, 2007)

Until December 2008, there was no coherent European framework for road transport ITS and for interconnection with other transport modes. On December 16th, 2008, the European Commission issued the “Action Plan for the Deployment of Intelligent Transport Systems in Europe” (European Commission, 2008), which outlined six priority areas for action. The progress on the implementation of this Action Plan is to be reported in 2012.

The Action Plan identifies the role of ITS on:

- Greening transport by relieving congestion and reducing energy consumption.
- Improving transport efficiency, e.g. maintaining a paperless information trail in the management of the flow of goods (eFreight) or providing Real-Time Traffic Information (RTTI) services.
- Improving road safety and security with the use of Driver Assistance Systems such as Electronic Stability Control (ESC), Adaptive Cruise Control (ACC), Lateral Support, Collision Warning, Emergency Braking Systems, etc.

Especially in the area of European ITS coordination, the set-up of a specific ITS collaboration platform between Member States and regional/local governments to promote ITS initiatives in the area of urban mobility was planned for the year 2010. The “Action Plan on Urban Mobility” (European Commission, 2009) included the vision of assistance on ITS applications for urban mobility to complement the previous Action Plan. The zoomed areas include: electronic ticketing and payment, traffic manage-

ment, travel information, access regulation and demand management, and address the opportunities opened up by the European Galileo GNSS system. A starting point was set at the launch of a study on improving interoperability of ticketing and payment systems across services and transport modes, including the use of smart cards in urban transport with a focus on major European destinations.

3.6.2. Environmentally-Friendly Vehicles (EFVs)

The introduction of environmentally-friendly vehicles (EFV) into urban transport is most common in Western European countries at present and Sweden has played a leading role towards this goal. Public authorities have made resources and financial support available to encourage innovative freight transport and logistics concepts including EFV and new vehicle technologies in urban areas, by a mix of incentives and regulations. Low-emission vehicles can help cities confront problems of air- and noise-pollution caused by road traffic

Environmentally-friendly vehicles can be running on (Allen et al, 2007):

- *Alternative fuels*, including LPG, CNG, Bio-Fuels and Hydrogen-based technology. Technologies and fuels already exist but significant market penetration has yet to be achieved.
- *Diesel and petrol*. Euro engine emissions standards for goods vehicles are helping to significantly reduce emissions. Particulate traps can be fitted to vehicles to capture particulates before they enter the atmosphere.
- *Electric and hybrid vehicles*. Electric vehicles are especially suitable to reduce noise emissions and produce no exhaust emissions.

The promotion and use of EFVs in urban freight transport has been encouraged by several urban authorities and national governments (Sweden is a pioneer on the field, see 4.1). National programmes like the PIEK-programme in the Netherlands or the French “National Programme on Goods in Cities” have evidenced that there are successful results to be expected by such programmes and support measures.

Alternative fuels, for instance, can significantly reduce vehicle emissions. The following **Table** is presented by Sathaye et al. (2006):

Fuel	Considerations
Emulsified Diesel	<ul style="list-style-type: none"> – 17-20% decrease for NOx emissions – 17-50% decrease for PM emissions – Increase for VOC – Reduction in fuel economy
Biodiesel	<ul style="list-style-type: none"> – Increase for NOx emissions – Decrease for PM, CO, hydrocarbons, air toxics
Natural Gas	<ul style="list-style-type: none"> – Does not decrease GHG emissions – Storage and safe handling difficulties
Propane	<ul style="list-style-type: none"> – Decreases NOx and PM emissions by 80% – Does not decrease GHG emissions
Ethanol-Diesel Mix	<ul style="list-style-type: none"> – Little data available at the time of issue

Table 6: Examples of alternative fuels to diesel (Sathaye et al, 2006)

Key stakeholders involved in EFV introduction schemes are:

- Local authorities: the local and regional government needs to initiate a Policy Strategy for EFVs
- Political support: politicians at the local and national level must support the strategy, especially for tax incentives
- Distribution: fuel distributors must be involved
- Vehicles: vehicle producers need to be involved in order to get a range of different vehicle models.



Figure 8: Scania's first ethanol truck which came out in 2008 (SCANIA, 2010)

The BESTUFS Good Practice Guide on urban freight transport gives a number of examples for the following EFV initiatives (Allen et al, 2007):

- Informal partnerships: urban authorities, transport operators and urban businesses have come together to set up sustainable solutions based on a more environmentally friendly form of urban freight transport
- Tax reductions and advantages for EFVs, alternative fuels and the installation of modern filter technology on diesel vehicles
- Freight transport operators that have used EFVs for urban deliveries, often as part of research projects co-funded by public authorities
- Special permission to access parts of the urban area such as shopping and business districts for vehicles that meet certain emission standards
- Road pricing schemes that provide discounts and exemptions for goods vehicles that meet certain emissions standards
- Funding of innovative research projects and trials in the field of urban freight transport by using EFVs

However, there are several obstacles related to the wider use of EFVs. The main failure factors are (Allen et al, 2007):

- Higher operational costs of EFV
- Low capacity/volume of electric vehicles
- An insufficient filling station infrastructure
- Reliability problems and defects resulting in high maintenance requirements of EFV

Most EFV projects are currently supported by public financial budgets.

3.6.3. Discussion

The intention of this chapter has not been to give a deep review of ITS solutions neither of all the progress and research currently made on Clean Vehicles, but rather to give a rough overview of these relatively new technological fields. Below there are some further recommendations that regard these two fields: ITS first and Clean Vehicles second.

Giannopoulos (2009) foresees the following topics as being the most likely developments in future ITS:

- a) More vehicular and infrastructure intelligence.
- b) Improved and more integrated electronics for location, tracking, and communication, and the associated information-technology systems.

- c) New intelligent models and algorithms to process the data and information gathered (with the systems developed so far), and transform this information into timely and meaningful advice tailored to the needs of the different stakeholders along the different transport chains.

The BESTUFS Best Practice Handbook on ITS (Karrer et al, 2007) notices the complexity of problems in transport and traffic management, therefore concluding that a comprehensive solution is required for different kind of problems and impacts. Authorities cannot stand alone to find solutions for appropriate ITS solutions. In co-operation with different interest groups like shop owners and freight transport operators ITS applications should be integrated in urban freight transport policies. The cities' authorities can provide data and application about the general traffic situation in town or introduce traffic flow management for freight movements by usage of telematics information and communication systems. The special expectations of freight operators and delivery points have to be taken into account.

Therefore public supported traffic management measures should correspond with the requirements of freight operators, which mean to integrate companies' interests.

Concepts should be developed and should contribute to an economic and consensual solution that would be well accepted among the users. So with respect to financial investments and time of planning the measures carried out by public authorities should be supported and checked from independent sides. Because of high investments in telematics the approach should follow the participation of different interested parties.

On the field of **environmentally-friendly vehicles**, most projects are currently supported by public financial budgets. Private operators tend to change their fleets only if:

- there is a clear financial benefit for the company
- there is an adequate alternative fuel station network
- there are marketing benefits for the company
- the company has a strong commitment to environmental issues
- suitable vehicles are available

The success of promoting EFVs often depends on framework conditions like (Allen et al, 2007):

- Emission and environmental regulations and standards
- Incentives like tax reduction (fuel price development)
- Filling station network availability
- Individual transport strategy and deployment of vehicles

A combination of incentives and restrictions as used by public authorities in Germany, France, the Netherlands, and other European countries has shown that developments in EFV have started. However, only if the operating costs and reliability of EFV improves compared with traditional fuel technologies will a large-scale introduction of EFVs be achieved. Public funding and support measures can help to foster and promote EFVs.

4. Case Study: Stockholm

4.1. Introduction – A city in the front line of sustainability

Overview

Stockholm is the capital and largest city in Sweden, situated on 14 islands on the south-central east coast of Sweden. It is strategically located at the mouth of Lake Mälaren. Over 30% of the city area is made up of waterways and another 30% is made up of parks and green spaces. 841,612 people live in the municipality of Stockholm which covers 188 km², 1.25 million people live in the urban area (377.30 km²) and 2 million in the metropolitan area (6,519 km²), which equals to 22% of the total country's population. This population contributes to 28% of Sweden's Gross Domestic Product (GDP). Stockholm is therefore Sweden's economic engine.



Figure 9: Stockholm's location and overview (by author)

Moreover, Stockholm is also Scandinavia's economic center. Two thirds of the Fortune 100 companies which have their head offices in Scandinavia have chosen to locate them in Stockholm. Stockholm is also home to one of the world's largest ICT clusters, one of Europe's largest life science clusters and Northern Europe's financial centre. This, combined with the city's central location and its leading position as a cultural centre, is what makes Stockholm the capital of Scandinavia.

In the 2006 European Innovation Scoreboard, prepared by the Maastricht Economic Research Institute on Innovation and Technology (MERIT) and the European Commission, Stockholm was ranked as the most innovative city in Europe. Also, an environmental survey of the Reader's Digest Magazine ranked Stockholm as the "greenest" and most "livable" city in the world in 2007.



Figure 10: View of the city of Stockholm (Flickr, 2010)

The Green City

In 2009 Stockholm was awarded the title as European Green Capital 2010 – as the first Green capital ever in the European Green Capital Award scheme. The award is given to a city that (European Commission, 2010):

- has a consistent record of achieving high environmental standards
- is committed to ongoing and ambitious goals for further environmental improvement and sustainable development, and
- can act as a role model to inspire other cities and promote best practices to all other European cities.

Stockholm was the first city to be given this award for a number of reasons related to the city's long-lasting environmental policy. Stockholm's first Environmental Programme was launched in the mid 1970s. In 1998, the "Swedish Environmental Code" (the central legal framework for environmental issues) declared that "the purpose of this Code is to promote sustainable development which will assure a healthy and sound environment for present and future generations" (SFS, 1998). In 1999, the Swedish Parliament decided to "leave a society to the next generation where the major environmental problems are solved".

The city has an Integrated Management System which ensures that environmental issues are included in the city's budget, operational planning and monitoring. Environmental monitoring is accessible to everyone (Stockholm Stad, 2010b).

All these years of successful environmental work have turned Stockholm into one of the world's greenest cities. More than 90% of the population lives within 300 metres of a green area. There are extensive plans for developing new green spaces in the future or improving existing ones, which already cover 30% of the urban area.

At the same time the water quality is maintained at the highest levels all over the city and swimming and fishing is safe even near the city centre. Drinking water comes from Lake Mälaren and is treated into two waterworks west of the city. Its quality is tightly controlled by the Food Administration Authority.

The waste water from Stockholm and some neighboring areas is treated in two plants with advanced technology for removing nitrogen and phosphorous, exceeding the ambitions of the EU Urban Waste Water Directive. Biogas is produced in the waste-water treatment plant and then upgraded for use in public buses as well as private cars and taxis. The excess heat in the sewage water is recovered for domestic heating. Collection of food waste for biogas is to increase from 4,500 tons to 18,000 tons between 2008 and 2012.

The city has an excellent waste treatment system and uses innovative production methods such as vacuum controlled underground transportation of solid waste. 25% of the waste produced by the residents is recycled, 73.5% is recovered for production of district heating (energy recovery by incineration) and 1.5% is biologically treated. More than 70% of the households have access to district heating. The conversion from oil heating to district heating has reduced greenhouse gas emissions by 593,000 tons since 1990.

Stockholm has also set the ambitious target of becoming a fossil-fuel free city by 2050. CO₂ emissions have already been reduced by 25% compared to the levels of 1990 and correspond to 3.4 tons per capita – half of the national Swedish average. This is made possible by the high proportion of renewable energy for district heating, reduced traffic congestion, more clean vehicles and green electricity. The City of Stockholm uses eco-labeled electricity and the aim is for 100% of all the electricity the city purchases to be environmentally certified.

The public transport system is efficient, reliable and functional. Some 90% of the residents live within 300 metres from public transport with an hourly or more frequent service. During peak hours, 78% of all trips to the inner city are made by public transport and 68% of all the trips within the city centre are made on foot or by bicycle. Stockholm has a network of 760 km of cycle lanes which is still expanding. An internet-based travel planner for bikes, covering both the inner city and neighbouring municipalities is available online (Stockholm Stad, 2010c).

Since 1994, Stockholm has actively campaigned for clean vehicles to be introduced on the market as well as providing adequate infrastructure for fuelling them. The effort is paying off: clean vehicles make up an impressive 40% of sales. Of the total vehicle fleet in early 2009, 14% were ethanol or biogas-fuelled, hybrid-electric or ultra-low emission vehicles and the trend is positive. All inner-city buses operate on biogas or ethanol; 50% of refuse trucks and 40% of taxis either consume biofuels or are hybrids. The City of Stockholm's vehicle fleet aims to be 100% clean by the end of 2010, and many private companies are moving in the same direction.

An environmentally oriented congestion charge was introduced in 2006 for cars travelling in and out of the inner city area during day time hours (see section 4.2.2.). The emission reduction levels were approximately 10-15% and the traffic was reduced by around 20% improving the air quality by 2-10%.

The city has integrated this environmental policy with its development projects. Two new eco-profile residential areas are being built, using the experienced gained from the innovative Hammarby Waterfront (Hammarby Sjöstad - see section 4.3.1.). Located on former brownfields, the Stockholm Royal Seaport aims at being fossil fuel free by 2030 (see section 4.3.3.). The area is intended to be a showcase for sustainable urban construction where innovative environmental technology and creative solutions are developed, tested and presented. The city district is to be an example for other cities to follow, a world class environmental urban district.

International Programmes

Stockholm is famous for its pioneering action for the promotion of environmentally-friendly ('clean') vehicles, already since 1994. The city participated in or coordinated many European or world-wide projects in that direction, but also other aspects of urban goods distribution have been researched as well. The most important of these projects are roughly described below.

In 1996, eight European cities signed the Stockholm Resolution pledging their support for zero and low emission vehicles as an important element in providing sustainable urban mobility. This was the beginning of the **ZEUS project** (Zero and low Emission vehicles in Urban Society) which lasted for three years and showed the great potential in improving the conditions for zero and low emission mobility in European cities. ZEUS (European Commission, 2000):

- identified and clarified market barriers;
- identified actions cities could take to reduce or remove barriers;
- took active steps to break down market barriers; and

- tested several types of vehicles, fuels and complementary transport planning measures.

The project **IDIOMA** (Innovative Distribution with Intermodal freight Operation in Metropolitan Areas) supported innovative projects in urban freight transport in different cities. During the period 1999-2001, different concepts aimed to improve the distribution of goods within urban areas, including Stockholm. Regarding Stockholm in particular, the aim was to implement technical solutions for coordinated composite distribution by Frigoscandia, a large transport provider of temperature-controlled logistics services. They tested a vehicle equipped with the specially designed IDIOMA refrigerator cabinet to supply goods to the Burger King restaurants in Stockholm. The technology used and tested was a multi-temperature vehicle which enabled the simultaneous distribution of goods with three or more types of temperature requirements (European Transport, 2002).

Stockholm also took part in the **ELCIDIS** (Electric Vehicle City Distribution) project, a very successful project which gained great publicity on the field of clean vehicles. The ELCIDIS project tested a better solution for urban logistics by approaching the subject in a dual way, in order to set an example for clean and efficient urban distribution in the 21st century (European Commission, 2002):

- by organising urban distribution using quiet and clean hybrid-electric vehicles
- by achieving a more efficient organisation of urban logistics by more efficient routing of the vehicles and the use of urban distribution centres (UDC)

The ELCIDIS project ran from March 1998 till August 2002 with objective to provide the viability of (hybrid) electric vans and trucks for urban distribution, preferably with the use of an Urban Distribution Centre, showing the environmental benefits of such an application and promoting incentives for the use of those vehicles.

ELCIDIS in Stockholm focused on the introduction of nine vehicles, six hybrid trucks (Mercedes Benz 1217 Atego - weight 12 tons) and three electric vans (Citroën Berlingo Electrique) for goods distribution in the city centre and region. The nine environmentally adapted vehicles replaced regular diesel and petrol vehicles and thus helped to reduce pollution and noise in Stockholm.

As a main result, the project succeeded in verifying the principal merits of using (hybrid) electric vehicles in urban delivery concepts. ELCIDIS provided indisputable proof that there are no predominantly objections to the use of hybrid and electric vehicles in urban distribution, neither from the company managers nor from drivers, and certainly not from local authorities.

Company managers benefited from the positive publicity for using these vehicles. Drivers also found the performance of these vehicles very satisfactory. Local authori-

ties welcomed the view on a realistic future solution for their transport related environmental problems.

The largest European programme in which Stockholm participated (and coordinated) has been the **Trendsetter project of the CIVITAS Initiative** (2002-2006). The objectives of the city Stockholm, during that time, were (Civitas Trendsetter, 2006b):

- to reduce the emissions of fossil CO₂ by 20% from 1990 to 2005
- to reduce the emissions of NO_x reaching a daily average not exceeding 60µg/m³ by 2006
- to reduce the emissions of particulates, reaching a daily average not exceeding 100 µg/m³ by 2006
- to reduce the share of residents that are exposed to noise maximums higher than the recommended level to 10%, i.e. 50% reduction
- to increase the number public transport passengers by 100,000 by 2005 (15% increase)
- to increase the number of clean vehicles to 5,000 by 2005 (5% of the public and private fleet)
- to maintain its leading position in the field of clean vehicles and gain a leading position in the field of sustainable transport management.

Through the Trendsetter project, the city aimed at the following targets:

- to reduce annual fossil CO₂ emissions by 9,300 tons by 2005
- to reduce annual NO_x emissions by 70 tons by 2006
- to reduce annual particulate emissions by 1,850 tons by 2005
- to reduce the share of residents exposed to noise maximums higher than recommended level to 10% within the environmental zones
- to increase the number of clean vehicles to 300 by 2005
- to increase cooperation with other European cities

The explicit measure titles of Trendsetter in Stockholm were:

- Widening of the environmental zone (see 5.2.1.)
- Congestion charging (see 5.2.2.)
- Smart card systems and integrated ticketing
- Reduced parking fees to promote clean vehicles
- Increased public transport passengers
- Material logistics centre – to optimise freight deliveries at a construction site (see 5.3.1.1.)
- Logistic centre for Old Town of Stockholm (see 5.3.2.)



Figure 11: Trendsetter activities on the map of Stockholm (Civitas Trendsetter, 2006b)

- Make bicycling attractive
- Creation of a visitor web for optimal trip planning
- Traffic monitoring and supervision
- Accessible road network (street data)
- More adaptive signal control in a bus priority system
- Clean and efficient heavy-duty vehicles
- Waste collection with biogas-fuelled vehicles
- Clean municipal fleets
- Making clean vehicles less expensive
- Increasing clean vehicle use in private company fleets
- Web-portal for drivers of clean vehicles
- Improved biogas refueling infrastructure

Particularly on the field of logistics, there were two measures included in the Work Package 9, titled “WP9: New Concepts for the Distribution of Goods”. The first measure (WP 9.1) “Consolidation of material to large construction site” consisted of the establishment of a logistics centre in the developing area of Hammarby Sjöstad.

The project was a major success with both environmental and financial benefits for the actors involved and gained world-wide recognition. The second measure (WP 9.3) “Consolidation of restaurant supplies in medieval Old Town” was mainly driven by a medium/small-sized private company which faced many difficulties on its way to persuade clients use its logistics centre. However the project managed to work for some years. Both these projects are described in detail further below.

The Trendsetter project also included measures to promote clean vehicles, such as providing 26 clean (biogas) trucks, reducing parking fees for clean vehicles, increasing the number of clean vehicles in the municipal fleet, promoting the use of biogas-fueled vehicles for waste collection, improving biogas refueling infrastructure and subsidizing the purchase of private clean vehicles. A web-portal for promoting clean vehicles and sharing information was also created (Miljöförordn, 2010).

The project also assisted the preparation for the implementation of the Trial scheme of the congestion charges in 2006. The target of widening the Environmental Zone by including the developing area of Hammarby Sjöstad was not fulfilled because of construction delays. Therefore, attention was given to increasing compliance with the zone rules, which was also very successful.

Although some of the activities were altered all delayed, the most important targets of the Trendsetter project have been met. For example, the target for an increase of clean vehicles was 300 but the achieved increase of 3,000 was far greater. The Trendsetter project contributed very clearly to the increase in clean vehicle sales. The targets of reducing CO₂, NO_x and noise were fulfilled. The bio-fuelled vehicles were satisfactory for the drivers. The use of fossil resources decreased. Finally, the cooperation between stakeholders in Stockholm increased.

On December 2005, Stockholm was hosting the **NICHES** Workshop, when the **OS-MOSE Awards** were launched in order to reward local authorities who have shown the courage to introduce innovative and daring measures in the urban transport field. Stockholm did not receive an OSMOSE Award, but was rewarded as a ‘Gold Star Winner’ for the city’s long term strategy to promote clean vehicles in three levels of action: political (procurement), infrastructural (introduction of filling stations), vehicle/bus (pre-commercial procurements).

Stockholm was the coordinating city of the **BEST project** (Bioethanol for Sustainable Transport) which dealt with the introduction and market penetration of bioethanol as a vehicle fuel, establishment of infrastructure for supply and fuelling of bioethanol, and the introduction and wider use of ethanol cars and flexible fuel vehicles on the market. The project was co-financed within the 6th framework programme and lasted from January 2006 to December 2009. Ten demonstration sites participated, located in Europe, China and Brazil. During the project (Miljöförvaltningen, 2009):

- 77,000 flexifuel cars and 310 E85 pumps were demonstrated at nine sites;
- 190 bioethanol buses and 12 ED95 pumps were demonstrated at five sites;
- Four conventional vehicles were converted to run on bioethanol;
- Three hybrid electric vehicles running on an E25 blend were tested;
- Several different low blends were tested;
- There was extended guidance of followers on issues of vehicles and fuels distribution, fuel standards, fuel handling regulations, tariff information and clean vehicle definitions;
- Incentives and disincentives for market development were identified;
- There was a sustainability assessment for up-scaling of bioethanol production and consumption;
- There were lifecycle analyses of various bioethanol supply chains and contributions to developing biofuels certification frameworks.

The project was very successful in demonstrating that bioethanol is a reliable and environmentally-friendly alternative to fossil fuels. The technology is currently under development and further energy-efficiency can be achieved. Biofuelled trucks are already in the market with satisfactory results. The project increased Stockholm's prestige in clean vehicles promotion and innovation.

Stockholm is currently participating in the **CLEANTRUCK project** of the LIFE European programme. CLEANTRUCK will run from January 2010 to December 2013 and its primary objective is to demonstrate the commercial and technical viability of alternative fuels and new technologies for goods distribution vehicles. It is planned to construct: filling pumps for the alternative fuels ethanol ED95 and biomethane; filling stations for CO₂ for use as a refrigerant in order to reduce the use of hydrofluorocarbons (HFCs); and mobile stations for N₂ to inflate tyres. The project will also facilitate the procurement of 30 ethanol ED95 trucks, 30 dual-fuel trucks and 20 electric-hybrid trucks by private distribution companies. The project will further support innovations by training around 100 drivers in 'Heavy-Eco-Driving' (European Commission, 2010d).

