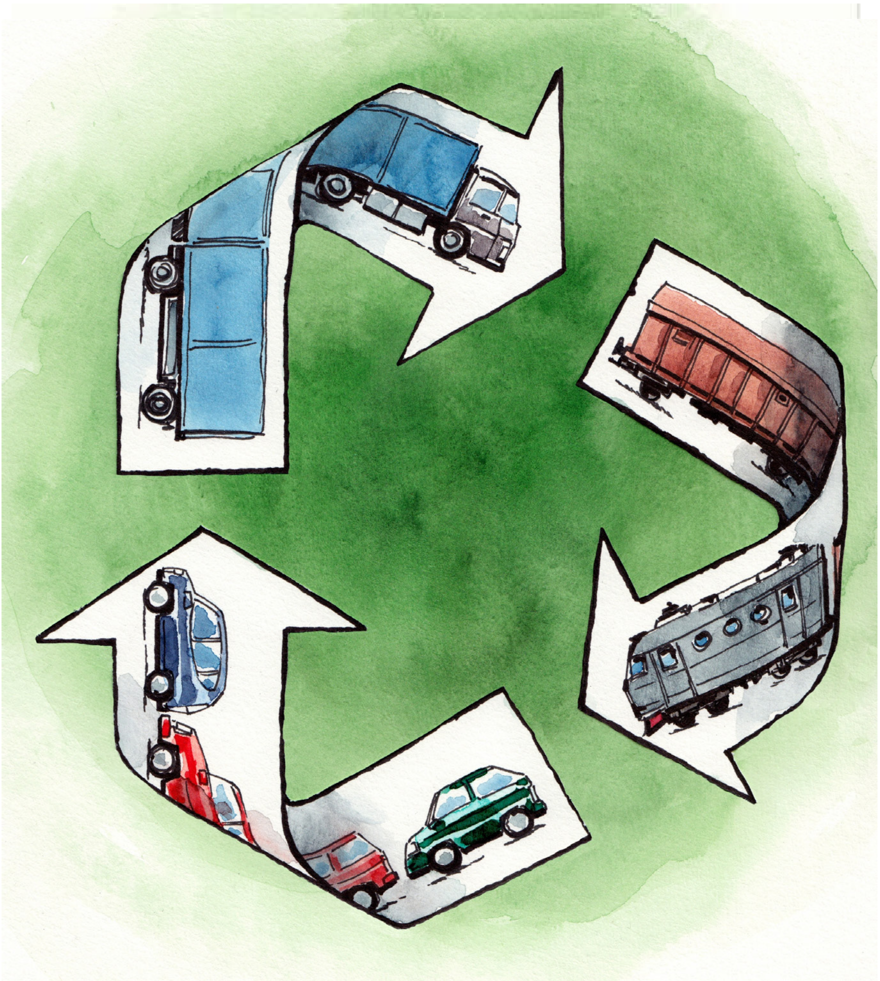
Rethinking Transport in the Øresund Region

Policies, Strategies and Behaviours



Edited by
Carl-Magnus Carlsson, Tareq Emtairah, Britta Gammelgaard,
Anders Vestergaard Jensen and Åke Thidell

ØRESUND ECOMOBILITY

EUROPEAN UNION
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Interreg IVA
ÖRESUND – KATTEGAT – SKAGERRAK

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Lund University

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The Øresund EcoMobility project brought together a network of regional competencies from academia, industry, and public authorities, involved with sustainable and climate friendly transport solutions. This unique network of regional competencies consists of over forty experts within areas such as: clean technology and bio fuels development, environmental science, infrastructure, city and transport planning, logistics, economics, transport policy, and supply chain management. This network was made possible through support from the European Regional Development Fund (Interreg IVA).

The content of this book is as diverse as is the social, economic, and ecological impacts of transport and mobility. This means that the chapters that constitute the book build on different academic traditions and styles. The ambition of the editorial committee has been to maintain these differences as far as possible, as we consider them an important part of the knowledge sharing. The editorial committee is not responsible for the individual contributions.

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Malmö, Lund, and Copenhagen 16 March 2012

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Part III: Travel behaviours and mobility management

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Introduction

Rethinking Transport in the Øresund Region

Øresund EcoMobility contributes to knowledge creation for sustainable transport and green logistics, city transport, and energy systems with a specific focus on the conditions and needs of the Øresund region. In this book, long distance goods transport and strategies for green corridors through the Øresund and Europe are studied, multi-criteria models for analysis in transport and infrastructural planning are tested, City Logistics and the challenges within urban areas are scrutinised, challenges for fossil free transport systems are analysed, and mobility management in municipalities and use patterns in leisure travel are considered. In addition, the role of knowledge transfer between companies is examined. New energy systems are fundamental in creating a sustainable future, but are not enough – new forms of governance, planning, and stakeholder involvement to create sustainable supply chains are also needed. In the Øresund Region, the largest hub in Scandinavia for transport of goods and people, efficient and at the same time environmentally safe transport is a key factor for sustainable regional development.

The Øresund Region is comparable to many other growth regions in the world, although, it has been fortunate enough not to suffer from the worst drawbacks of recent increases in transport development. However, this does not mean that we can become complacent. Increased congestion, noise, and emissions that largely can be attributed to transport of goods and people, have become evident. Today, with climate change at the forefront of the agenda for policy makers and public authorities, companies, organisation, and citizens it is important for all stakeholders, present and future, to become engaged in the discussion surrounding the implications of growth in the transportation network of the Øresund Region. *Rethinking Transport in the Øresund Region: Policies, Strategies and Behaviours*, is an important contribution in such a process of knowledge sharing and capacity building for the region.

Øresund EcoMobility aims at innovating for economic, social, and environmental sustainability by addressing issues of green logistics, city transport, travel behaviour, and renewable energy systems. Through using new approaches to transport policies and legislation, by exploring new strategies in decision making and demand management, and by allowing for new forms of association to induce better allocation and use of resources and infrastructure, this book provides some of the answers and paths forward to help achieve a more sustainable future.

The Øresund EcoMobility Project

In the Øresund Region, a wide range of initiatives to bring about climate friendly solutions within the transport sector have been launched during the last decades. Some of the efforts were the result of policy changes in Sweden and Denmark, but many took the form of discreet projects and experimentations, often sprung out of local and regional initiatives. A whole set of different actors, other than just public decision makers, have been involved in innovating and implementing solutions for a transition to climate friendly transportation. These included businesses, universities, and multi-actor networks. These efforts are instrumental to the development of knowledge and regional competencies. In 2009, the Øresund EcoMobility project was initiated to gather these competencies in a unified network of universities, industries, and regional authorities and to share this knowledge. The project is co-financed by the European Regional Development fund, InterregIVa.

The contributions to this book

A wide range of transport related knowledge development and knowledge sharing with specific focus on the conditions and needs of the Øresund Region, is outlined in this book and presented in three parts. The first part of the book deals with policies, resources, and infrastructure. In particular, how to comply with the demand for a more sustainable transport system by new frameworks for governance, involving a range of different actors is discussed. The prospects for shifting from oil-based fuel to alternative vehicle fuel, such as biogas, and the implications this might have for the society are addressed. Furthermore, the possibilities for creating a green freight transport corridor in the Øresund Region and how to design an attractive region considering both the environmental and business aspects are examined.

The second part of the book deals with strategies and decision making for sustainable transport and logistics, from a number of different perspectives. The chapters in this part range in topics from dealing with logistical challenges and governance in Urban Distribution, via the development of a decision support model for sustainable transport planning, to the role of inventory control and shipment consolidation in planning. Several of the chapters stress the importance of stakeholder involvement in the process of planning new approaches in City Logistics, as well as advocating shop characteristics as a main factor for successful implementation of Urban Consolidation Centres. In addition, the central role of logistics service providers in the green supply chain and new business models are discussed. New forms of association including Public–Private–Partnerships, social enterprise, and reassessment of legislation are also explored. Companies are also capable of learning from each other, and this section of the book presents examples from which small and medium enterprises (SMEs) may learn from large companies' sustainability programmes. Together, these chapters present important tools and new approaches to sustainable transport and logistics for different stakeholders in the Øresund Region.

The third and final part of the book brings together contributions that deal with demand-side aspects and end-user perspectives in the transition towards climate friendly transportation. Departing from the understanding that technology-centred solutions to the challenges of sustainable mobility will not be sufficient on their own, the contributions in this part of the book are unified by the underlying concern of how to bring about change in travel behaviours. The contributions tackle this concern from two complementary perspectives.

Part 1: Policies, resources, and infrastructure

The political, infrastructural, and resource base for climate friendly transportations are set out in Part 1 *Policies, resources, and infrastructure.* In the first Chapter, "Governance for sustainable transport in the Øresund Region," Jamil Khan introduces the concept of governance (as opposed to government) and show how sustainable mobility efforts in the Øresund Region are shaped and implemented, not only by public decision makers, but by a whole set of different actors. He discusses the need for policy change at different levels (policies, institutions, and paradigms), in order to induce long-term change towards a low-carbon transition, and the experience of mobility management against this backdrop. Furthermore, he shows that the projects, initiatives, and policies, that are described and analysed in this book, can be placed in a larger framework of sustainable transport governance in the Øresund Region. The main conclusion in the chapter is that the path towards sustainable transport is shaped by, and dependent on, the collaboration and interactions of a complex set of different actors, both public and private organisations, as well as individuals acting as consumers and citizens.

In Chapter 2, "Rapid adaption of the transport system in light of peak oil – vulnerability and fuel-saving potential in the Øresund Region," Karin Neergaard and Katarina Evanth explore how the transport system can be adapted to decrease the use of fossil oil. They examine what level of oil savings is achievable in the event of a crisis and which measures can be implemented quickly, e.g. within half a year. The measures with the greatest potential in the Øresund Region (aside from the mandatory measures of fuel rationing and driving bans) are identified as those that increase the share of public transport trips. Several of the measures that are suggested in the chapter, for instance measures that decrease transport demand, are also measures with many co-benefits and high cost-effectiveness. It should also be noted that many of these measures also help to address other problems including local air pollution, global carbon dioxide emissions, traffic noise, barrier effects, and congestion.

In the chapter on "A green transport corridor within the Øresund region," Per Homann Jespersen and Sandrina Lohse look at the challenges for the Øresund region as a transit region for freight between Scandinavia and the rest of the European continent. In their research, they identify two main challenges for the region: (i) How do you get the most out of being a transit region? (ii) How do you minimise the negative impacts of being a transit region? Jespersen and Lohse recognise that a dedicated effort to develop Green Corridors through the Øresund Region will not only be helpful to reduce the environmental and climate impacts of freight transport, but it can also contribute to the overall attractiveness of the region and be a showcase for innovative ways to develop transport to meet the targets set out by the White Paper on Transport and by the Climate Strategy of the EU. In the chapter, the authors point out that in order to provide the right conditions for co-modal freight transport, it is necessary to consider the terminals, both the physical and organisational side of them, together with knowledge of co-modal transport. In addition, Jespersen and Lohse explore infrastructure and the need for a common standard for freight trains and the configuration in the new Fehmarn Belt fixed connection, in order to provide a joint foundation for rail freight transport in the Øresund region.

In Chapter 4, "Alternative energy carriers for transportation sector and their use in the Øresund Region," Dimitar Karakashev and colleagues present properties, fuel characteristics, and practical applications of various energy carriers in the transportation sector. The current utilisation of alternative energy carriers in Øresund region is briefly outlined in terms of implementation plans in transportation system, fuels distribution infrastructure, and suitable vehicles. Furthermore, a comparison between fuels suitable for use in light and heavy vehicles is made, based on fuel characteristics, environmental impacts, energy security impacts, vehicle capital and maintenance costs, fuel costs, safety handling, and net carbon dioxide emissions.

Bo Mattiasson and Maria Andersson discuss biogas as fuel for the transport sector in Chapter 5, "Biogas – the fuel of tomorrow from yesterday's waste biomass". The current and future situation for biogas as transport fuel in Sweden and Denmark is considered in the context of the Øresund region is presented. The paradox of what should come first, the biogas filling station infrastructure or the vehicles that will utilise it, is also explored. Among other aspects, the increasing competition for biomass for the production of fuel and a range of other products is discussed and framed in the overall growing need for food production in the world.

Part 2: Strategies and decision making

The second part examines *Strategies and decision making* for enabling changes in the logistic systems and operations of transporting goods and people, including decision support tools for integrating environmental consideration in transport planning."Themes and Challenges in Making Urban Freight Distribution Sustainable" by Maisam Abassi and Mats Johnsson are discussed in Chapter 6. After presenting a number of challenges to urban distribution from previous studies, the analysis of the concept of City Logistics highlights that three areas are recognised as most important; innovation, integration, and information. Firstly, concerning City Logistics, innovative solutions must be considered. Additionally, there must be a strong integration of partners and actors in the supply chain. Finally, information plays a vital role in realising effective control of activities in the urban logistics system. The chapter also proposes that a holistic view on sustainable development is essential in order to understand the economic, environmental, and social effects of urban freight distribution. It further recommends that activities and strategies in City Logistics should be adaptive, as each urban area is unique. Differences among the shape, size, nature, and society of urban areas, have led to different types of freight distribution. To tackle these challenges, the urban freight distribution system should harness the complexity, encourage visionary leadership, and promote both top-down and bottom-up changes.

In Chapter 7, "Sustainable Urban Distribution in the Øresund Region", Carl-Magnus Carlsson and Mats Janné deepen the analysis of new forms of governance and stakeholder involvement in planning for urban consolidation centres (UCCs). Traditionally, large-scale solutions and top-down implementation of consolidation centres and terminals have dominated their development. Traditionally the focus has been on the transporters, forwarders, and suppliers of goods. Furthermore, the costs of external effects, legislative measures, and an inflexible logistical approach, have overshadowed the views and needs of the shops themselves. The argument is that in order to ensure long-term sustainability of a UCC, the focus of implementing and running urban consolidation programmes should shift to the end users' needs and introduce new forms of governance. Societal and social factors should be given more emphasis in the analysis, as well as stakeholder involvement in decision making and planning. The role of the authorities should be to enhance the benefits of new measures in distribution to increase city attractiveness – the positive external effects of urban consolidation – rather than focusing on pricing the costs of the negative effects of urban distribution. New business opportunities for transport services should be developed. Social entrepreneurship initiatives and social enterprise should be encouraged by a reassessment of the rules and legislation in transport planning, and the interaction of public, private, and goods transport should be taken into account when planning for the urban transport system. By promoting the emergence of social enterprise and other new forms of association and decision making in urban freight, new societal benefits can be detected and capitalised.

In Chapter 8, Kristian Hvass and Kasper Teilmann address the importance of studying "Shop Characteristics that Determine UCC Interest" in planning. The UCC appears to be an apparent solution for reducing negative consequences of urban freight. However, UCC establishments are often supply-side driven and rely on a top-down approach. Long-term success is often reliant on the purchasing of extra services by participating shops. This suggests that a small-scale, demand-side driven approach is more appropriate; where the businesses that might benefit from UCC participation is determined by the type of goods sold (e.g. garment, food, small or medium sized specialised shops) and shop size. Through a study on the potential of establishing a UCC in the city centre of Copenhagen, the authors identify unique combinations of six shop characteristics that are favourable for UCC establishments providing extra services. The study thereby answers the question: which combination of shop characteristics, e.g. number of deliveries and suppliers, shop location, and ownership structure, determines the attractiveness of participating in a UCC programme utilising extra services? A mixed method approach, combining case study and qualitative interview data, along with a method new to logistic studies, multi-value qualitative comparative approach, is used. The results suggest that those shops that are interested in UCC participation lack a systematic delivery system, are dissatisfied with their current delivery system, and often have poor storage facilities. Whereas businesses that have an in-house or alternative solution that is comparable to an UCC supply system, are not interested in participation. In addition, most businesses that show interest for the UCC have a low weekly delivery to supplier ratio, which may indicate few deliveries but large volumes. Such deliveries can strain shop resources, and these businesses are UCC-interested. This analysis implies that assessing the potential of establishing an UCC requires a thorough evaluation of the underlying characteristics of the shops in a particular area.

Anders Vestergaard Jensen and colleagues report on the application of a decision support framework for sustainable transport planning in Chapter 9; “The EcoMobility Modelling Framework for Sustainable Transport Planning”. The generally acknowledged cost-benefit analysis (CBA) is commonly used for a systematic quantification and comparison of the various benefits and costs generated by a project, however, the CBA is often found to be inadequate in incorporating and assessing multiple criteria, especially when considering environmental or social issues, which are usually intrinsically difficult to quantify. This chapter introduces the EcoMobility (EM) modelling framework. The EM consists of two parts: (i) a decision conference, and (ii) an Excel-based software model (EM-model). The latter employs the use of two multi-criteria decision analysis (MCDA) techniques, namely REMBRANDT (ratio estimation in magnitudes or deci-bells, to rate alternatives that are non-dominated), which is based on pair wise comparisons, and SMARTER (simple multi-attribute rating technique exploiting ranks), which is based on criteria rankings. The concept of a decision conference (DC) is introduced in order to formalise and to put into operation group processes that enable the assessment of non-quantifiable impacts/criteria within a decision support context; a concrete form of stakeholder involvement in decision making. The model is presented by a case study in the Øresund region considering the alternatives for a new fixed link between Helsingør (Elsinore) in Denmark and Helsingborg in Sweden. The case study has proved the decision support system to be a valid and useful tool for making decisions under complex circumstances of multiple objectives, conflicting interests, and involvement of different stakeholders. Further, the EcoMobility modelling framework can be used for the localisation problem of an Urban Consolidation Centre (UCC) in e.g. Copenhagen.

Chapter 10, “Innovating for Green Supply Chain Management: The logistics service providers´ perspective” by Britta Gammelgaard and Günter Prockl, points out that if companies react to customers´ demands on sustainable logistics services, this may create cost savings and therefore more business for the logistics service providers. In Denmark, the EFFIE award granted by the Danish Freight Forwarders´ Association in collaboration with Danmarks Transport-Tidende was established in 2010. The awards recognising excellent performance on the criteria of efficiency, innovation, and energy use are given. In this chapter, three specific cases; two winners of the Danish EFFIE award, and one runner-up, are presented as examples of how logistics service providers can be proactive in innovating logistics services in a green supply chain management context. From these cases, it became clear that environmental sustainability is an important issue, however, at this point in time it is something that is expected rather than a factor that can create orders in concrete customer relations. If, however, improvements in environmental sustainability also create economic sustainability, it would be appreciated. The analysis showed that logistics service providers use a formal innovation process model but only to a certain extent, as they are afraid that it would kill the creativeness of their associates. As international research results have proven that this does not happen, a more formalised approach to innovation for sustainability may be the road forward to improved environmental sustainability. In addition to economic and environmental sustainability, future customers may also want to know about social issues not only in the contracting company but also in subcontractors companies. Transparency in the transport and logistics chains will in the future be a ‘must,’ and mutual trust, information sharing, and a long-term approach will create a so-called ‘win-win’ for the logistics service providers, their customers, and the environment. There is much more to gain in the Øresund and Nordic logistics service industry by opening up to innovations for sustainability in relation to both customers and suppliers and the supply chain as a whole.

”Design and Control of Sustainable Supply Chains” is the topic in Chapter 11 by Sven Axsäter et al. It is becoming more apparent that in order to be more environmentally friendly, distribution systems should favour shorter shipments, less handling, reduced number of trips, more direct routes, and better space utilisation. Strategies to achieve this involve shipment consolidation, larger batch quantities, lateral transhipments, and combinations of different modes of transportation. However, these strategies may have negative effects on productivity, customer service, and/or inventories from a supply chain perspective. A competitive and sustainable solution that avoids sub-optimisation requires that the transportation system is carefully coordinated with upstream and downstream supply chain inventory and production decisions. Here, new methods for improved inventory control of multi-stage distribution systems to avoid emergency deliveries by air, efficient use of emergency orders, express transhipments, and shipment consolidation in supply chain inventory systems are useful. New efficient approximation methods for the evaluation of such system structures have been developed and can be used when choosing between different transportation modes. Through improved inventory control, the need for emergency air shipments from the central warehouse can be reduced significantly, with positive effects on both costs and emissions. The idea is to use the slow, more environmentally benign, transportation mode as the basic option, but when needed, temporarily switch to the fast mode. By using such a policy, we can reach more or less the same low inventory costs as a system that is based exclusively on fast transports by air. Still, we obtain a system with substantially lower transportation costs and better environmental qualities. The shipment consolidation models can also aid in the evaluation and optimisation of combinations of different types of transportation modes such as train and truck.

As shown in Chapter 12, “Sustainability Models in the Oresund Region in the Transport Sector: Learning for SMEs from Large Corporations” by Lise Lyck et al., implementing sustainable transportation in SMEs is essential for a sustainable transportation development in the Øresund region. As large corporations are in the media’s spotlight, many have developed extensive sustainability programmes, however, most SMEs are lagging far behind in this area. When considering the status of most SMEs’ sustainability programmes, along with the fact that the SME accounts for quite significant amounts of the total CO2 emissions, there are huge potentials for reductions for SMEs. There are however two significant barriers that have to be overcome to realise this potential. The first and perhaps greatest challenge facing the SME when working towards making the company more sustainable is that often they have limited financial resources and tight budgets. The other major challenge is that most SMEs do not have the knowledge and competences required to successfully develop and implement a sustainability strategy. From the case studies conducted in this chapter, it is shown that the major sustainability issues for knowledge sharing between large companies and SMEs are in “How to gain knowledge,” “How to cut cost,” “Meeting the needs of partners,” and “Building image.”

Part 3: Travel behaviours and mobility management

Part 3, *Travel behaviours and mobility management*, brings together perspectives on the demand side with specific focus on transport users and mobility management. The first perspective is instrumental in the sense that it aims to examine the various approaches and range of measures to influence transport demand, under for instance, the concept of mobility management (MM) and the institutionalisation of MM practices in the Øresund Region (Chapters 13 and 14). In Chapter 13 “Mobility Management – background, progress and state-of-the-art in Sweden and Denmark “ for instance, Joanna Dickinsson and colleagues report on the history and background of MM in Sweden and Denmark and how this has shaped actual practices on both sides of the Øresund straight. Their study documents the range of activities at various administrative levels concerning MM in both countries, and contrast divergent histories and commitments for MM within national transport policies. For instance, they lament the toning down of measures to influence the demand for transport and reduce car dependency in the recent national transport policies in Sweden, while in reference to the Danish case, they point to increasing use of mobility management-oriented measures in national policy decisions and initiatives, although the concept is not explicitly mentioned. A worrying conclusion from the review provided by Joanna Dickinsson and colleagues is that MM as a concept has yet to take its right place in the transport planning in national transport policies of both countries.

On the other hand, policies and measures at local and regional level seem to be moving ahead of national policies in this area. Christian Brandt and Peter Arnfalk, in Chapter 14, "Mobility Management moving in – The journey of integrating MM into decision making processes in municipalities" report on experiences of integrating MM practices into local traffic planning within municipalities in the Øresund region and elsewhere in Sweden. While much of past efforts aimed at applying the concept of MM within local municipalities evolved from isolated and often externally funded initiatives, the current challenge facing programme managers include the issue of scaling up demonstration projects and building up resources, processes, and competencies for full-scale application and integration into other municipal functions. Their case analysis further points to the need to locate the function of MM independent from the traditional traffic departments within municipalities to better integrate with other units of a municipality, particularly those that are responsible for decisions that can shape the demand and nature of transport activities, such as enterprise development and economy departments.

The second perspective is exploratory in nature and aims to challenge established notions about mobility as a goal in and of itself and the way mobility decisions are made in everyday life. This discussion is invoked in the context of travel for leisure in the Øresund Region in Chapter 1, "User Perspective in Mobility Management choises: The experience with leisure travel in the Øresund Region". Emtairah and colleagues present findings from an empirical study of leisure travellers and their mobility choices to four destinations within the Øresund region. They report on travel choice determinants and critically examine those within the leisure experience context. Insights from their study are brought into the question of how to effectively mobilise citizen-consumers for sustainable leisure travel. Their conclusions highlight the potential role of upstream actors such as transport service providers and downstream actors such as attraction or destination managers, in the transition towards more sustainable leisure practice within the Øresund Region. Examples mentioned include the need to better integrate information and offers regarding alternative mobility choices in the promotion materials for destinations in the Øresund Region. Environmental prerogatives alone will not be sufficient to create a noticeable shift towards climate friendly transport options without considerations of other aspects that factor into the decision-making process such as convenience and price.

Part I

Policies, resources and infrastructure

1. Governance for sustainable transport in the Öresund region

Jamil Khan

When the Öresund link between Denmark and Sweden opened in the year 2000 it was described as a historic achievement that would link the two countries together and form one larger Öresund region. Some ten years later these expectations have been partly fulfilled with approximately 20,000 vehicles and 29,000 commuters traveling by train across the bridge daily. Increased transport between the Swedish and Danish side is a core aspect of regionalisation and the Öresund link has contributed directly to this increase. At the same time, a low-carbon transition is an outspoken policy goal on both sides of the strait. The City of Copenhagen has as a goal to become carbon neutral by 2025. On the Swedish side, both the city of Malmö and the regional parliament in Skåne have similar goals. It may sound paradoxical to talk of sustainable transport in the Öresund region since the very idea of creating a larger region is based on increased transport, however, this tension between sustainability and mobility, lies at the heart of transport policies at all levels, from the EU down to the local. Still, as this book shows, there are many positive initiatives and developments going on in the Öresund region when it comes to sustainable transport patterns.

The aim of this chapter is to put sustainable mobility efforts, which are described in this book, into a governance framework in order to understand what they are and what they can achieve. I will do so by discussing two overlapping themes. First, I will introduce the concept of governance (as opposed to government) and show how sustainable mobility efforts in the Öresund region are shaped and implemented not only by public decision makers but by a whole set of different actors. I will further discuss some of the concerns that can be raised when governance is carried out by a combination of public and private actors. Second, I will discuss the need for policy change at different levels (policies, institutions, paradigms) in order to induce long-term change towards a low-carbon transition, and I will discuss the experience of mobility management against this backdrop.

Governance and sustainable mobility

Political scientists have observed, over the last decades, how the conditions for, and forms of, societal steering has changed. From being dominated by hierarchical steering, via regulations and administrative policy instruments, societal steering has become more complex and difficult to manage due to increased economic integration (globalisation), the financial problems of the welfare state and an ideological shift towards a neoliberal policy of deregulation and privatisation. The political institutions that are traditionally associated with the national welfare state have increasingly become dependent on other societal actors (firms, households, interest organisations) as well as international actors and institutions (Pierre and Peters 2005). One effect of this is that societal steering today is more and more characterised by co-operation and negotiation between stakeholders, both public and private, and that the responsibility for the design and implementation of policy measures is increasingly delegated to other levels, both upwards (e.g. the EU), downwards (regions, municipalities) and outwards (market, civil society). Another sign is the proliferation in the use of policy instruments that are market-based or that rely on collaboration, dialogue and voluntary initiatives (Jordan et al 2005). These developments have been evoked in order to describe a shift from government to governance, i.e. from hierarchic forms of steering to more horizontally defined forms of steering (Rhodes 1996, Kooiman 2003). However, it is debated to what extent new forms of steering have actually replaced, or merely complemented, traditional regulation, and whether the governance shift has really lessened the influence of political institutions (Pierre and Peters 2005). Irrespective of how the shift is interpreted, the contemporary governance debate has contributed to bringing in new perspectives on the conditions of steering and a broader focus on "the whole range of institutions and relations that are involved in the governance process" (Pierre and Peters 2000, p. 1).

Sustainable transport is clearly a policy area were the governance shift is visible and developments in this area are shaped and implemented by a variety of public and private actors at all levels of policymaking. At the regional and municipal level, there are many autonomous initiatives that to various degrees are connected to policies at national and EU-levels. In this respect the Öresund region provides an interesting illustration. This book deals with such diverse aspects of sustainable transport as the greening of city logistics, mobility management and the development of alternative fuels. While being different in many respects, they share two similar governance characteristics. First, all policy initiatives that are described in this book are based on interaction between public and private actors and, second, they have all emanated from the local and regional level.

The main actors in *city logistics* are the commercial companies that produce, distribute and sell goods, i.e. logistic service providers, large corporations, retailers and shop owners. From a pure market perspective, their overarching goal is to maximise profits that implies creating efficient city logistics from a commercial point of view, while it is the role of municipalities and other public actors to promote and enforce environmentally benign behaviour. However, this simplistic view of governance is not valid, neither from a theoretical standpoint nor when looking at governance practice. It is very clear from the contributions in this volume that it is essential to involve private actors in both the development and implementation of initiatives to create greener city logistics. It is equally clear that private actors themselves can be drivers of improving sustainability. In Chapter 7, Carlsson and Janné study the development of urban consolidation centres (UCC) which can be considered a social innovation for greener city logistics. A UCC is a terminal where goods arrive from different suppliers and then are delivered to shop owners and other customers in a specific urban area. The UCC has great potential to reduce both congestion and local and global emissions. Carlsson and Janné show that the consolidation of goods in urban areas has traditionally been both initiated and run by municipalities with focus on the supply side of distribution, i.e. the logistic service providers. Most of these initiatives have failed since they have not involved shop owners that are the main users of a UCC. This shows that top-down governance arrangements are not adequate and that there is a need for a broader network or market approach. Municipalities should not run programmes but rather have a role as enablers. Private or public-private companies are better equipped to run a UCC that could also be seen as a new business opportunity.

Mobility management can be defined as measures that have the aim to change attitudes and behaviours of travellers in a more sustainable direction, by reducing transport demand or inducing modal shift. Mobility management is an example of a new mode of governance since it is based on information, voluntary measures and networking activities. However, to be effective it needs to be combined with infrastructure planning and economic incentives. The main policy actors in mobility management have been municipalities and public transport companies and the main receivers of policy have been individuals as commuters or leisure travellers. In Chapter 13, Dickinson et al show how mobility management in Sweden has grown out of local and regional initiatives and successively become more incorporated in transport policies at the national level. In Denmark, on the other hand, national support was initially important but has later decreased. An important challenge for mobility management is to become an integrated part of transport planning instead of something that takes place in particular projects while mainstream transport planning leads to an increase in travel volumes and car driving. Arnfalk et al show in Chapter 14, with case studies from Swedish municipalities, that good networking is essential for successful mobility management, within both the municipality and outwards with business and private actors. I have previously studied the importance of networking for effective municipal climate governance since success depends on the engagement of a broad part of the public administration and not only the environmental authorities (Khan 2010). In the Copenhagen area, an on-going project around mobility management called Formel M, is an example of public-private cooperation and networking. It includes regional authorities, municipalities, transport companies, as well as public services such as hospitals and business organisations. Mobility management, as a new mode of governance, has so far mainly been directed towards commuters. However, Emtairah et al, argue in Chapter 15, that more attention needs to be paid to leisure travel since it constitutes a large part of local and regional transport. When addressing leisure travel it will be even more important to include a variety of actors such as transport service providers and destination managers.

The regional development of *alternative energy carriers* in transportation is another area where public-private cooperation and network governance is important. In Chapter 4 by Karakashev et al, a broad overview is provided of different alternative energy carriers and their use in the Öresund region. Biogas and ethanol are the two energy carriers that are most widely used today. The development of biogas in southern Sweden provides a particularly interesting case of network governance, since it has been promoted and implemented by a wide variety of actors including university departments, regional and municipal waste companies, transport companies, energy companies, farmer organisations, and local and regional politicians. Specific interest organisations around biogas have been established and a network of dedicated persons has evolved. In 2010, the region of Skåne was appointed by the Swedish government as one of three pilot regions for energy and green development much owing to its work on biogas.

Are new forms of governance a threat or a remedy?

It should be clear from the chapters in this book, that sustainable transport governance in the Öresund region is the concern of a variety of societal actors who all have their own motives for pursuing this agenda. Two questions shall be discussed here in relation to this. First, what are the implications for democratic legitimacy and goal achievement when a public policy goal (sustainable transport) is formulated and implemented in a non-hierarchical governance setting? Second, what is (and should be) the role of public actors, particularly the state, in this kind of governance setting?

Turning to the first question, political scientists disagree as to whether new forms of governance pose a threat to democratic legitimacy and goal achievement, or are they in fact the remedies to an old system that was not working. Traditionally, environmental governance has been characterised by a threefold gap in legitimacy, implementation and governance capacity (Bäckstrand et al 2010). In light of this, new modes of governance offer a promise of being both more effective and legitimate by bringing in new actors to policy formulation and implementation. In the examples examined in this book, this promise can be clearly seen clearly and in many cases, it has been essential to directly engage private actors in both problem formulation and implementation. Collaboration and dialogue are at the heart of policy initiatives such as city logistics and mobility management schemes. However, with the delegation of responsibilities also come some important concerns. Since policy formulation is the result of negotiations between public and private actors, there is a risk that the outcome will accommodate certain special interests rather than the public good. This is particularly the case when policy is developed by a closed network of actors rather than through an open process (Fischer 2006, Khan 2010). When it comes to network governance of sustainable city logistics, Carlsson and Janné discuss the importance of involving user groups such as shop owners. Such an opening up increases both the legitimacy and implementation capacity of initiatives. However, the involved actors will still comprise a tight network of stakeholders and the question remains how the concerns of citizens are addressed in these networks. It seems imperative that public authorities retain some influence on the projects so that business interests do not override environmental and other public interests. To the extent that principally private companies or civil society carries out implementation, there is an important issue of accountability. Who is responsible for goal achievement and to who can people turn if they feel that their needs are not catered to? Is it the policymakers or is it the private implementers?

This leads us to the second question about the role of the state and other public actors in an increasingly horizontal governance setting. When discussing network governance, Sørensen (2006), among others, has developed the concept metagovernance to describe how politicians and decision makers should carry out political steering. In metagovernance, the state is an enabler and facilitator, and is responsible for creating the right arenas were policies are formed and implemented by a variety of actors. The ideas of Janné and Carlsson on the development of sustainable city logistics are a good example of metagovernance in practice. While metagovernance is interesting from a policy management perspective, it however remains problematic since it does not address the question of the democratic legitimacy of network governance. In their book on new modes of environmental governance, Bäckstrand et al (2010) find that many voluntary and network based governance arrangements actually work in “the shadow of hierarchy” with an either implicit or outspoken threat of harder policies (regulation or taxes) if soft policies do not work. In this perspective, the state retains its policy responsibility by a preparedness to step in if it is deemed necessary to achieve publicly decided goals. Another important role of politics is to create visions and formulate policy goals (Khan et al 2011a). There are several examples of this function on both sides of the Öresund strait, at both the city and regional level. It is crucial that local, regional and national authorities manage to live up to their dual role as policy drivers and policy enforcers. Otherwise, there is an apparent risk that the individual efforts by public and private actors, and by individuals, will not lead very far. We should avoid the dichotomy of top-down vs. bottom-up while describing or studying the policy process for sustainable transport. Central policy makers do not create policies in isolation. Likewise, local or private initiatives cannot sustain in the long run without central support. The development of biogas in Skåne is a good example of the interaction between bottom-up processes and top-down policy making.

Policy change at different levels: the example of mobility management

Achieving the transition to a sustainable transport system will require not only thorough changes of technology and behaviour, but will also require an equal shift in terms of policy and governance. Political scientists discuss the need for changes and reforms at different levels in order to achieve substantial societal change, such as a genuine move toward sustainable policy making (Eckersley 2004, Hall 1993). Eckersley (2004) talks of four levels: new policy instruments, new policy goals, changes in the hierarchy between policy goals, and a change in the view of the core obligations of the state. Most environmental policy is enacted at the two first levels with a proliferation of new policy instruments and environmental goals. However, to achieve real change, Eckersley argues, there is also a need for a more fundamental policy change that puts environmental concerns on par with other policy areas such as social welfare, agriculture, energy, unemployment and economic growth. Based on this discussion we have developed a framework for analysing the type of policy changes that are vital to a successful governance of transition processes (Khan et al 2011b). We argue that changes are (or might be) needed at three different levels: (i) new policy instruments, (ii) institutional changes and, (iii) changes in paradigms. In the following section, I will use the example of mobility management in the Öresund region to illustrate the need for policy change at different levels.

New policies and measures

The mobility management initiatives and measures that are described in this book are mainly located at the level of policy measures, in the form of projects that are organised and driven mainly by municipalities but also by some private actors. Action at this policy level is necessary in order to give incentives for change. Innovation of policy instruments is a vital part of environmental policy change since there is often a need for new approaches and the letting in of new actors. Typically, mobility management initiatives are introduced in the form of projects or programmes that include different measures to reduce transport demand and change transport behaviour. Information campaigns and dialogue with user groups are important measures when combined with measures such as improved infrastructure for bicycles and improved service of public transportation. Economic instruments such as increased parking fees can also be used. Policy measures are mainly introduced at the local level by municipal authorities while there are few examples of national policy instruments with a mobility management focus. Overall, mobility management efforts have shown good results in some municipalities, especially when it has been combined with a holistic planning for sustainable transport. However, policy implementation is fragmented and transport trends in general point in the opposite direction.

The need for institutional changes

Mobility management projects affect people´s habits as well as attitudes and can have important impacts on the individuals that participate. However, the long-term effects of mobility management are very much dependent on the existence of structures, both physical and organisational, that support and facilitate the behavioural changes that are desired. If car drivers are going to shift to public transport or cycling these alternatives, have to be as attractive as the car. If people are going to travel less in general they have to access to the same services with less transportation. Studies have shown that there is a strong connection between physical planning in cities and regions and the level and character of personal transport (Holmberg, 2011). The proximity to bus stations and the quality of cycle paths for example are crucial aspects. The successful mobility management efforts are those that are accompanied by investments in infrastructure that support sustainable transport patterns. Within cities there are good examples of how mobility management and physical planning has gone hand in hand leading to more sustainable transport patterns. Copenhagen and Lund are two examples in the Öresund region. Much of the increase in transport occurs at the regional level, though, and here the possibilities for steering are diminished. In Sweden, regional planning is rather weak and there is a need for institutional changes to make the regional level more important. Regional planning across two countries is even more complex and the past ten years of regionalisation has contributed to an increase of all types of transport modes in both personal transport and goods.

Another institutional aspect is to what extent mobility management has become an integral part of transport planning in municipalities and regional bodies, or whether it remains something project based. Dickinson et al (insert ch number) describe the history of mobility management in Sweden and Denmark and paint a picture of fragmented integration. Although mobility management ideas increasingly are mentioned in national policy documents official transport policy is still dominated by an infrastructure supply approach. At the local level, mobility management is usually carried out in project form and is not integrated in mainstream transport planning.

Curbing mobility is not an option! Or is it?

Mobility management is ultimately about affecting transportation behaviours towards more sustainable transport modes, a more efficient use of transport modes, and lessening demand for transport in general. Mobility management then clearly has a discursive, or normative, feature to it that says that in order for transport system to become sustainable we have to change our behaviours. To understand properly the prospects of mobility management efforts being successful, we have to put it in the context of a broader discursive struggle about how a sustainable transport system can be reached. I argue that there exists such a discursive struggle between one side that maintains that technological solutions will mostly solve the problem (meaning that present trends in transport volumes can go on) and the other side that instead argues that there is a need for major changes in transport patterns. This discursive struggle cannot be easily attributed to particular actors but rather is integrated in the decision processes within and between organisations, companies, governments, and authorities. I will give examples of the discursive struggle at three policy levels: the EU, Sweden, and the region of Skåne.

In the European Commission's White Paper on Transport (2011), a road map is presented for reducing greenhouse gas emissions attributed to the transport sector by 60 per cent to 2050. On the one hand, the White Paper envisions many necessary changes in transport patterns including a large modal shift from road transport to railway for long distances and an increased role for public transport and cycling in cities. On the other hand, we can also find the famous paragraph 18 that reads "Curbing mobility is not an option". Overall, the White Paper presents a techno-optimistic vision that wishes to merge emissions reductions with increased transport activity. At the level of national politics, the Swedish transport political goals are a good illustration of the discursive struggle going on. Transport supply is still the main focus and the general goal reads: “The general goal for Swedish transport policy is to secure a socioeconomically efficient and long term sustainable transport supply for citizens and business in the whole country” (Swedish Gov. 2009, p. 14). Still, a change can be traced since “accessibility” has become an important sub-goal, instead of mobility. Accessibility can, however, be interpreted in many ways. In the preparatory work for the transport goals, the state-owned research institute SIKA (Swedish Institute for Transport and Communication Analysis) suggested that increased accessibility should be achieved with “the least possible transport work” (Swedish Gov. 2009, p. 18). This was going too far and the government did not include this formulation in the transport goals instead stating that “it is not a goal in itself to reduce transport” (Swedish Gov. 2009, p. 20). While the mobility paradigm is being challenged in national policy documents, Wendle et al. (2011) note that it is still dominant in actual planning processes from national to local levels. Petterson (2011) has analysed regional transport plans in Skåne and compared the discourses on regional enlargement and sustainable transport. He has shown that regional enlargement assumes a greater weight while the sustainability goals are adapted to fit into this discourse. Thus, increased rail traffic and cleaner technology become the main routes for sustainable transport while transport demand management is marginalised in the policy discourse.