Road freight transport in Sweden: policy and facts

As has been already mentioned, the Swedish political system is in general very sensitized in environmental issues. The road transport sector has received great attention as it is a major polluter. The overall goal of transport policy in accordance with the Swedish Parliament's decision in 1998 is to ensure a socio-economically efficient transport system that is sustainable in the long term for individuals and the business community throughout the country. This goal is divided into six subsidiary goals:

- *an accessible transport system*, where the road transport system is designed to meet the basic transport needs of individuals and the business community
- *a high level of transport quality*, aided by the design and performance of the road transport system
- *safe roads*, where the long-term goal of road safety is to eliminate fatal or serious injuries as a result of road accidents
- *a good environment*, aided by the design and performance of the road transport system
- *a regional development*, aided by the design and function of the road transport system
- *a gender-equal road transport system*, designed to fulfill the transport needs of both men and women.

In 1998, Sweden introduced an **eco-label for freight transport** (Caceres and Richards, 2000). Green procurement means that companies include environmental performance when choosing transport services. Transport chain environmental management involves life-cycle analysis of the impacts of manufacture, distribution, use and retirement of products. Transporters are evaluated in terms of their environmental impacts. In 1998, Swedish State Railways launched the GreenCargo service brand which offers environmentally-labeled, door-to-door overnight transport.

At the end of 2006, a large number of companies, researchers, organisations and public authorities joined forces to work towards a shared goal: to reduce the climate impact of goods transport on Swedish roads. The joint initiative bears the name “**On the road to climate neutral freight transportation (KNEG)**” and aims to halve emissions from the typical Swedish long-haul transport operation by 2020 compared with 2005. The 16 current participants are seeking to accomplish this ambitious goal by (Trafikverket, 2010):

- increasing the efficiency of transportation logistics (optimal use of transport modes, better use of existing freight capacity, eco-driving)
- increasing the efficiency of fuel production (high lifecycle energy efficiency, high energy density, energy efficient fuel production with low CO2 emissions)
- increasing vehicle efficiency (energy efficiency, technological improvements)
- increasing the use of renewable fuels (increase low-blending, second generation renewable fuels by 2015)

Among the partners of the initiative, the Swedish Road Administration committed to contribute to the common purpose by:

- implementing eco-driving requirements for all driver’s licenses
- supporting trucking companies who want their trucks to observe speed limits

- supporting the development of new transportation solutions that make it possible to leverage the road network for longer and heavier vehicles
- supporting the development of innovative solutions for deliveries in urban settings

The increasing need for road transport, with all the unpleasant consequences that it implies, is the main responsible for this level of sensitivity and awareness that is noticed. **Road freight transport accounts for 40% of all freight transport modes (in ton-kilometers) in Sweden, but it is responsible for more than 90% of the total CO₂ emissions from freight transport (SIKA Statistik, 2009). In addition, the share of the road mode in freight transport is expected to increase to 45% in 2020 (SIKA Statistik, 2005).**

According to Transport Analysis (Trafikanalys, 2010b) for the year 2009, the Swedish road freight transport was 35 billion ton-kilometres, vehicle mileage was 2.6 billion kilometres, the amount of goods carried was 334 million tons and the number of shipments was 37.7 million, for the whole country. Empty trips were 568 million km, approximately one quarter of the total mileage.

The above numbers imply great reductions in road freight traffic in comparison to 2008, which can be explained by the recession which resulted in a decrease in the demand for freight transport. Specifically, road freight ton-kilometres decreased by 17 percent, professional vehicle mileage decreased by 10 percent, quantity of goods decreased by 9 percent and the number of shipments by 1 percent.

According to the same report (Trafikanalys, 2010b), in 2009, businesses within the Stockholm County received 36.5 million tons of goods through road transport, of which 74 percent was coming from locations within the same County. There were 95,276 light trucks and 12,128 heavy trucks registered in the Stockholm County, and 43,494 light trucks and 4,404 heavy trucks registered in the city of Stockholm, in 2009 (Trafikanalys, 2010a). In 2008, 1.9% of the light trucks and 1.7% of the heavy trucks registered in the city of Stockholm were alternative-fuelled vehicles (SLB-analys, 2009).

There is little data concerning urban freight movements in Stockholm. In a report presented by BESTUFS in 2006 (Browne and Allen, 2006), the authors reported only five types of freight data collection surveys available at the time. They were all conducted on national level and the possibility to extract urban data was considered very difficult (with the exception of the road accidents police reports).

Åkerman and Höjer (2006) showed that with the current growth rate in transport, the sustainability targets for reduced energy use in 2050 are impossible to achieve, even with the use of advanced technological systems, as they are expected to be in

2050. In their sustainable model, freight transport per capita needs to decrease by 27% compared to the levels of 2000, something that is totally opposite to the current trends.

Since the implementation of the Congestion Charging System (the Trial in 2006 and the permanent implementation in 2007) there is some information about the amount of trucks crossing the tax cordon during the charging hours (6 am.-7 pm.). In 2008, there were 64,135 truck passages towards the inner city of Stockholm during charging hours. They account for 18% of the incoming vehicles (SLB-analys, 2009).

Green logistics strategies in Stockholm

Stockholm's location on 14 small islands makes the transportation difficult both regarding transit traffic and traffic inside the city. Stockholm has about one million inhabitants and about 1.5 million living on reasonable commuting distance. There is political support for making the city's transport system even more environmentally compatible by substituting conventional vehicles with clean vehicles and making logistics services more effective. More effective and attractive public transport means combined with intelligent traffic information technologies are other important fields.

In the following sections of this chapter we are taking a close look to some city logistics strategies that involved various levels of interference and support from the city authorities, from total (like the Environmental Zone and the Congestion Charging System) to partial (like the various logistics centre schemes). Of course, this thesis cannot cover every possible logistics strategy that has ever been implemented in Stockholm, especially when it comes to private, single-company consolidation centres, which also exist in the area. The case-studies presented in the following sections (4.2 and 4.3) match the following criteria: originality, different levels of public authorities' interference and availability of relative information.

According to BESTUFS (Karrer and Ruesch, 2007), the first 'urban freight platforms' appeared in the Stockholm area in the 1950s, when transport companies started building terminals for distribution in the area. The terminals were also used for storage of goods on demand. Later they were connected to the railroad network so that freight trains could enter directly into the terminal. However, it was just one company per terminal and there was no cooperation. Today, there are many platforms of single transport operators or forwarders (wholesalers), which have been under constant growth. New terminals are built a few miles outside the city, usually with a rail connection.

Although particularly among the forwarders there are efforts made to cooperate over company borders, examples of multi-company distribution centres are scarce. There have been a number of trials, but most of them have failed for different reasons. There is also some restraint in the land use planning regulations when it comes to traffic disturbance from freight platforms. In some Swedish cities there are restrictions of the truck sizes, while in Stockholm, as we will see, there is the Environmental Zone which regulates truck engine class.

In this research we came across two other multi-company logistics centres that we do not present in detail. The first one was built in 2002 by 5 transport companies (2 more joined later), consulted by the transport research institute TFK. The platform, which was a completely private initiative named '**Stocodist**', covered 35,000m² in the outskirts of Stockholm. It was built to handle fruit and vegetables coming from central Europe by road, destined for distribution in the city. Distribution was made by a neutral single transport company which was paid a monthly fee by each participant company. The key element of this cooperation is that none of the companies involved considers distribution as their core business and hence there is no fear of losing in competitiveness by contracting a third part for that service (Karrer and Ruesch, 2007).

Another effort for goods consolidation, this time driven by the public authorities, was made in 2005-2006, when a contract was signed with DB Schenker. The project '**Miljöeffektiva varuleveranser**' ('Environmentally efficient goods deliveries') aimed to (1) separate shipments from supplier agreements, (2) coordinate a local distribution, (3) apply environmental requirements on goods vehicles, and (4) improve the city's supply system. The project was hoping to use consolidation to replace 3-4 truck deliveries a day by one or two deliveries per week (Vägverket, 2008).

During the project the following negative factors have been observed (Miljömiljarden, 2006):

- Difficulty of information exchange. It became obvious that there is no communication framework between the city stakeholders;
- The city's decentralized organisation. The various participants have priorities of their own and are not ready to commit to a common target in the same level;
- In a large organisation (such as DB Schenker) it takes a long time to prepare and enforce any decision.

Although the preparations for the project were costly and took more than a year to complete, the project had to cease early, after just 2 months of operation, due to a different political party winning the national elections. There is still interest in the project by the political opposition, but the elections of 2010 did not bring any change

to the political governance of Sweden, so it is not likely that there will be any action in this direction in the following few years.

Recently there has been a proposal by members of the Environment and Health Administration which suggested an integrated use of logistics centres to serve three major areas in Stockholm, but it was not approved for funding (Hugosson and Sunnerstedt, 2008). A rough design of the proposal can be seen in **Figure 12**. This proposal could serve as basis for new ideas.

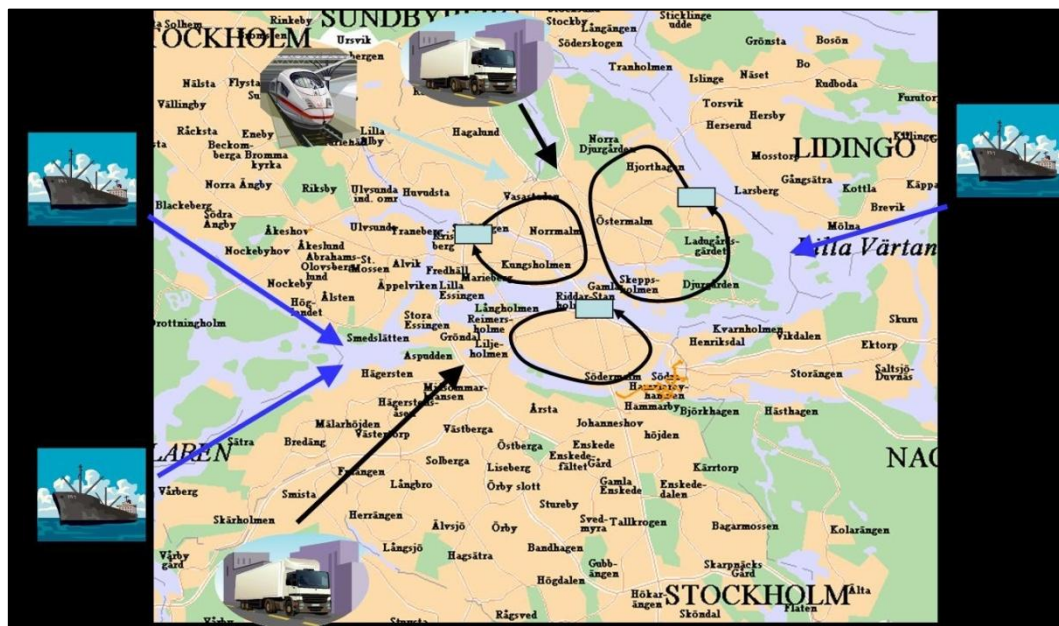


Figure 12: The rejected proposal of Hugosson and Sunnerstedt (2008)

On other fields of city logistics strategies, things have been better. We have already shown how Stockholm has been a leading city on the field of promoting clean vehicles over the last 16 years. However, the progress in the field of **Intelligent Transport Systems and Services (ITS)** must not be ignored.

The former Swedish Road Transport Administration (SRA) drew up a national ITS strategy for the period 2006-2009. The three primary goals of this strategy have been (Vägverket, 2005):

- Improving road safety by increasing compliance with rules and regulations in commercial traffic and organised passenger transport,
- Improving accessibility for work-related journeys for gainfully employed persons on designated commuter routes in metropolitan areas and other major labour market regions in the country,

- Improving efficiency of commercial traffic on a designated commercial road network.

The strategy is characterized by a clear and customer-oriented target image that is combined with a reliable and efficient working method. The main areas to achieve more efficient commercial transports have focused on making progress towards a robust goods transport network and on achieving faster and more reliable bearing capacity information. ITS measures related to commercial transport include (Vägverket, 2009):

- Queue-warning
- Weather warnings
- Operator-controlled free-text Information
- Journey time information
- Information about temporary diversions/road works
- Lane/motorway control
- Road-user charging in urban areas
- Monitoring and control of hazardous goods transport

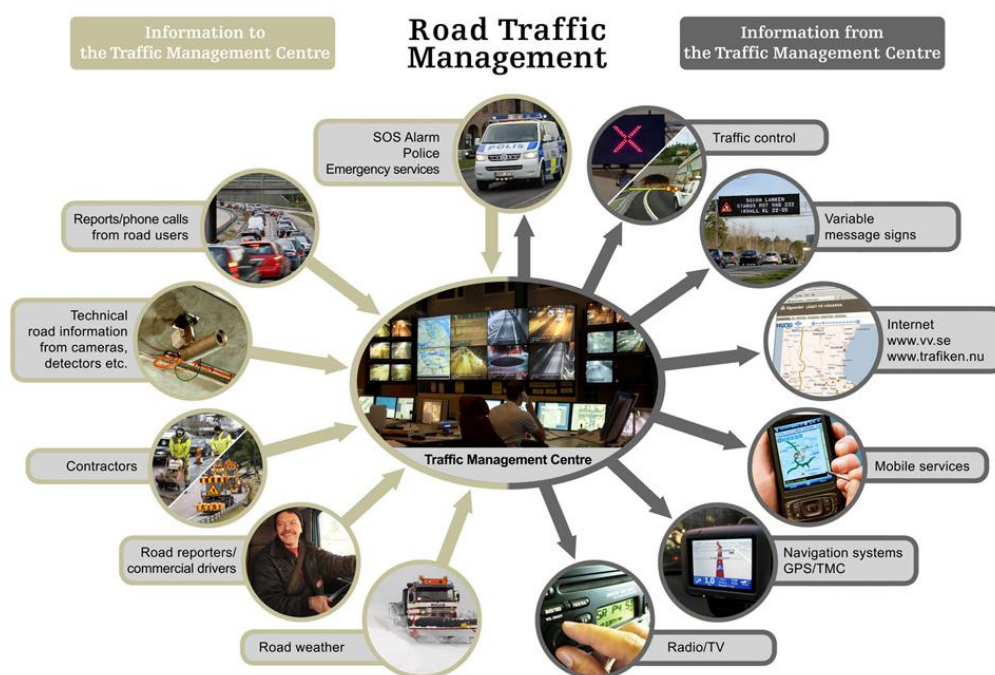


Figure 13: Information flows to and from the Traffic Management Centre (Trafik Stockholm, 2010)

The newly-formed Swedish Transport Administration has four traffic management centres all around the country. Trafik Stockholm is the one servicing the area of the capital through a number of different channels (see **Figure 13**). The centre is responsible for the delivery of information about the current situation to the general public via radio, internet and mobile services. Moreover the centre handles calls reporting incidents on Stockholm city's streets, public squares and parks.

Additionally, there is a number of websites which provide professional and non-professional drivers with traffic information and route selection services.

- **Trafiken.nu** (2010) offers a comprehensive and current picture of the traffic situation for an easier journey planning
- **Läget på vägarna** (2010) offers information about traffic conditions, road-works, weather conditions and camera locations on a high quality map
- **Godstrafiken.nu** (2010) gives extensive information about all different types of freight transport in order to facilitate sustainable and cost-effective transport solutions
- **Yrkestrafiken.se** (2010) has been developed to help users in the road transport industry to get easy access to information, application forms, and self-service applications by bringing together material from several Swedish authorities regulating commercial traffic.

Swedish Transport Authorities and Organisations

There are a number of active authorities within transportation in Sweden. On April 1st 2010, the Swedish Rail Administration (Banverket), the Swedish Road Administration (Vägverket) and the Swedish Institute for Transport and Communications Analysis (SIKA) were phased out. Instead, the Swedish Transport Administration (Trafikverket) and Transport Analysis (Trafikanalys) began operations. The new authorities cooperate with LfV (the LfV Group – Swedish Airports and Air Navigation Services), the Swedish Maritime Administration (Sjöfarsverket) and the Swedish Transport Agency (Transportstyrelsen).

The active authorities in transport have the following responsibilities (Trafikverket, 2010a):

- **The Swedish Transport Agency (Transportstyrelsen)** stipulates rules and monitors how they are followed, grants permission (driver's licenses and certificates), registers change of ownership and manages congestion and vehicle taxation.

- **The Swedish Transport Administration (Trafikverket)** is responsible for long-term planning of the transport system for all types of traffic, as well as for building, operating and maintaining public roads and railways. The Swedish Transport Administration is also responsible for administering the theoretical and driving tests needed to receive a driving license and taxi driver badge, as well as the theoretical test for the professional know-how needed for a transport license and certificate of professional competence.
- **Transport Analysis (Trafikanalys)** reviews bases for decisions, assesses measures and is responsible for statistics.
- **LFV** is responsible for civilian and military air traffic control in Sweden, as well as for safety and development of Swedish air space.
- **The Swedish Maritime Administration (Sjöfarsverket)** is responsible for safety and navigability at sea, as well as for building, operating and maintaining navigation infrastructure.
- **The National Public Transport Agency (Rikstrafiken)** works to achieve basic accessibility of interregional public transport via procurement, for example.

The transport-related publications of the Swedish Transport Administration and the former Swedish Road Administration are very useful and can be found in the relevant websites.

A significant organisation in the field of research and innovation is **VINNOVA** (The Swedish Governmental Agency for Innovation Systems). It is a State authority that aims to promote sustainable and social growth through funding research and developing efficient innovatory systems. VINNOVA's activities cover a broad range of fields, with transportation being a major one among them. Within the field of transport, VINNOVA has focused on three areas: innovative vehicles, vessels and their systems, innovative logistics systems and freight transport as well as infrastructure and efficient transport systems.

Framtida Handel (Future Trade) is a pioneering alliance between companies, local authorities, regions and the Swedish government aiming to achieve sustainable trade in convenience goods. The common vision was formulated in 2005 and since then it has served as a basis for goals, strategies and proposals for specific action.

TFK is a prominent private research organization in the transport and logistics area which was founded in 1949 and aims to improve efficiency, reliability, safety and sustainability in the transport sector. TFK disseminates results through reports, presentations, conferences and seminars.

4.2. Logistics Strategies on city-level

4.2.1. The Environmental Zone

Introduction

The Environmental Zone in Stockholm (as well as in Göteborg and Malmö) came into force on the 1st of July 1996 and was probably the first environmental zone to protect a city centre in the world. The city of Lund also developed its own Environmental Zone since January 1999 and the city of Helsingborg since 2008. Uppsala, Umeå, Örebro and other cities have also have performed studies about the possibility of developing their own Environmental Zone.

Heavy vehicles constitute 5% of Stockholm's vehicle fleet, but are responsible for 40% of hydrocarbon emissions. The objective of the Environmental Zone was to reduce air pollution (and secondarily noise pollution) and maintain accessibility to the city centres of these Swedish cities. It is an important tool to reduce nitrogen oxides and particulate matter coming from heavy-duty vehicles and acts as a complementary emissions standard for the new vehicles that are used in the city. It plays an important part in the government's plan to achieve higher quality in the urban environment.

The National government approved of the use of this measure, which was voluntarily implemented by the municipal governments. The areas that were characterized as 'environmentally sensitive' and were included in the Zones were areas that (Trafikkontoret, 2008):

- contain a big number of apartment buildings
- have streets with many pedestrians and cyclists
- contain buildings that are particularly sensitive environmentally
- contain parks or green areas that are easily harmed by the environmental effects of traffic

The Zone in Stockholm includes the districts of Södermalm, Kungsholmen, Vasastaden, Norrmalm, Östermalm and Ladugårdsgärdet, covering an area of approximately 35 km² (5 x 7 km) with about 250,000 residents and 280,000 work places.

Exempted through routes are Essingeleden including the part of Drottningholmsvägen which joins Tranebergsbron, Söderleden, Klarastrandsleden, Stadsgårdsleden, Långholmsgatan, Västerbron and Götgatan. Klarastrandskopplet,

Kungsbrokopplet and Kungsbron between Kungsbrokopplet and Terminalslingan, the Riddarfjärd exit and access, Södra Järngraven are also exempted.

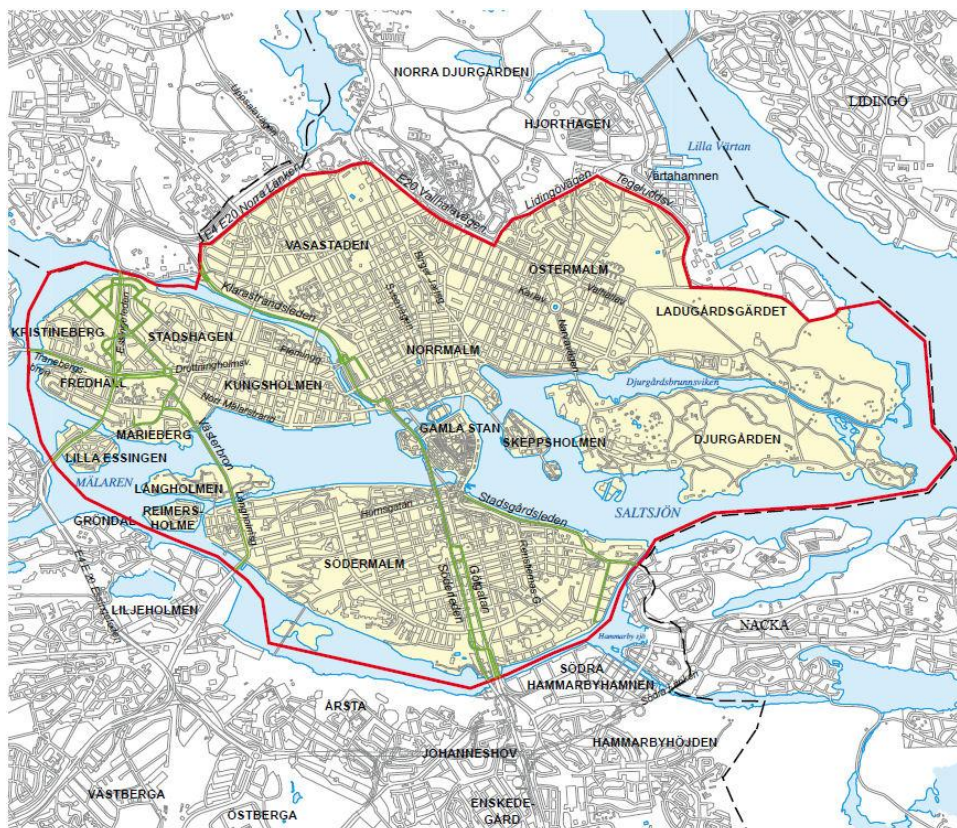


Figure 14: Overview of the Environmental Zone of Stockholm (Trafikkontoret, 2008)

Project Development

In 1992, there was a change in the traffic legislation (1972:693) that allowed local authorities to take measures that confine the traffic of trucks heavier than 3,5 tons with diesel engines, in urban areas. So, in the spring of 1993, the city council of Stockholm decided that all diesel vehicles that don't keep up with the standards of environmental class 1 would be forbidden to access the city after 1997.