The impression of this brief résumé of the discursive struggle is that mobility remains a dominant paradigm even though it is being increasingly challenged. It is appealing for decision makers to adhere to “win-win” strategies where the needed emission reductions are achieved without having to interfere with people´s travel habits or the concerns of industry. What does this imply for the mobility management initiatives that are described in this book? Basically, it means that they are implemented in a current that goes in the opposite direction. On the one hand, people are told in mobility management projects that they should change their travel behaviours. At the same time, people receive a myriad of other signals that urge them to impose the opposite behaviours. While this may appear disheartening for those engaged in mobility management initiatives, the point is to see this work as part of the discursive struggle. By showing that there are alternative ways of thinking about transport and sustainability and that these ideas can be translated in to everyday practices, existing norms are being challenged. Norms are not changed overnight but piece-by-piece in a constant discursive struggle.

Conclusion

In this chapter, I have shown that the projects, initiatives, and policies that are described and analysed in this book can be placed in a larger framework of sustainable transport governance in the Öresund region. This governance is not the business of public actors only, such as governments, regional authorities, and municipalities. Rather, the path towards sustainable transport is shaped by, and dependent on, the collaboration and interactions of a complex set of different actors, both public and private organisations, as well as individuals acting as consumers and citizens. Still, there is a special role for politicians and public authorities in securing democratic legitimacy of sustainable transport governance and providing political visions and direction. In the end of the chapter I argued that policy changes are needed at different levels: policies and measures, institutional changes, and changes in paradigms and discourses. This was exemplified by discussing the mobility management efforts that are described in this book. It was shown that while individual projects can show good results in particular municipalities, long-term change will require that mobility management becomes integrated into transport planning at all policy levels and that the current paradigm of mobility as a goal in itself is challenged.

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2. Rapid adaption of the transport system in light of peak oil – vulnerability and fuel-saving potential in the Öresund region

Karin Neergaard and Katarina Evanth

The transport system's oil dependency in light of peak oil

The days of having a steady supply of inexpensive oil are running out. Oil is a limited resource and a number of calculations show that demand will soon exceed supply. "The age of cheap oil is over." (Fatih Birol, Chief Economist at IEA, 9 November 2010)

According to the latest World Energy Outlook 2010, peak oil occurred in 2006. Further to this, a study from the German Federal Ministry of Defence has indicated that peak oil occurred in 2010, while another report, this time from Kuwaiti scientists, predicts that peak oil will occur in 2014.

According to a BP Statistical Review published in 2009, there is enough oil to last for 42 years. Chief Economist Fatih Birol at IEA stated in 2010 that the world each year uses 6.7 per cent of the remaining oil reserves.

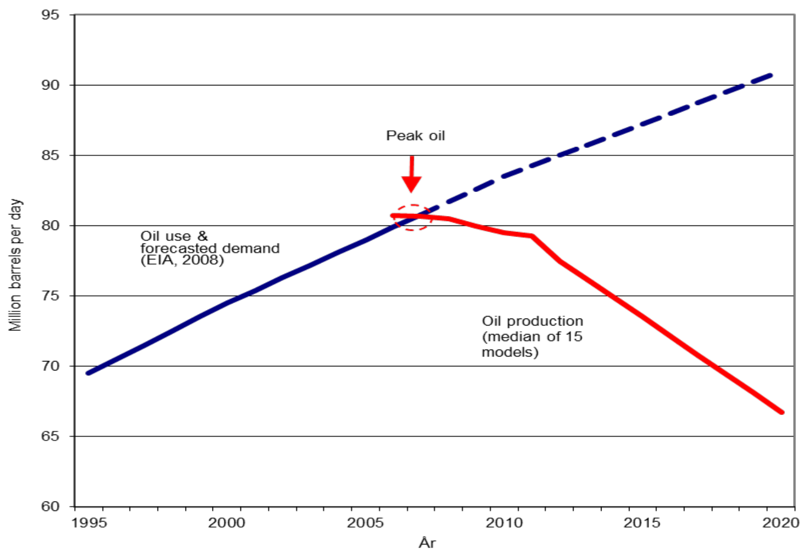

Chart 1: There is a clear and growing gap between the amount of oil required according to forecasts of EIA (blue line) and the remaining oil (red line).

What happens when we exceed peak oil, and demand exceeds supply? Nobody knows. Most likely we will have to use oil more efficiently and change our lifestyles. However, most economists agree that when peak oil arrives, oil will be expensive.

In the case of Sweden and Denmark, the risk of higher prices is probably not the biggest threat since the effects of oil prices are abated by our fuel taxes, but rather secondary effects caused by the unrest that can result from price increases in other countries.

The record high oil price of 2008 showed that the transport system is intrinsically linked to oil use. According to several researchers, among others Nobel Laureate in Economics for 2008, Paul Krugman, this price peak was one of the most important reasons for the beginning of the deep recession that several countries are still experiencing.

The transition from an oil-based society is often described as dramatic in different studies. The following quote from Peak of World Oil Production[1] exemplifies this: ”Previous energy transitions (wood to coal, coal to oil, etc.) were gradual and evolutionary; oil peaking will be abrupt and revolutionary”

Both the United States Department of Defence and the German Federal Ministry of Defence have, in the past few years, studied what happens during an acute oil shortage, since the issue is strategically central to both their respective national security policies. In the 2005 report *Saving Oil in a Hurry,* the International Energy Agency (IEA) pointed out the need for organisations and authorities to have a plan for how disruptions in the oil supply can and should be handled:

“Much stronger action is needed to accelerate the transformation of the global energy system.”

In light of this, Trivector has analysed the vulnerability and robustness of the Swedish transport system, with concrete analyses for the Öresund region and Stockholm County. The fuel-saving potential for different measures that can be carried out quickly in case of an oil crisis, a rapid price increase, or similar events have been analysed based on current travel patterns. This chapter summarises the results for the Öresund region.[2]

The transport sector together with the food and agricultural sector are the two most oil-dependent sectors in Sweden. The Swedish transport sector accounts for as much as 77 per cent of the use of oil products, and in Denmark the corresponding figure is 67 per cent (according to the Swedish and Danish Energy Agencies).

While other sectors have decreased their oil use, the transport sector has done so only marginally. In 2009, 94 per cent of the Swedish transport sector’s energy use consisted of oil products and only a small proportion utilised electricity (used by trains), Compressed Natural Gas (CNG), biogas, or ethanol. In Denmark, this share is even lower. In 2007, 98 per cent of the Danish transport sector’s energy use consisted of oil products.

Road passenger transport accounts for the largest portion of oil product use. Sweden’s three metropolitan areas account for a considerable proportion of that use and trips in

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[1] Hirsch et al, 2005, Peaking of World Oil Production: Impacts, Mitigation & Risk Management.

[2] The project has been financed by Vinnova with additional financing from the EU Interreg project Tillhåll 2 (TIllgänglighet för ett Livskraftigt och Långsiktigt HÅLLbart Skåne-Blekinge) for analyses of the Skåne-Blekinge region as well as from EcoMobility (an EU Interreg IVA project) for analyses of the Öresund Region

'larger cities' constitute the largest volume of that amount (according to Statistics Sweden's classification into H-regions). Further, citizens living in sparsely populated areas make up only a relatively small share of the total number of kilometres driven on the roads each year. The Malmö region along with Hovedstaden (that is Eastern Denmark including Copenhagen; "Hovedstaden" means "capital") account for more than half of the distance travelled in the Öresund region annually.

Travel habits in the Öresund region

Analysis of travel habits in the Öresund region is the basis for the evaluation of fuel-saving potential. The analysis is based on the Swedish national travel survey from SIKA, "RES 2005/2006", and the 2008 Danish national travel survey conducted by DTU[3]. It should be noted, however, that the Danish travel survey does not include international flights as the Swedish survey does. This fact has complicated the comparison between the regions. Therefore, in some figures and graphs presented here, the flights have been excluded from the Swedish data. Comparatively, Denmark has very few domestic flights of the type that are common in Sweden.

In the following text, the Öresund region is divided into Sjaelland and Hovedstaden on the Danish side, and Skåne and Blekinge on the Swedish side. Skåne and Blekinge are further divided into H-regions (SCB grouping of municipalities by local and regional population base, along the scale of urban-rural).

In total, more than 80 per cent of the distance travelled is dependent on oil products such as gasoline, diesel, or jet fuel. Sixty-five per cent of the distance travelled is made by car (see pie chart).

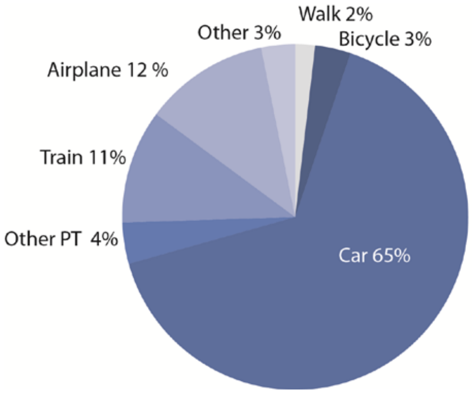

Chart 2: Travel (passenger km) in the Öresund region.

[3] The two databases have been merged and analysed by Trivector. DTU have contributed with the Danish data and former SIKA with the Swedish data.

The entire Öresund region – from Hovedstaden to the regions of Blekinge and Sjaelland – has varied conditions, which are illustrated in the Marimekko chart below. Hovedstaden and the Malmö region are relatively similar. Perhaps somewhat surprising is that the travel per person per day is considerably higher for Sjaelland than for the other regions. It is mainly the number of kilometres with car that is higher.

Although cycling accounts for relatively few kilometres, the Marimekko chart shows that both the number and share of kilometres is higher in Denmark. This is especially characteristic for Hovedstaden, where as much as 7 per cent of the total distance travelled is done by bicycle. This can be compared with 3 per cent for the Malmö region.

If we do not include air travel, the proportion of car trips in Skåne/Blekinge and Sjaelland is the same: 78 per cent. The proportion in Hovedstaden is 67 per cent, only one percentage point less than in the region of Malmö.

From an oil-dependency perspective, it can be noted that trips that would not directly be hit by a decreased oil supply (trips by foot, bicycle, train, and bus) only account for about 20 per cent of the total kilometres driven on roads in the region of Öresund. However, large parts of the bus fleet in the region, and some train lines, are still dependent on oil.

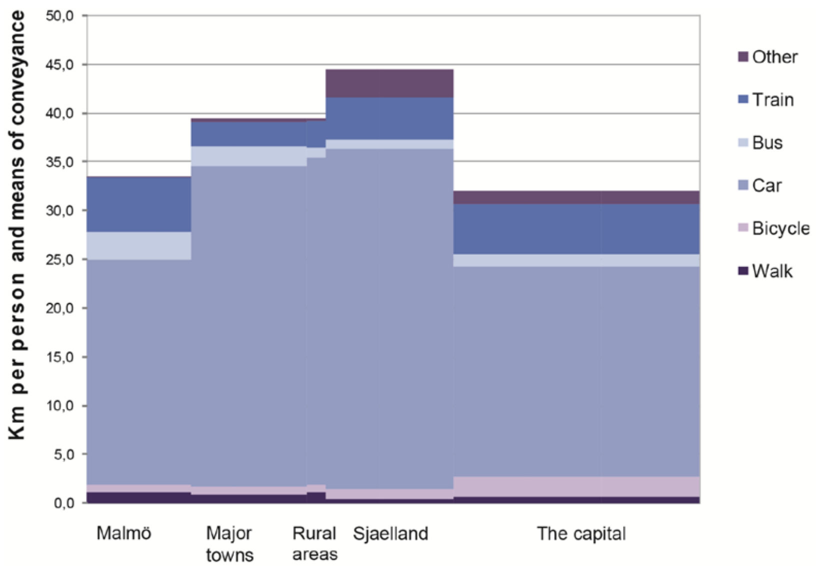

Chart 3: Passenger km per person and day divided by mode of transport (y-axis) for different parts of the Öresund region (x-axis): Malmö, major towns, rural areas, Sjaelland and Hovedstaden (Eastern Denmark including Copenhagen). The x-axis also shows the population of the different parts. Thus, one can see that car travel in Hovedstaden is a bigger target group than car trips in rural areas even though the km per person is higher in rural areas.

Today, leisure travel dominates the share of km in road traffic (41 per cent). This share has gradually increased. This applies not only for the Öresund region, but also for the whole of Sweden. Leisure travel, along with the category "other," accounts for half of travel, plus or minus five percentage points. Work and school trips account for approximately 25 per cent of km travelled, except in Sjaelland, where the proportion is slightly higher. Business travel accounts for about 10 per cent, slightly below on the Danish side and slightly above on the Swedish side.

Oil use for passenger transport in the Öresund region

Based on the travel habits that have been presented earlier, an estimate of the oil use for passenger transport can be made.

The bar chart below shows the oil use for road passenger transports in the Öresund region classified according to purpose of the trip and transport mode. As previously mentioned, leisure travel in the Öresund region accounts for a large proportion of all trips and consequently a large proportion of the oil use (44 per cent). The car is the dominating mode of transport with 84 per cent of the oil use of passenger transport, while air travel accounts for 14 per cent. Please note that our figures for Danish air travel are based on assumptions and may therefore be too low.

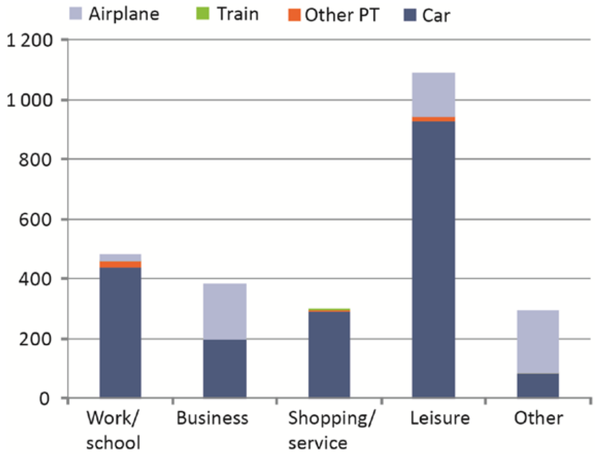

Chart 4: Oil use for passenger transport in the Öresund region divided by purpose of trip and means of transport (million litres per year). Leisure travel includes visiting relatives and friends, giving others a ride. Airplane-share is calculated with the assumption that Danes fly as much as Swedes do.

Short- and medium-distance trips, i.e. trips below 50 kilometres, account for a large part of the oil use for car trips in the Öresund region: 29 per cent compared to 25 per cent in Sweden. On average in Sweden, the share of car trips longer than 80 kilometres account for the largest part: 38 per cent.

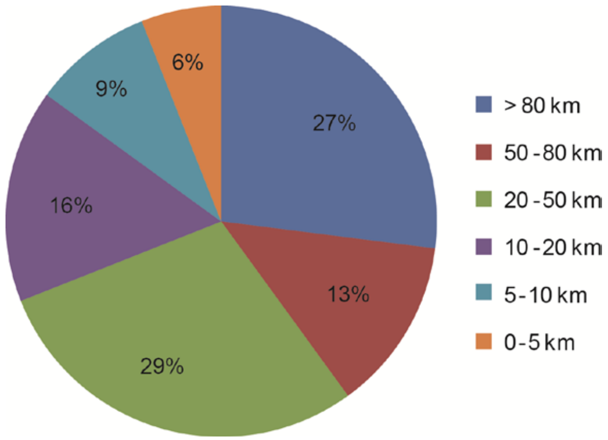

Chart 5: Oil use for car travel in the Öresund region divided by journey length.

On average, an inhabitant of the Öresund region uses 657 litres of oil products per year and about half a litre per metric mile for passenger transport, excluding air travel. The metropolitan regions – the Malmö and Stockholm regions and Hovedstaden – have the lowest oil use per kilometre, lower than the national average for Sweden and the Öresund region (see table below).

Region	Litres per 100 km	Litres per inhabitant
The Öresund region	4.4	657
Malmö in Skåne Blekinge	4.0	485
Major towns in Skåne-Blekinge	4.8	692
Rural areas in Skåne-Blekinge	4.9	699
Hovedstaden	4.1	459
Sjaelland	4.8	731
Stockholm	4.0	478
Sweden	4.6	655

Table 1: Oil intensity index for passenger transport, excluding air.

When it comes to the use of oil products expressed in litres per inhabitant and year, Hovedstaden ranks the lowest if comparisons are made excluding plane trips. The regions of Malmö and Stockholm lie below the national average for Sweden when it comes to litres of oil products for passenger transport per inhabitant/ year if plane trips are included. Since the regions of Malmö and Stockholm have relatively high number of plane trips, the difference is even larger if one does not include plane trips in the comparison.

One-third of public transport is dependent on oil products

For the entire Öresund region, 34 per cent of travel with public transport is dependent on oil products (2009). Public transport in Eastern Denmark is more dependent on oil products than Skåne and Blekinge, due to a large share of diesel buses and to the fact that some trains still run on diesel. For the regions of Skåne and Blekinge in total, 18 per cent of travel with public transport is dependent on oil products, which in this case is due to diesel buses.

The public transport operator Blekingetrafiken only has diesel buses, while the public transport operator Skånetrafiken has a large share of biogas buses, with 56 per cent of their entire bus fleet and more than 90 per cent of their city buses run on biogas (2009). Seventy-seven per cent of all the travel (measured in passenger kilometres) in Skåne is carried out by vehicles powered by renewable fuels.

Biogas prices follow the oil price index, which means vulnerability in face of oil price increases in spite of having a relatively low share of diesel buses. There is, however, a limit on the increases and Skånetrafiken is working to make the biogas price decoupled from the oil price in the future.

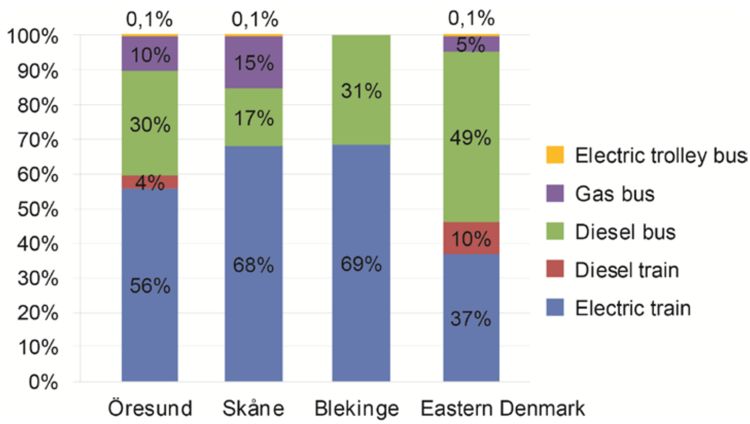

Chart 6: Share of diesel, gas and electricity in public transport in the Öresund region.

To summarise, the analyses show that there is a large potential in:

- Decreasing shopping trips, leisure trips, and "other" trips. These trips done solely by car account for 27 per cent of the transport sector's total use of oil products. [In Öresund: 1 700 million litres of oil per year]
- Decreasing business trips, which comprise 10 per cent of the transport sector's total use of oil products. [In Öresund: 400 million litres of oil per year]
- Transferring car trips to public transport in the three metropolitan areas (if there is enough capacity). [In Öresund: 900 million litres of oil per year].

At the same time, preferences are such that most people would readily decrease their commuting trips while they would rather make more leisure trips, especially long journeys. In a normal state – without any shortage or crisis – leisure trips are therefore often the most difficult to influence, while the opposite is probably true in the event of a shortage or crisis situation.

Measures dealing with road freight transport have a relatively small effect, since road passenger transport is dominant. Freight transport accounts for 35 per cent of road transport while passenger transport accounts for 65 per cent, according to compilations made by the Swedish Energy Agency in 2009. However, there are some uncertainties regarding the figures for shipping, which means that freight transport by sea, and consequently the total freight share, can be somewhat larger.

Possible oil savings with various voluntary and mandatory measures

What level of oil savings is possible to achieve in the event of a crisis and which measures can be implemented quickly, e.g. within half a year?

Experience from previous fuel crises, the oil crises in the 1970s, the oil blockade in Great Britain in 2000, and others, show that we can expect changes in travel behaviour and modes of transport solely as a result of a crisis or large price increase, without carrying out any measures. Car trips for shopping, visits, taking children to activities, and trips that fall under the category “others,” are those that often decrease the most, i.e. the trips that are most difficult to influence under normal circumstances. For example, if the price of petrol increases 80 per cent on a short-term basis, car travel is estimated to decrease by 16 per cent. A crisis situation with high crisis awareness can lead to an even larger decrease. This may also be the case if fuel prices remain high on a long-term basis. If the price increases 10 per cent on a long-term basis, car travel is estimated to decrease by 6-8 per cent.

However, circumstances indicate that it is wise to be prepared. The authorities have an important role in being a driving force for preparedness. Preparatory activities might include making available information to companies and persons to help them to voluntarily change their travel behaviour in order to save fuel well ahead of a potential crisis. In our more densely populated regions, capacity-raising measures are needed to meet increased demand on public transport as well as repressive measures to quickly decrease the usage on a short-term basis in the transport sector; in this case within six months.

In addition to measures to increase travel by foot, bicycle, and public transport, examples of measures of a more voluntary nature that have been analysed in the study are: campaigns to save fuel, voluntary agreements with companies regarding green travel plans, e-meetings, teleworking, eco-driving, as well as voluntary speed reductions for commercial traffic on roads, by sea, and by air.

Measures of a more mandatory and restrictive nature are changes in speed limits, fuel rationing, and driving bans under certain times.

Economic measures have not been studied closely since the study has been conducted under the assumption that market forces are at work during a crisis and automatically lead to higher fuel prices. If, however, the normal functions should be out of play and price increases do not occur, one can consider the measure of having an added fuel tax or other economic measure.

Three scenarios and possible savings of 1-30 per cent of oil use

How much fuel can be saved is determined by different contemporary social and environmental factors, and therefore the calculations made are based on three different scenarios:

- The first scenario refers to the normal state, i.e. what the effects of different measures are expected to be without any impact on price or crisis to speak of.
- The second scenario refers to the effect of a moderate price increase and a somewhat raised public crisis awareness
- Scenario three refers to a sharp increase in price or a local shortage situation and high public crisis awareness.

The fuel-saving potential for each measure has been estimated based on what is known of the measure's effects under normal circumstances and the experiences from earlier fuel crises and similar events.

There are a number of uncertainties in the estimated fuel-saving potential. For instance, the effects are very dependent on contemporary social and environmental factors, which influence both price and crisis awareness.

The most effective measures to decrease travel are resource-limiting measures such as fuel rationing or driving bans on odd or even dates.

Among the voluntary measures, e-meetings are one of the most effective measures, where the result in the scenario with the largest effect is estimated to be about 5 per cent of the transport sector's total oil product usage.

The transfer of private car transport to public transport can also have a considerable effect in the long run, but since the public transport systems in the metropolitan areas currently have a very limited maximum capacity in peak hour traffic, the effects are difficult to assess. If it is assumed that public transport capacity can increase by 50 per cent with the help of adaptation of working hours and other capacity-raising measures, the oil saved can correspond to 4 per cent of the transport sector's total oil product usage.

In the three metropolitan areas, it is estimated that the potential to transfer travel to public transport mainly applies to leisure trips during off-peak times, since there already are large problems with the capacity during the morning and afternoon peak hours. To increase the travel with public transport for trips to and from work, working hours would have to be spread out over a larger part of the day. This to some extent can be done voluntarily in case of a crisis, but most likely requires emergency planning.

Fuel-saving campaigns with voluntary speed reductions constitute one of several other voluntary measures that are relatively easy to carry out in the event of a crisis, and that have an acceptable effect. For the target group of private motorists, it can mean savings for scenario three of almost 2 per cent. The same measure for commercial road traffic as well as for aviation and shipping is estimated to yield just as large of savings.

In the normal state, reduced speed limits are estimated to yield equivalent savings of 3-4 per cent of the transport sector's total oil product use in Sweden. The normal state refers to how the average speed normally is for different speed limits without consideration given to an increased compliance of speed limits, which can be the case in a crisis situation or with support of extra traffic controls and speed cameras. The effect refers only to the direct effect and not the indirect effect on decreased car travel and transfer to other modes of transport. Four per cent refers to a more advance method, which is more difficult to implement. Three per cent refers to a simple procedure that entails reducing the speed limit on all roads with current speed limits above 90 km/h to 90 km/h and all speed limits of 90 km/h to 70 km/h.

With increased crisis awareness, increased police controls, or more speed cameras (ATK), the estimated effect can be more than double. For instance, driving at 90 km/h instead of 110 km/h corresponds to a 10-15 per cent decrease in fuel consumption. Indirect effects are estimated to give an additional effect that is just as large as the direct effects, that is to say, a total of 6-8 per cent.

To summarise, the measures with the greatest potential in the Öresund region (aside from the mandatory measures of fuel rationing and driving bans) are those that increase the share of public transport trips. But, as previously mentioned, this is based on assumptions that the public transport's capacity can increase by 50 per cent with the help of adaptation of working hours and various measures to increase capacity. Examples of such measures are the more efficient use of vehicles and infrastructure, the expansion of the vehicle fleet, and the reconfiguration of supply chains. Currently, the capacity is fully utilised in many parts of the system in Skåne, particularly during peak periods.

After public transport measures, e-meetings will come to form an important measure. As shown earlier, a large share of business trips are done by car and plane in the Öresund region.

Measure	Policy instrument	Reduction in million litres of oil per year for scenario			Acceptance (++ to --)
Measures to reduce traffic		**1**	**2**	**3**	
Teleworking & compressed work week	Info.	12	26	70	+
E-meetings	Info.	32	65	162	++
Workplace travel plans – commuting	Info. & Policy	6	14	26	+
Driving bans on odd or even dates (or Sundays)	Enforcement			680 (170)	--
Fuel rationing	Enforcement	453	613	1314	-
”Shift”-measures					
Public transport measures	Info. & Supply	2	44	225	++
Bicycling measures	Info. & Supply	11	23	45	++
Carpooling for commuting & events	Info. & Econ.	6	12	35	+
Efficiency measures					
Fuel savings campaign, including	Info.	8	19	100	++
Eco-driving and voluntary speed	Info. & Policy	5	24	63	++
Speed reduction Skåne and Blekinge (Max 90 km/h, etc.)	Enforcement	25			+

Table 2: Examples of measures to reduce oil use in a short perspective (within 6 months). Reduction in million litres of oil per year for scenario 1 (“normal case”) - 3 (sharp price increase and/or local shortages) for the Öresund region.

Preparatory measures and a proactive strategy to decrease vulnerability

Several of the measures mentioned can and should already be implemented now, before a crisis is upon us. This is to increase our ability for adaptation in the event of a possible crisis in the future, but also for climate and environmental reasons. An important conclusion of the project is that preparatory measures are needed to speed up the process in event of a crisis. Good preparatory planning also influences how successful the measures will be.

The path we choose to reach a more sustainable transport system today is of significance for how vulnerable we will be in the event of a possible oil crisis in the future, but also how well we will reach our goals within climate, environment, and energy. Continuing along the current path, via the national goal of 10 per cent renewable energy within the transport sector for the year 2020 – a low goal compared to the more ambitious one of having a fossil-free vehicle fleet by the year 2030 – means that we are putting off a large part of the work to the future. If we, on the other hand, choose a proactive strategy and make large efforts to decrease our oil-dependency early, we can make use of these efforts for a longer time and at the same time make our transports become less vulnerable.

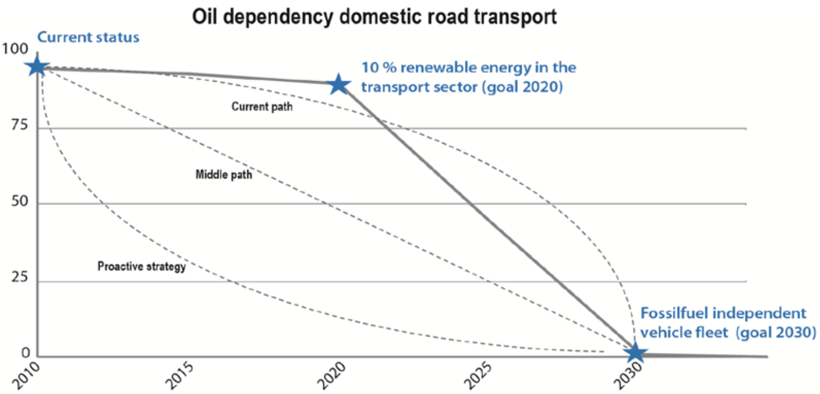

Chart 7: Different scenarios of decreasing oil dependancy and reaching a fossil free vehicle fleet by 2030

Possible options are important for decreased vulnerability and planning for alternatives requires strategic and long-term planning. Based on the current car- and oil-dependency, the transport system's vulnerability and resistance to crises can be improved through increased investments in public transport, walking, and cycling. Even the implementation of several of the quick-acting measures discussed in this report in preparatory purposes would decrease the vulnerability and furthermore speed up the decrease of our emissions from the transport sector.

Several of the measures that are suggested here, for instance measures that decrease transport demand, are also measures with many benefits and a high cost-effectiveness since they also solve many more problems such as local air problems that with detrimental health effects, global carbon dioxide emissions, traffic noise, barrier effects, and congestion. New environmentally effective vehicles and fuels will, for example, not be enough to create sustainable transport systems in cities where congestion is an important issue. The types of transitions that are needed for sustainable development do not happen by themselves; steering is needed.

In conclusion, we wish to accentuate the importance of working with direct crisis preparedness-measures as well as measures that increase the choice of options and decrease our dependence on oil and thus at the same time can also increase our chances to decrease the transport sector's influence on climate and environment. Some measures that should be implemented right away, and can be regarded as long-term measures as well, are for example (some reference to Mobility Management chapters here):

- Development of bicycle infrastructure
- Increased supply of public transport, not in the least for the leisure segment
- Strategy how to reduce dependence on diesel for public transport
- Information and support to companies/workplaces regarding workplace travel plans for commuting trips and business trips. To legislate about long-term requirements can increase the incentive for companies to work with these issues. In this regard, Swedish authorities can play an important role as forerunners.
- Parking charges at companies as a part of the above and increased control of fringe benefit taxes for parking spaces.
- Campaigns for cycling and public transport
- Optimisation of road speed limits based on environmental and traffic safety aspects.
- In a longer perspective: prioritisation of walking, bicycling, and public transport in planning of new developments

Other preparatory measures, especially needed to speed up the process in the case of a crisis, are for example:

- Prepare fuel-saving campaigns that supply the public with advice on how to save fuel and the effectiveness of these methods, so that the measures can be implemented quickly when they are needed.
- Hold information campaigns and training courses about eco-driving and speed, and planning optimisation in all transport sectors, so that this knowledge will be present if and when a critical need arises.
- Encourage (or require) that vehicles have automatic speed limits or so-called fuel-advisory systems in order to achieve good effects of eco-driving in the event of a crisis. In effect, these are computer programmes that continuously monitor the driving and provide different forms of support to the driver, with the aim of reducing fuel consumption.
- Plan for how public transport quickly can be expanded.
- Make decisions and develop strategies, as well as framing criteria to quickly be able to implement reduction of speed limits. Moreover, one should especially consider variable speed signs and speed cameras on very congested routes, where the possibility of a quick speed reduction in a crisis situation can lead to significant fuel savings.

- Develop a new rationing system; this must be done if rationing is to be used as a quick measure in Sweden.

There are many stakeholders that can contribute to better preparedness. The main responsibility for crisis preparedness planning primarily rests with the Swedish and Danish Energy Agency and the Swedish and Danish Transport Administrations. Other important stakeholder are the oil companies, who are obligated to keep an emergency supply, the municipalities and the public transport authorities who are responsible for public transport in the counties and in certain cases the municipalities. The necessary decisions must be taken by the politicians.

3. A Green Transport Corridor within the Øresund Region

Per Homann Jespersen and Sandrina Lohse

1 Background

"…in a world of rising oil prices, growing congestion and looming climate change, the EU's transport system needs a radical overhaul to maintain its role of growth engine and keep pace with mounting global competition. In order to avoid having to limit our freedom of movement, we need to break the shackles of transport's dependency on oil, but without sacrificing its efficiency." [Siim Kallas, Vice-President of the European Commission, Commissioner for Transport (COM 2011 b, p.1)]

With the 2011 *White Paper on Transport* the European Commission presents its strategically based vision towards a competitive transport system that aims to achieve fossil fuel/resource independence and at the same time a reduction of at least 60 per cent carbon emissions in the transport sector by 2050[1]. Furthermore, the commission aims to shift 50 per cent of medium and long distance freight journeys from road to rail and waterborne transport and to reduce 40 per cent of their shipping emission.

Nevertheless, the highly ambitious goals of the commission towards an efficient and strongly CO2-reduced transport system makes it necessary to act beyond the 'business as usual' approach, due to the fact that the transport sector is a significant and still growing source of Green House Gas[2]. Hence, the transport sector has to overcome various obstacles through contributions of all transport stakeholders and set concrete activities along all elements of the transport system.

Studies have proven that transport operators are confronted with a long list of obstacles (barriers) while initiating fossil free freight transport solutions[3] such as e.g.:

- Alternative fuels are more expensive than fossil fuels
- Uncertainty of which technology will be used in the future
- Taxes on transport have national focus, no common EU regulation based on fair and efficient pricing

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[1] *'Commission analysis shows that while deeper cuts can be achieved in other sectors of the economy, a reduction of at least 60% of GHGs by 2050 with respect to 1992 is required from the transport sector, which is a significant and still growing source of GHGs'* (COM (2011) 144a, p.3)

[2] *'By 2030, the goal for transport will be to reduce GHG emissions to around 20% below their 2008 level. Given the substantial increase in transport emission over the past two decades, this would still put them 8% above the 1990level.' (*COM 2011 b, p.5)

[3] Region Zealand (Denmark) workshop on 'Fossil free freight transport for Region Zealand' on the 26th of August 2010 at Roskilde University 'Søminestation' in Denmark.

- Cross-border transport initiatives are complicated since national transport planning and regulations are different in each EU country, hence no common approaches exist
- Transport operators have a lack of knowledge of combined transport

Although development of new technologies in more resource-efficient vehicles and cleaner fuels is ongoing, it is unlikely that these developments on their own can achieve the necessary reduction of emissions. Nor can they solve the problem of congestion in Europe.

However, the Commission's initiative on Green Freight Transport Corridors underlines the need to concentrate large freight volumes for transfers over long distances and encourages the use of multimodal transport solution combined with "*advanced technology in order to accommodate rising traffic volumes while promoting environmental sustainability and energy*" (COM 2007, p.11).

2 *Green Corridor approach of the EU*

The concept of Green Freight Transport Corridors was put forward in 2007 by the Freight Transport Logistics Action Plan (COM 2007/607) as measure 2.5:

"The concept of transport corridors is marked by a concentration of freight traffic between major hubs and by relatively long distances of transport. Along these corridors industry will be encouraged to rely on co-modality and on advanced technology in order to accommodate rising traffic volumes while promoting environmental sustainability and energy efficiency. Green transport corridors will reflect an integrated transport concept where short sea shipping, rail, inland waterways and road complement each other to enable the choice of environmentally friendly transport. They will be equipped with adequate transhipment facilities at strategic locations (such as seaports, inland ports, marshalling yards and other relevant logistics terminals and installations) and with supply points initially for bio fuels and, later, for other forms of green propulsion. Green corridors could be used to experiment with environmentally-friendly, innovative transport units, and with advanced ITS applications." (COM 2007, p.11)

Four years later, the EU White Paper on Transport 2011 (COM 2011b) does not define the term. However, it has set ten goals for a competitive and resource efficient transport system, where especially goals 3 to 6 are highly relevant for the approach of Green Freight Transport Corridors (see text box below).

Optimising the performance of multimodal logistic chains, including by making greater use of more energy-efficient modes

(3) 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed.

(4) By 2050, complete a European high-speed rail network. Triple the length of the existing high-speed rail network by 2030 and maintain a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail.

(5) A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services.

(6) By 2050, connect all core network airports to the rail network, preferably high-speed; ensure that all core seaports are sufficiently connected to the rail freight and, where possible, inland waterway system. (COM 2011a, p.9)

Green Transport Corridor definition

Green corridors promote the development of a cleaner freight transport system. They endorse the EU vision towards an integrated and sustainable transport system. Green Corridors provide the most environmentally friendly, sustainable, efficient and safest connection for freight transport in Europe.

Green Corridors deliver transport solutions that are more economically, ecologically and socially viable than other (non-green) corridors. The transports within the corridors are efficient, and when possible the optimum transport modes are used. Hence a large proportion of the goods transported within the corridors are often international or long-distance transport, through intermodal transport, with use of freight trains, inland waterways, modular road trains, trucks using alternative fuels, trucks with the best EuroNorm, or other efficient and more environmentally-friendly transport modes between the shipment points. At the trans-shipment points, the goods will be shifted to local trucks in an efficient manner in regard to time and cost, to be distributed to the receivers. (Tetraplan – Kyster-Hansen, H. 2011)

According to the White Paper, European policies towards an integrated and sustainable transport system should focus on the provision of sustainable, innovative, intermodal and interoperable regional and national transport and logistics networks, infrastructures and systems. Furthermore, European policies should encourage modal shift strategies with energy efficient means of transport, aim for the optimisation of infrastructure capacity, and promote internalisation of external transport costs.

3 The Øresund Region within a Green Transport Corridor

Ambitions towards Green Transport Corridor in the Øresund Region should include:

To provide **modern, efficient and 'greener' transport solutions** that highlight *co-modality*. That should involve e.g. the improvement of knowledge for transport operators about and how to access co-modal trans-shipment terminals, which will therefore make it possible to make optimal use of all transport modes. Hence transport buyers have a wide choice of offers for their needs – including also the most environmentally-friendly solutions on the market.

The region should offer a platform for business stakeholders, possibly supported by research programmes, for the testing of new developments in the transport sector (ITS/ICT solutions, alternative fuels solution, mode types).

Aim towards **harmonised regulations and standards** for terminals and connections that support interoperable and reliable transport solutions but do not prevent innovation. Hence terminals should be *open, accessible and effective trans-shipment points.* Set focus on *Intelligent Transport Systems (ITS) and Information and Communication Technology (ICT) solutions*[4] that are implemented according to accepted standards and will be easily and openly accessible for intermodal logistics and transport operators along the corridor.

To provide an **innovative transport infrastructure** that encourages economically attractive *sustainable logistic solutions*[5]. A modern and well-maintained infrastructure for major connections and terminals will enable all operators to deliver fast, frequent, reliable, and cost-efficient freight and passenger transport on through and within the Øresund region. In addition, this infrastructure should support a gradual transition to alternative propulsion technologies[6] (clean transport system[7]). The Øresund region is part of the TEN-T core network and this could enhance further modernisation of the infrastructure, including innovative elements.

3.1 Corridor of Connections

Railway and sea transport are from an energy point of view the most efficient freight transport modes – provided that they are organised efficiently. The European Union has for years invested large sums of money into getting freight from road to rail, which has lead to some significant improvements in the national and international freight rail systems – but this in turn has not lead to a significant increase in the market share of rail.

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[4] Among these are for example: ERTMS for railways, real-time information systems and satellite-based for ferries.

[5] For example McKinnon (2010), pp.3-30

[6] Currently, this includes LNG (liquid natural gas) as fuel for ships, liquid bio fuel or liquefied biogas as fuel for trucks, and a more sustainable power generation for the railways (which will be electrified until 2030 on the main lines).