The cities of Stockholm, Göteborg and Malmö made concerted efforts to develop proposals for the environmental zone of each city and to develop a common regulatory framework for all three of them. There were also discussions on the extension of the legislation on more types of vehicles such as buses, light trucks and passenger cars. The scheduled date for the enforcement of the Zones was on 1 January 1996.

In January 1994 a proposal was made by the Real Estate and Traffic Administration and was sent to the Urban Planning Authority, the Stockholm County Police, the Highway Authority, the Environmental Protection Agency and to a further number of

major companies and organizations. The consultation would be managed by the Real Estate and Traffic Administration.

In 1995 it was decided that the Environmental Zone would be introduced in April 1996, prohibiting the access of diesel-powered trucks over 3,5 tons, which did not belong to environmental class 3 or better. In 1999, demands would be placed on environmental class 1 or equivalent. For the transitional period of 1996-2000, all models which would have been 6 years old or less would be admitted in the zone. Environmental classification regulations were in accordance to the corresponding European rules.

Exemptions were proposed to be granted for special vehicles of different types, like fire trucks. Public transport vehicles would also need to be exempted from the high expectations.

The Zone included the so-called internal traffic area, as it is known to the drivers. The area was marked by prohibiting road signs. Some major routes were exempted by the provisions. Before the northern parts of the “Rings” were developed, Vallhallavägen and Lidingövägen were also excluded. Exemptions were also made for special vehicles, bus traffic and foreign distribution vehicles. In order to verify that a vehicle complied with the regulations, it brought on its windshield a visible mark of environmental sensitivity (8x12 cm), identifying the vehicle’s travel time within the environmental zone.

The decision to introduce the Environmental Zone was appealed by the Stockholm County Haulage Contractors. Highway Authority also complained that the regulations were discriminating in favor of foreign vehicles owners. The Zone would apply only for Swedish-registered vehicles. The final starting date for the implementation of the Environmental Zone was set for 1 July 1996.

The Environmental Zone was introduced on the planned date. The main rule was that a vehicle would belong at least to the environmental class 3 or it would be less than 8 years old (since the date of registration).

The first joined evaluation for the three Environmental Zones took place at the end of 1997. It spanned a wide field, from compliance monitoring to environmental and socio-economic assessments.

In May 1998, a new exemption was added to the regulations, after a decision of the City of Stockholm. The vehicles that were exempted were vehicles that were 6 years-old or younger and met the Swedish environmental criteria, even though they didn’t meet the European classification criteria.

The Stockholm Environmental Zone took part in the European Civitas project Trendsetter, during 2002-2006, which aimed to reduce the city's traffic congestion and environmental impact. The project focused on ways to increase compliance among the Zone users. The target of widening the Zone to include Hammarby Sjöstad was postponed for the future because of delays of the district's construction. The project also included ways to provide better information to drivers and companies and regulate penalties for the violators (Civitas Trendsetter, 2006b).

Eventually, the Trendsetter project yielded positive results, since the understanding and obedience of the Environmental Zone increased. Also, the acceptance of clean vehicles increased as a result of this measure.

In 2002 a new rule, concerning the emissions of nitrogen oxides, was added to the existing rules of carbon oxides and particulate matter emissions. The new rule was based on the age of the vehicle, rather than on the Swedish concept of environmental class. That means that even foreign-registered vehicles become subject to the rules.

In 2007 there was a new definition of "environmentally sensitive areas" and included: "areas where many people gather, for instance parks, green passage ways, sensitive buildings, streets with many users and areas exposed to noise and exhaust fumes or where there is a risk that environmental quality standards are exceeded."

In order to move towards a regulatory framework that was based on issues other than the age of the vehicle, but also to comply with the European Commission's requirements, the four cities with an Environmental zone and the Ministry of Industry jointly submitted a proposal for new regulations. The new rules came into force on the 1st of January 2007, Trafikförordningen (1998:1276). The new rules meant that each municipality can decide on its own about developing an Environmental Zone or not, but is subject to the same rules and emission standards as every other municipality with a Zone. The municipalities can only decide upon the geographical area of their Zone. The Traffic Office in Stockholm decided on December 11th 2006, that the area of the local Environmental Zone remains the same as applied since 1996.

The Environmental Zone Rules

The basic rules to be followed in the Environmental Zone area are the following. More details can be found at DieselNet (2010).

- All heavy, diesel-powered trucks and buses are permitted to be driven in the Environmental Zone for at least six-years, calculated from when the vehicle is first registered, regardless of the country of registration.

- Euro 2 or 3 vehicles can be driven in an environmental zone for eight years. In both cases the time is calculated from the year in which the vehicle was first registered.
- Euro 4 vehicles can be driven in an Environmental Zone up to and including 2016, regardless of the year of registration.
- Euro 5 vehicles can be driven up to and including 2020, regardless of the year of registration.

Monitoring of the rules in the Environmental Zone is a police task. The illegal traffic is punished with fines. Compliance with Environmental Zone rules is the responsibility of the drivers. The fine is currently 1000 SEK (approx. €106)

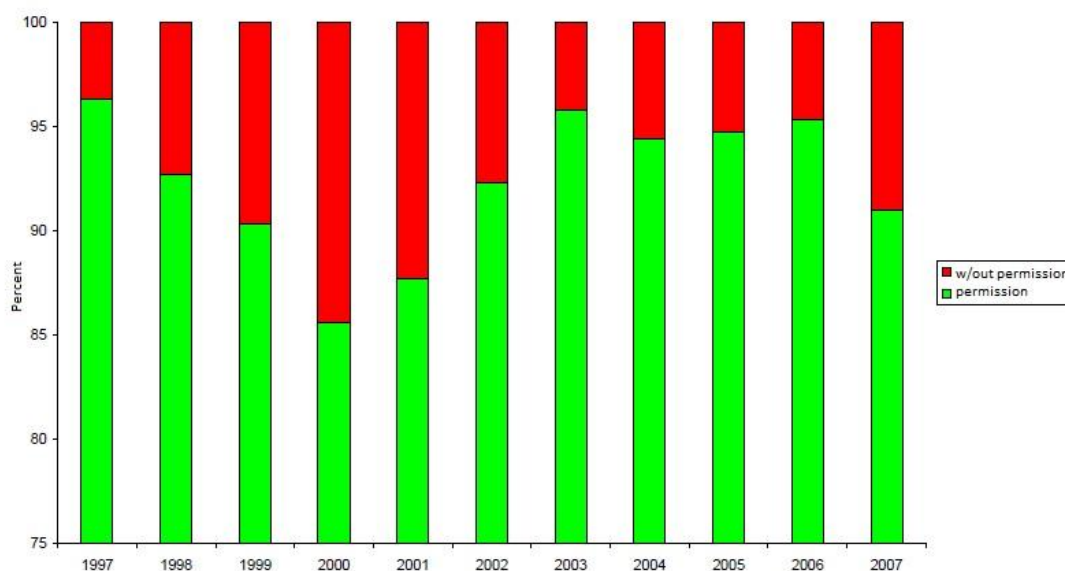


Figure 15: Compliance levels in Stockholm's Environmental Zone (Trafikkontoret, 2008)

During the period of participation in the Trendsetter project (2002-2006), obedience to the zone rules has increased, as is shown in **Figure 15**.

Changes in the Heavy-duty Vehicle Fleet

The following **table** shows the number of trucks broken down by different types of fuel. The vast majority of trucks (>3.5 tons) in traffic operate on gas. It is also clear that there were no trucks running on gas inside Stockholm or Stockholm County in 1996.

	Diesel	Gasoline	Ethanol	Natural gas/ Biogas/ Motor gas
Municipality 1996	3,658	225	1	0
Municipality 2007	4,108	119	0	70
County 1996	10,011	591	2	0
County 2007	12,168	306	1	113

Table 7: Total registered trucks in traffic for different fuels (Trafikkontoret, 2008)

Figure 16 below shows the average age of heavy diesel-powered vehicles on the road in the municipality of Stockholm and Stockholm County between 1996 and 2007. It is shown that the average age of these vehicles has been reduced for the specified period. The medium age of buses has fallen by 1.5 years and the medium age of trucks has fallen by 0.5-1 years. It is very clear that trucks registered in the Stockholm Municipality are younger than those registered in the Stockholm County

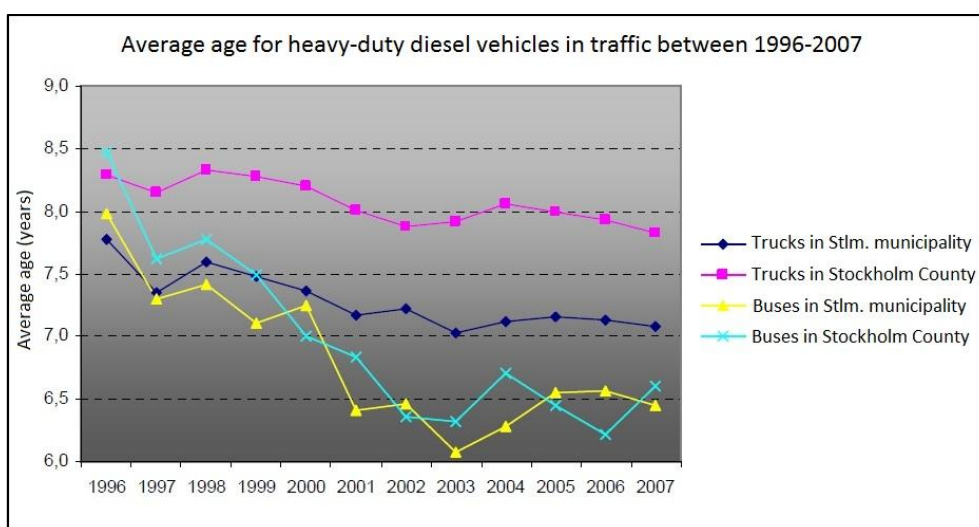


Figure 16: The average age for heavy diesel vehicles in traffic between 1996 and 2007 (Trafikkontoret, 2008)

The proportion of newly registered heavy duty diesel vehicles in the municipality of Stockholm and Stockholm County between 1996 and 2007 is shown in **Figure 17**. The proportion of newly registered buses in the Municipality is the largest and most variable, between 10 and 30%. It could be due to the fact bus contractors make major contracts where parts or whole fleets are replaced simultaneously. The freight transport industry consists of smaller actors who buy a few trucks at a time. It must

not be ignored, though, that some of the vehicles may have not been registered and used immediately after their purchase, so they could be older models than the year of registration.

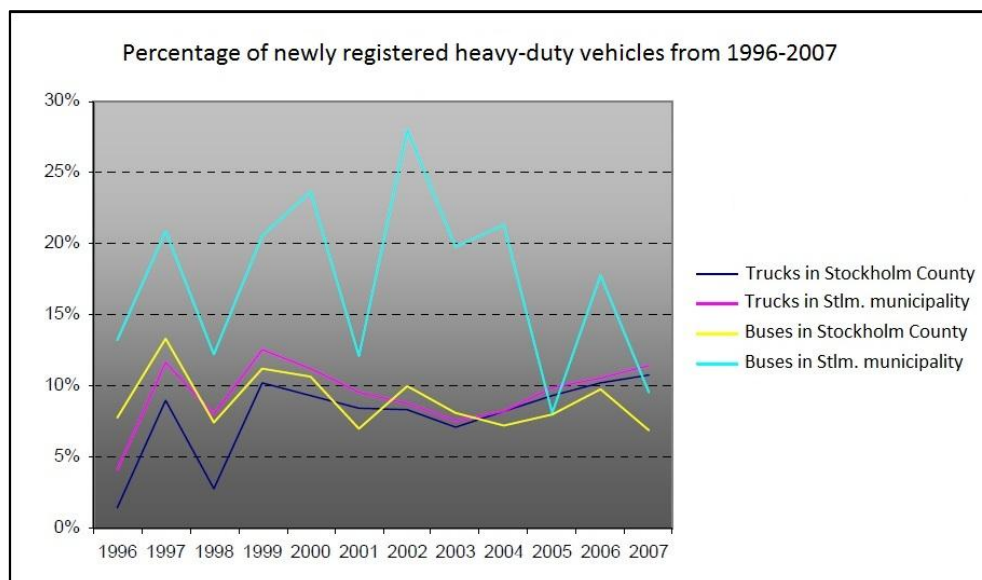


Figure 17: Percentage of newly registered heavy-duty diesel vehicles from 1996 to 2007 (Trafikkontoret, 2008)

Environmental Impact

The emissions that are related to each Euro class can be seen in the following table:

Euroklass	Datum	CO	HC	NOx	PM
Euro I	1992 < 85 kW	4,50	1,10	8,00	0,61
	1992 > 85 kW	4,50	1,10	8,00	0,36
Euro II	1996.10	4,00	1,10	7,00	0,25
	1998.10	4,00	1,10	7,00	0,15
Euro III	1999.10	1,50	0,25	2,00	0,02
	2000.10	2,10	0,66	5,00	0,10/0,13*
Euro IV	2005.10	1,50	0,46	3,50	0,02
Euro V	2008.10	1,50	0,46	2,00	0,02
Euro VI	2013.04	1,50	0,13	0,40	0,01

Table 8: Emissions for diesel engines according to European standards [g/kW⁴] (Trafikkontoret, 2008)

To watch the environmental impact of the Environmental Zone, emissions of particulate matter (PM), hydrocarbons (HC) and nitrogen oxides (NOx) were measured in 1997 and 2000. The methodology used was different in each case.

During the first year of operation of the Environmental Zone:

- Particulate matter emissions decreased by 15-20%
- Hydrocarbon emissions decreased by 5-9%
- NOx emissions decreased by 1-8%

The estimates made in 2000 showed that:

- Particulate matter emissions decreased by 40% compared with a situation without an Environmental Zone
- Hydrocarbon emissions decreased by 25% compared with a situation without an Environmental Zone
- NOx emissions decreased by 10% compared with a situation without an Environmental Zone

The impact estimated for the first year of the operation of the Zone (1996-1997) was not as big as expected. The reason is that most of the users chose engine replacement instead of control devices, vehicle fleet was not so old as had been assumed in the preliminary calculations and vehicles that were purchased were not the latest model.

The latest study on the impact of the Environmental Zone was conducted in 2007 (Trafikkontoret, 2008). The methodology used to estimate the reductions is based on four different scenarios:

1. The real emissions of the actual heavy duty vehicle fleet of the city of Stockholm
2. The emissions that would correspond to a vehicle fleet with the characteristics of the fleet of the wider Stockholm County
3. The emissions that would correspond to a vehicle fleet with the characteristics of the fleet of the whole of Sweden
4. The emissions that would correspond to a vehicle fleet with the characteristics of the fleet of Sweden without the cities that have an Environmental Zone (Stockholm, Göteborg, Malmö and Lund in 2007)

So, if one wants to estimate the environmental impact of the Environmental Zones should directly compare the results of the first and the last scenario. The estimated emissions of hydrocarbon, nitrogen oxides and particulate matter can be seen in the following figures.

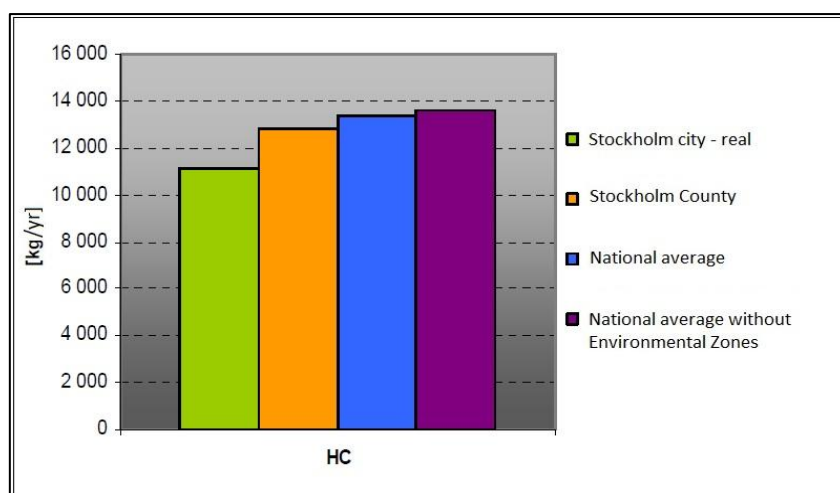


Figure 18: Emissions of Hydrocarbon from heavy trucks in the Environmental Zone in 2007 (Trafikkontoret, 2008)

In the first **Figure** we can see that the hydrocarbon (HC) emissions in 2007 in the Stockholm Environmental Zone were about 11,000 kg. The estimates for a heavy duty vehicle fleet (>3,5 ton) with the characteristics of the Stockholm County fleet would be just under 13,000 kg. The estimates for a heavy duty vehicle fleet with the characteristics of the whole Swedish fleet would be just over 13,000 kg. And the estimates for a fleet that would look like what the national fleet would be without the Environmental Zones are almost 14,000 kg.

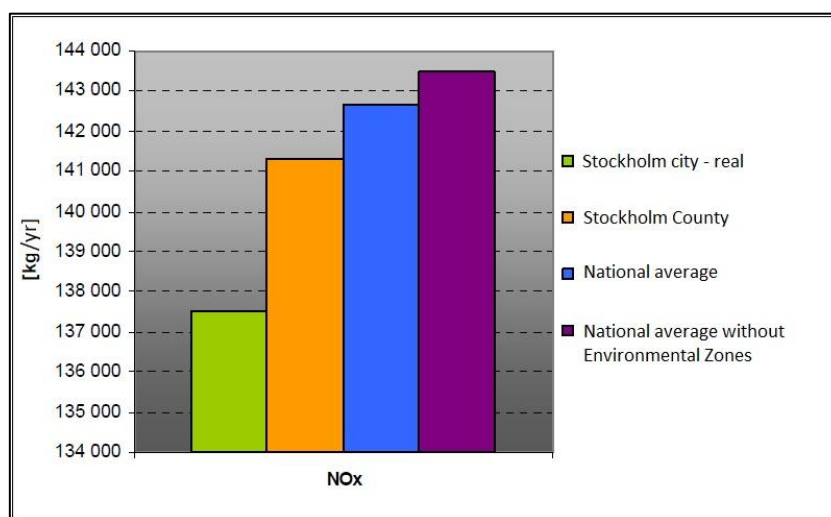


Figure 19: Emissions of nitrogen oxides (NOx) from heavy trucks in the Environmental Zone in 2007 (Trafikkontoret, 2008)

Figure 19 shows the emissions of nitrogen oxides from heavy goods vehicles in the Stockholm Environmental Zone in 2007. Emissions in the city of Stockholm were more than 137,000 kg. Emissions from vehicles similar to the Stockholm County ve-

hicles would be approximately 141,000 kg. Emissions from vehicles similar to the average Swedish vehicles would be approximately 142,000 kg. Emissions from vehicles similar to the average Swedish vehicles, without including the Environmental Zone cities, would be 143,000 kg.

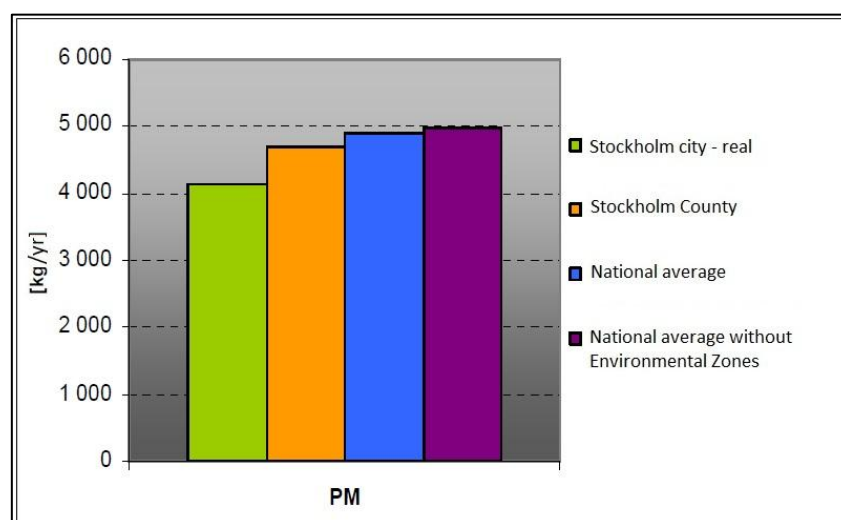


Figure 20: Emissions of particulate matter from heavy trucks in the Environmental Zone in 2007 (Trafikkontoret, 2008)

Figure 20 shows emissions of particulate matter (PM) from heavy trucks in the Environmental Zone in 2007. Emissions for the Stockholm City vehicle fleet were about 4,000 kg. Emissions from a fleet similar to the Stockholm County fleet would be approximately 4,500 kg. Emissions from a vehicle fleet similar to the average Swedish fleet would be just below 5000 kg. Emissions from a fleet similar to the average Swedish fleet would be almost 5,000 kg.

Summing up the results of the 2007 impact assessment, the Environmental Zone in Stockholm reduced emissions of nitrogen oxides by 3-4%, hydrocarbon by 16-21% and particulates by 13-19%, compared with a situation without the Zone.

The above results are bound to some great uncertainties in the type of data used. Calculations are based mainly on statistics of the number of registered vehicles and the average mileage in Stockholm, but the vehicle can be registered at an address, moving in a different geographical area. There are thus no data on which vehicles are actually operating in the Environmental Zone and the proportion of their total mileage carried out in the Zone.

Conclusions

Some issues that were pointed out by the Trendsetter project had to do with the need to change the national laws, which had often been a barrier to the Environmental Zone implementation. Other barriers in Stockholm have been the procurement laws imposed by EU directives and the case law, which has slowed down the implementation process considerably.

The Environmental Zone clearly forces new technology on the market by encouraging the purchase of cleaner or upgrading vehicles, which has noted effects on nitrogen and particle emission and concentrations. An advantage to this is that the operation cost is put upon the polluter. Thus the Environmental Zone follows the “polluter-pays” principle (Rapaport, 2002).

The City of Stockholm is considering possible further developments of the Environmental Zone. The focus is drawn to the possibility of including restrictions for cars without catalytic converters and commuter routes, and also adding stricter environmental requirements to the existing ones. Passenger cars and light trucks/buses could be included. Other restrictions may concern specific streets and also there should be some stimulation of an early introduction of newer vehicles and requirements for transport plans for larger businesses.

The City of Stockholm has currently (2007) no plans of widening the Environmental Zone area. Earlier thoughts about including the newly built (planned to be completed in 2017) area of Hammarby Sjöstad, are no longer considered. Stockholm City can propose changes in the regulatory framework but has no right to take decisions (Trafikkontoret, 2008).

The example of Stockholm and the other Swedish cities has been followed by many other cities around Europe and around the world. Different names, like “Low Emission Zones” or “Clear Zones” have been given to similar practices (Civitas Trendsetter, 2002). These strategies have proved their success in mitigating the negative impacts of urban freight transport.

4.2.2. The Congestion Charging System

Introduction

The Congestion Charging System was introduced as a demonstration project, with the name 'The Stockholm Trial', from January 3 till July 31, 2006. It included a road toll scheme, formally a tax decided by the national parliament, supplemented by extension of public transport services from August 22, 2005 to July 31, 2006.