[7] A core theme of the EU 2020 strategy and the common transport policy is to decarbonise transport. The aim of the EU Clean Transport Systems (CTS) initiative is to present a consistent long-term alternative fuel strategy and possible measures to take in the short and medium term. More about this initiative is available at: http://ec.europa.eu/transport/urban/vehicles/road/clean_transport_systems_en.htm

Explanations at many different levels can be put forward. Such explanations could be the economical factor, the competition with road transport and the lack of knowledge by transport operators and forwarders of rail/intermodal transport.

Figure 1: *Øresund Bridge view from Malmö (Region Skåne)*

However, against the perspective of significant rise in prices for fossil fuels in the next twenty years and the political desire to reduce dependence on fossil fuels, it is necessary to get the available alternatives to work efficiently if we wish to maintain the same level of freight transport in the future as we have today.

Thus, it is the ambition of the Øresund Region to make it possible for all users to move freight from road to rail, by providing a new corridor and by developing in the corridor new solutions that can make rail much more attractive for the transport buyers.

Freight transport across the sea provides connections for a large variety of freights and goods, whether it is bulk, tank products, containerised items or ferries.

Example I: Improve knowledge of transport forwarders and operators for co-modal/intermodal transport solutions

An important hindrance for co-modal solutions lies often in a lack of knowledge of the transport operators, which acts a barrier due to the complexity of railway operations. Therefore a further simplification of the user platform for rail freight transport is needed along with education systems that reduce the hesitation for such co-modal operation, through improved understanding of co-modal system.

Example II: Coordination of standards for rail between national authorities for new and upgraded infrastructure

Initially each country had its own standards when it came to railways. Some of these standards have been harmonised by the International Union of Railways (UIC) or the EU, such as signalling, control and management systems (ERTMS, ETCS). In other areas, standards do not have big significance such as type of supply voltage for electrical trains – modern electric trains can, without significant cost, drive on a diversity of systems. Some standards are not harmonized, among others, maximum length of train, maximum axle load, and gauge (profiles for e.g. tunnels and bridges). It would be very costly just to change these standards. Nevertheless, it would be prudent to agree on a standard for new and refurbished infrastructure that gives as little hindrance to trains from other countries as possible – this will gradually move us towards a 'single European track.' Even if this would only be an agreement between Denmark and Sweden (additional Germany that provides an extended connection over the up-coming Fehmarn Belt fixed link), it would be beneficial.

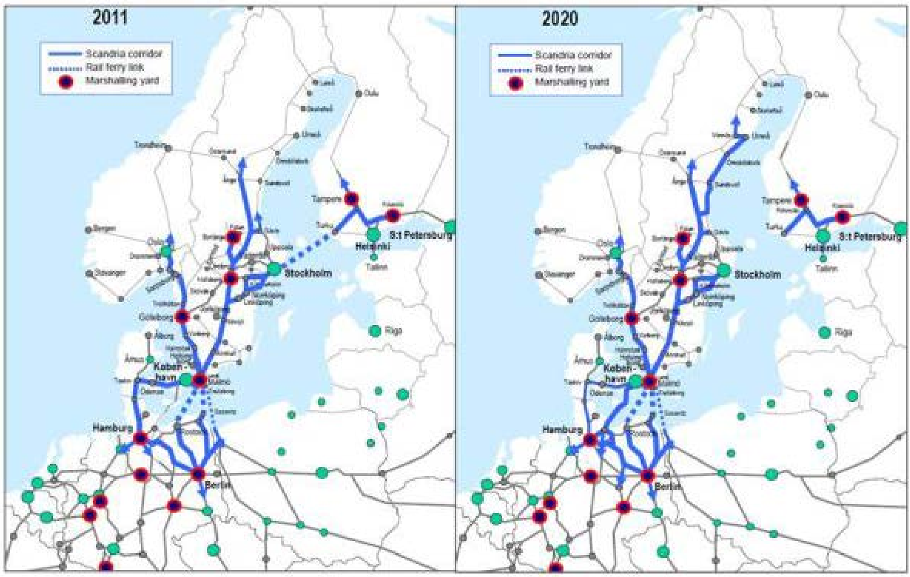

***Figure 1**: Main rail freight lines connecting Scandinavia with Germany/East Europe (2011 & 2020) (Boysen 2011, p. 22 and 23)*

3.1 Corridor of Terminals

Terminals are the nodes of co-modality, where freight from sea, rail and road is exchanged. If these nodes are not time- and cost-efficient as well as reliable, then the whole system will be inefficient, and the 'mono-modal' truck transport will prevail, further endangering environmental and climate targets. Thus, the efficiency of ports and road-rail transfers is crucial.

For bulk freight there is usually tailor-made solutions, and often we see transport chains mainly on sea and rail. The biggest challenge is in containerized transports, where the standard containers or truck trailers are moved between the three modes of transport. This sector is the one with the greatest growth and also the one that asks for standardised solutions.

A network of intermodal trains or unit trains (trains going back and forth between two terminals with none or very little reconfiguring) within terminals of the Øresund region could be an objective of the region's development. To comply with demands for speed of delivery and just-in-time delivery, these unit trains should have a high frequency and should be reliable; reliability being more important than speed. At the same time, to be economical, the trains should be as close to full length as possible.

Example III: Establishing a network of open access terminals in the corridor with certified levels of operations

Establishing a network of open access terminals in the Øresund region with certified levels of operations is crucial for making co-modal transport efficient and attractive. The network of port and road/rail terminals could eventually become an initiator of ITC projects to reduce bureaucratic load for transport buyers and establish measures for consolidating freight streams, i.e. electronic freight transport planner.

3.2 Corridor of Innovation

ITC solutions for advanced management of transport and consolidating freight flows

The EU White Paper proposes "freight corridor structures" to "support efficient, innovative and multimodal transport services." Consolidation of freight flows is crucial for the economic and environmental feasibility of freight transport within all modes. A fully loaded truck or ship, and a full-length freight train emits less pollutants and greenhouse gases per ton-km than a partially loaded unit.

Nonetheless, competition in the transport sector often results in much less than optimal load factors, which is fundamentally due to the fact that 'raw' transport is cheap and does not contribute significantly to the cost of most products. When it does, e.g. in distribution to supermarkets or over very long distances, freight transport is actually optimised.

Figure 3: *Old keys for railway track changes in Wustermark Germany*

Consolidation of freight flows is taking place in e.g. ‘freight exchanges,’ where different transport operators share information on freight orders in order to optimise transport. It is however a tricky issue being competitors and co-operators at the same time, and thus the freight exchanges are not as efficient and widespread as would be desirable from an environmental point of view.

A solution that has been proposed and also partly implemented is to make an electronic freight transport planner, equivalent to what we know from the public transport system. In its most radical form this would bring the transport buyer in direct connection with the transport operators to buy door-to-door transport, and thus holds the possibility of a much more efficient freight transport system.

A barrier for more co-modality is the different administrative and legal framework within the different transport modes. ITC systems as well as new organisational forms should be found to bring transport buyers nearer to a paper-free transport system and to reduce transaction costs in the co-modal systems.

Example IV: Innovative transhipment technologies

Improvement of the competitiveness of co-modal transport versus single mode choice will be possible though innovative transshipment technologies within terminals. However, none of the current technologies have managed the breakthrough to attain major market shares.

Terminals should offer an interoperable system for managing booking, confirmation, data exchange, and the entrance of lorries and associated cargoes at the gates of the terminals. Such a system makes transshipment procedures easier and less complex for terminal users such as transport forwarders. This interoperable system should be compatible with EU-wide terminals along major and highly concentrated freight flow corridors.

Energy efficiency and renewable energy

The greatest challenge for the freight transport system towards 2030 is to maintain or even to increase freight flows while at the same time drastically reduce the emission of greenhouse gasses.

The main rail lines within the Øresund Region area are already electric or will be electrified by 2020[8] and thus have high energy efficiency and hold the potential to reduce greenhouse gas emissions as the power sector is becoming greener. Whereas for short-distance and light duty trucks, e.g. services and city distribution has a potential for the development of electro mobility[9].

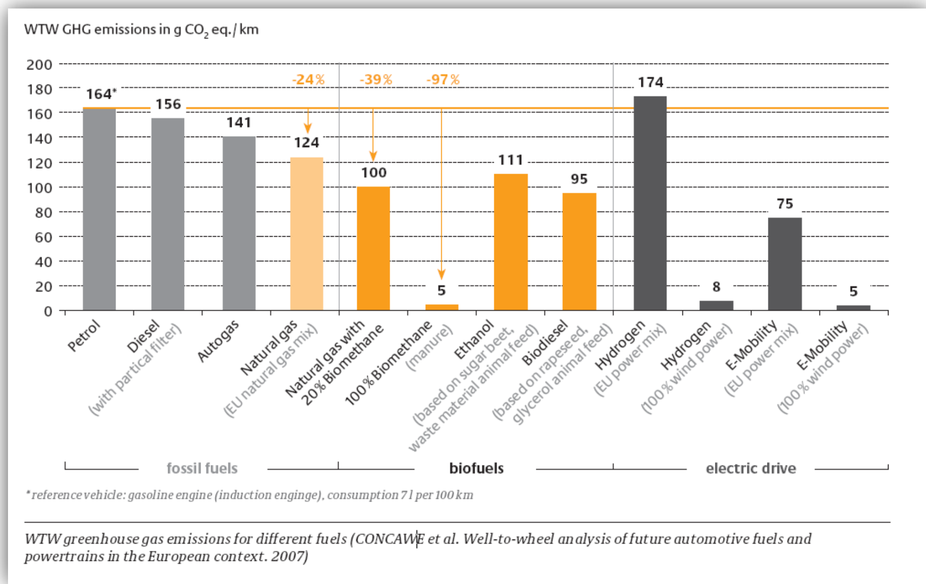

Figure 2: *Well to Wheel greenhouse gases. Passenger cars (DENA 2011, p.5)*

No system-wide solution based on electricity is probable for long distances and heavy duty trucks in the next twenty years. Thus, bio fuels and especially biogas seem to hold the potential for decarbonising truck transport also in the short run. The trucks exist, the resource base is present in the region and Sweden already has a network of biogas stations. Hence, the Øresund Region should support this by supplying the corridor with an infrastructure that makes long distance transport along the corridor based on biogas possible.

[8] For example Ringsted-Rødby is not electrified yet.

[9] The city logistic group of the EcoMobility project has developed a model for a sustainable urban distribution in the Øresund region.

Example V: Establishing an infrastructure of compressed/liquefied biogas stations in the Øresund Region

The Øresund Region should actively help to facilitate the establishment of a corridor infrastructure for the provision of biogas fuel for vehicles. In the short-term natural gas will be a suitable transition technology, which can substitute biogas.

Companies, authorities, and knowledge institutions should be brought together to propose common standards and strategic recommendations, while sharing valuable knowledge on biogas resources and implementation in the transport sector. This can also initiate cross-border collaboration and facilitate business opportunities, which will help further the establishment of biogas implementation in the Øresund Region.

4 Key messages for policy actors in the Øresund region

The Øresund Region is a transit region for freight between Scandinavia and the rest of the continent. The two main challenges for the region are:

- How do we get the most out of being a transit region?
- How do we minimise the negative impacts of being a transit region?

Good, well-functioning, and diverse transport infrastructure is a precondition for making the Øresund Region attractive for companies to settle in. A necessary condition, but not a sufficient condition – attractiveness depends on many other factors.

A dedicated effort to develop Green Corridors through the Øresund Region will of course be helpful to reduce the environmental and climate impacts of freight transport. In addition, it can also contribute to the attractiveness of the Region by being a showcase for the way to develop transport to meet the targets set by the White Paper on Transport (COM 2011a) and by the Climate Strategy of the EU.

The Danish and Swedish governments are already providing a lot of the framework by improving rail infrastructure and constructing the Fehmarn Belt fixed connection. This is a window of opportunity for actually moving freight from road to rail, but more has to be done than just build the infrastructure.

The terminals – both road-rail and harbours – should be looked at to ensure that conditions for co-modal transport are optimal. Open access of terminals is an important issue to secure competition and volumes of freight. Organisational models and technologies that could smoothen the transfer between road on one side and sea and rail on the other should be carefully considered.

Knowledge of co-modal transport among actors in the logistics sector, and especially forwarders and operators is necessary to actually move some of the freight to rail, and ITC systems should be provided to make co-modality work with less friction.

When building new rail, the countries involved should try to develop a common understanding of the standards for i.e. train length and gauge, in order to give operators in the different countries more flexibility when organising their transports.

It should be considered how the capacity of the Fehmarn Belt fixed connection could be optimised for both freight and passenger trains. Setting a minimum required speed for freight trains could be one of the options.

Also road freight transport should be focused. Truck transport will remain the main transport mode for decades to come. But heavy and long distance trucks will only have biofuels as a non-fossile alternative for many years. Thus, being in the front by providing infrastructure for compressed and liquefied biogas along the corridors could already have a significant impact; we already have the trucks and the Swedes have shown the way with their biogas strategy.

Most of these projects will only be realised if business cases can be established. However, policy actors in the Øresund Region can do a lot by regulatory framing and selective support of the projects.

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4. Alternative energy carriers for transportation sector and their use in the Öresund region

Dimitar Karakashev, Irini Angelidaki, Per Jørgensen, Yifeng Zhang, Bo Mattiasson, Maria Andersson and Anton Freiesbleben

1. Introduction

The transport sector is consuming a significant amount of fuels. Liquid hydrocarbon fuels, such as petrol and diesel, are very well suitable for the transport sector. First and foremost they are easily storable and portable, making them ideal for use in tanks in vehicles. Secondly, a well-developed infrastructure for the distribution and sale of liquid hydrocarbon fuels exists globally, including the ubiquitous petrol station. In addition, liquid hydrocarbon fuels are easily handled, and have a good energy density, making the ratio between the amount of fuel and the number of kilometers possible to drive with its combustion quite acceptable. Therefore, since their discovery liquid hydrocarbon fuels have been indisputably the main and unchallenged fuel source. However, due to the recent discussions about climate change, and resource availability in the future, high interest in alternative fuels has emerged.

A number of alternative energy carriers are currently used in transportation sector. Among them, synthetic gasoline, synthetic diesel, DME, biodiesel, ethanol, biogas, methanol, and electricity are utilised in different vehicles produced commercially. Butanol and hydrogen are also promising alternative fuels. However, engines made to run on butanol and hydrogen are mainly produced for demonstration purposes and almost no vehicles are readily available on the market at present.

The properties, fuel characteristics, and practical applications of the energy carriers in the transportation sector are presented in this book chapter. The production and distribution of some alternative fuels, with respect to process technology and facilities currently available, are also presented in this chapter. In addition, the current utilisation of alternative energy carriers in the Øresund region is briefly outlined in terms of implementation plans in transportation system, fuels distribution infrastructure, and suitable vehicles. Comparisons between various fuels suitable for use in light and heavy vehicles are also made, based on fuel characteristics, environmental impacts, energy security impacts, vehicle capital and maintenance costs, fuel costs, safety handling, and net carbon dioxide emissions.

2. Use of alternative fuels in transport today

Ethanol

Ethanol is an alternative vehicle biofuel and fuel additive. Ethanol, as a fuel, reduces harmful tailpipe emissions of carbon monoxide, particulate matter, oxides of nitrogen, and other ozone-forming pollutants (American Coalition for Ethanol). Notwithstanding it recent resurgence, the use of bioethanol as transport fuel, however, is not new. As early as 1908, Henry Ford designed automobile engines to run on ethanol, even proclaiming bioethanol to be the fuel of the future. (Figure 1) (Energy Aware Organization, 2011).

Figure 1: Henry Ford's ethanol engine

Despite early developments in ethanol and Henry Ford's enthusiasm for the fuel, fossil-based fuels emerged as the predominant transport fuels. It would not be until the first energy crisis in the 1970s that renewed interest in ethanol would spur further development and production of the fuel. This is in part attributable to an apparent relationship between crude oil prices and the increase in production of bioethanol (Figure 2).

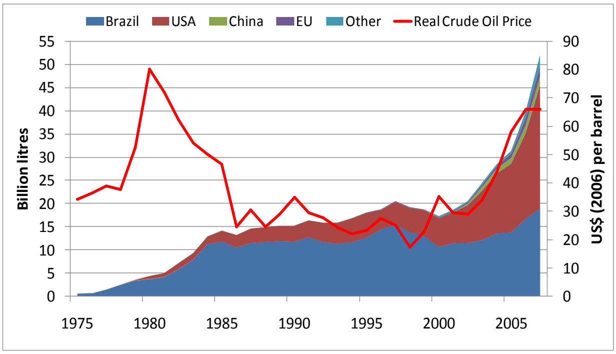

Figure 2: Relationship between crude oil prices and the increase in production of bioethanol

The 1970s energy crisis was followed by several initiatives around the world for finding alternative fuels for road vehicles. Foremost amongst these were: the National Alcohol Program (NAP) (ProAlcool) in Brazil (World Resources Institute, 2002), and the Gasohol programme in the USA (EPA United States Environmental Protection Agency, 1978). To this day, the main ethanol producing countries in the world remain Brazil and USA, while a number of other countries produce the fuel in smaller quantities. In Brazil, the NAP was initiated in middle 1970s and the production of ethanol based on the fermentation of sugar cane resulted in over 26,000 gas stations able to provide anhydrous ethanol for cars. Additionally, several million cars were put on the road that could run solely on ethanol. Similar to the NAP in Brazil, was the Gasohol programme in the USA. However, unlike Brasil, maize was used in USA as the primary feedstock.

Ethanol (C2H5OH), liquid at room temperature, can be used either alone or in different blends with gasoline. Pure ethanol has a lower energy content when compared to gasoline, and approximately 50 per cent additional ethanol volume is required for the same energy compared to gasoline. Due to this characteristic, ethanol is currently utilised primarily as a gasoline additive, in quantities ranging from 5 per cent to 85 per cent. Ethanol fuel characteristics (Wikipedia, 2011 b) are presented in Table 1.

Properties	Units	Gasoline	Pure Ethanol
Oxygen content	100 per cent	Close to 0	36
Octane Number	100 per cent	85 – 94	113 – 114
Vapor pressure	Bar	0,48 – 1,034	0.159
Lower heating value	MJ/Liter	31 – 32	21

Table 1: Ethanol is primarily utilised as a gasoline additive

In addition to its lower energy content, pure ethanol has other limitations as a fuel, including cold-start problems and high volatility. These can be overcome though by making different blends of ethanol and gasoline (Table 2).

Fuel	Ethanol content (per cent v/v)
E5(North Europe incl. Øresund region)	5
E10 (Gasohol) (North America)	10
E85 (North America, Sweden)	71-85
E95 (Sweden)	95
Hydrous ethanol (Alcool) (Brazil)	95.5
Gasoline (Brazil)	24
Oxygenated fuel (USA)	7.6
Reformulated gasoline (USA)	5.6

Table 2: Different blends of ethanol and gasoline

When comparing ethanol blends with gasoline alone, it has been shown that reductions of 8 per cent with the biodiesel/petrodiesel blend (B20) can be achieved. Different types of ethanol blends have recently become more widespread in Øresund region (Scania, 2008) (Table 3).

Fuel	Use	Countries
E5	Light vehicles (cars)	Denmark, Sweden
E85	Flex fuel vehicles (FFVs)	Sweden
E95	Buses and trucks	Sweden

Table 3: Different types of ethanol blends

Butanol

Butanol as an alternative biofuel has recently become an interesting choice due to its favourable fuel characteristics when compared to other fuels. Historically, butanol has been produced by anaerobic fermentation since the beginning of the 20th century. The process known as Acetone-Butanol-Ethanol (ABE) fermentation, gets its name from the simultaneous formation of acetone, butanol, and ethanol. Fermentation of a biological substrate is mainly performed by using *Clostridium acetobutylicum*. The industrial production of butanol by fermentation continued in many countries until the 1980s, however, from the 1960s onwards butanol gradually became less economical due to increased price of substrates, low solvent yield, and an increased competitive process based on fossil fuels.

Butanol exists as four isomers, namely, n-butanol, 2-butanol, i-butanol, and t-butanol. The four isomers contain about the same amount of heat energy and are essentially identical in blending with gasoline, and in combustion; however, the methods for manufacturing each isomer is very different. Some features of butanol, important for the engine performance, are shown in Table 4.

Parameter	Value
Octane number	87
Vapor pressure (Bar)	0,023
Lower heating value (MJ/Liter)	27.8

Table 4: Some features of butanol

Compared with ethanol, butanol has many advantages (Butamax Advanced Biofuels LLC, 2011) that are attractive for application as a liquid fuel. Butanol's advantages when compared to ethanol are the following:

- butanol is non-corrosive;
- it has lower vapour pressure;
- it has 50 per cent higher energy content per unit of weight; and,
- it can be blended with gasoline at any ratio without the necessity for modification of vehicle engines.

Butanol is attracting increased interest as a transport fuel, in part thanks to entrepreneurs like David Ramey, who proved it was possible to drive his ordinary car across USA only using butanol as fuel (NABC Report 19, 2007). Despite some of butanol's favourable characteristics, butanol has not yet been used in large scale as a fuel for transportation.

Methanol

Methanol (CH_3OH) is the simplest alcohol with unique characteristics that make it useful as an alternative fuel. Methanol has been used for more than 100 years as a solvent, and as a chemical building block to make products such as plastics, plywood, and paint. It is also used directly in windshield-washer fluid, gas-line antifreeze, and as model airplane fuel.

Methanol is a colorless, odourless and flammable liquid. Methanol has traditionally been produced through gasification of a feedstock (natural gas and/or coal) into synthesis gas ($CO + H_2$), which is further converted to methanol in presence of catalyst at high temperatures. Since methanol lacks carbon-carbon bonds, it does not leave any particulate residue after combustion (Dave, 2008). In addition, due to it being partially oxygenated, methanol requires less oxygen for complete combustion than conventional gasoline fuel, however, this is also means that it has lower energy content, roughly 19.7 MJ/kg.

It is possible to use methanol in internal combustion engines and doing so results in increased thermal efficiency and increased power output (compared to gasoline), although methanol's lower energy content leads to higher fuel consumption. Due to its lower energy content (half that of gasoline), fueling an engine with methanol requires more frequent filling when compared with gasoline, or as an alternative, larger fuel capacity to store increased volumes of fuel. For this reason, methanol is mainly utilised as transportation fuel in heavy trucks able to carry out relatively large fuel volumes. Another drawback of methanol as a fuel is its corrosiveness to some metals, particularly aluminium used in engines.

Methanol as an engine fuel has primarily been used in the auto racing industry. Pure methanol is required by rule to be used in Champ cars, Monster Trucks, USAC sprint cars, and other dirt track series. Drag racers and mud racers, as well as heavily modified tractor pullers, also use methanol as their primary fuel source. Mud racers have mixed methanol with gasoline and nitrous oxide to produce more power than gasoline and nitrous oxide alone. In conventional automobile fleets, low levels of methanol can be used in existing vehicles, with the use of proper co-solvents and corrosion inhibitors. The European Fuel Quality Directive allows up to 3 per cent methanol with an equal amount of co-solvent to be blending in gasoline sold in Europe.

Hydrogen

Molecular hydrogen H_2 is a colourless, odourless and non-poisonous gas with very low specific gravity. Hydrogen, the lightest of all gases at around 14 times lighter than air (Lide et al., 2007), is mainly produced from fossil-based (steam reformation of natural gas, partial oxidation of coal or oil) and biomass based processes (thermochemical and biological routes). In addition to being the lightest gas, hydrogen also has the highest heating value of all potential vehicle fuels; 1kg hydrogen contains as much energy as about 2.5kg natural gas or about 2.8kg gasoline (Das 1996). On the other hand, due to low specific molecular weight, the volumetric energy density of H_2 is very low; 3.7L of liquid H_2 has the same energy as 1L of gasoline.

A potential drawback of hydrogen gas is that it must be handled with extreme care, since hydrogen has a wide ignition range in air, and low ignition energy. However, despite this, hydrogen leaks are diluted rapidly due to its high diffusion coefficient 812 times higher than gasoline's (Rocky Mountain Institute, 2003). In air atmosphere, hydrogen is not particularly volatile and does not explode easily but rather burns. The theoretical explosion power is 22 times lower than that of gasoline (Rocky Mountain Institute, 2003).

The future energy economy will have an important role for hydrogen as a clean, CO_2-neutral energy source. The major advantage of energy from hydrogen is the lack of polluting emissions, since the utilisation of hydrogen either via combustion or via fuel cells, results in pure water. One potential application for hydrogen is that it can be used in fuels cells providing power for the vehicles. To power vehicles typically fuel cell stack are applied, and hydrogen is provided as fuel from hydrogen tanks placed in the vehicles (Hub pages, 2011; Tangient LLC, 2011). In most situations concerning its use as a transport fuel, hydrogen would be transported from the production site to the end users as a gas, via pipeline. Ideally, the current natural gas distribution system would be used for at least the initial stages of a transition to hydrogen. Hydrogen also could be shipped in liquid form, in tank trucks, rail cars, or for short distances, in vacuum-jacketed pipelines. The last option would be feasible only for shipment to large potential end users, such as airports.

Biodiesel

Biodiesel is an alternative to petroleum-based diesel fuel (petrodiesel). Biodiesel is defined as the mono alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, for use in compression-ignition (diesel) engines (Fukuda et al., 2001). The most common fatty esters contained in biodiesel are those of palmitic (hexadecanoic) acid, stearic (octadecanoic) acid, oleic (9(z)-octadecenoic) acid, linoleic (9(z) 12(z)-octadecanoic) acid, and linolenic (9(z), 12(z), 15(z)-octadecatrienoic) acid (Knothe 2008). Commercial biodiesel production started in 1991 with plants capable of producing up to 100,000 tonnes of biodiesel per year, being constructed (Li et al., 2007). The process technology is well understood and established, although there are some variants on the technologies used (Marchetti et al., 2007). In standard production, triglycerides present in extracted crude oil, are converted into esters through transesterification (Figure 3) with alcohol (often ethanol or methanol) usually in the presence of a catalyst: acid, base or enzyme (Marchetti etal, 2007).

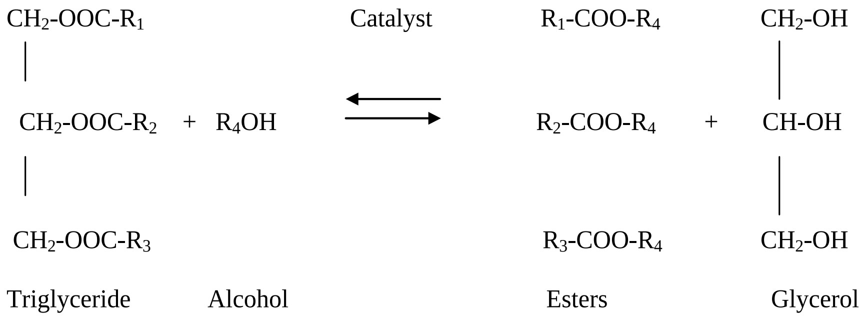

Figure 3: Triglycerides converted into esters through transesterification

Biodiesel have received considerable attention in recent years as a renewable, biodegradable, and non-toxic fuel. Estimations showed that a potential market of 20EJ by 2050, which is around 10-20 per cent of total energy supply, is forecasted **(**IEA Energy Technology Essentials OECD/IEA 2007).The most important characteristics of biodiesel as they relate to use as a transport fuel are the cetane number, heat of combustion (heating value), and kinematic viscosity (Knothe 2008).

The cetane (CN) number is a dimensionless parameter related to the ignition quality of a fuel in a diesel engine. Generally, higher CN values reflect better ignition quality of the fuel. The CN of a given compound depends of the chemical structure of the compound. The CN increases with an increasing chain length and increasing saturation. Branched and aromatic compounds have low CNs. Thus, compounds found in biodiesel, such as methyl palmitate and methyl stearate, have high CNs, while methyl linolenate has a very low CN.

When considering biofuels, the heat of combustion increases with an increasing chain length and decreases with an increasing unsaturation. The European standard for using biodiesel as heating oil, EN14213, specifies a minimum heating value of 35 MJ/kg. The heat of combustion is important for estimating fuel consumption; the greater the heat of combustion, the lower the fuel consumption.

Another important characteristic of biofuels is the kinematic viscosity, and is the main reason why fats and oils are converted to biodiesel. The viscosity of biodiesel is approximately an order of magnitude lower than that of the fossil oil, resulting in better atomization in the combustion chamber of the engine, and making it an ideal candidate for use as a transport fuel. Generally, viscosity increases with the number of CH2 moieties in the fatty ester chain and decreases with an increasing unsaturation. Viscosity increases exponentially with a decreasing temperature, influencing flow properties.

Considerable research has been done on producing biodiesel from vegetable oils including palm oil, soybean oil, sunflower oil, coconut oil, and rapeseed oil. Animal fats, although mentioned frequently, have not been studied to the same extent. Some methods of production applicable to vegetable oils are not applicable to animal fats due mainly to natural property differences. Oil from bacteria, fungi, and algae (single cell oil (SCO)) have also has been investigated (Li et al., 2007). Research on SCO production from microalgae has showed high production potential, amounting to 46 ton of oil per hectare per year (Demirbas, 2007). However, SCO production is still in its infancy, and in particular SCO from algae seems quite uneconomical.

As transport fuels, biodiesels can be used in pure form (B100) or may be blended with petroleum diesel, in any concentration, for use in most injection pump diesel engines. New extreme high-pressure (29,000 psi) common rail engines, however, have strict factory configurations limiting the use of biofuel blends to B5 or B20 depending on manufacturer. In addition, biodiesel have different solvent properties than petrodiesel, and can degrade natural rubber gaskets and hoses in vehicles, especially affecting those manufactured before 1992. Finally, biodiesel has been known to break down deposits of residue remaining in the fuel lines of engines in which petrodiesel has been used (Biodiesel Handling and Use Guide). As a result, fuel filters may become clogged with particulates if a quick transition to pure biodiesel is made. Therefore, it is recommended to change the fuel filters on engines and heaters shortly after first switching to a biodiesel blend. Biodiesel blends are widely distributed by Statoil filling stations in the Øresund region (Sweden, Denmark), and in other EU countries (Norway, Estonia, Latvia, Lithuania and Poland).

Synthetic diesel, synthetic gasoline and DME

The term synthetic fuel is usually defined as a liquid fuel obtained from coal, natural gas, or biomass. Many types of synthetic fuels can be produced but among the most promising for transport fuels are synthetic diesel, synthetic gasoline, and DME (di-methyl ether). These fuels are produced via synthetic gas (H_2+CO) emerging from the gasification of various feedstocks. Synthetic fuels have environmentally desirable properties especially in terms of exhaust emissions, however, they are expensive to produce, and the profitability depends highly on the competing oil prices and the feedstock used. Additionally, synthetic fuels can only be considered as renewable if biomass is applied as feedstock to produced the fuel.

Synthetic diesel produced by Fisher-Tropsch (FT) conversion is mainly composed of linear alkanes, has a low content of aromatic hydrocarbons, and is virtually free of sulphur. This fact results in a fuel with a high cetane number (CN), almost double the CN of ordinary diesel fuel. Another synthetic fuel, synthetic gasoline is a complex mixture of hydrocarbons. Through the procedure of advanced refining, synthetic gasoline can be made very similar to standard gasoline as measured by parameters such as octane number. DME (Di-methyl ether) is the simplest ether with the chemical formula (CH_3OCH_3). DME is a promising fuel for diesel engines. It has a high cetane number (55-60), high oxygen content, and absence of C-C bonds, which gives a clean combustion with low exhaust emissions when compared to standard diesel fuels.

A number of synthetic fuels are currently being produced in Sweden. Two large-scale plants of interest are located in:

- Piteå, Sweden is home to a bio-DME production facility that utilises black liquor (waste from paper mills) as feedstock. The demonstration plant is part of an EU supported project where all aspects from production of DME, construction of filling stations, and trucks are tested. The production is based on gasification followed by synthesis of DME from syngas as described above. If all black liquor produced from paper mills in Sweden is converted to DME, it can substitute 50 per cent of all diesel used for road transport in the country (Volvo Bio-DME).

- Vaenamo, Sweden has a demonstration plant for gasification of biomass to produce transportation fuels including FT diesel and DME (Zhang, 2010).

Biogas

When biomass decomposes in an oxygen-starved environment, called anaerobic digestion (AD), biogas is produced (Angelidaki et al., 2011). Biogas consists essentially of methane (50-75 per cent CH_4), CO_2 (25-50 per cent), and other minor components e.g. H_2, and H_2S (Angelidaki et al. 2011). However, the AD process is complicated since organic polymers (carbohydrates, proteins, and lipids) are first degraded into monomeric building blocks such as monosugars, amino acids, fatty acids, and glycerol; these products are then turned into organic acids, which are converted further into acetate, H_2, and CO_2. Finally, methane is produced from acetate and from $H_2 + CO_2$. The energy content of biogas is lower than that of natural gas due to the content of CO_2, and in addition, biogas must be pressurized, and purified, in a process called 'upgrading,' by removing carbon dioxide and water vapour, before it can be used as a transport fuel. Several technologies are commercially available for biogas upgrading. Biogas upgrading adds additional costs when it is to be used as transport fuel. However, research and development in the area is very intensive, and it is projected that soon more efficient and economical technologies for biogas upgrading will emerge, e.g. at DTU a new upgrading technology, H_2 produced by water electrolysis, using excess windmill electricity, is used in a biogas reactor to produce high methane content biogas.

One of the main advantages of biogas is that almost any biomass can be converted into biogas, unlike in the production of alcohols or biodiesel, where only carbohydrates or fat, respectively, can be used. In this sense, the biogas process is very versatile in respect to the organic molecules that can be used. A number of organic molecules, including sugars, lipids, proteins, and volatile fatty acids, are commonly utilised in the production of biogas. Due to this fact, the biogas process, when compared to the processes to produce other fuels such as bioethanol, biohydrogen etc., has numerous advantages in the production of transport fuel.

At present, large-scale industrial biogas production is common in many European countries, with Germany and Denmark maintaining leading positions. In industrial biogas production reactor volume is large, in the range of 2,000 – 4,000 m^3, with biogas plants often having several reactors of this size (e.g. the biogas facility in Lemvig, Denmark has 4 reactors with a total reactor volume of almost 18,000 m^3). The most widespread reactor type for biogas production is the continuously stirred tank reactor (CSTR), and manure is the most common substrate for industrial biogas production. In most cases, industrial waste streams are added to manure substrates in order to boost biogas production from 10 to 30 per cent. Biogas can also be produced from sludge from wastewater treatment plants; however, the anaerobic treatment of sludge is mainly used for the stabilisation of the effluents of the wastewater rather than energy production.

Concerning distribution, there are several alternative ways to distribute biogas to the point of utilisation (Johansson 2010). In areas where a natural gas grid exists, the injection of biogas directly into the existing infrastructure proves a very efficient way of distribution. Pressurised biogas, often above 200 atm pressure, stored in high pressure tanks is another possible means of biogas distribution when a grid connection is not available. However this further increases the cost of biogas, as handling the heavy pressurised vessels is expensive. An alternative method involving liquefied biogas, which has been used by buses running on methane in Denmark since the 1980s, is another tested and proven method of distribution. By freezing biogas to a temperature where it becomes liquid, it is possible to increase the energy density, and thereby reduces its volume substantially. Liquefied biogas presents itself as a very interesting alternative for heavy vehicles, including trucks.

Biogas is widely used in the public bus transportation system (Figure 4) in Sweden and a large number of biogas filling stations are installed in Sweden.

Figure 4: Biogas is widely used in the public bus transportation system

Electricity

An electric vehicle (EV) uses one or more electric motors for propulsion rather than being powered by an internal combustion engine. EVs include electric cars, electric boats, electric motorcycles and scooters, electric bicycles, and other modes of transport involving electric propulsion. EVs are characterised by the highest engine efficiency of existing propulsion systems and zero tailpipe emissions. The use of electricity as an energy carrier for these vehicles offers the opportunity to broaden the range of primary energy sources in road transport. However, problems such as the weight and durability of batteries, cold cars due to lack of excess heat used for heating up the interior room of cars, lack of charging infrastructure, and range anxiety amongst the general population, are a number of barriers to be overcome for the wide adoption of EVs. With progress and advances in battery and energy storage technologies, current barriers present within the market will be addressed and increasing numbers of EVs are expected to enter the market in the coming years.

The EV industry landscape is comprised of a number of actors including battery developers and manufacturers of hybrids EVs (HEV), plug-in hybrids, and battery EVs. The latter element is considered here as three sectors: major auto industry original equipment manufacturer (OEMs), EV companies that currently have vehicles in the market, and EV start-ups that may have concept vehicles but where commercialisation and market introduction is still uncertain. At present, EVs are mainly appropriate for light vehicles utilised for personal and development of EVs for heavy transport vehicles is not economical.

The past year has seen some major advances in all of the three EV categories. The forecast in early 2007 that there will be over 50 hybrid models in the market by 2010 now needs to be refined into a projection of how these will be divided among regular HEVs, plug in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs).

Project Better Place

The project Better Place (PBP) is an ambitious plan created by Silicon Valley entrepreneur Shai Agassi to create EV recharging grid networks. The PBP is aiming to create a market for EVs through equipping major cities and eventually entire countries with networks of charging stations. PBP would use renewable energy sources such as solar and wind, for production of electricity to be used in EV, and thereby create a new model for selling both cars and fuel. Nissan and its alliance partner Renault are PBP partners, and have plans to produce EVs on a commercial scale.

In Denmark, the project is aiming to create around ½ million charging stations and 150 battery swap stations. Under the Agassi business model, EV owners would rent the battery and pay a fee based on distance driven; thus, the age of the battery will not be an issue. Battery replacement should be at least as fast as filling a tank with petrol.

Norway is also strongly pushing EV technology. Think Global is a major actor in the EV scene, as is Miljøbil Grenland, a subsidiary of Norsk Hydro (and also a partner of Canada‘s Electrovaya) (Fleet et al., 2008).

Railborne electric vehicles

The fixed nature of a rail line makes it relatively easy to power electric vehicles through permanent overhead lines or electrified third rails, thereby eliminating the need for heavy onboard batteries. Since electric vehicles do not need to carry a heavy internal combustion engine or large batteries, they can have very good power-to-weight ratios. The following Figure 5 shows an electric locomotive in Sweden (Wikipedia Railway electrification system).

Figure 5: Electric locomotives under wires in Sweden

Trolley buses

The only trolley bus system in Øresund region was established in Landskrona, Sweden in 2003 and serves commuter traffic between the outlying railway station and city centre.

3. Comparisons of fuels for light vehicles

Among the ten energy carriers described in this chapter, only seven, i.e. synthetic gasoline, synthetic diesel, DME, biodiesel, ethanol, biogas, and electricity, can be utilised in light vehicles. The remaining fuels are either produced for demonstration purposes with no vehicles available for commercial sale (as in the case of butanol and hydrogen) or they are used mostly in medium and heavy-duty trucks and buses (in case of methanol). Based on the fuel characteristics (particularly the octane number) and the environmental impacts, biogas, bioethanol, and electricity, appear to be promising alternative energy carriers for powering light vehicles.

Biogas, with its high octane number, has recently become widely used in some European countries (Sweden, Switzerland, and Germany) as a transportation fuel for cars (Biogas as Vehicle Fuel: A European Overview, 2003).

Ethanol, from safety issues point of view, is less favourable when compared to the other alternatives. This is mainly due to the explosive properties of the ethanol blended fuels.

Electricity is the only energy form without any emissions to the environment. However, availability of cheap sources for electrical energy generation (to charge batteries in electrical cars) is a major pre-requisite for the commercialisation of battery-powered light EVs. Electric cars need major improvement in batteries durability, distance range covered by a charge, and recharge time, in order to be a realistic alternative to fossil fuels.

Taking into consideration energy security impacts, production of electricity, synthetic gasoline, synthetic diesel, and DME are not always renewable; the production of these energy forms depend on both the biomass and fossil fuel (coal) availability for each country. Nations that are rich in biomass and coal can produce and use synthetic fuels to offset their use of petroleum derived fuels and foreign oil.

With respect to their ability to form flammable/explosive mixtures, biogas, ethanol, and DME need special consideration, as these fuels are more flammable than the others discussed in this chapter.