The stated purpose of the Trial was to test whether the efficiency of the traffic system can be enhanced by congestion charges. The toll was expected to reduce congestion, increase accessibility, and improve the environment. The targeted traffic reduction across the cordon was of 10-15%. This target was based on previous studies on the design of road toll schemes in Stockholm.

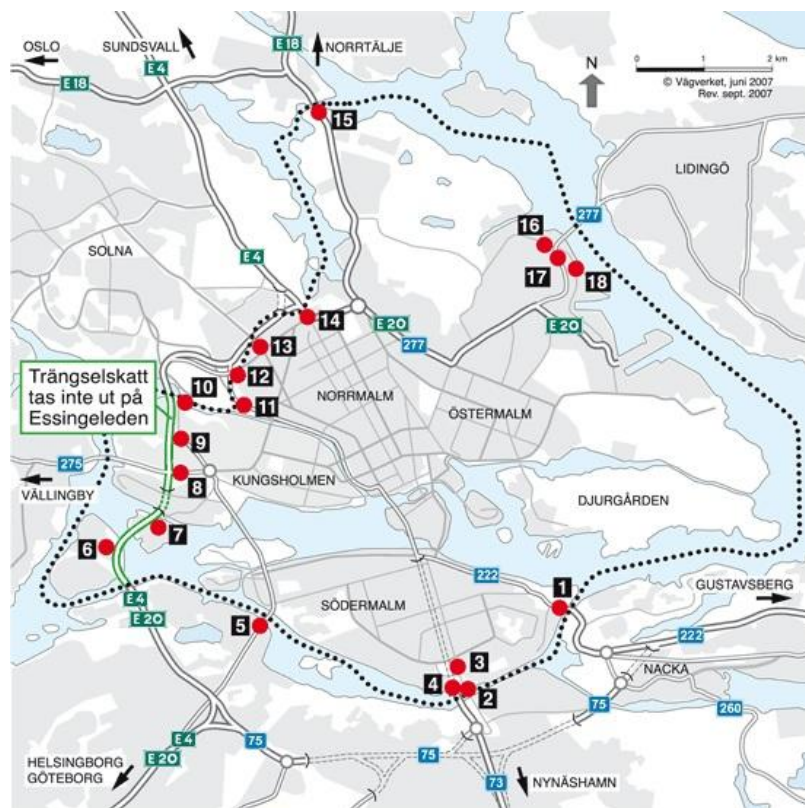


Figure 21: The Congestion Charging area and checkpoints (Transportstyrelsen, 2010)

The area of the toll zone is about 45 square kilometres. The zone has a little less than 300,000 inhabitants, of which approximately 60,000 commute to workplaces outside

the zone. The zone also has 23,000 workplaces, employing approximately 318,000 persons, of which more than two-thirds are commuting from outside the zone.

The Trial turned out to be a milestone in the development of urban road pricing, as it was the third full-scale demonstration of an urban congestion charge, after Singapore and London. It achieved to change the general public opinion in favor of tolls. This finally resulted in the implementation of a permanent scheme from August 1st 2007, following a referendum vote. A similar congestion charge is also planned for the city of Göteborg for the year 2013

Project Description

The “full-scale trial in Stockholm” was conducted in an attempt to reduce congestion and improve the environment. It included the trial implementation of a congestion tax, expanded public transport services and more park and ride facilities near city access roads. Principal players involved were the City of Stockholm, Stockholm Transport (SL) and the Swedish Road Administration (SRA).

The objectives of the full-scale trial were (Vägverket, 2006):

- to reduce traffic to and from the city by 10 – 15 % during rush hour
- to achieve a better level of service in Stockholm city traffic
- to reduce the emissions of carbon dioxide, nitric oxide and particulate matter
- to offer a better urban environment for the residents

The City of Stockholm was responsible for coordination with other municipalities and for providing general information about the full-scale trial, such as why it was being conducted. It was also responsible for surveys and evaluations. Stockholm Transport was responsible for the expansion in public transport during the trial period as well as for the construction of park and ride facilities and information related to this. The Swedish Road Administration was commissioned to build and operate the system for the congestion tax, including the collection of the tax and public information on this regard.

On June 2, 2003 the Stockholm City Council passed a decision to conduct a trial implementation of environmental charges in the Stockholm inner city zone. A special Environmental Charges Secretariat was set up for investigation, coordination and information purpose. The inquiry concluded that congestion charges had to be collected as a state tax, as it is stated by the Swedish law that a charge can only be levied when the payer receives something in return. Due to the fact that the payment only provided the right to use existing infrastructure, the congestion charge was con-

sidered to be a tax. Further, as a municipal authority was not allowed to tax anyone other than its own inhabitants, the congestion tax had to be a state tax.

The Congestion Tax Act (2004:629) was issued on June 17, 2004 after being approved by the Swedish Parliament. The Swedish Road Administration was commissioned to ensure that it had contracted the necessary equipment by the 1st of September 2004. Preparations for the full-scale trial initiated in April 2005. The extended public transport became active on August 22, 2005 and the Congestion Tax was implemented on January 3rd, 2006.

The Congestion Tax in Stockholm was the second in the world to be based on a time-differentiated scheme, after Singapore. It was active on working days from 6:30 a.m. to 18:29 p.m. and followed the amount variation that is shown in the following table:

Time	6:30-6:59	7:00-7:29	7:30-8:29	8:30-8:59	9:00-15:29	15:30-15:59	16:00-17:29	17:30-17:59	18:00-18:29
Tax (SEK)	10	15	20	15	10	15	20	15	10

Table 9: Tax amount per vehicle crossing (Transportstyrelsen, 2010)

The same time-variation was kept after the permanent implementation of the Congestion Charge in 2007, and the maximum tax amount per vehicle per day is 60 SEK. There is no Congestion Tax during weekends, public holidays (and the day before) and July.

Passages which are subject to tax made by a vehicle during one month are aggregated in the form of a tax decision and the amount is to be paid in arrears. The Swedish Transport Agency will send a payment slip to the owner of the vehicle at the end of each month. The payment slip will also include information about the number of passages and the amount per day. The tax must be paid into the Swedish Transport Agency's congestion tax account no later than the date stated on the payment slip. If the tax is not paid on time, a surcharge of SEK 500 (€ 53) will be made.

Exemptions from the Congestion Charge

The following vehicles are exempted from the Congestion Charge:

- emergency service vehicles
- buses with a total weight greater than 14 tons

- diplomatic cars
- motorcycles
- vehicles registered abroad
- military vehicles
- 'green' vehicles running completely or partially on electricity or gas other than LPG or on a fuel blend consisting primarily on alcohol

Especially the exemption of green cars was planned to cease after August 1st, 2012, but a new rule ceased the exemption of green cars from the congestion tax if they are registered after January 1st, 2009. The main reason for this alteration was that the percentage of green cars grew very rapidly and threatened the congestion-reducing ability of the charges. 'Green cars' are considered those that have been certified to be able to use any of the following fuels: bio gas, E85, ethanol, electricity, producer gas, methane, methanol, natural gas or hydrogen (Transportstyrelsen, 2010).

Finally, an exemption, known as the 'Lidingö rule', is made for vehicles that pass two different control points within 30 minutes, one of which must be a control point at Gasverksvägen, Lidingövägen or Norra Hamnvägen. This exemption had to be made because the island of Lidingö (approx. 30,000 inhabitants) in the northeast of Stockholm is only connected to the rest of Sweden by a road that goes through the toll cordon. Essingeleden, the western relief road is also free to move through the charge cordon.

The Technical System

The development, construction and operation of the technical system were contracted to IBM Svenska AB, which in turn engaged a number of sub-contractors. With only 14 months of preparation time available, the system was built and ready to function on the appointed day.

Eighteen control points have been set up at Stockholm city entrance and exit roads. Vehicles are registered automatically both on the way in and out of the inner city zone. The traffic flow is not affected as drivers do not have to stop or slow down when crossing a control point. There are two ways to identify vehicles:

- through photographing their number plates, or
- via the onboard unit, for those vehicles that have one.

The congestion tax system consists of four principal components:

- roadside equipment to collect passage information

- pre-processors, to process the information from the control points and generate tax decisions
- a business process platform, to book tax decisions, handle payments, reminders and reports
- a web portal – with both a public website and an Intranet for the benefit of the Customer Services and the National Tax Board.

The technical equipment at a control point is installed on three gantries or columns above the carriageway and in a control cabinet at the side of the road. Cameras for photographing the rear and front number plates are installed on the first and third gantry, respectively. Laser detectors and transceiver aerials for vehicle identification via the onboard unit are mounted on the middle gantry.

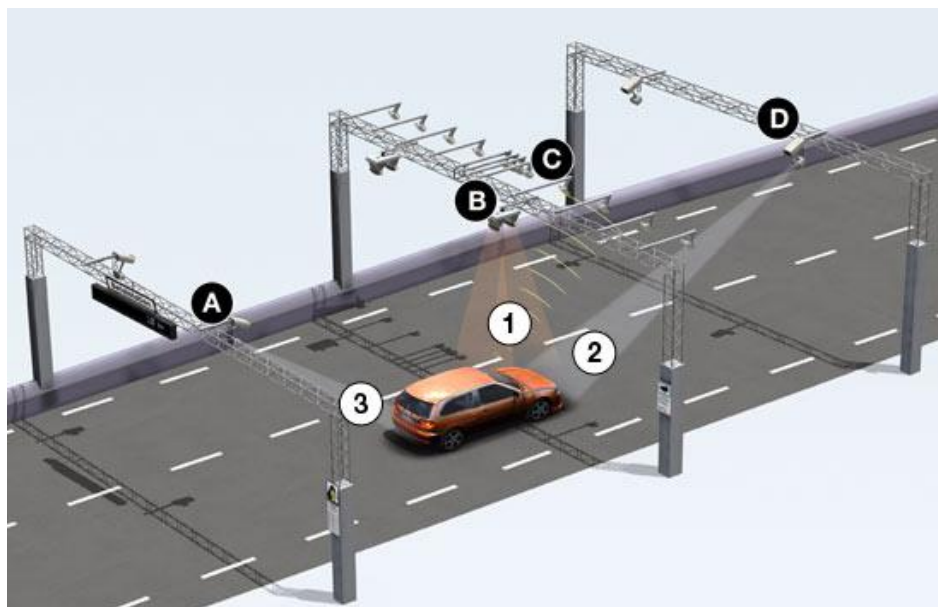


Figure 22: Roadside equipment. A. Cameras for rear number plates, B. Laser detectors, C. Transceiver aerials, D. Cameras for the front number plates. 1. The aerials transmit a signal to the onboard unit and receive information to identify the vehicle, 2. A photograph of the front number plates is taken using infrared technology, 3. When the vehicle has driven past the second laser beam the rear number plates are photographed (**Transportstyrelsen, 2010**)

The information from cameras, laser detectors and onboard units is sent to the Multi-Lane Controller (MLC) unit in the control cabinet at the roadside. There the vehicles' passage information is packaged in a file that is forwarded to the pre-processor. The pre-processor processes the files from the control points and generates a tax decision for every vehicle. If the pre-processor cannot identify automatically the number plates, the images are sent for manual identification. For privacy reasons, the photos show only a small part of the car around the plates, and not the passengers and the cabin.

For every vehicle subject to the tax, the various amounts for crossing control points during the day are added up to generate a tax decision, which cannot exceed the amount of SEK 60 per day. Then the tax decisions are sent to the business process platform for handling. Passage information is stored in a database until the tax is paid and the case is closed. The business process platform also generates the reminders sent to vehicle owners who have not paid in time.

The system has worked out brilliantly so far, managing to handle traffic data without losses at a percentage of 99.997% for 82 million vehicle passages in 2008. This level of capacity shows that only a catastrophic failure such as a sustained power outage at a payment point could result in any loss of data.

An important tool for communicating with the public has been the creation of the full-scale trial website (Stockholmsförsoket, 2010), which was replaced by the Swedish Transport Agency's website (Transportstyrelsen, 2010). In the page 'Mina skattebeslut & Preliminära dygnsbelopp' ('My tax decision & Provisional daily amounts') vehicle owners can find information about their own current tax decisions and how to pay them. Onboard units can also be ordered from this website.

Customer Services have also been in use for giving the public an opportunity to find quick answers to their personal questions and matters. A peak of 10,000 phone calls a day was reached during the first months of the trial period.

Traffic Effects

Based on traffic simulations made before the trial a 10-15 % reduction of the number of vehicles crossing the cordon was expected during the charging hours. To make these changes measurable, the traffic data of 2005 (before the charges) were collected and compared with the later measurements (with the charges).

Traffic effects appeared immediately (**Fig. 23**), reducing traffic across the charging cordon by approximately 30 % during the first week, before settling down at a surprisingly stable decrease of about 22 % less traffic than the corresponding periods of 2005. When charges were abolished, August 1st, 2006, traffic immediately jumped back to almost its old level. In fact there was a remaining traffic decrease of about 5-10 % compared to 2005 (Eliasson, 2008).

The exact size of the residual effect is uncertain, since data from the period August 2006 to July 2007 (from the end of the trial to the reintroduction of the charges) are less reliable due to road works and technical problems with the measurement equipment. The reason for the residual traffic decrease is not certain and it should not be found in factors such as changes in fuel prices, because they are too small to

cause such a large decrease. It is possible that some car users developed new travel habits during the trial, which remained even when the trial was over.

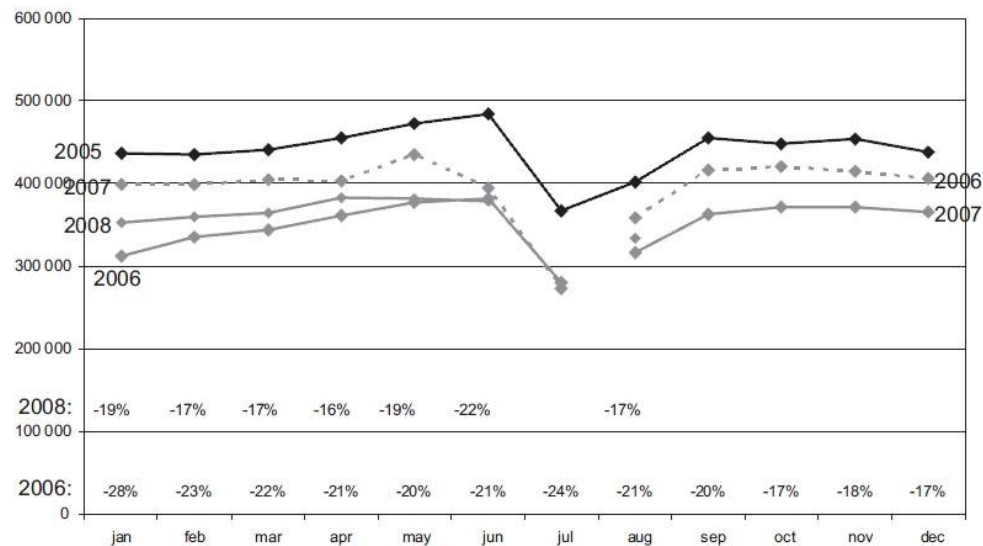


Figure 23: Average number of vehicle passages across the congestion tax cordon between 06:00 and 19:00. Dashed lines indicate the periods without charges. The percentages at the bottom are traffic decreases relative to 2005 (Eliasson, 2008).

Since the re-introduction of the charges in August 2007, traffic has once again decreased and stabilized around 18 % compared to 2005 levels. The paper of Eliasson (2008) explains this small traffic increase (compared to -22% of the 2006 trial period) by increasing population and car ownership, a steadily increasing share of exempted alternative-fueled cars (from 3 % during the trial to 13 % during 2008), and by inflation which caused the average charge to drop in real terms. The paper also points out that this increase would not have been possible without the charges, due to road capacity constraints. However, the official traffic analysis of the Traffic Office finds that there is no traffic increase between 2008 and 2009, and therefore, identifies an “unusually large reduction of traffic during the first months of the trial in 2006, rather than a significant increase of traffic since that time” (Trafikkontoret, 2010). This large reduction during the trial can be explained by bad weather conditions during the winter, and by a difficulty for the drivers to adapt to the new system and understand it.

The percentage of passages of vehicles that were exempt from the tax grew steadily to reach 28% in autumn, 2008. It was mainly the alternative fuel vehicles that were responsible for this increase (from 3% in 2006 they reached 13% in 2008) and, since

they were putting the anti-congestion effectiveness of the charges at risk, the administrators of the charges had to cease exempting those vehicles in 2009.

The number of vehicle kilometres driven in the inner city was reduced by around 16%. Outside the inner city, on the outlying approach roads and outlying streets, traffic volumes fell by just over 5 %.

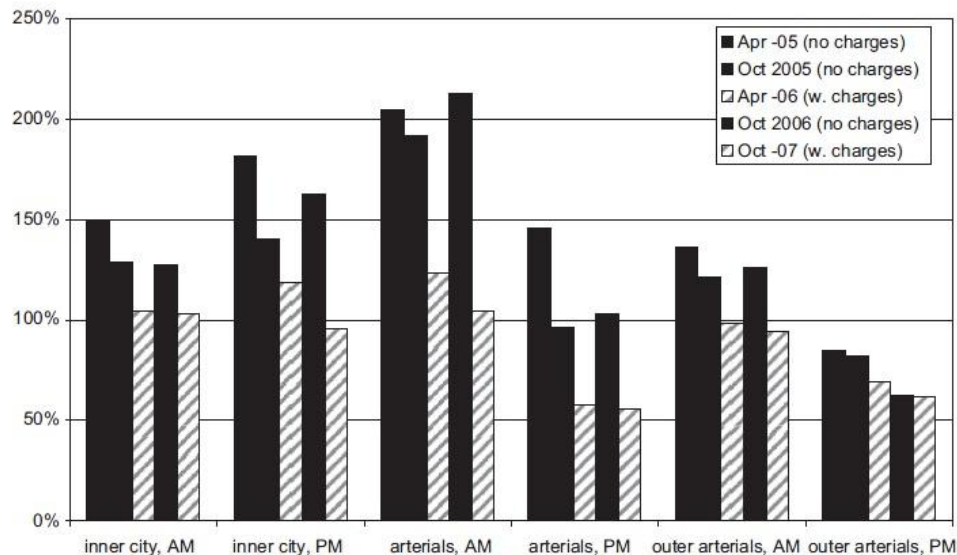


Figure 24: Average travel time increase over free-flow travel times for various categories of links, April and October 2005-2007. Striped columns are periods with charges. (Eliasson, 2008)

Even more dramatic than the reduction in the number of vehicles was the reduced congestion, especially on the approach roads, but also in the inner city. **Figure 24** presents increases in travel time over free-flow travel time, also called the ‘congestion index’: 0% corresponds to free-flow travel time, while 100% corresponds to twice the free-flow travel time. The congestion index is averaged over different road categories: the inner city, inbound arterials near the cordon and inbound arterials further from the cordon. Measurements are taken from all weekdays for six consecutive weeks for five different time periods: April and October 2005 (before the charges), April 2006 (during the trial), October 2006 (after the abolishment of the charges) and October 2007 (after the reintroduction of the charges). “AM” refers to the morning peak 7.30-9.00 and “PM” refers to the afternoon peak 16.00-18.00. Periods without charges appear dark grey and periods with charges have grey stripes.

The effects in congestion were much greater than expected. Eliasson (2008) stresses the “astonishment of seeing almost empty streets during rush hours”. This also

played a huge part in enhancing public acceptance of the charges and literally turning public opinion in favor of them, as the effects were so visible. The press also covered this effect enthusiastically.

There is lack of data to support any definitive analysis on the charges' influence on traffic safety. The congestion charging cannot be held responsible for any change in traffic accidents, although it increased average speeds by reducing congestion. Research remains to be made on this field.

Effects on Commercial Transport

The impact of Stockholm's congestion charging on commercial transport is difficult to evaluate, because the initial targets of the charges did not include improving goods distribution's efficiency. Since there was no such objective, there was also no need for monitoring and measuring this impact. Therefore, there is a surprising absence of data and research related to how and if commercial transport was affected by the charges. The only two studies available concern the Stockholm Trial and no research has been done since the charges' permanent implementation in 2007.

There is one study (Transek AB, 2006a) that measured the impact of the Stockholm Trial on different vehicle categories, by comparison to data from 2004. It showed that the light truck traffic had declined by 22% and heavy truck traffic had declined by 13%, between 2004 and 2006. However variations on the different city entrances were significant. For example light trucks that went through Mariebergsbron increased by more than 50% during the Trial. In total commercial traffic accounted for 22% of the total passages through the tax cordon, in 2006.

An interview-based study (Transek AB, 2006b) with truck drivers and transport companies was carried out during the Stockholm Trial, and provides a good view on how the charges were perceived by the freight transport sector. The study held interviews with drivers and management from three major transport companies that operate in and around the area of the charges cordon. The study provided the following results:

- The congestion charges improved accessibility for distribution vehicles in the inner city. The greatest change was noticed around noon, from 10:00 to 13:30 (see **Figure 25**).
- The total annual number deliveries remained unchanged, but the deliveries were made faster, increasing each vehicle's productivity by 25 percent.
- There have been changes in route selection. Bergshamraleden and Tranebergsbron are no longer preferred, due to increased congestion. A newly preferred street is Klarastrandsleden.

- The average speeds measured were unchanged in some routes, reduced in some junctions and increased in some other parts. The measurements were made for a trip from the Lund industrial area to Stockholm centre and cannot give general results.
- The transported weight increased by about 7 percent since the previous year, but this could equally be due to the economic boom or actions of individuals. The total number of deliveries remained unchanged but the number of deliveries per hour increased by 25 percent (from 4 to 5).

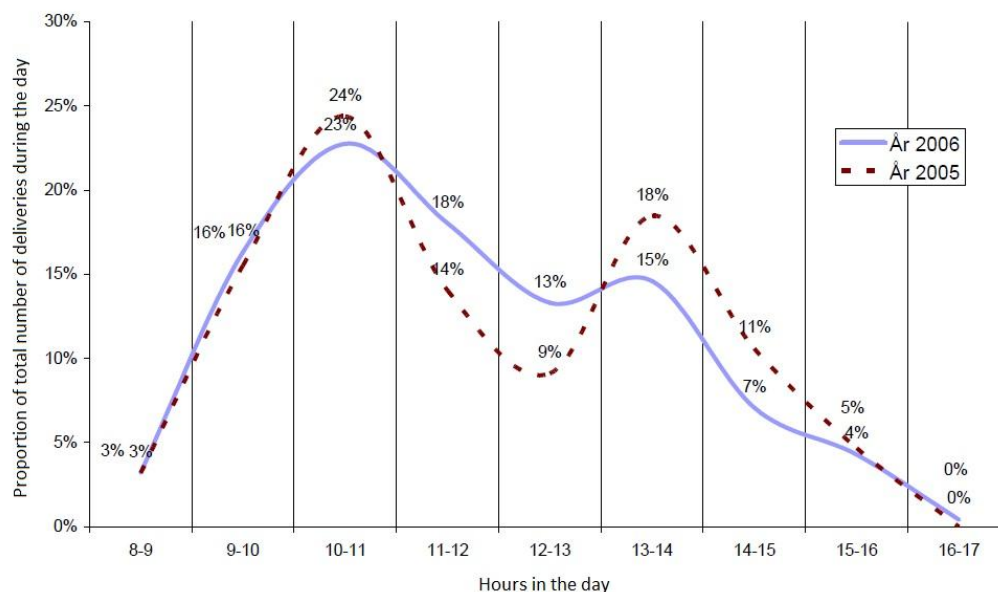


Figure 25: Freight deliveries in the inner city during the day. (Transek AB, 2006b)

The opinions expressed by the drivers and management were quite uniform and are listed below:

- Transport to and in the inner city was made easier at the beginning of the Trial, because of reduced traffic congestion.
- The problem with cars parked on loading/unloading zones remained the same.
- Transport through Essingeleden, Tranebergsbron, Bergshamraleden, Järva krog, Stäketleden and Södra länken was delayed.
- Transport speeds have increased in some entrances, such as Kista-Norrtull.
- The transport industry was undergoing a renaissance and any impact on the number of shipments cannot be securely related to the charges.