Taking all these points into account, with the current technology, it is only biodiesel, bioethanol electric cars (for short distance transport), and biogas that are viable alternatives. Several assessments point to biogas as the most sustainable alternative biofuel for the transport sector. Sweden is leading in the utilisation of biogas in the transport sector, while Denmark is lagging behind in its application. However, clear interest in utilising biogas for transport has been recently expressed in Denmark.

4. Comparisons of fuels for heavy vehicles (trucks)

There is currently intensive research on alternative fuels for heavy vehicles. Swedish companies such as Scania and Volvo are investigated the possibilities for utilisation of alternative fuels in their engines. Many factors were considered in this evaluation: energy efficiency, capital and maintenance costs, fuel costs, and net CO_2 emissions.
Cost-benefit analyses conducted by Scania has shown that biodiesel appears to be the most promising alternative fuel for utilisation in heavy trucks. Scania has designed vehicles to run on 100 per cent biodiesel and special engines have been developed for ethanol blend E95 in local/regional transport. The Scania ethanol engine running on ED95 is unique, since it is based on diesel-concept without spark plugs. Although, since the energy content of ethanol is less than that of diesel, more fuel needs to be injected thereby requiring the entire fuel system to be adapted.

Another Swedish firm, Volvo, has conducted similar cost benefit analyses to those undertaken by Scania and has concluded that DME is the most promising fuel for heavy vehicles with respect to energy efficiency. DME was suggested as strong candidate for a more long-term future fuel, due to best well-to-wheel energy efficiency, in addition to the fact that this fuel is close to being CO_2 neutral if produced from biomass.

Both Scania and Volvo have evaluated biogas as another promising fuel for utilisation in heavy vehicles. The biogas engine works with spark plugs and has special tanks built from composite materials that are able withstand 200 bar pressure in order to optimise payload.

5. Conclusion

Among the ten alternative transportation energy carriers described in this chapter, only biogas, bioethanol, DME, hydrogen, and biodiesel are used in transportation sector in Øresund region.

Biogas is widely used in public bus transportation system in Sweden and plans for implementation of biogas in Danish transportation system are already established and public discussions initiated.

Bioethanol is used in different blends with normal gasoline in Øresund region: E85 (85 per cent ethanol, 15 per cent gasoline) and E95 (95 per cent ethanol, 5 per cent gasoline) are used only in Sweden; E5 (5 per cent ethanol, 95 per cent gasoline) is used in both Sweden and Denmark.

DME is being tested in Sweden as vehicle fuel on some heavy trucks. The activities are part of an EU project (2008-2012) with participation of Volvo and Swedish Energy Agency.

Hydrogen refueling stations were opened in Copenhagen (Denmark) by Shell in 2009. The infrastructure established can refuel 15-20 cars per day. So far only limited amount of hydrogen- driven vehicles are currently in use in Øresund region (8 cars in Denmark, 1 car and some busses in Sweden) (Allan Schrøder Pedersen, Risø DTU, personal communication).

Regarding biodiesel, Danish Transport Authorities recently announced that from 2012, all diesel blends sold in Denmark should contain 5.75 per cent biodiesel. This legislation is entirely in line with EU directive 2003/30/EF.

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5. Biogas – the fuel of tomorrow from yesterday's waste biomass

Bo Mattiasson and Maria Andersson

Introduction

As already mentioned in this book, there is consensus around the statement that fossil fuels must be phased out and be replaced with renewable alternatives. When it comes to biofuels for vehicles, one has to start with biomass that later will be converted into biofuels as described in chapter 4, and which puts demand on access to land for production of the biomass. A growing demand for biomass, as a raw material for biofuels and chemicals, at a time when we are facing a growing population and a concomitant increasing demand for food, means that one needs to try to optimise the utilisation of biomass. Actually, it is the utilisation of land that is the important issue. Unless dramatic improvements take place, there will be a lack of area for supplying biomass for all the different needs.

Waste biomass can be used to reduce the demands for cultured plants for biofuel purposes. There are huge amounts of waste biomass that potentially could be utilised for biofuel production. Heterogeneous waste is preferential for conversion into biogas, while well-defined waste streams can be converted to other fuels. Anyway, the bottom line is: how far can I drive a car on a certain amount of biomass, or on the biomass that I can harvest from a certain area of land? In this comparison, biogas is a very attractive alternative. Biogas has, in comparison to other biofuels used today, been shown to have a superior profile both in terms of area efficiency as well as life cycle emissions, and is regarded as one of the most sustainable vehicle fuels of the future (Börjesson and Mattiasson, 2007).

Conversion of surplus biomass into biogas that can be used as vehicle fuel has several different positive environmental effects.

Waste resources

Society holds enormous volumes of waste of biological origin. Much is not properly handled. Spontaneous anaerobic decomposition leads to methane dissipation into the atmosphere. One example is the municipal solid waste (MSW) generated within many of the megacities (>20 million inhabitants), which today is poorly handled. In many countries, the majority of the MSW is today deposited in landfills, which stands for a significant contribution to greenhouse gas emission (Gao et al, 2010). A more efficient utilisation would be beneficial from many points of view. In Europe, a constant increase in the number of anaerobic digesters for MSW has been witnessed since the beginning of the 1990s when it was introduced, and there are now approximately 200 digesters in operation in 17 European countries. These digesters are handling in total around 6 M tonnes of MSW per year (De Baere and Mattheeuws, 2010).

Although MSW is attracting the most attention, there are larger potential resources in agriculture for biofuel feedstock. In temperate regions, where winter makes agriculture impossible during a period of the year, the harvesting of crops is undertaken during autumn. In connection to harvesting, huge amounts of biomass is left in the fields to decompose and contribute to building humus and raising the carbon content of the soil. The only problem here is that the easily degradable material left on the fields decomposes rapidly during the winter and early spring without contributing to the soil improvement. If that material was collected and treated in an anaerobic digester, the easily degradable material could be converted into biogas, with the more recalcitrant fractions being recovered as biofertiliser. In addition, the nitrogen balance could be substantially improved since there is a large leakage of nitrogen during the winter months.

The total Swedish potential of biogas production from waste products, with the largest fraction being derived from manure and biomass left in agricultural fields, has been estimated to be around 10 TWh in energy (Linné et al, 2008). Even if 100 per cent of waste products cannot be recovered, it is still an impressive resource.

Sludge from wastewater treatment plants constitutes a large problem in modern societies. Since the quality of the wastewater cannot be guaranteed, there is a risk of contamination of heavy metal ions, pharmaceuticals etc., being present in the sludge. Therefore there are restrictions on the use of such sludge as fertiliser, even though it contains several useful elements. In Western Europe alone, more than 10 M tonnes of dry weight is said to be produced every year (Wei et al, 2003).

Industrial waste represents another category of potential feedstock for biogas production. Food processing industries often produce waste streams with a low, or even negative value. One example from the tropical areas is the enormous amounts of bagasse (the residue left after squeezing out the sugar rich juice) from sugar cane production. This resource is often used inefficiently as an energy source for boiling the juice in order to concentrate it. The total global amount bagasse produced is estimated to be 180 million tonnes per year, and it is estimated that at least 50 per cent of that could be used for the production of biofuels and chemicals (Kim et al, 2004).
Provided an inventory was made, it would become clear that there are enormous resources for biogas feedstock from the food industry in the Öresund region that still have not been utilised.

The biogas puzzle below is often used when discussing the biogas issue with local governments, since they often start by stating that there is no potential for biogas production in their region. After having gone through the puzzle exercise they often have changed their mind.

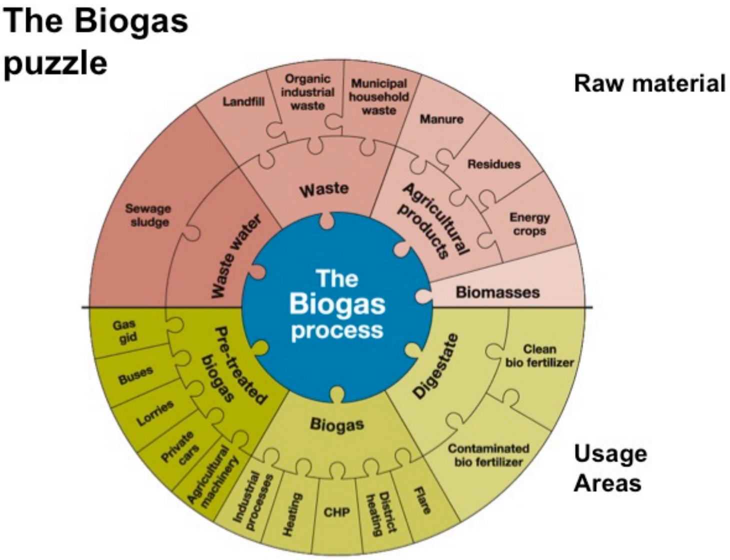

Figure 1: *The biogas puzzle showing the sources of biomass in brown and the use of the biogas and rest products in green. (Source: Biogas Syd).*

Inventories of biomass resources in the Öresund region

Inventories have been made and some are still ongoing within the Interreg IVa programmes Ecomobility and Biorefinery Öresund. The idea is to find volumes and location of surplus biomass, in addition to possibilities for future cultivation of energy crops.

In Skåne an inventory has been made with the aim of creating a GIS-tool such that any resource identified is also given coordinates for location. By such a set of data it will, in the future, be easier to strategically plan where to build biogas production units, as well as to estimate the volumes of substrate that can be foreseen to become available (Björnsson et al, 2011). Within Biorefinery Öresund, there have also been studies on industrial side streams on both the Danish and the Swedish side.

When compiling the data, one can calculate an upper production volume that might be produced. However, not all biomass will be collected, and there might be alternative uses for at least some of the biomass streams. With this taken into account, it is calculated that a production of up to 3 TWh of biogas is possible within the next decade in the province of Skåne.

Why methane and not alcohols or biodiesel

During the food crisis in the 1970s, academics tried to calculate the surface efficiency in terms of how many persons that could be fed from the crops from 1 hectare of land. Today, this question has been reformulated to - how far can I drive on the biofuel produced from the crops from 1 hectare of land?

One characteristic of anaerobic digestion is that almost all biomass can be converted into methane and carbon dioxide under anaerobic conditions. This implies that essentially any kind of biomass can be utilised in contrast to other potential biofuels like alcohols, where carbohydrates are utilised, and biodiesel where fats constitute the raw material. Figure 2 illustrates the difference in efficiency between two strategies to make biofuels, biomethane and bioethanol, from crops grown on the same area of land. Figure 2 illustrates clearly that biogas is more surface efficient than ethanol. Other alcohols, such as butanol, are even less efficient. Earlier it has been shown that ethanol is more surface efficient as compared to biodiesel.

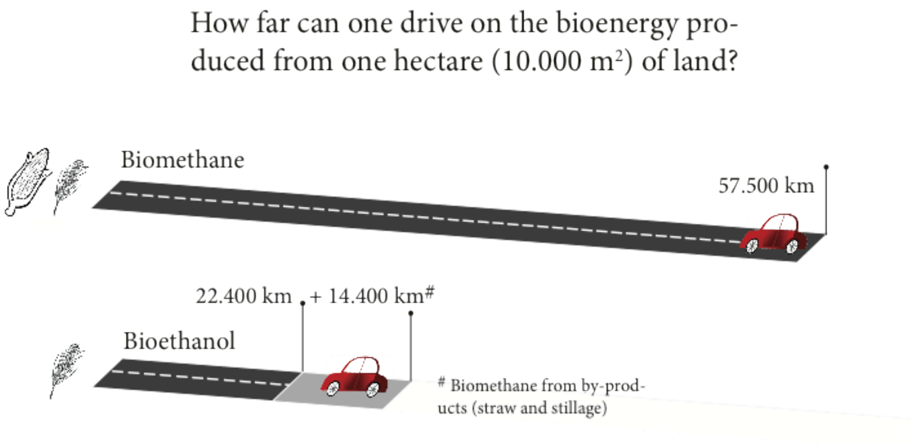

Figure 2: *Comparison of the efficiency of biofuel production from crops grown on a certain area of land.*

By these comparisons it is not said that we preferentially should try to cultivate energy crops for biofuel production. When it comes to biogas, there is enough waste material to process. Municipal solid waste constitutes one major resource base for biogas production. Waste and side-streams from biomass processing industries represent another attractive resource. Additionally, sludge from wastewater treatment plants, and waste biomass from agricultural activities like crop residues and manure represent yet more readily available sources. If these resources are utilised first, before crops are planted specifically for biofuel production, one could gain two positive effects:

- the production of biofuels as fossil fuel substitues
- a reduction of spontaneous methane leakage to the atmosphere from decomposing biomass

Both these factors would positively contribute to reducing the green house gas problem connected to global warming.

Production technology

The production of biogas is by no mean a recent development. The technology used to produce biogas is, to a large extent, the same as what has been used since long back. However, in order to improve the economical outcome and reach viable processes, the productivity level needs to be raised. It should be stated that although the process to create biogas has been established for some time, it is still not properly understood in all its details. A mix of more than a hundred different microorganisms are involved and the product of one may be the substrate for the next one. In Figure 3, a schematic presentation illustrating the decomposition of biomass into biogas is given.

Traditionally in the production of biogas, a stirred tank reactor, in which the biomass is suspended in water and slowly stirred, is utilised. As the process proceeds, gas is formed and collects in the top of the reactor. The gas may be harvested while the reaction continues. Although it is tempting to speed up the process by adding more substrate to the reactor (up to a certain level that may be a successful strategy), if too much biomass is added, the formation of organic acids is faster than the conversion of the acids into biogas. This leads to enrichment of organic acids, the pH drops, and the process ceases to function. At this stage it may be necessary to empty the reactor and restart. Considering that many biogas reactors are of several 1000 m^3, one can imagine the practical and logistical problems arising from an attempt to empty a reactor. That is why it is essential to monitor and operate reactors correctly in order to ensure that process failures do not appear.

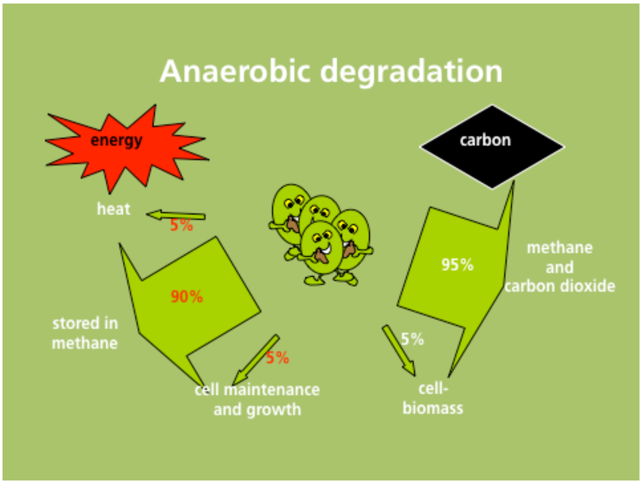

Figure 3: *Schematic presentation of mass and energy flows in an anaerobic digestion process.*

Bottlenecks

Since the process for biogas production is complex, there are several places where things may go wrong. As mentioned previously, 'over-feeding' is an event where acid enrichment may cause process failure. However, to operate the reactors optimally means that one has to find a balance between what the different microorganisms require for their well-being. Trace metals are another factor that has recently become important if one wants to optimise anaerobic digestion. The microorganisms need nickel, molybdenum and other heavy metals, and such elements may not be present in high enough concentrations within the reactor.

When different biomass sources are to be used, it is valuable to know how to mix them correctly. As a practical example, feeding cattle has shown that combining different feedstocks in the right proportions results in cattle that are healthy, grow large, and of course, produce gas. In this sense, a cow can be regarded as a mobile biogas reactor, and just as cattle are sensitive to their feed mixture; it is realistic to expect the same to be valid for the mechanical reactors producing biogas. Therefore, the development of recipes for feeding bioreactors is needed. Moreover, process control is essential for optimal performance of the anaerobic digester (Liu et al, 2006).

Upgrading

Biogas in its raw form from the digester, although possible to be used for running an engine, must be upgraded by raising the energy content and the quality of the gas in order for it to be used as a reliable and cleaner transportation fuel. Carbon dioxide may constitute up to 40 to 50 per cent of the total gas volume, and to remove it is essential. Traces of hydrogen sulphide, ammonia, and water must also be removed. The upgrading of biogas can be done using a few different techniques. Common to all however is that the initial investment is high, and therefore only units with a certain production volume can bear the cost.

Water scrubbing of the biogas has been successfully applied, and today there are several competing technologies available on the market. Regardless of the upgrading technology utilised, the resultant biogas at the end of the process needs to be at least 96 % methane. If the gas is to be injected into the national gas grid, then small amounts of propane need to be added in order to match the energy content of natural gas.

Experiences of biogas as a vehicle fuel

Biogas is dried, odorized and compressed (to approx. 200 bar) in the upgrading process. Odourisation of the biogas is completed so that leakages can be detected (methane is odourless). Carbon dioxide present in the biogas is also removed during processing. Although this step is not necessary, the transportation of a superfluous gas (from a vehicle fuel point of view) reduces the capacity of the vehicle to transport fuel and is deemed beneficial. Compressed gas is the most frequently used way of utilising upgraded biogas. However, this puts some limits on the amount of gas that can be transported with a vehicle. Therefore, biogas is mainly used for district transportation and private cars, and so far biogas has not been suitable to use for trucks for long distance operation.

Biogas is, at present, also being evaluated as a fuel for tractors to be used in agricultural activities. In agricultural transport distances are short (especially if the gas is being produced locally) and raw gas (after removal of hydrogen sulphide and water content) can be used.

A recent technology in the biogas industry called cryo-separation is offering promise in the conversion of biogas into a usable and viable transport fuel. In cryo-separation, biogas is chilled down until it becomes liquid, and then by raising the temperature, different fractions of the raw biogas can be driven off. Pure methane (at least 97 per cent pure) may then be used in liquid form, and then the energy density is far improved making it also suitable for trucks. Trials on the resultant fuel derived from cryo-separation are ongoing in several countries. In Sweden, both Volvo and Scania are offering trucks that have been modified to run on the liquid methane. In order for this to become a good alternative, one needs to have a good distribution system for fuel, and that is a limiting factor for all biogas as a vehicle fuel. Compressed gas is now supplied at 127 filling stations (the number has been increasing quite fast in the last few years) in Sweden. Liquefied biogas is still on the experimental stage and only a select few filling stations will offer the fuel during the initial phase of development.

Exhaust gases after combustion

When a car is run on biogas alone, it emits only 8-15 g of carbon dioxide per km, which is the lowest among all other vehicle fuels used today. A normal environmentally classed car in Sweden is permitted to emit up to 120 g CO_2 per km (Miljöfördelar med biogas, EON homepage, 2011). In comparison to vehicles operated on petrol or diesel, a biogas vehicle also emits less carbon monoxide, hydrocarbons, nitrogen oxides, and sulphur compounds (Johansson 1999; Biogas in Sweden, 2011).

Other products from the biogas process: biofertiliser and carbon dioxide

Anaerobic conversion of biomass into biogas also results in the production of a residue that contains most of the nutrients that were present in the biomass. This residue is an excellent biofertiliser. Biogas is a mixture of methane and carbon dioxide, and before the gas is used as vehicle fuel, one has to remove the carbon dioxide. Thus, there are two additional products besides methane from the anaerobic digestion.

The biofertiliser is composed of more recalcitrant parts of the biomass that has not been degraded during the digestion. This material is per se an excellent soil improver and also constitutes a potential carbon sink. When it is returned to the soil, it takes time before it is metabolised and thereby returned to the carbon cycle. Nitrogen is found in the liquid fraction after digestion and phosphorus is recovered from the solid fraction. How good a biofertiliser however, is dependant on the composition of the biomass that was fed to the digester.

A problem with biofertilisers from wastewater treatment plants, additionally when municipal solid waste is processed, is that one does not have proper control of the incoming material, and thus it is not possible to guarantee the quality of the outgoing biofertiliser. Fear of the presence of heavy metals and other environmental pollutants has restricted the application of sludge, especially from wastewater treatment plants. There is a call to certify the biofertiliser by more rigorously controlling the incoming material and analyzing the residue. Should this happen, it will be possible to get the full benefit from the biofertiliser.

The biofertiliser is especially attractive to ecological farmers, since they are not using conventional industrial fertilisers. For these farmers, nitrogen may be a limiting factor, esp. if they do not have animal breeding with manure collection on the farm.