- The biggest problem reported by the transport companies was the administration of the tax payment. They had to make different payments for every different vehicle, instead of registering the entire fleet together.
- Apart from the new tax they had to pay, an additional cost was created by increased traffic in previously uncongested roads.

The average company's cost created by the congestion tax was between 1,500 and 2,000 SEK per day or 210,000 SEK for the whole Trial period. Extra administrative costs of dealing with transponders, controlling the tax and other extra work were estimated at 100,000 SEK. Thus, the total costs of the congestion charge for a transport company during the seven months of the Trial were around 300,000 SEK (or € 32,000).

However a study of equity effects of the Stockholm Trial showed that commercial traffic (regarded as a group) has a net gain even before any share in revenues (Transek AB, 2006c). The value of travel time gain is (on average) higher than the congestion tax paid (**Figure 25**). According to this study, the adaptation costs are so low that they do not show up in the chart.

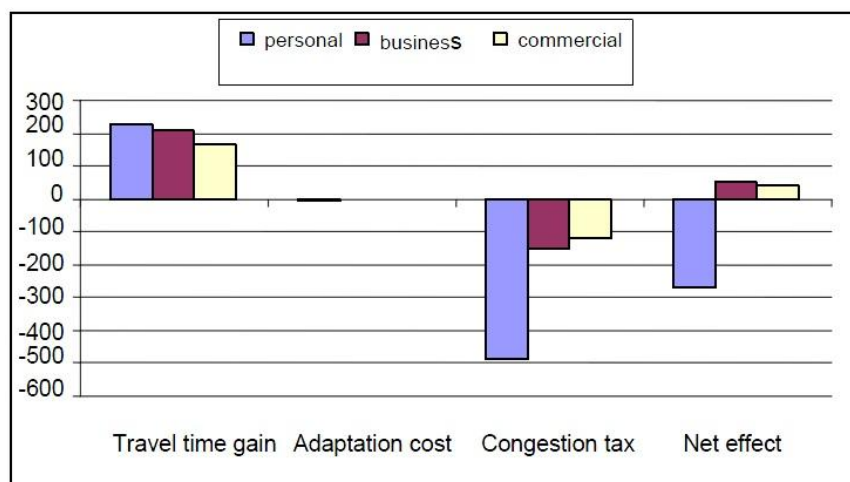


Figure 26: Direct road-user effect for personal, commercial and business travel in SEKm/year (Transek AB, 2006c)

The Environmental Manager of Schenker Åkeri AB (one of the companies interviewed in the second study) argued that the company will save 38 vehicles per day in the inner city because of the increased accessibility. Other truck operators consider it unfortunate that there are no environmental initiatives for heavy transport. Although there are no green vehicles on the market, there should be the possibility to reward high standards vehicle fleets.

In general the transport companies did not notice any direct impact of the congestion tax on the business. They were initially positive about the congestion relief during the first three months of the project, but later on, they noticed an increase of congestion to the old levels. Overall, they were not satisfied by the Stockholm Trial, mainly because of the administrative issues related to the payment of the taxes (Transek AB, 2006b).

However it is possible that these administrative problems of the tax payment might have been eliminated by the introduction of automatic Direct Debit payments. The fleet owner can create a prepaid account for all the vehicles of his fleet and have the congestion tax paid automatically. It is also possible to choose from two different modes of tax announcements:

- Single notifications – an .avi or EDI file per vehicle
- Collective notifications – a collective .avi or EDI file containing the total for all vehicles registered in one or more organisation's account or branch account.

It needs to be further investigated if these modifications have eliminated the administrative problems faced by transporters and reduced the extra administrative costs.

Opportunities for Evening Distribution

An interesting pilot project investigating evening distribution in the district of Östermalm began in November 2005. The project was initiated by the Dialog Forum "Framtida Handel" which is mentioned in the introductory section of this chapter. The evaluation of the results has been carried out by Chalmers Energy Centre CEC.

Two wholesale companies were involved in the project. The original plan was to choose delivery times between 17:00 and 20:00 in the evening. However, in most cases the actual delivery times were between 16:00 and 18:00. The main reason for this was lack of flexibility from the retailers' side.

The main results of the pilot project can be summarized as follows (Franzén and Blinge, 2007):

- There was a clear reduction of the trip time by about 10 minutes (total trip duration: 85 minutes), during the congestion charging scheme.
- There was a clear reduction of trip time to about 15 minutes for evening distribution (18-20 pm) compared to afternoon distribution (14-18 pm).
- The estimated environmental impact was at least 20% lower per vehicle during the project. The impacts are related to the average speed of the vehicles.
- It is easier for the drivers to unload the vehicles at the specific loading bays outside of morning hours, as there are fewer competitive vehicles around.

However, the number of passenger cars parked (wrongly) in loading zones along the streets was higher. Overall, it is less stressful for the drivers.

- The success with evening distribution is dependent on the attitudes of the shop keepers.
- Another key issue is the ability of the transport company to effectively plan new routes during evening hours.

The project ended in November 2006. The project offered valuable knowledge on the issue of off-peak-hours distribution in Stockholm. No data was found to indicate that similar activities were carried out after this project, and since the permanent implementation of the charges.

Environmental effects

Changes in road traffic patterns have affected the emissions of pollutants. The proportion of alternative-fueled vehicles on the total number of vehicles has increased from 3% during 2006 to 14% at the end of 2008. In fact, exemption from the congestion tax was the single most significant incentive for those buying alternative fuel cars. Alternatively fueled buses also increased from 6% to 38% for the same period.

Out of the total vehicle kilometres travelled in the City of Stockholm, the proportion of alternative fuel vehicles has increased from 4% in 2006 to 10% in 2008. Petrol-fueled vehicles have decreased, while diesel fuel vehicles have increased. The proportion of heavy traffic (buses and trucks) has remained unchanged during 2006-2008. Among the heavier trucks, alternative fuel vehicles only make up a couple of percent.

During the Trial, CO₂ emissions originating from motorized vehicles in the inner city fell by between 10 and 14 percent as a result of the congestion tax. Reductions of a further 4 percent have been estimated since the permanent implementation of the congestion tax.

Carbon monoxide emissions have dropped about 15% between 2005 (without tax) and 2008 (with tax). Particulate matter (PM₁₀) emissions in the inner city have dropped by around 15 to 20 percent with the tax. Nitrogen oxides have decreased by around 10 percent for the same period.

In the case of particulates, PM₁₀, the increase in clean vehicle fleet is indifferent, because they originate from road surface wear due to studded tyres. The drop in their percentage noticed during the measurements could be due to meteorological conditions, and not due to the congestion tax.

It is not very clear exactly how much is the contribution of the congestion charges to environmental improvements in the city, but it can be said that: i) emissions have declined faster than what they would have done otherwise, due to more alternative fuel vehicles, and ii) traffic volumes have been somewhat lower during periods of congestion charge (SLB-analys, 2009).

Conclusions

Transportation systems worldwide are undergoing a shift from supply side techniques to demand management. The reason for this is that “we can’t build our way out of congestion” (Replogle, 2006). On that ground, the Congestion Charging system is turning out well for Stockholm. The cost-benefit analysis (Eliasson, 2009) shows that the system will have recovered its investment cost in 4 years in terms of social benefits and in 3,5 years in financial terms. The achievements against congestion and pollutants emissions have been significant and on accordance to the targets that were initially set.

An issue that was raised from this research is that there has been hardly any evaluation of the charges’ impacts on freight transport, particularly since their permanent implementation in 2007. It is necessary that more research is carried out on this matter. It is not known if there have been changes on trucks’ travel patterns after the end of the Trial and after the permanent implementation. The pilot project with evening distribution showed that different logistics practices can be successfully combined. Success is more likely to occur when these practices consist parts of an integrated transport policy.

It should also be examined if the problem with tax payment still remains for the transport companies. It is likely that this problem has been solved with automatic payments by Direct Debit. Another problem that the drivers reported to be unaffected by the charges was illegal parking on loading zones. Other measures are necessary to deal with this.

However, the current view of these professional road users – the freight carriers – remains unknown. Three and a half years after the permanent implementation of the charges, it would be interesting at least, if not useful, to know the transporters’ opinion on this traffic management scheme, which after all, is still a recognized green logistics solution.

4.3 Logistics Strategies on district-level

4.3.1. Hammarby Sjöstad – Logistics Centres in a new urban area

Introduction

Situated not far from the inner city, the area of Hammarby Sjöstad was an entirely industrial area until the early nineties, and since then, it has been Stockholm's largest urban development project. The cornerstone of the project was to introduce an environmentally strong profile to a new mixed residential and office area.

As a result, Hammarby Sjöstad is now an exciting new district of Stockholm where urban intensity is contrasted with tranquil green areas and waterways. The area is generously provided for means of public transport, carpools, light rail trains and commuter boats. And it counts its own environmental programme for managing sewage, waste water and local energy production.

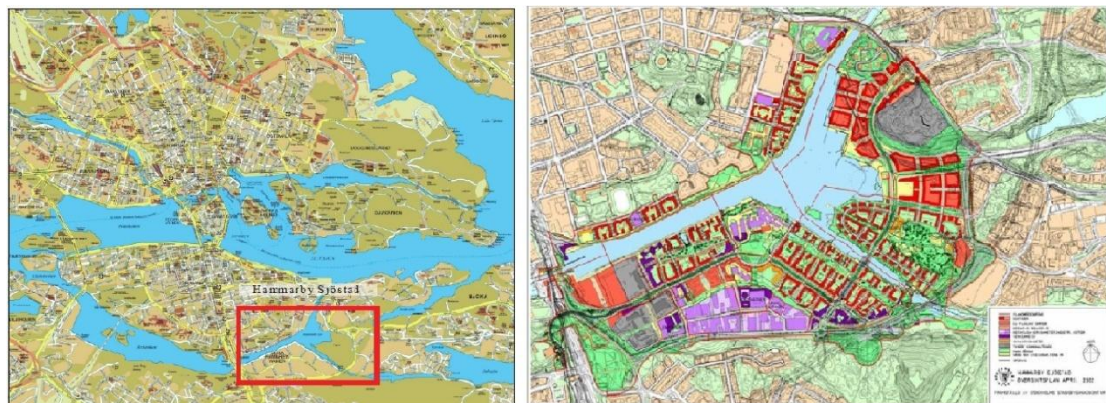


Figure 27: Location and overview of Hammarby Sjöstad (Poldermans, 2005)

Since day one, the City Council has imposed tough environmental requirements on the buildings, technical installations and traffic management in Hammarby Sjöstad. The overall environmental goal was that the impact placed on the environment by emissions from Hammarby Sjöstad should be a massive 50% lower than the corresponding level for newly constructed housing areas dating from the early 1990s in

Stockholm. This strategy has been known as “*dubbelt så bra*” (double as good) (Poldermans, 2005).

The plan involves an area of about 200 ha (2 km² of which 40 ha is water) between Skanstull and Danvikstull and concerns both areas north and south of the Hammarby lake (“Hammarby sjö”). The complete district will have around 10,800 apartments for 24,000 citizens and 290,000 m² for commercial use (new offices, light industry and retail). This plan kicked off in 1995 and should be realized in 2017. It was estimated to cost around 20 billion Swedish Crowns (around 2 billion euro), of which the City of Stockholm contributed 4 billion Swedish Crowns (some 400 million euro) (Exploaterings Kontoret, 2010).

Everyone living in Hammarby Sjöstad is part of an eco-cycle which handles energy, waste, sewage and water for both housing and offices. In this eco-cycle, combustible waste in the area is recycled as heat; food waste is converted into biogas; and energy is produced in a renewable fuel district heating plant in the area.

This eco-cycle which represents the core of the environmental and infrastructural planning was developed by the Stockholm Water Company, Fortum (energy company) and the City of Stockholm Waste Management Administration. It is known as ‘The Hammarby Model’, and can be seen in **Figure 28**.

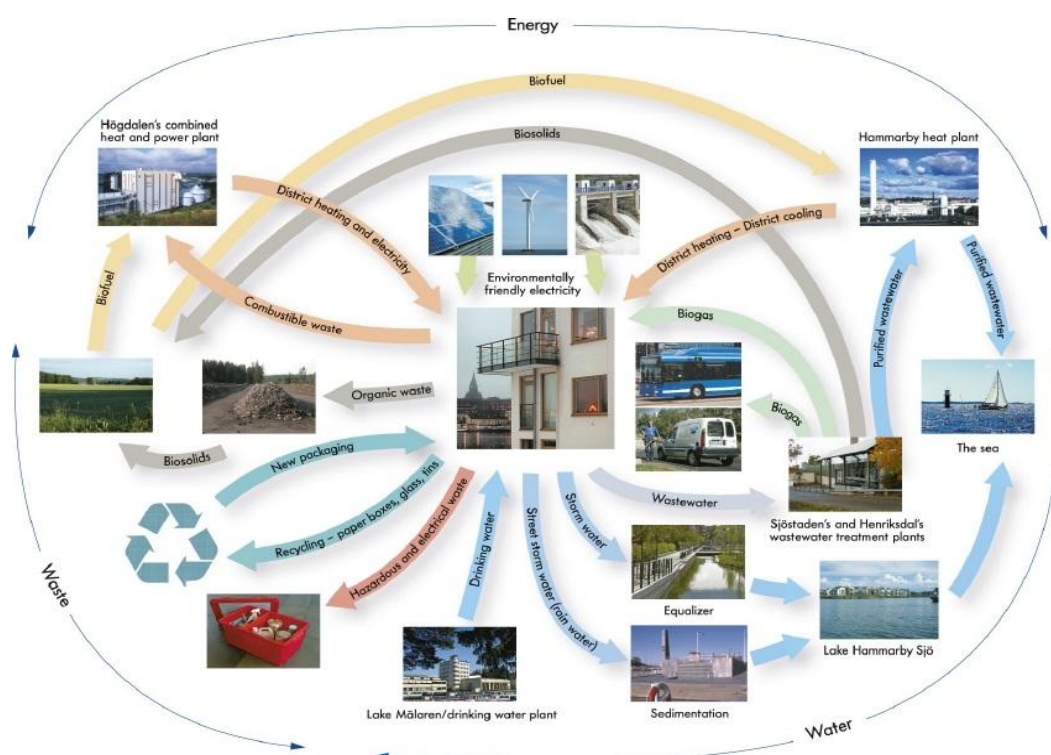


Figure 28: The Hammarby Model (Hammarby Sjöstad, 2010)

It shows sewage processing, energy cycles, refuse and the stations and plants where treatment takes place. The complex model also shows the importance of biogas for citizens: it is used in the kitchens and as fuel for cars and buses as well. This is an environmentally friendly solution which reduces emissions. The strong point of the model is its holistic approach to infrastructure service provision and its integration of otherwise separate systems in order to accomplish the environmental objectives set forth by the local parliament.

4.3.1.1. Construction Consolidation Centre (CCC)

The building process in Hammarby Sjöstad is a long and difficult process with a huge environmental impact for the surrounding area. Incoming heavy truck traffic during the peak period of the constructions was estimated as one truck delivery every 40 seconds. This peak period was expected to start in mid 2001 and last for five years (however the intensity of the construction works became lower after two or three years) (Persson and Bratt, 2001).

Thus a construction consolidation centre (CCC) was created in the entrance of the site and opened its gates on March 23rd, 2001. It received all small deliveries (less than four pallets) and stored the construction materials temporarily. Deliveries were then made with special vehicles to the different construction locations in accordance with the construction time plans. The centre was set up and operated over a 2.5 years. In December 2003 it was dismantled and moved into a building nearby to make room for new residential buildings (Ekerlund and Stuhmann, 2003).

The area inside the CCC was about 3,500 m² which were protected by alarm systems for the material storage. Outside the premises, about 4,000 m² were available for the CCC. Ten people were employed at the CCC. The vehicle fleet consisted of three trucks with a crane, one large heavy vehicle with a long crane, three forklifts and a pick-up vehicle.

The objectives with establishing the CCC would be to reduce the number of direct small deliveries to the site by approximately 80%. Without the CCC, the construction site would receive over 400 uncoordinated deliveries per day, or roughly 700 tons of construction materials into the area per day, during peak period. Furthermore, the traffic net was overloaded by the arrival of goods in lighter vehicles, the construction of a high-speed tramway in the area, and the traffic generated by approximately 4000 employees coming to work at the 400 businesses active in the area. Develop-

ers, contractors and subcontractors had to co-ordinate services to meet the established time schedules and environmental goals. At the same time the area should be viable for residents who had already moved in.



Figure 29: The Construction Consolidation Centre in Hammarby Sjöstad (Brisvall, 2002)

The CCC also aimed to increase the transport load ratio via collective deliveries when the lorry ratio would otherwise be low. As a complement, a technology procurement contest of traffic direction systems was conducted. Experience from the extensive reconstruction of the Potsdamer Platz in Berlin, where a traffic direction system was implemented, showed that environmental gains and significant time-savings are possible via efficient control of construction and goods traffic.

A task force was formed with representatives of all contractors, the LIP-Council and the Stockholm City Real Estate, Streets and Traffic Administration Office to collaborate in these issues.

In 2002 the City of Stockholm joined the Trendsetter project of the Civitas Initiative (see 4.1). Among the 20 Trendsetter measures that regarded the city of Stockholm, was the optimization of the Hammarby Logistics Centre operations, which constituted the Work Package 9.1 “Construction Materials”.

The objectives for WP 9.1 were (Civitas Trendsetter, 2006a):

- To decrease the number of small direct deliveries (fewer than 4 loading pallets) to the site by 80% through co-transportation
- Less traffic congestion in the construction site

- Improved living conditions at the site for new inhabitants
- Improved working environment
- To reduce energy use and emissions of CO₂, NO_x and particles.

The main problem was the large number of vehicles coming to the area and causing congestion. Decreasing the number of vehicles in the area would reduce congestion, improve the living conditions and the working environment in the area as well as reduce energy use and emissions.

A lot of space was needed for the materials storage and handling. This depended on almost no delivery coordination and a lot of material coming to the area at the wrong time. This material would get damaged and could cause bad indoor climate for the clients. The CCC provided temporary material storage in order to avoid all this.

A smart computer system was the tool for distribution of goods from the CCC. A web-based calendar was created to prevent traffic congestion. Each contractor who used the same road had their own community in the calendar where they scheduled their direct deliveries (which were not reloaded at the CCC) increasing the transparency of incoming deliveries among the contractors. This enabled all project managers to synchronise their orders and activities to other surrounding construction work.



Figure 30: Traffic guidance with smart traffic signs (Brisvall, 2002)

The CCC provided a traffic coordinator who supported the area. In case of congestion, the traffic coordinator had the possibility to send traffic info through SMS to

concerned contractors. This SMS also reached variable signs at the entrance of the area (see **Figure 30**). The coordinator also had the possibility to send SMS to contractor's mobile phones. The aim with this procedure was to avoid serious congestion inside the area and it worked out with great success.

The partners with the largest interest in the information were the ones with a building site at the most difficult position in the area, i.e. at the end of the roads. It was hard to make it work since the partners with easy access did not see the need of supplying their information to make it easier for the partners with more difficult access.

Environmental Impact

The table below shows the indicators used for the measures in the evaluation.

Indicator	Unit	Hammarby Sjöstad construction site	
		Without CCC	With CCC
Energy Use	<i>Joule/year</i>	1600 G	170 G
Emissions of fossil CO ₂	<i>Tons/year</i>	119	12.5
Emissions of NO _x	<i>Tons/year</i>	0.729	0.077
Emissions of PM	<i>kg/year</i>	12.3	1.3
Noise levels	<i>dB(A)</i>	55 dB(A) exceeded 360 times/day	55 dB(A) exceeded 260 times a day
No of trips (Total number of goods vehicles moving in the area)	<i>No or qualitative 5-degree scale</i>	360	260
Living conditions	<i>Noise hours</i>	55 dB(A) exceeded 360 times/day	55 dB(A) exceeded 260 times a day
Working environment	<i>Noise hours</i>	55 dB(A) exceeded 360 times/day	55 dB(A) exceeded 260 times a day
Vehicle km (Vkm) by vehicle type (peak/ off peak or total)	<i>Vkm per day</i>	64	26
Vehicle load factor	<i>%</i>	~50	85
Queuing time/stop time	<i>Minutes/trip</i>	~60	6
Small deliveries	<i>Vehicles/day</i>	219	169

Table 10: The measures with Trendsetter Common Indicators and WP Common Indicators used in the evaluation. (Civitas Trendsetter, 2006a)

Since there was no actual situation without the consolidation centre, only calculations with estimates and assumptions have been made for that scenario. The centre's computer system that stores delivery data (number of goods, the receiver and the sender of the goods) has been used for the scenario "with CCC". Counts were

made to get an overview of the total incoming transports to the area. Interviews were made with contractors, drivers and suppliers. Also case studies have been made. The information from the case studies is presented in a Master Thesis/Report (Ekerlund and Stuhmann, 2003) and the most important results are presented here.

Three scenarios are presented as diagrams: A situation with and without a CCC with two different consolidation levels; 2 and 6. Consolidation level 6.0 is the best situation for peak periods and is being compared in the table above.

Through this project there has been a reduction in the number of trips in the area by 12,500 during peak period (2.5 years = 700 days). This means a mean value in reduction of 20 trips per day during this period. During highest peaks there was a consolidation factor of 8, which means that 100 vehicles went into the CCC and was consolidated to about 13 vehicle trips from the CCC (8 vehicles into the CCC and one consolidated vehicle distributing the goods in the area). The mean value of the consolidation was 6. The mobility index in the area was good, valued as index 4 on a scale of 1-5.

The working and living environment is valued in noise hours. More accurate would be to look at the reduction of exceeded maximum noise levels per day. During the highest peak, the CCC helped reduce the number of times the maximal noise levels (55 dB(A) as a standard limit according to the National Swedish Road Administration) were exceeded by 100 times per day, compared to a situation without the CCC.

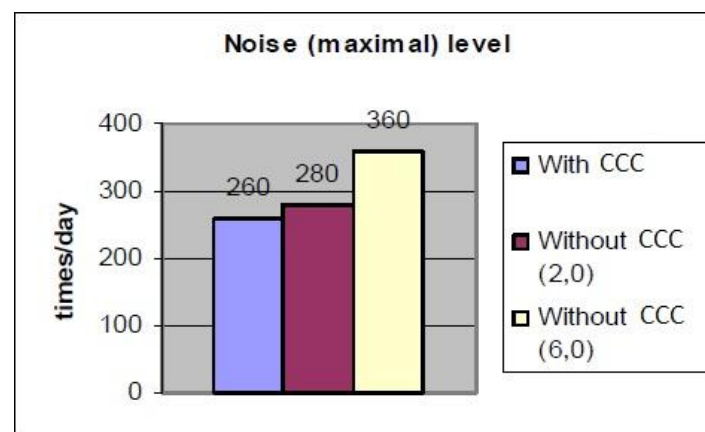


Figure 31: Noise levels for the Hammarby CCC (Brisvall, 2002)

The calculations were made with a simulation program from the Environmental and Health Administration in Stockholm and were based on the noise levels of a passing lorry and the number of times vehicles drove by a certain point in the area.

The vehicles in the project drove approximately 26 kilometres per day. The number of vehicle kilometres was reduced with 38 kilometres per day with the CCC compared to a situation without the CCC. The difference between the different situations can be seen in **Figure 32**.

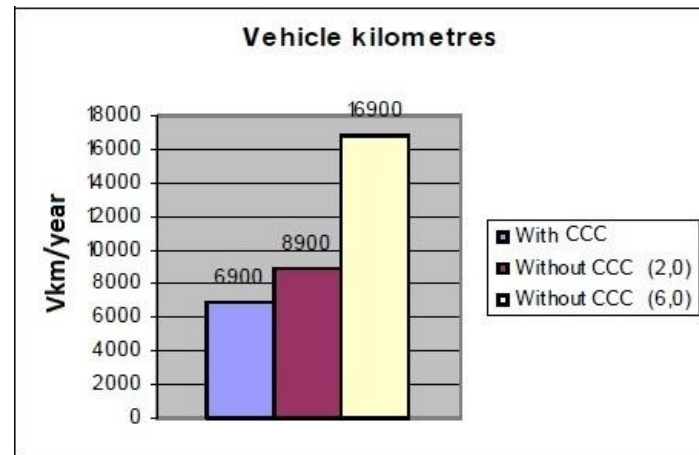


Figure 32: Annual vehicle kilometres in the area. (Brisvall, 2002)

Almost half of the total number of vehicles in the area during the project period were private cars (=111). The total number of delivery vehicles is therefore 169 per day, see **Figure 33**. The reduction of vehicles compared to a situation without the CCC was 50 vehicles per day (delivery vehicles).

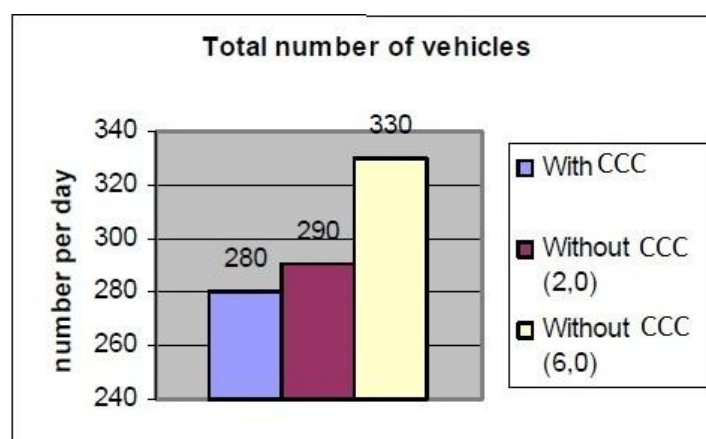
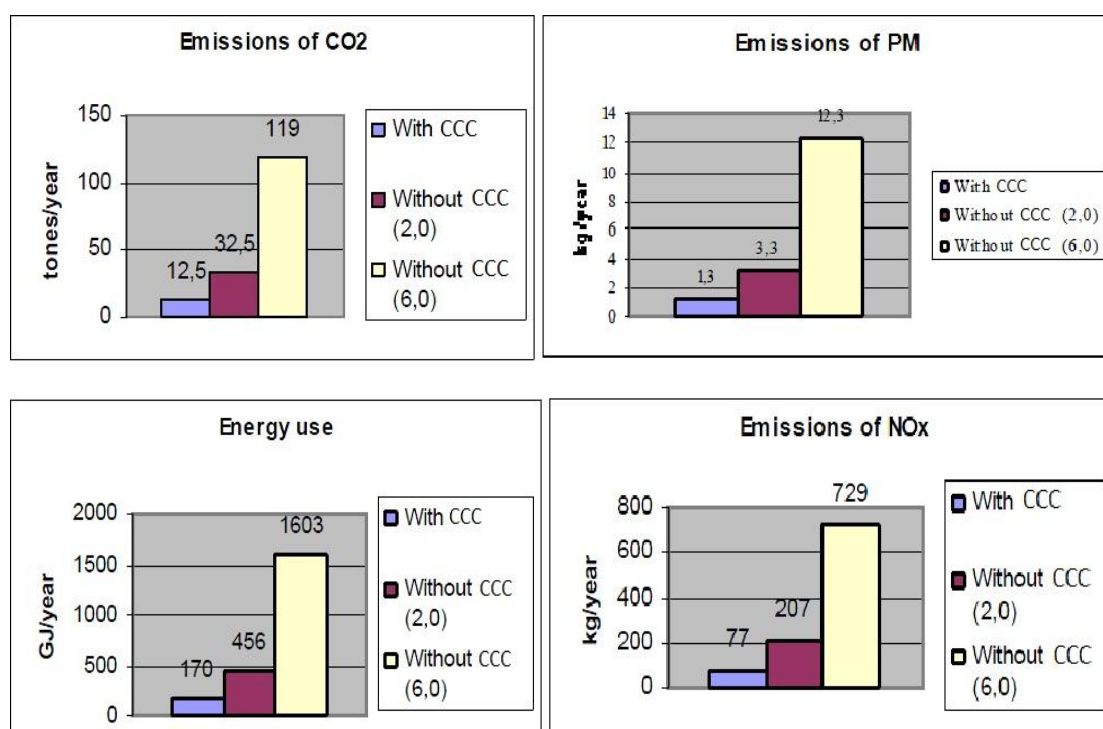


Figure 33: Total number of vehicles in the area. (Brisvall, 2002)

The emissions were reduced during the peak project period according to the objectives of the project and the energy use was reduced with almost 1.5 TJoule.



Figures 34-37: Emissions of CO₂, PM and NO_x and energy use in the three possible scenarios in Hammarby Sjöstad (Brisvall 2002)

One important synergy effect that affected the environmental impact of the constructions in Hammarby Sjöstad was the existence of the Environmental Zone (see Chapter 5.2) in the nearby area. Although Hammarby Sjöstad itself is not included in the Zone, most of the vehicles that arrived on the construction site had to pass through the Environmental Zone. This had a positive effect in the environmental quality of the trucks used, since they had to comply with the strict Zone standards.

Economic aspects, costs-benefits

According to the Trendsetter report, it is hard to realize in numbers and figures the cost benefits of pilot schemes. There are no quantifiable numbers of the exact amount of money saved with each measure. Mainly, benefits originate from less vehicle kilometres and a better use of the vehicles. Costs are related to initial investments and development.

Initially, the implementation and operation of the consolidation centre was sponsored by the City of Stockholm, by 95%. After a while, when different services became more familiar to the clients (contractors) and they understood that they could

save money using the CCC's different services it was possible to increase the prices, and by the end of the project it was almost a breakeven for cost/income. The city contribution was then about 40% of the budget.

The most important service for the project was to reduce the number of trucks in the area. To stimulate this, the co-transportation service prices were very low. The major part of the income came from temporary material storage and extra services (just in time delivery, part deliveries, goods delivered by crane into the building). To achieve a good turnover, the CCC's charge for the temporary material storage started after day 4.

The CCC charged the contractor for all the extra services. Their benefit was money saved thanks to less traffic congestion, less damaged goods etc. Unfortunately those benefits are not always clear to the builders. The delivery companies were one of the big winners of this solution because the contractor did not charge them. There was a contact between the CCC and the contractors and each user was invoiced monthly according to the amount used.

The practical operation of the CCC was performed by a subcontractor hired and financed by the City of Stockholm. The subcontracting activities included investments in the vehicles, stock/office-building and supervision system, running the vehicles and employing the staff. All income from different services was shared between the subcontractor and the City. To start with, the subcontractor received a large part of the income until the break-even point, when the city received a larger part of the profit.

The Trendsetter report points out the need to visualize hidden costs, for example transports, theft and damaged goods. While the project was running, a case study tried to measure such hidden costs, but the target was not reached because "no-one really wishes to find out the correct figures. Theft and damaged goods are today an accepted part of the building industry." (Civitas Trendsetter, 2006a)

The distribution through the CCC hides the correct costs. They include extra bonuses but they never show the real costs, which of course include the costs for the bonuses.

Executives on all levels were negative about the project from the beginning, but now the service is in demand despite being more expensive. One reason for this is that there were many situations where the time schedule couldn't have been held without the CCC.

Conclusions

In total, the project was very successful. According to the calculations for the period when the CCC was in place there have been large reductions of both emissions and congestion compared to a situation without a CCC. A reduction of almost 90% of the energy use and emissions of carbon dioxide was reached. The prerequisites for the CCC were very good – with both a well defined area and an obvious problem with congestion and long queuing times. Those problems could be solved within the project and the result was positive.

The project was operated without any major problems. A huge interest has been seen for the project and the management has presented it in at least 50 seminars. Experiences have been shared with for example London and La Rochelle for similar services (for example the Heathrow Airport Construction Consolidation Centre).

It is important in large construction projects to plan the logistics carefully from the beginning. Plans for technology as well as a logistics centre and definite rules have to be a natural part of the project. The logistical problems will appear sooner or later in any large construction site, but if solutions are not implemented from the beginning it will be difficult trying to convince all partners that some acts or regulations will help them as well as the whole project.

Looking back at the project there is a better acceptance for the project from the contractors from before. Some contractors that showed skepticism in the beginning now see the advantages; the possibilities to keep up with time plans etc., and are demanding these services despite a higher cost.

In Trendsetter newsletter No 5, June 2005, Johan Brisvall, project leader of the CCC made the following statement: “I consider this as the future way to build. The construction managers said to me that without the centre they could not have done so well. It helped them to secure the time plan. In the beginning the logistic centre was sponsored by the City of Stockholm but in the end the cost for the project almost made break even. One of the results of the centre is that the number of small deliveries to the site was reduced by approximately 80 percent. That meant considerably less congestion, and as well a better environment for those who already had moved into the area.”

4.3.1.2. Logistics Centre for e-commerce

The first local logistics centre in Hammarby Sjöstad opened in December 2002, with the goal to reduce environmental impact through coordinated transports. The centre was responsible for delivering on-line purchased daily goods, dry cleaning services

and distribution of food and beverages, in a coordinated way that would reduce CO₂ emissions. (Persson et al, 2003)

The Local Logistical Centre Project started in the year 2000, when the first residents began to move in the district (Persson and Trepte, 2000). The project was aiming at inhabitants, homes and care for the elderly, schools, restaurants and other businesses in Hammarby Sjöstad.

Establishing a local logistical centre was considered to be a possible sustainable solution. Four surveys were carried out during the project, to verify the working hypothesis of less environmental impact with the chosen form of coordinated transports. The results of the surveys were more than encouraging with one indicating that almost 70 percent of the population was experienced with on-line shopping and willing to take advantage of the services provided by a local logistical centre (Ericson, 2001). Another survey showed that even at a 10 percent level of on-line shopping of all daily goods, energy consumption and CO₂ emissions could be reduced by 5-7% and 7-8% respectively (Persson and Bratt, 2001).

In 2001 a Purchasers Group was established for the Technology Procurement of the logistical project planned and arranged by the LIP-Council. Members of the Purchasers Group were representatives from building contractors, internet based daily goods suppliers, schools, elderly care organizations and the City of Stockholm's Real Estate, Roads and Traffic Administration (Persson et al, 2003).

In the beginning of 2002 the LIP-Council launched the Local Logistical Centre Technology Procurement to find an environmentally oriented enterprise willing to operate the centre. The competition was won by Home Department AB in August 2002.

Home Department's business idea was based on a system where residential, business and organizational customers in the area subscribe to transport or logistical services. Through a monthly paid subscription fee to Home Department's services the customer gets delivery of purchased goods to their home or business door. The monthly subscription fee for residential customers was SEK 500 (approx. € 60), while business customers had individual agreements or subscription.

Deliveries took place at fixed time windows. Residential customers could choose between 5 and 7 pm or between 7 and 9 pm in weekdays. Business customers and other organizations could choose either between 8 to 10 am, or between 11 am and 4 pm.

The customers could place their orders on Home Department's home page, where about 20 different important suppliers and shops providing on-line purchasing were represented. The suppliers or shops paid a fee to Home Department for each separate delivery. Home Department then collected the goods at the shop and consoli-

dated them with other goods to the area and to the specific customer. Alternatively the shop had the possibility to deliver the goods to a coordination centre in Årsta 4 kilometres from Hammarby Sjöstad.

Home Department used light lorries of the highest environmental class to minimize environmental impact during the collection of deliveries. Goods distribution was executed by electrical lorries, from the service centre to the customers' doors or reception points at the agreed time. Calculations showed that Home Department's logistical services replaced 10 diesel-supplied lorries with one electrically driven lorry serving the area daily. At the same time, the use of private cars for daily goods purchasing decreased.

The goods and services offered by the Home Department's home page were the following (Persson et al, 2003):

- Daily goods from two major suppliers
- Dry cleaning
- Shoe repair services
- Film and music
- Cameras, film and photo supplies and services
- Kitchen equipment
- Office equipment and supplies
- Clothes from two major supply chains
- Books
- Package services and stamps from the Swedish Post Office
- Various home equipment and tools
- Ecologically produced fresh food directly from local farmers
- Pharmaceuticals
- Wine and other alcoholic beverages
- Take away food

One very interesting part of the project is the cooperation with BeM ("Bondens egen Marknad" = farmers market), a market of local food producers that provides the customer with important information about the quality and origin of the products. The idea was a direct box delivery of farm products to 5000 consumers and some schools, restaurants, retirement homes, specialist shops and supermarkets in Hammarby Sjöstad.

Home Department aimed to provide its services to approximately 2000 households (20 percent of the area) and a significant number of businesses and other organizations by the completion of the district. The short-term goal was to reach 500 customers during the first two years.

Unfortunately this goal was never reached and the logistics centre had to shut down after one year of operation. Although the project received positive media coverage, there can be found a number of reasons for the failure of the project: the high cost of living in the area of Hammarby Sjöstad, the economic recession in Sweden and the fact the many of the cooperating stores stopped providing on-line services and left the project (City of Stockholm, 2003).

Conclusions

The project showed that implementing new concepts takes time. From a community perspective, endurance pays off in the long run. It would therefore be an advantage if the procurement procedures would be organised in a manner that ensures the use of logistical services. The process would also benefit from political decisions taken in support of coordinated deliveries.

The Technology Procurement of the Hammarby Sjöstad logistical centre was thoroughly based on several studies and surveys. However the results of the studies were not verified during the operation of the centre. After a few months of operation, only one percent of all residents utilized the services offered by the centre. This level corresponded to the average level of on-line shopping for the country as a whole.

Advice from the project to other municipalities include (City of Stockholm, 2003):

- Start the process with coordination of transports of goods to your own municipal service units and to private companies;
- Start off by offering a limited range of products in order to see how it turns out and then gradually extend the offer to new categories;
- A sufficient number of purchasers is vital – municipal service units, private companies or residents all form the base of potential customers;
- Efficient deliveries require a thought-through administrative system and coordinated routines that optimizes the logistics;
- Private consumers are an important target group, but it takes long-term efforts in order to change the consumer habits. In Sweden, one percent of all everyday commodities are purchased through the internet. This number is probably not representative for other countries since Sweden has Europe's highest degree of internet-commerce but can give an idea of the future evolution. Calculations should be based on local conditions;
- Secure support from the political leadership and involvement from the municipal service units and private companies through personal contacts, training, information, marketing and media.

4.3.2. Gamla Stan – A Logistics Centre for the Old Town

Introduction

Gamla Stan is the Old Town of Stockholm, built on the Stadsholmen island right in the heart of Stockholm. Gamla Stan, with its medieval streets and alleys dating back to the 13th century, is the home of the Royal Palace, the Stockholm Cathedral and the Nobel Museum. There are about 3,000 inhabitants and about 9,000 people who work here. Approximately 100 restaurants and hotels require regular deliveries of food in the Old Town. Hotels aside, the 85 restaurants generate 120,000 deliveries per year (some of them receiving up to six deliveries per day), made by ten suppliers.

The streets are narrow and steep. The cars have to share the space with a big number of pedestrians, residents, people working in the area, tourist groups, school classes and other visitors to churches, museums, restaurants and shops in the area. Apart from disturbing the people, freight traffic generates undesirable emissions and noise, deteriorating the erosion of historical buildings. Therefore traffic is only permitted between 6 a.m. and 11 a.m. After 11 a.m. only rescue vehicles, taxis and other exempt vehicles are allowed in the area.

There is also a speed limit in most of the area where cars must “drive according to pedestrian speed” i.e. around 6-7 kilometres/hour. The knowledge and obedience of the rules are very limited, and in general no police controls are carried out in the area. Regular counts made by local NGOs and Home2You show that about 1 vehicle/minute enters the regulated area.

Project Description

In 2002, the city of Stockholm participated in the TRENDSETTER Project of the Civitas Initiative, with the aim to improve mobility, air quality and quality of life while reducing noise pollution and traffic congestion by promoting innovative projects. One measure among the 19 activities planned for the city of Stockholm was to set up a logistics centre that would serve businesses in the Old Town. The project was part of the Work Package 9 (WP9) – ‘New Concepts for the Distribution of Goods’, which had the following objectives (Civitas Trendsetter, 2006a):

- To demonstrate measures to increase the efficiency of goods distribution in various environments (construction site, inner city and hospital area).
- To demonstrate how energy consumption, emissions and noise from freight traffic can be reduced in sensitive areas using more efficient logistics and alternative means of transport.

- To provide examples of “Green city logistics”, how it can be implemented and the possible incentives for commercial operators.

The project in Gamla Stan had the name WP 9.3 “Consolidation of restaurant supplies in medieval Old Town”. Its objectives were:

- To decrease the number of small direct deliveries to restaurants and shops in the Old Town through co-transportation with clean vehicles.
- Less traffic congestion during delivery hours in the Old Town.
- Improved environment for inhabitants, visitors and people working in the area.
- To reduce energy use and emissions by estimated savings corresponding to 30,000 km of driving diesel lorries.



Figure 38: The Old Town (Gamla Stan) and the location of “O-Centralen” (by author)

The project was implemented in January 2004 when Home2You, a medium sized transport company, took up the task to operate a logistics centre for the supply of goods to restaurants in the Old Town of Stockholm, Gamla Stan. A terminal building just outside the Old Town (55 m², named “O-Centralen”) as well as a new biogas delivery van (Mercedes Sprinter) were purchased for the service. A marketing campaign and the inauguration of the reconstructed terminal and biogas vehicle were held in June 2004.

The operation began in summer 2004. Each of the 14 initial customers in the Old Town would receive one delivery per day instead of six. The targeted amount of cus-

tomers was 25 but in the spring of 2005 they had already reached 30 – 35. Two of the three biggest restaurant suppliers for the area were initially involved. The third one participated for a testing period from the end of May 2005 but chose not to be included in the project in the end. A different customer, the Royal Palace, also expressed an interest in joining the project later.

This was the first time to implement consolidation of restaurant supplies in this area. New technology was also used for refrigeration in the delivery vehicle, developed by the KTH (Royal Institute of technology). Route planning was developed by the driver of the vehicle, due to his experience of the town accessibility. No computer systems have been used during the project.

The “O-Centralen” continued to operate after the end of the Trendsetter period, but currently has been moved to a different location due to the construction works for the new underground train *Citybanan* right next to the site. Currently Home2You is transporting goods directly from two suppliers to the Old Town, without consolidation.

Many obstacles appeared on the way

The main problem to be solved was how to deliver the needed goods to the businesses with the minimum negative effects on the people, streets, buildings and environment. The biggest barriers of the project have been (Civitas Trendsetter, 2006a):

- The lack of customer demand and involvement
- The lack of overarching knowledge and interest from the different bodies of the town and their lack of flexibility

The project emerged from discussions among local NGOs, politicians, officials and a small/medium sized company, but not from the demand of the actual customers, i.e. the restaurants and their suppliers. The actual customers have not been part of the discussions. They are on a low organisational level in terms of finding common solutions on general logistics problems, instead they prefer individual solutions. The lack of traffic control after 11 a.m. gives them the possibility to make deliveries against regulations.

The project met many other obstacles on the way. In the beginning, the plan was to use an electric truck for the goods deliveries. Unfortunately that truck was destroyed in a garage fire of unknown causes, and a new truck had to be purchased, this time biogas-fuelled. It took two extra months before the new vehicle arrived. The top of the new vehicle was too small, so a new top had to be used instead.

Another problem connected to the vehicle was that the refrigerating unit (in any truck) was run on diesel, creating both noise and emissions. This was seen as an opportunity for cooperation with the Royal Institute of Technology in Stockholm and the research on the use of natural refrigerants connected to batteries. The company's representative mentioned a number of problems with the van in a discussion with the author.



Figure 39: The biogas vehicle with decals that show suppliers and customers (Civitas Trendsetter, 2006a)

Soon it was found that the delivery time was long and an ordinary diesel truck had to be used in parallel. After some time of using the logistics centre it became obvious that the ordinary delivery time frame permitted in the Old Town (i.e. 6 a.m. to 11 a.m.) was not enough. An application of exemption for the biogas van was made.

Waiting for the outcome of the application put “O-Centralen” in a limbo situation. The project could not take any more customers for reasons of delivery capacity. This made the marketing campaign difficult. With just a few customers it was not possible to achieve environmental and efficiency objectives. It was also too expensive to have an employee in the Logistics centre with just two customers (suppliers). So during this time deliveries were made from the suppliers’ warehouse. These deliveries were not consolidated with other customers but the vehicle was fully loaded. The permission for delivering goods until 16:00 p.m. was finally issued in January 2005 for one year.

Other difficulties met by the project have to do with the communication with political and administrative forces in Stockholm. The City of Stockholm has been very positive about the project, but in practice, very little flexibility has been shown.

All activities where foods are involved are strictly regulated for hygienic reasons. The foods handled by the logistics centre were very carefully and individually wrapped up. There was the idea of taking back from the restaurants empty packaging materials such as cardboard, and avoid empty returns, but the Food Safety Authority of the Environment and Health Administration did not allow it. The same authority did not allow mixed deliveries to shops and restaurants, although they were coming from the same suppliers.

The logistics centre was just a place for (re)loading the goods and not for storing, but the Food Safety Authority demanded there would be the same standards as activities dealing with food. Therefore they demanded rebuilding of the premises.

A compromise between different aspects would have helped the situation. Regular traffic controls to enforce traffic regulations would have also helped the process of showing the benefits of consolidated transports. After all, the City of Stockholm would have a lot to gain from the success of this effort.

Finally, the “O-Centralen” had to be moved, since it coincided with an area of extended construction works for the *Citybanan* underground train. There is a large amount of truck traffic currently (September 2010) in that area and there would be no possibility to use the logistics centre without interfering largely with the constructions. The company is currently making direct deliveries between two suppliers and some restaurants in Gamla Stan, until the *Citybanan* construction works are complete.

Financial Aspects

The investment costs were very high. For a bigger company it would not have been a problem to buy another truck and hire one or two more employees, but Home2You is only a small/medium sized company of annual sales somewhat bigger than 2 million euro (Troedson, 2005). High economic risks and big investments were difficult and more customers were necessary for making greater investments on the project. The only other financial aid was Trendsetter’s contribution for measurements, meetings and reports.

The ‘limbo stage’ mentioned above caused a difficult economic situation and delivery consolidation could not be put into practice. After that period, it was considered necessary to get all three biggest suppliers of the area to participate in the project, so that benefits and costs would balance, and there would be personnel hired to run the “O-Centralen” more efficiently. However, the third supplier only joined for a trial period and then abandoned the project.

No subsidies have been given from the City of Stockholm and the project was supposed to be self-financed. The moving force has been Home2You's interest in being a part of tomorrow's sustainable logistics market. Some positive economical effects have been gained by the company, as well new customers and marketing. However the success of such a project is much safer when it is financed and 'owned' by a city, rather than a small/medium sized company.



Figure 40: Deliveries with the biogas van in the Old Town (Civitas Trendsetter, 2010)

Estimated Results

The evaluation was based on invoice data from the "O-Centralen" as well as several assumptions. By the end of the Trendsetter project, the "O-Centralen" numbered 30 to 35 customers in the Old Town. The estimate of the total number of deliveries in the "After" column was based on an assumption of 30 customers. The values used for the estimates of NO_x and PM emissions from diesel vehicles are twice as high as a common emission calculation for diesel vehicles. These values were used in an early application of the project and were maintained in the final report for unknown reasons.

	Before	After
CO ₂	0.44 kg/km (diesel vehicle)	0 kg/km (biogas vehicle)
NO _x	7.32 g/km (diesel vehicle)	1.2 g/km (biogas vehicle)
PM	0.226 g/km (diesel vehicle)	0.012 g/km (biogas vehicle)
Fuel Consumption	0.17 l diesel/km	7.2 MJ biogas/km
Number of deliveries	120,000 /year	117,268 /year (9 trips less per day)
Vehicle kilometres	1 km/cage	0.33 km/cage (biogas vehicle)

Table 11: Assumptions for calculations (Civitas Trendsetter, 2006a)

The final TRENDSETTER Evaluation Report presented the following results created by the use of O-Centralen for the selected indicators:

Indicator	Unit	Before	After
Energy Use	<i>Joule/year</i>	924 GJ	917 GJ
Emissions of fossil CO ₂	<i>Tons per year</i>	63.8	62.5
Emissions of NOx	<i>Tons per year</i>	1.061	1.042
Emissions of PM	<i>Kg/year</i>	2.71	0.8
Noise levels	<i>dB(A)</i>	122	122
Total number of goods vehicles trips in the area	<i>Number</i>	120,000	117,268
Vehicle kilometres	<i>Vkm per day</i>	480	474
Vehicle load factor	<i>%</i>	67	80
Small deliveries	<i>Vehicles/day</i>	329	324

Table 12: The indicators used in the TRENDSETTER evaluation for the Old Town area (Civitas Trendsetter, 2006a)

The results show that the outcome of a logistics centre for the Old Town is good. There seemed to be a huge potential for reduction of the total number of vehicle kilometres if the logistics centre succeeded in gaining more customers. The “O-Centralen” managed to reduce the total number of trips by 9 trips per day and the number of vehicle kilometres by 6 km per day. If it was further developed, it was expected to reduce the number of direct small deliveries to the Old Town by 17%.

It should be mentioned that there has been a synergy effect with the Environmental Zone. The oldest and low-quality vehicles had already been sorted out and the vehicles that are used in the area are often quite good, from an environmental perspective.

Conclusions

The Old Town in Stockholm is a typical medieval city centre as can be found in many European cities. If a working system is developed it has a good possibility for implementation in many similar cities in Europe. This could be a driver for other similar projects. There is a need for special solutions for this kind of areas. The main barrier for vehicles is the narrow streets. But to find a solution with a small biogas-fuelled

vehicle as in Stockholm is a good solution to the problem and becomes an additional driver for continuing with the project and makes it easier for other cities to motivate.

The biggest driver of the project has been the interest of other groups to the project. Locals, politicians and officials, but also NGOs and the media are convinced that the “Logistics Centre model” is a model for the future. But, it is also important that the company, Home2You, has a genuine interest in consolidation of goods and environmental issues. Kag Troedson, Home2You’s director, presented the following results in the first BESTUFS II Conference in Amsterdam (Troedson, 2005):

- Success for such projects takes time
- Change in traditional logistics practices is very hard
- There is no distinct owner of the business and no obvious reasons for change
- It is very hard to convince stakeholders that this is the right thing to do in financial terms.

For Home2You, a small/medium sized company, it has been a tough experience to be part of the project. It is difficult for companies of such sizes to be part of a European project as Trendsetter, which is designed for big companies and operations. Small companies have different problems than big ones.

Another important conclusion from the Old Town project is that if the municipalities wish for successful projects of this kind, they need to coordinate the different authorities involved. The real estate authority must communicate and discuss relevant issues with for example the energy and traffic authorities. These aspects seem to be a problem in most cities. Within the city, there are a lot of different authorities, but not any natural forum for discussions on subjects that concern more than one authority.

4.3.3. Norra Djurgården – Possibilities for coordinated transport and ITS solutions

Introduction

A re-development project is being planned for the industrial area of Norra Djurgården (Stockholm Royal Seaport), in the north-east of Stockholm, similar to that of Hammarby Sjöstad (see section 4.3). Spanning from Husarviken in the north to Loudden in the south, it is Sweden's largest urban development area. It is planned to be a modern, innovative and environmentally friendly neighbourhood, and is expected to be completed by the year 2025.

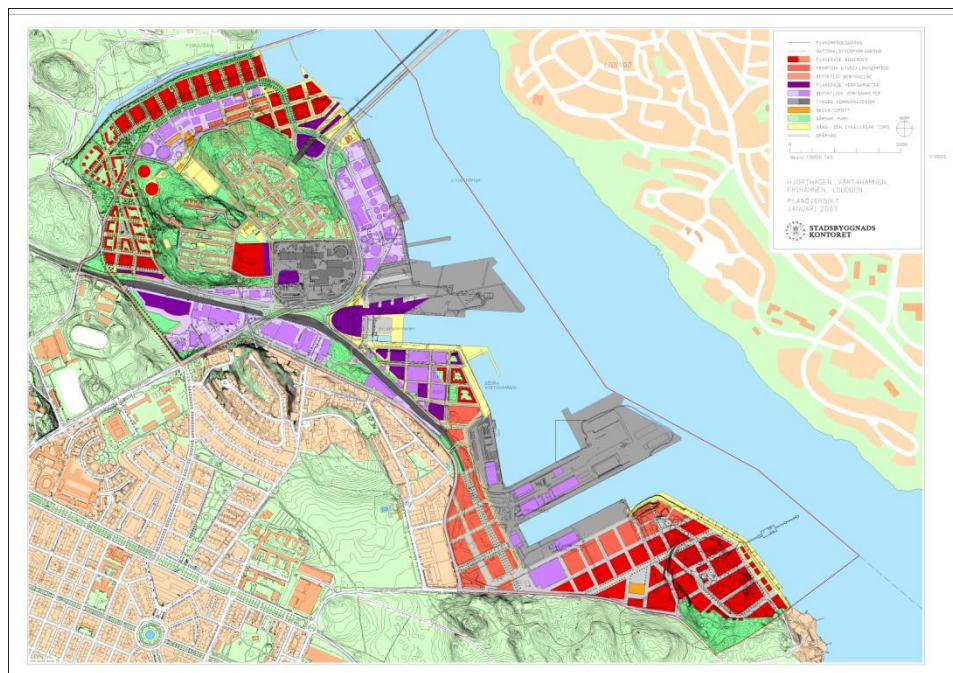


Figure 41: Overview of the development area (Stadsbyggnadskontoret website)

The planning process began in the early 2000s and includes, inter alia, 10,000 new dwellings and 30,000 new workplaces. Constructions began in 2009, and the first residents will be able to move in, in 2012. The examined area covers 236 ha (2.36 square kilometres) and includes four parts: Hjorthagen, Värtahamnen, Frihamnen and Loudden. There will be areas of housing, workplaces, education, public and private services, cultural events and entertainment. It is located only eight minutes by bike from the city centre, or five minutes by subway (Stockholm Stad, 2010a).

The City of Stockholm decided in the Environmental Programme 2008 – 2011 that the Norra Djurgården will be given a clear environmental profile, with the use of the experience gained from Hammarby. Norra Djurgården is also promoting the Swedish environmental technology and generates new technologies that will benefit all housing projects in Sweden. Through innovative technologies and creative solutions, Norra Djurgården intends to become an international display for sustainable urban planning. The environmental work in Norra Djurgården has also been supported by the Clinton foundation, since May 19th, 2010.

The constructions rate is estimated to reach about 500 apartments per year and the energy consumption target is 55kWh per m² and year. The environmental goal is to achieve CO₂ emissions lower than 1.5 ton per inhabitant by 2020 (while in 2008 the average emission per person in Stockholm was 4.5 ton per person) and that the area will be fossil-fuel free by 2030, a target which is more ambitious than the one of Stockholm city as a whole, which is to be fossil-fuel free by 2050. Another goal for Norra Djurgården is to be prepared for climate change, e.g. increasing precipitation (City of Stockholm, 2009).



Figure 42: The vision for Norra Djurgården (Stockholm Stad, 2010a)

The new district will also be home to the city's new main port for passenger ferries and cruise ships. The pier in Frihamnen features the most modern cruise terminal in Scandinavia. Lowering emissions, energy consumption and noise is a key priority for

the Ports of Stockholm. The goal is to classify among the most environmentally friendly ports in the world.

Creating a totally new urban area provides an excellent opportunity for sustainable development. City planners can pioneer cutting edge solutions and the focus will be given in minimizing energy use, waste and transport needs. Experience gained from Hammarby Sjöstad can serve as a starting point in this direction.

Project TransOpt

A feasibility study of environmentally friendly solutions concerning freight transport in the new area has been conducted by Sustainable Innovation i Sverige AB (SUST) in cooperation with Logica, Riksbyggen and JM and The City of Stockholm (Development Office), under the name TransOpt. VINNOVA (Environmental innovators) has co-financed the project with 440,000 SEK. An extra funding of 100,000 SEK has been contributed by the different parties involved. SUST has been the main responsible and coordinator for the project, with the aid of specialists from WSP (Kristoffersson et al, 2010).

Project TransOpt aims to accelerate the development of both technologies (ITS) and business models for the optimization of road freight transport in urban environment and thus contribute to sustainable transport and economic value creation. The latter may be the value created by efficiency gains in transport, but also through the development of IT solutions that have a high degree of generalization in the global market. This in return can lead to the development of competitiveness of the Swedish industry (new ITS solutions, efficient transport chains) and contribute to the national environmental and transport policy objectives.

The feasibility study provides scientific basis for the development and demonstration project planned, mainly in two areas:

- Freight transport in urban areas, both generally and for Norra Djurgården, in areas such as freight volumes, types of goods, freight carriers, traffic, transporters, customer demands, constraints and potentials for coordinated transport.
- ITS (Intelligent Transport Systems) solutions for the optimization of freight transport, including making inventory of the current state and the different systems used by carriers and assessing the possibility of integration in order to share information and the need for IT support for business relations between carriers.

Based on the knowledge base created by the feasibility study, it is possible to move on to the next step (Development phase).

The feasibility study has focused on the areas where constructions will begin earlier, namely Hjorthagen and Värtahamnen. By the time these two areas are completed, they will include 6,700 new homes and more than 350,000 square meters of premises for services, offices, retail and other activities.

The two charts below show the expected occupancy rate in Hjorthagen and Värtahamnen. Forecasts have been based on data from May 2010. Uncertainty exists particularly as regards the timetable for the area of Värta where the permissions process is not yet clear.

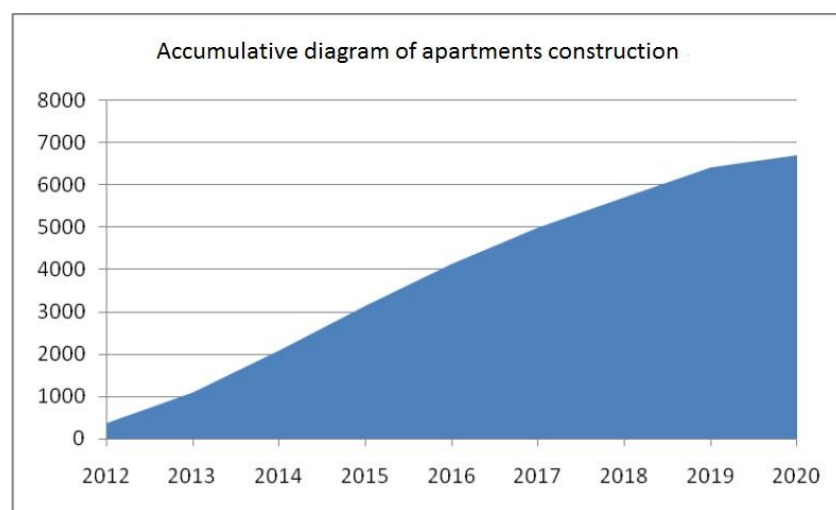


Figure 43: Forecast of apartment constructions in Hjorthagen/Värtan (Kristoffersson, 2010)

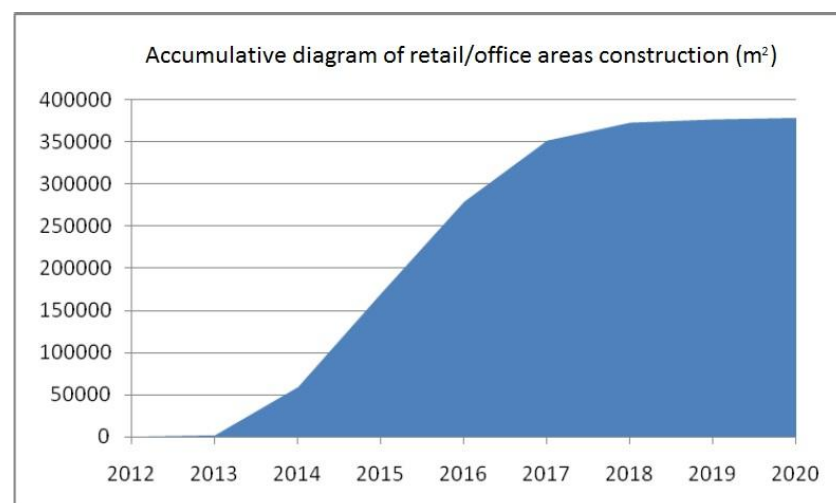


Figure 44: Forecast of retail/office constructions in Hjorthagen/Värtan (Kristoffersson, 2010)

The feasibility study estimated the freight volumes that will be demanded by the project. As the area is already a suburb of Stockholm, the study didn't take into account any materials for the construction of roads, water supply, sewage, electricity, telecommunications and other infrastructure.

The future demand in freight transport generated by the area has been divided into three categories:

- Construction materials
- Commercial materials (office supplies and retail goods)
- Residents' materials (mainly groceries)

The construction materials for the period 2011-2018 are estimated to reach 1.5 million tons, which is equivalent to 230,000 shipments towards the construction site. The peak of construction activities (2013-2015) will generate 50,000 movements per year or 200 hundred movements per working day. The variation in frequency of the shipments is expected to be large.

Approximately 30,000 tons of waste products will be generated during the construction phase, demanding 5,000 to 10,000 outgoing shipments.

The commerce-related shipments towards retail and office premises in the newly built area are expected to be over 1,100 per day. Of course the transport frequency varies depending on the different types of activities. The shipments will be performed by carriers in loops but also directly by suppliers' vehicles. This last part tends to cover the largest amount of transports but not always the greatest amount of goods.

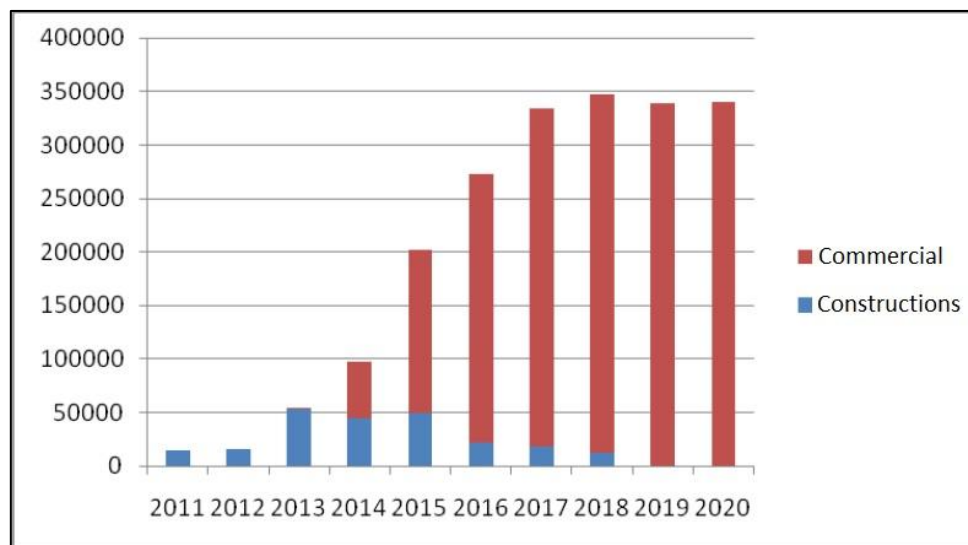


Figure 45: Forecast of total number of shipments, construction- and commerce-related (Kristoffersson et al, 2010)

The commerce-related transports are much more than construction-related ones, while construction-related ones carry much greater loads in tons (see **Figure 45**). The number of shipments will gradually increase until 2020 when it will stabilize at around 350,000 per year.

The area will accommodate 6,700 apartments and 15,000 employees. They will consume about 37,000 tons of groceries per year (food and drink) and produce about 5,700 tons of outgoing waste per year. The number of movements generated by residents' groceries consumption has not been calculated. It is not possible to know exactly where the residents and workers will purchase these goods, within or outside the area, and if they will use their own cars or other means of transport or maybe e-commerce. However in the TransOpt presentation workshop, the average amount of 17 trips for groceries per month has been mentioned (Kristoffersson, 2010). It is also stated that those who use e-commerce might save 1-2 shopping trips per week that way.

Possibilities for coordinated distributions

The problems related to transport which are encountered at large construction sites and urban areas have been analyzed already in other parts of this thesis, and include pollution, negative effects on climate change, noise, congestion and accidents. Coordinated transports can reduce these effects even by half, as it has been shown in similar cases, such as Hammarby Sjöstad. More efficient use of distribution vehicles also means reduced transport costs.

The feasibility study has focused on the possible impacts of establishing a logistics centre in the area of Norra Djurgården and the preconditions that are necessary for the implementation of such a solution. The idea is that it can initially work as a construction consolidation centre and then, after the completion of the construction phase, it can function as a commercial logistics centre for the area.

This solution appears to be beneficial mostly for the contractors, constructing companies and carriers involved, especially from a cost-efficiency point of view. Availability and time savings are secondary benefits for the above stakeholders. On the other hand, the main benefit for the municipality (which will also be the initial capital investor) will be the environmental and social impact of coordinated transport (the creation and operation of a logistics centre in the area can be reasonably assumed to reach a reduction of 45% for construction-related movements and 40% for retail/office-related freight movements).

During the second phase of operation of the logistics centre, different stakeholders become involved, like shops and offices and, of course, the residents. Shops and of-

fices will benefit from accessibility, efficient infrastructure, attractive and good shopping environment for residents and visitors, that can be translated in their main interest, profitability. Residents on the other hand can enjoy a good living environment, minimal access of large trucks and supply vehicles, and high availability of goods.

However the study identifies a number of obstacles that need to be overcome:

- Freight receivers are often small competitors out of touch with each other.
- Freight carriers might have financial liabilities to their clients, which they have to release and let be substituted by the logistics centre operator.
- There are only a few natural promoters for co-distribution.
- For the individual actor the impact of coordination seems small. A greater impact can be achieved only when more actors are involved. Those who have the greatest interest to initiate the coordination are often not the same actors who are best positioned to take the initiative.
- The main difficulty is that there are no developed business models to implement the co-distribution. Since it is a businesslike solution, it is essential to look for profitability and business benefits for the actors (freight carriers) that can attract them to cooperate.
- Other difficulties that concern the operation of a logistics centre or other forms of co-distribution are IT systems and administrative systems.

The feasibility study concludes that the establishment of a Logistics Centre in the area is very beneficial and the above obstacles should be overcome. Given the difficulty of any other stakeholder to take such an initiative by themselves, the City of Stockholm should be the one to do so. The possible regulatory systems are numerous, but only the municipality has the power to force more actors to participate into this cooperation.

The proposal is, primarily, the creation of a logistics centre for the management of construction materials, similar to the one that existed in Hammarby. The City must take the initiative and bring together the 20 property owners involved in the area of Hjorthagen/Värtan.

To cover the demand of the peak of the construction period, the centre should be established and operational by the beginning of 2013. It should provide transshipment and storage services for approximately the two-thirds of the total amount of the construction materials. A pilot option for direct deliveries can also be offered, in order to maximize transport efficiency.

The dimensioning of the necessary facilities has been made with the experience from the Hammarby constructions centre. A total enclosed area of about 4,000 m² should

be adequate, including a warehouse/office facility of about 1,000 m². Moreover, the vehicle fleet can consist of 3-4 trolleys/forklift loaders and 3-4 trucks (various sizes). The number of employees depends on the level of service that is intended (opening hours). There were 10 full-time employees in Hammarby.

The location of the centre must be chosen carefully. It can either be located inside the Norra Djurgården area or at a distance from it. Both possibilities have advantages. On the way from Stockholm to Norra Djurgården there are many existing terminals that can be used with some adjustments, escaping the cost of creating a completely new facility. A location far from the construction site might mean less transport needs for the participating carriers.

On the other hand, this option is rather inappropriate for a future transformation of the centre to serve residents' needs, especially if they have to pick up goods themselves. One more reason to keep the terminal close or inside the area of interest is educational. It becomes easier to notice it as part of an environmentally friendly area, more people might be interested in using it and its real significance is rescued from being belittled. A possible disadvantage is that the construction logistics centre may have to be moved after a few years for accessibility reasons.

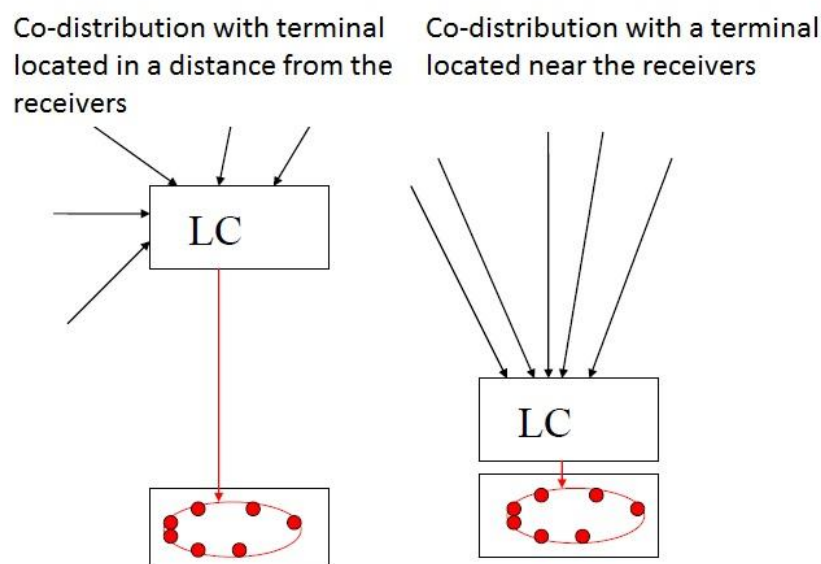


Figure 46: Possible terminal locations (Kristoffersson et al, 2010)

ITS solutions

The handling and transport of goods in the logistics centre must be done with the greatest efficiency and quality, and the lowest possible environmental impact. There is a need for effective technological solutions, like ITS and low emission vehicles (e.g. electric vehicles).

The usual notification of the incoming goods to a customer, redirected to a logistics centre needs to be upgraded with new data on the new freight receiver, which is the logistics centre, for the first part of the incoming transport. For the second part of delivering goods, new information on goods and goods recipients is necessary to be added.

Four different proposals related to ITS solutions have been thoroughly examined by the feasibility study:

1. The transfer is manual while arranging the goods for the planned distribution loop in the area. This means that there will be manual registration of the new shipment at the moment of its reception at the logistics centre.

This solution is simple to implement, and no adjustments to the IT system are required. It involves, however, much manual work for the registration of cargo data to the final customer. And it needs to update the IT system when adjusting the logistics centre as a recipient of goods for all businesses and residents in the area.

2. IT-based information processing at the reception of goods and data registration for the final shipment. This requires that there is an agreement between carriers on: which information is shared, how it should be done and when it should be done. This technical solution is based on the internet and uses a standardized format for the transfer of information such as XML. This kind of transfer is called push-technology, meaning that anyone who has information, in this case the initial carrier, initiates the information transmission to the logistics centre.

This solution implies that there is an agreement between the carriers, affecting their IT systems. Further study needs to be made on how to manage the reception and re-loading processes, together with the supporting information management that will achieve rational and cost-effective operations.

3. A combination of manual and automated processing of information transmission by sending an e-mail to the logistics centre with all the goods' data, which is then recorded in their IT systems.

This solution is very similar with the manual handling of the first solution. It is very dependent on the ability of information management to integrate e-mails and support the cargo handling process like in option 2. With low or zero integration, this option seems more like an alert system for incoming goods.

4. Early warning system via SMS or other mobile communications from carriers to the logistics centre, with the necessary information for incoming goods.

This option is similar to the previous option by e-mail. It would also require some adjustment on the carriers' IT systems to obtain the necessary degree of integration and harmonization. The advantage of SMS or other mobile services is that they provide more accurate indications of when the goods should be expected, taking into account the current traffic conditions. The carriers may have mobile equipment where all cargo information is stored and send it right before the goods arrive at the logistics centre.

Complement and support of the above proposals can be provided by digital maps and GPS navigation, which can also include data about the current traffic situation, for example through TMC. These can be used for both parts of the transport chain, to and from the logistics centre, and are considered as valuable instruments to plan and optimize shipments.

Cost-benefit analysis

It has been very difficult for this study to make anything than a rough estimate of costs and benefits. The calculations have been based on an assessment of both environmental benefits and economic effects. It is worth noting that the calculations consider only the Hjorthagen/Värtan area, but it is very likely that an establishment of such a centre might serve other areas as well.

The location of the facility will affect both the environmental and economic costs and benefits. Longer distance from the area increases carbon savings. Also the utilization of an existing terminal can reduce very much the initial costs.

The analysis assumed that the centre will be established in an existing terminal from 2013 and will additionally serve retail/office-related transports from 2015. Two-thirds of the constructions materials are assumed to go through the centre, with a loading factor of five (five vehicles being replaced by one). A loading factor of seven can be assumed for the retail/office-related transports. Residents' goods and waste

have not been taken into consideration in the analysis. The centre's vehicles are assumed to be moving on biogas electricity and the carriers' vehicles on diesel.

The expected reduction on incoming transport for the period 2013-2020 is about 100,000 less movements or 45%. Retail/office-related transports might be reduced by 145,000 movements per year (400 a day) which equals to 40%.

Each of these movements that are avoided can be translated into some 'profit' from salaries, vehicles used and fuel. The analysis estimates this 'profit' around 300 Swedish Crowns for each constructions-related movement and 200 Swedish Crowns for each retail/office-related movement. All together they are represented by 210 SEK per replaced movement.

The cost of the logistics centre depends very much on the grade of consolidation and the number of daily routes. These numbers can show how many vehicles and employees are necessary. Other important costs are the costs of vehicles and terminal operation. The analysis estimates an average cost of 130 SEK per replaced movement.

These numbers provide a result of a social profit of about 75 million Swedish Crowns for the period 2012-2020. It must be noted that this is a rough estimate and does not take into account the business model that will be used, as well as any other unknown details.

It must be noted that partial funding for the centre could be granted by European programmes, like LIFE+, ERA-NET, etc.

Environmental Impact

The replaced construction-related movements during the period 2013-2020 are estimated to have used more than 850,000 liters of diesel and emitted approximately 2,200 tons of carbon dioxide. The replaced commerce-related transports would have used 550,000 liters of diesel per year, emitting 1,400 tons of carbon dioxide per year. The logistics centre's vehicles' emissions will be negligible, since they are assumed to be running on biogas and renewable electricity.

The amount of particulate matter and nitrogen oxide emissions has been very difficult to estimate, because it relates to the types of vehicles that will be replaced. Assuming that all the vehicles would have been of the best environmental category (Euro 5), the replaced constructions-related movements would produce 100 kg of particulate matter, 7,600 kg of nitrogen oxides and 420 kg of carbon monoxide, and the replaced commerce-related movements would have produced 65 kg of particulate matter, 4,900 kg of nitrogen oxides and 270 kg of carbon monoxide per year.

Noise levels can be reduced by smaller vehicles driving in the area, especially by the use of electric vehicles used by the logistics centre. The amount of noise reduction has not been estimated though.

Other benefits

The reduction of the number of freight movements in the area will improve accessibility for the other road users. The logistics centre can make better use of the road network by the use of real-time information on traffic conditions. A positive impact in road safety can also be assumed, through reduced number of vehicles and experienced trained drivers.

The reduced risk of goods being damaged or stolen is also very important for the contractors. Experience from Hammarby showed that there was great reduction in such incidents.

Conclusions

The feasibility study (Kristoffersson et al, 2010) makes clear that there are many benefits for all the stakeholders involved in a creation of a Logistics Centre in the area of Norra Djurgården. The Centre's double nature of handling constructions materials at first, and commercial materials after the end of the constructions, doubles the centre's efficiency and indicates an integrated thorough solution.

The 'Zero Option' of not taking any measure for coordinated distribution can bear many unpleasant consequences that will have to be taken care of afterwards, in a reactive manner. This way of planning is not appropriate for an innovative development project with such high environmental goals.

The establishment of a Logistics Centre in this area is a matter of national interest. It can efficiently face problems such as pollution, climate change, noise, congestion and accidents by reducing the total number of freight movements almost by half. The experience from Hammarby Sjöstad has put the foundation for spreading this good practice, providing positive results and attracting stakeholders. However the initiative for this solution can only be taken by the City of Stockholm.

5. Conclusions

The City of Stockholm has set the ambitious target of becoming a fossil-fuel free city by 2050. CO₂ emissions have already been reduced by 25% compared to the levels of 1990. But the city has still a long distance to cover before the target is achieved. The transport sector accounts for a great amount of CO₂ emissions, especially road transport. In freight transport, the road mode accounts for 90% of the total CO₂ emissions from all modes. Åkerman and Höjer (2006) showed that the current transport growth in volumes and energy use pose a huge obstacle in achieving the high environmental targets, even with the use of advanced technology as it is expected to be in 2050. Hence, it is obvious that any sustainable policy against fossil fuels and air pollution needs to take serious measures to minimize the impact of road freight transport.

The European Commission is pointing towards the direction of incorporating freight transport in local policies and plans and to improving the management and monitoring of transport flows. The idea is that any urban mobility policy must cover both passenger and freight transport. It is essential for local authorities to consider all urban logistics related to passenger and freight transport together, as a single logistics system. Particularly concerning freight transport, the goal is the realization of an intelligent and integrated logistics system, where development of ports and intermodal terminals is a key element.

In Stockholm, there has been great effort and progress in forming an efficient passenger transport policy, discouraging the use of private cars. However, it seems that it is still early before we can speak about an integrated and concrete urban freight transport policy. Joint initiatives like *“On the road to climate neutral freight transportation”* (see section 4.1) are positive and encouraging, but it can be said that there is no actual political pressure for change. The character of such initiatives usually is more based on “good will” among participants.

So far, developing freight transport logistics in Europe has been primarily a business-related activity and a task for industry, and Stockholm is no exception. Nevertheless, the European Commission urges authorities to create the appropriate framework conditions and to keep logistics on the political agenda. This framework approach can concentrate on improving the preconditions that Europe can offer for logistics innovation and leave the internal running of company logistics to the companies themselves.

A key issue is Stockholm’s governmental structure which is decentralized. There is no unique authority responsible for logistics. Instead, there are several different author-

ities involved and lack of communication and coordination between them is not rare. Each and every one of these authorities deals with many different subjects and has different priorities. As a result, there is very little urban freight transport data available, mainly originating from a few individual surveys, the database of the congestion charging system and the vehicle registration records. The need for a new city instrument that deals mainly with urban freight is evident.

Unfortunately, the logistics sector is a very competitive one and there is suspicion and unwillingness when it comes to sharing data about shipments and clients. There is no organisation among the members of the sector which would provide solutions to the common problems. Instead, every company throughout the supply chain tries to solve its problems on its own, in the most profitable way. Often, this means the choice of solutions that consume more energy and generate more emissions. Coordinated deliveries can improve this situation a great deal. But cooperation is hard to appear without governmental initiatives.

In addition, measures like logistics centres are not always financially profitable for all stakeholders. A lot of projects have been abandoned for this reason all around Europe. Most companies are unwilling to participate because there is no obvious reason why they should share their customers and give away part of their own services to third parties. Strong governmental support is necessary not only in financial terms but also in terms of providing adequate proof of the profitability of the measure, creating incentives that encourage participation or even using regulations to impose it, when this is necessary.

Furthermore, people usually react negatively when change is imposed to them. Politicians usually avoid opposition with the voters and always have to clarify what exactly are the reasons and the expected benefits behind every measure. However, measures like the Environmental Zone, the Congestion Charging, the various logistics centres, etc. showed that many people initially opposed them, but, after the implementation, their opinion changed to supporting the measures. Some brave politicians stood behind those measures.

The national legal framework has also been an obstacle in several cases, like the Environmental Zone or the Congestion Charging. Changes had to be made at a slow pace through long periods of time. This thesis did not attempt to deal closely with legal issues, mainly because of the lack of knowledge of the Swedish language and due to the width of the subject. However, it is an interesting field that needs to be closely examined.

Two important city logistics tools are currently implemented and operating by the authorities in Stockholm: the Environmental Zone and the Congestion Charging System. Both can be considered very avant-garde in a global level. Stockholm was one

of the first cities to implement these measures in 1996 and 2006-2007, respectively. The results are very positive and the environmental benefits for the city are obvious and indisputable, setting the example for other cities around the world.

The Environmental Zone is estimated to have reduced emissions of hydrocarbon by 16-21%, emissions of nitrogen oxides by 3-4% and emissions of particulate matter by 13-19%. These results were reached by setting tight standards on heavy-duty vehicles' age and engine class. The Zone clearly pushed towards younger and more technologically advanced vehicle fleets, which pollute much less than older ones.

The Congestion Charging System, unlike the Environmental Zone, affected almost all vehicle categories and not only the heavy-duty vehicles. Its primary objective of reducing congestion was largely accomplished by achieving a reduction of 18% of vehicles entering the inner-city and a reduction of 16% in total vehicle kilometres within the inner-city. It also pushed the clean-vehicle market. In just three years, the proportion of alternative-fueled vehicles in the total vehicle fleet increased from 3% to 14%. These achievements yielded great environmental results: CO₂ emissions dropped by 14-18%, CO emissions dropped by about 15%, PM₁₀ emissions dropped by 15-20% and NOx emissions dropped by about 10% in the period 2005-2008.

The impact of the Congestion Charging scheme on urban freight transport is not well assessed, though. A reduction of 10% in truck passages during tax times was observed, but it is not known how these passages were replaced or whether they moved in later hours. In general, road pricing improves accessibility, reduces travel times and improves delivery times' accuracy. At the same time it increases the costs for transport companies and it might actually transfer congestion to different streets, previously uncongested. The carriers in Stockholm still have not had the chance to express their opinion on the charges.

The Hammarby Sjöstad Construction Consolidation Centre was a groundbreaking success. The use of the logistics centre reduced the number of small deliveries in the construction site by 80% and the total average number of deliveries by around 28%. Energy use, CO₂ emissions, NOx emissions and particulate matter were all largely reduced by 90%. The CCC gained global fame and set the target for similar projects all over the world. The leading role of the City of Stockholm in financing the project was a key factor for its success.

An interesting point that came up from the CCC project was the lack of information about the hidden costs. There was difficulty in figuring the exact costs of the material transportation and how these are included in the products' final price. At the same time, costs related to thefts and damaged goods were also hard to estimate, since they are accepted parts of the building industry.

In contrast with the Hammarby CCC, the O-Centralen which did not have financial support by the City faced many more difficulties. The idea of a single carrier serving the sensitive area of the Old Town with low emission vehicles should be in the list of priorities of the City authorities. However, letting this job to private initiative, even with the support of a major European project, such as Civitas Trendsetter, is always a risk. The City could have embraced the project more dearly.

The experiences and positive impressions gained by the Hammarby CCC can be the foundations for future similar projects in Sweden. Norra Djurgården may be one of them if the project TransOpt is approved. The particularity of this project is that the proposed logistics centre can serve two different purposes: a) the consolidation of constructions materials during the construction phase, and b) the consolidation of goods deliveries to the local businesses and residents, once the construction phase is completed. A lot can be expected in terms of environmental, but also financial benefits, in case the scheme is approved.

Similar logistics measures, based on detailed and thorough studies, must always be promoted by the city authorities. There is enough experience in European level to support that there are multiple benefits for all stakeholders, but most importantly they contribute a big deal to the city's sustainability and viability. It is time for an integrated city logistics policy, even if it means to implement top-down measures that oppose the current business status in the area of Stockholm.

As a conclusion, this thesis can report that Stockholm is in general a city which has done a lot for a sustainable future. The steps already made in the area of urban freight transport are significant, but there are two ways one can look at the situation as it is now: comparing it to other cities around the world, or comparing it to what is really necessary to be done by a city on a planet where ecological balances have broken since a long time ago. Being realistic, we must say that the latter is the only way to see it, and this implies that there is a lot more to be done before we are in the position to feel content by Stockholm's logistics' efficiency and sustainability. We should be optimistic, though. If there is any city in the world where change is possible, then this must be Stockholm.

6. Recommendations

6.1. A sustainable urban freight transport policy for Stockholm

This thesis attempted to approach the broad issue of Green City Logistics strategies and their applications in Stockholm. It does not claim to have covered each and every possible aspect, but it managed to produce a picture of the present views on Stockholm's urban freight transport. The following recommendations emerged from research on European and Swedish literature and hope to serve as a guide for authorities, transport companies and transport-related or environment-related organisations that wish to promote more efficient and sustainable urban freight transport.

The ideal situation would be the creation of a city authority which would deal with the management of freight transport in Stockholm. A primary function should be the collection of good quality freight transport data, to identify flows of goods and locate bottlenecks and problematic areas. Communication with transport companies and cooperation with research institutes from the beginning is vital. The next step would be the formation of a concrete and integrated freight transport policy for the city of Stockholm. Experts from different stages of the supply chain should be consulted or participate in the policy formation. The objective needs to -at least- comply with the rest of the city's high environmental targets. Then, the objective can be broken down into specific measures and strategies, chosen by necessity and effectiveness criteria and spanning in all time horizons (short-, medium- and long-term).

A very effective administrative tool that should be examined is Public Private Partnerships (PPPs). They can be used for financing, building and operating infrastructure projects, as well as for the negotiation and setting of framework conditions and agreements between public and private sectors. Main fields for establishing a PPP is on the optimization of urban distribution, road pricing and the construction of logistics and distribution centres. Other application areas for PPPs can include: the usage of ITS in urban freight, city access management, the development of environmentally-friendly vehicles for goods distribution, loading zone management, etc. Freight Quality Partnerships in London can act as a good example.

Sometimes, legal issues can be crucial factors for the implementation of some measures. Some regulations and demands can be hard to implement if there are legal barriers. Laws and regulations are possible to change if needed to adjust to the situation, but it is a difficult and time-consuming process. Clear results and possible benefits must be demonstrated to politicians. A pilot project could be easy to implement for a short period of time, exempted from regulations, and provide the necessary evidence of a measure's true significance.

Another parameter that applies to all measures is that all systems and projects need clear delimitation to be able to identify indicators and measure levels. A base line scenario has to be evaluated and serve for comparing and assessing results. Control and monitoring of the project and implemented measures are of grave importance. Indirect effects and synergies must not be ignored as well. Quantification of results facilitates understanding and support to the measures.

Many times, the public opinion or the actors affected by a measure react negatively at the beginning. Awareness campaigns are a possible tool to increase support for a measure. A pilot project with clear results can also be useful in this direction. Experience has shown that public and stakeholders' opinion often changes to positive after the implementation of a measure. The City's decisive support can be a success factor.

However, we must not forget that a city is usually a very small unit in the supply chain. Possibilities will be limited, unless cooperation on national (and even international) level is achieved. For example, similar logistics authorities can be created in other major Swedish cities and promote a common freight policy, with differentiations of local strategies according to the local problems and needs. The result would be that private transport would be forced to adapt in a more general situation, rather than a city's peculiarity. This option should be examined by the Swedish government.

The measures proposed below can be more effective and beneficial when they are used as a part of an integrated strategy and not separately. This is the reason why the author insists on the creation of an urban freight transport policy.

6.2. Consolidation of goods

A consolidation centre serving one or more companies, a single site or a whole area, can prove very beneficial for the area, as well as for the stakeholders involved. However, cooperation is difficult to trigger and delicate to handle. The city authorities must embrace such projects and support them in many different ways: financially, with good marketing and with regulations in favor of the use of the logistics centre. However, private funding is also a factor that can lead to a project's success. Large companies have the ability and interests to take initiatives and make them work.

A good way to start-up such a project is to form a project group consisting of representatives from many different affected organisations. The group members need to be convinced for the necessity of the measure and share the same determination for accomplishing the common target. Communication and flow of information is crucial, within the group as well as outside the group's borders.

It is important that the area addressed is well defined and has evident problems that create the need for a (bottom-up) solution. The problems need to be clearly identified before the solutions are found. The benefits of the project must be evident in order to persuade companies to participate. Information about previous projects can be valuable, but different areas have different problems and require different treatment. Different types of goods also have different prerequisites that need to be taken into account. E-commerce is still at its infancy but should be examined as an option, because it is expected to increase in popularity in the future. The possibility of minimizing empty returns by developing reverse logistics strategies should also be examined. Finally, logistics centres can be successfully combined with alternative-fuelled vehicles, to minimize pollutant's emissions and promote a 'green' image for the city.

Construction logistics centres are a new concept with many supporters in Stockholm, after the successful experiment in Hammarby. Their development should continue in future large-scale (but also in smaller-scale) construction projects and can lead to new possibilities, such as after-construction-use (like the proposed project for Norra Djurgården).

As mentioned above, green logistics measures are more efficient when they are used as part of an integrated strategy instead of being separate individual projects. A very interesting proposal was made by the Environment and Health Administration (Miljöförvaltningen) which suggested an integrated use of logistics centres to serve three major areas in Stockholm, but it was not approved for funding (Hugosson and Sunnerstedt, 2008). It could serve as basis for new ideas.

6.3. Other suggestions

In chapter 3.4 we discussed the case of night deliveries. Given the availability of technological solutions that minimize noise emissions and well-trained personnel, night deliveries can improve the efficiency of urban deliveries. A pilot project with evening distributions was implemented in Stockholm during the Congestion Charge Trial in 2005-2006 and provided a basis for further efforts.

The existing Congestion Charging scheme can function as a freight traffic management tool, not only for moving truck deliveries to different times of day, but also for interfering with route selection. Once we get a clear picture of the city's bottlenecks and problematic areas affected by trucks, different toll prices can be applied to manage truck passages from different entrances of the toll cordon. However, it is more urgent that the people behind the Congestion Charging System should start considering its impact on Stockholm's freight, assessing and managing it in a wise way.

A problem with parking on loading zones has already been mentioned. Strict enforcement of parking regulations and increased penalties can assist the situation. The use of Nearby delivery areas (ELPs), like the one described in 3.3.3 can also be considered. Last-mile solutions like this can substitute many heavy truck movements in sensitive areas.

Stockholm's location on 14 islands makes the conditions appropriate for the utilisation of waterborne urban freight transport. Such techniques have been implemented by the DHL postal service in Amsterdam and by the refreshments supplies in Utrecht with great success. It is a solution worth considering, as it can greatly reduce environmental impact and congestion created by road freight transport. It might even turn out that appropriate infrastructures, which may require only minor modifications, already exist in the city. This could largely reduce implementation costs.

European initiatives like Civitas and BESTUFS provided the opportunity for new ideas and promoted the exchange of information on urban freight transport among European cities. This knowledge network exists and is available for anyone who wishes to promote sustainable city logistics.

Three main areas of research were not included in this thesis, but are promising and recommendable: the views and interests of private logistics companies in Stockholm, the legislation issues that interfere with several logistics measures, and the possible applications of reverse logistics in the area. More research is needed on all these three fields.

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