The biofertiliser represents an interesting resource. Since nitrogen is present, there is less or no need for artificial fertilisers, and the same goes for phosphorous. Nitrogen is available in excess in the atmosphere and can in an energy demanding process be converted into artificial fertiliser. For phosphorous the situation is different. There are limited amounts of phosphate rich minerals and access to phosphorous will be a limiting factor for future agriculture. Therefore, use of the biofertiliser is a resource efficient strategy.

When carbon dioxide is removed from biogas, it can be used e.g. in green houses to promote plant growth. There are also efforts to integrate CO_2 production with cultivation of algae for the production of biomass for biofuel production.

In addition to the different preparations obtained directly from the digestion process, biogas production has also initiated the development of new technologies. This has led to establishment of several successful companies in the region supplying a growing world market.

The situation today

Within the Öresund region there are two distinct strategies to use biogas. In Denmark, priority has been on electricity and heat generation while much of the focus in Sweden has been on use of biogas as a vehicle fuel.

When introducing a new vehicle fuel to market, there often can arise the chicken-and-the-egg problem. Which comes first? The filling stations? Or, the vehicles that will utilise the filling stations? Today there is a network of filling stations on the Swedish side, while there are only a few on the Danish side. Still, however, there is a need for establishing more filling stations in order to facilitate the establishment of biogas as a convenient and attractive fuel amongst the public.

The organisation responsible for public transportation in the Skåne region, Skånetrafiken, has taken a strategic decision that all buses operating on tour lines shall be running on gas, and that is of course of immense importance.

This latter fact illustrates that politicians can strongly influence the development by for example channelling public purchasing in a certain direction that is regarded as good for the development of the society. The buses raise demands on access to biogas that in turn stimulates the building of production units and distribution systems.

Future prospects

Biofuels are at present a hot topic and will stay so for a foreseeable future. However, there are also trends in society to use biomass for replacing petrochemistry when producing chemicals and materials. This has led to the development of biorefineries where biomass is taken in and refined into a range of different products. From the petrochemistry industry it is known that chemicals and materials are approximately 10 times more valuable than energy products, and therefore one can foresee a competition for the resources between different areas of application. To add to the strain placed on these resources comes the population of the world that requires greater and greater food production to keep up with growing demand. With a limited amount of biomass available, it becomes increasingly important to optimise the use of such resources. Biogas is one attractive alternative in such a scenario.

Perspective of the Öresund region, future of biogas as vehicle fuel in Sweden and the Öresund region

As stated previously, the development of biogas production and distribution will to a large extent depend on political decisions; both with regard to taxation and public purchasing strategies. In Sweden, Region Skåne has recently decided to strengthen the biogas efforts in the region. As long as the ambitions are to have biogas as the major fuel for public transport in Skåne, there will be a push for higher production capacities, thereby increasing the availability of gas. On the Danish side, no corresponding strategy is seen yet. Experiences from Germany's energy sector with green certificates has shown that biogas for electricity generation grew rapidly with the help of government policy intervention. When the favourable arrangement started to come towards an end, biogas availability and development for vehicle fuel started to improve. Perhaps a similar development may also take place in Denmark?

A prerequisite for the wider use of biogas as a vehicle fuel is that it needs to be easy to fill the tank of the vehicle. For trucks, liquefied biogas may become a reality soon. There are trials ongoing and a few filling stations are under construction or being planned.

The potential for production of biogas vehicle fuel on both sides of Öresund is good, and therefore it is not unrealistic to project that a large portion of motor vehicle transport in the future could be fuelled with biogas. However, that is of course provided that such a development is an ambition within the Öresund region.

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Part II

Strategies and decision making

6. Themes and challenges in making urban freight distribution sustainable

Maisam Abassi and Mats Johnsson

Introduction to city logistics

Geographically speaking, the Øresund region is located in a very central position, particularly if we consider the expanding markets of Eastern Europe. The region is a natural gateway to the entire Baltic region, while at the same time it offers excellent transport links to the rest of Europe and to the world. The rich variety of transport and communications alternatives in the region satisfies both the requirements of cost-efficient shipping and swift easily accessible passenger travel.

The demand for efficient goods transports rises as consequence of a multitude of factors. One such factor is that the Just-In-Time principle nowadays can be implemented as a global strategy due to improved intercontinental communications. On top of this, the net value of transported goods is steadily rising, which means that the costs for capitalisation also have an upward tendency. As an example, it can be mentioned that the discounted present value of transported goods between Sweden and the rest of the EU has risen by more than 100 per cnet since the early 1970s.

During the past century, the planet's urban population grew ten-fold. Now more than half of the world's population is living in urban areas. As a result of this rapid expansion, urban areas continue to grow at a faster rate than any other land-use type. In Europe, approximately 80 per cent of the citizens live in urban environments (McKinnon et al., 2010).

Due to urbanisation: new infrastructures as well as buildings are built, jobs are created, diverse services are offered, and industrialisation is advanced. Growth in urban areas has been a generator of economic growth as well. In Europe, 85 per cent of the GDP (Gross Domestic Product) is generated in cities (EU, 2007).

Historically, the production and consumption of freight has dominantly taken place in cities, but with the industrial revolution and subsequently with globalisation this share has increased. Since the distances involved in economic activities have increased, the function of distribution has taken a new significance, particularly with the setting of large terminal facilities such as ports, airports, rail yards, and distribution centres. With containerisation as a tool supporting international trade, intermodal terminals have become a notable element of the urban landscape and handling movements that are originating from, bound to, or simply passing through a metropolitan area. The global urban and economic system has also become functionally specialised, permitting a global division of production and its associated freight volumes. Socioeconomic factors, such as rising income and consumerism should also not be neglected. All this incites a greater intensity and frequency of urban freight distribution and correspondingly improved forms, organisation, and management.

Developments in urban areas are not tied with just good news. Degradation of natural resources of the Earth like deforestation, shortage of land, and unequal distribution of power between rural and urban areas are just some cons to mention. Urbanisation also increases the mobility of humans as well as freights. Although economically and socially feasible, mobility in urban areas may lead to GHG emissions, local air pollution, energy/fuel consumptions, congestion, accidents, noise, and visual intrusion. It has also negative effects on residents' health when they inhale GHGs and/or are injured by accidents and noise.

In the European Union (EU), transportation still depends on oil and oil products for 96 per cent of its energy needs (EU, 2011). According to Eurostat (cited in Jönson and Tengström, 2005, p.235), transport's CO_2 emissions are increasing and are the fastest-growing sector in Europe. In the same continent, urban transport is responsible for about a quarter of CO_2 emissions from transport, and 69 per cent of road accidents occur in cities (EU, 2011).

In this regard, the EU (2011, p.3) has set goals to limit climate change below 2^oC by drastically reduce GHG emissions – from all sectors of the economy – by 80-90 per cent below 1990 levels until 2050. It is also estimated that a reduction of at least 60 per cent of GHGs by 2050 with respect to 1990 is required from the transport sector.

However, to achieve the EU's goals sounds tremendously challenging. It is clear that by current business as usual approaches, the goals cannot be reached (EU, 2011, p.4-5); instead new strategies with innovative solutions are required. Breaking the current approaches, ways of thinking, and patterns of behaviour is fairly complex, costly, and time-consuming. Although innovation can be radical, adaptation of new solutions as well as change of behaviour are just incremental.

Complexity of freight- than passenger transport (Wigan and Southworth, 2004; Himanen et al., 2004; Lieb and Lieb, 2010) and, in specific, urban freight transport and distribution (McKinnon et al., 2010, p.294; Jönson and Tengström, 2005; Waddell et al., 2007) make their sustainable development challenging as well. Evidence of such complexity can be witnessed in the large number of actors who influence freight distribution in urban/city areas such as Logistics Service Providers (LSPs), carriers, shippers/receivers (like retail stores, shops, restaurants, private consignees, and industries (construction industry, hotels, etc.)), residents, authorities, and researchers.

Another dimension of such complexity is the large number of activities which are/should be done in urban freight distribution operations. Consolidation, transhipment, coordination, sorting, kitting, sequencing, commercialisation, packaging, storage, handling, and transportation of freight as well as reverse logistical activities (recycling, repacking, refurbishing, waste handling, etc.) are just few examples to mention.

In addition, freight- than passenger movements in urban areas is much more heterogeneous and dynamic. Freights are distributed through many (distribution) channels. Furthermore, the channels (including routes and paths) may change rapidly specifically in post- and home-delivery services.

There are also a number of dilemmas in understanding simultaneous ecological-, social-, and economical- effects of new industrial trends on urban freight distribution. For instance, E-business/commerce, Just-In-Time (JIT) with shorter lead-times, regional business growth, may have antagonistic effects on triple bottom line of sustainability. McKinnon et al. (2010, p.286) truly claim that "the problems experienced by those performing freight transport and logistics operations in urban areas are far less well understood."

Until relatively recently, little attention has been paid to urban freight by researchers and policy makers (Dablanc, 2007; McKinnon et al., 2010; Álvarez and de la Calle, 2011). The scenario becomes even worse when it comes to awareness of- and attention to- sustainable urban freight distribution. However, this is the driving force – and maybe motivation – for us (the authors) in order to take a relatively holistic view to current initiatives as well as challenges in making urban freight distribution sustainable. Such a holistic view is essential in order to: understand how different actors of the chain look upon sustainable urban freight distribution, avoid sub-optimal policies / governing rules, and suggest close-to-reality solutions for tackling the challenges.

This chapter aims to explore, classify, and synthesize/analyse pattern of themes as well as challenges in making urban freight distribution environmentally sustainable. A concluding discussion for tackling the challenges is included as well.

What is City Logistics

This study is demarcated to logistics in city/urban areas. All initiatives related to city logistics/urban freight distributions are in the scope of the study. This is in line with scope of 'City Transport and Logistics' network of 'Øresund EcoMobility' project.

While the main focus of this study is on eco/environmental aspects of sustainability, due to the integrated nature of sustainable development, the integration of environmental issues with economic and social concerns, have also been considered. In addition, phrases such as environmentally- sustainable / friendly / sound / preferable / responsible, eco, and green have been used synonymously.

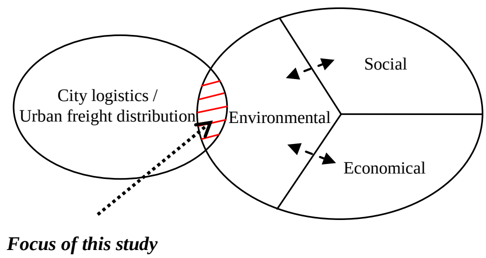

Figure 1: Focus and demarcation of the study

In the analysis of the concept of City Logistics there are three areas that are recognised as important for the drivers and challenges; innovation, integration, and information. Innovative solutions must be considered, there must be a strong integration of partners and actors in the supply chain, and finally information plays an important role in order to have an effective control of activities in the urban logistics system.

Three 'I's in making urban freight distribution sustainable

Three 'I's namely information, integration, and innovation play an important role in making urban freight distribution sustainable.

Information

Educating the urban stakeholders and sharing information about freight distribution, supply chain, and sustainable development among them is a must. Today, there is huge gap and lack of knowledge and visibility as well as misunderstanding about city logistics and future trends which may influence their sustainability and development. Both researchers and media (mass media, social media, electronic media, etc.) have great responsibility and role in reducing the gap.

Integration

Sustainable urban freight distribution requires cooperation, coordination, collaboration, and alliance among all its stakeholders. There is a great need for having 'merging actors/agents' who can integrate and unite all the involved actors/stakeholders - who influence urban freight distribution at different levels (locally, regionally, state, continentally, and globally) – as well as their strategies, tactics, and operations. It is also important to close the loop of urban freight distribution by integrating both forward and reverse flows of goods. Reverse logistical activities like recycling, reusing, and refurbishing of waste and packages are usually ignored in discussion and decision or policy making.

Innovation

It is clear that by current business as usual approaches and activities, urban freight distribution will not become sustainable; instead new strategies with innovation solutions are required. All incremental and radical innovative ideas that may optimise the mobility or decrease mobility by increasing accessibility should be in focus.

City Logistics and related areas

City logistics is an important process for totally optimising the logistics and transport activities by private or municipal companies in urban areas while considering the traffic environment, the traffic congestion, and energy consumption within the framework of a market economy. (Institute of City Logistics)

Alternatively, city logistics is involved in all the means over which freight distribution can take place in urban areas as well as the strategies that can improve its overall efficiency, such as mitigating congestion and environmental externalities. Most of the early applications of city logistics were undertaken in Japan and Western Europe, as these cities were more constrained by the lack of available land and had an established tradition pertaining to urban planning. Up to the 21st century the consideration of urban freight distribution within the planning discipline remained limited. This implies that urban planning generally does not pay much attention to issues related to urban freight distribution.

City Logistics is a conception with different meaning for different people based on their background and type of business they are involved in. At regional level, we observe different policy measures between cities in the same country (Van Duin, 2005). Despite the many differences, there are common challenges in urban goods movement as well (OECD, 2003), such as the significant contribution of transport in the total traffic, and the contribution of freight transport to problems of accessibility, congestion, environment, and safety. An important step is to identify the actors involved; three main actor groups are governments (national, local, etc.), professionals (shippers, receivers, and carriers), and those who are impacted (the actors affected, e.g. residents, shopping public, passenger traffic, etc.). The type of involvement can either be compulsory or voluntary.

When we look at the structure of City Logistics we can divide it in four major activities:

- Transport flow improvements, including:
    - cooperation between companies,
    - consolidation centres,
    - transport reorganising,
    - routing improvements, and
    - e-commerce
- Hardware (the means) including infrastructure, parking, unloading facilities, and technological innovations
- Policy (the context) including licensing and regulation,
- Research orientated contributions including modelling, and data.

Quak discuss several distinguish elements that are the basis for the framework (Quak, 2008):

- Actors
- Motivation of transport in urban area
- Drivers for policy / action
- Planning options
- Geographical elements
- Transport characteristics
- Physical and functional characteristics
- Research schools and methods used
- Success (objective-based) and key success indicators or barriers
- Degree and type of sustainability

The main objective for emphasising on cooperation between, usually competitive companies is to increase efficiency in order to improve the accessibility and decrease pollution (Hayashi, et al., 2006). Usually it involves pick-up and delivery operations of parcels in a city. The majority of research deal with cooperation between private companies that have an economic incentive, namely to increase the efficiency of their operations that consist of multiple drops (or pick-ups) per vehicle round trip. Different carriers cooperate by consolidating goods at a terminal, or by using a neutral carrier. Researchers initiate most of the studies on cooperation, whereas the carrier is expected to be the main actor to cooperate with his competitors.

Urban, in contrast to rural, is usually referred to cities and towns. The combination of urban and rural areas is called metropolitan area. It may also be called by similar phrases like city logistics, urban freight logistics, urban logistics, and urban goods movement (Dablanc, 2008).

Urban freight distribution deals with warehousing and, mainly outbound, transportation/traffic to customers in urban areas.

Innovative Urban Consolidation Centres (UCC)

The use of consolidation centres is a special form of cooperation, which was considered typical (and sometimes even a synonym) to city logistics initiatives, especially at the early stage. Several types of centres are included, e.g. city distribution centre, urban freight platform, freight village, etc., that have in common that flows from outside the city are consolidated (usually) with the objective to bundle inner-city transportation activities (Yamada and Taniguchi, 2006). The main objective is to make urban freight transport more efficient in order to reduce emissions and increase accessibility (reduce congestion in urban areas).

Intermodal transport is a different way of reorganising transportation. The discussed initiatives are very dissimilar; Kunadhamraks and Hanaoka (2006) introduce fuzzy logic to make a mode choice at an intermodal terminal. Intermodal centres for city logistics in the USA is mainly for long distance shipments of bulk and automotive products. In Van Duin and Van Ham (2001), emphasis is on regional rather than long distance transport. In this contribution, the authors look for niches in which intermodal transport is also feasible over a relative short distance. They find that waste collection in cities might be possible using intermodal transport, and results in a small improvement of accessibility and an increase in both logistics and transportation efficiency.

The areas of involvement varies between sustainability, economically, or legislation. The actual characteristics, the context, are described by three dimensions: 'where,' 'what transport characteristics,' and 'how.' 'Where' is described by four typologies: urban type (historical- modem, size), outlet type (e.g. retail or special, such as construction), spatial scarcity, and geographical focus (from international focus to a specific focus, e.g. one street or crossing). The 'what transport characteristics' is described by five typologies: product type (three elements: complexity, value, and volume), supply chain direction (forward, reverse, both), transport elements: (i) core goods, those goods that are essential to the business, e.g. groceries for a grocery store, (ii) non core goods, e.g. waste, money, and (iii) others, such as deliveries and service trips, delivery characteristics (time of day, drop-type: either single or multiple, and on-street versus off street deliveries) and finally, transport mode (road, rail, water, and others). The 'how' dimension considers the actors evaluating the project (or writing the paper) and the methods used to evaluate. Finally, we consider the results in the dimension 'what results’ on a checklist for city distribution evaluation from the Netherlands (see OECD, 2003).

Innovative Transport

The main idea to offer transport orders in an auction setting is to make transport more efficient (e.g. less empty kilometres because carriers can bid on shipments, for example a pick up, in areas where their vehicle already had to go to make a delivery). The auction initiatives are all evaluated using modelling techniques; the main results are that more competition increases the drive for efficiency, with the result that both shippers' costs can decrease and carriers' profits can increase. These initiatives are in the private sector.

In some special cases, such as the Dutch context with many waterways, intermodal transport might be useful in some niches in urban freight transport. Dependent on the infrastructure's availability (e.g. railway and waterway) it might also be an environmental friendly (and even economical) method of transport for long distances for some product groups. Nemoto et al. (2006) describe intermodal transport examples in the EU, US, and Japan and focus on the similarities and relationship between city logistics and intermodal transport.

Finally, the transport reorganisation by network strategies; these studies have a regional or even national scope. Hassall (2004a, 2004b) shows examples of improving efficiency by changing a company's private distribution network, which leads to more sustainable transportation. Overall, the transportation reorganising initiatives have only little in common, except that their scope is usually much broader than the city con text only. By making transportation more efficient (network strategies and auctions) it has also value for the cities, this is also true for intermodal transportation in the case it really results in an environmental improvement.

Technological Innovations

Many of the innovations discussed for City Logistics are not isolated; as a result of the innovation usually something else changes as well. These initiatives are normally related to (or include) initiatives that focus on consolidation centres. Underground logistics systems initiatives are a special case of technological innovations, but are also special case of infrastructure and transport reorganising. Marquez et al. (2004) evaluate the results of vehicle technology improvement, and Patier (2006) discusses the use of an electronic tricycle for the-last-mile delivery.

Underground freight transport systems focus on the feasibility, the potential, and the design choices of these systems in urban areas. The main objective in building an underground logistics system is to develop a sustainable urban freight transport system. Transport characteristics are that especially core goods are included and that (un)loading happens off-street. The overall results show that these systems potentially have a positive impact on the environment and on the reduction of congestion in the cities. However, the main conclusion is that because of the high (investment) costs, self-support is not possible. Large governmental subsidies are necessary. Therefore, it is only feasible if governments consider the (environmental, social and/or economic) gains high enough to make the necessary investments

Marcucci et al discuss that city administrators have designed and implemented a wide array of policies to tackle the urban goods transport issue (Marcucci, 2008). Some of the implemented policies are regulatory in nature and comprise dedicated parking bays for loading/unloading trucks, access restrictions to some areas of the city centre, time restrictions, vehicle restrictions according to the size of the vehicles, fuel used, fuel efficiency, and minimum load factor required. A second set of policies affects the costs of distributing goods within the city centre, e.g. by requiring the acquisition of time-based access permits or use of vehicles with low environmental impact.

A different, more ambitious, approach seeks to alter the logistics of the existing urban goods distribution by creation of urban freight consolidation centres (UFCC).

The urban space is thus prone to conflicts between different stakeholders, as high population densities are related to a low tolerance for infringements and disturbances. There are also opportunities for collaboration as city logistics open new realms of engagement for urban planning, but with diverging priorities according to the urban setting.

Challenges in the process of developing urban transports

Systematic review and content analysis of the literature led to identification of the pattern of discussed initiatives/themes and challenges in making urban freight distribution environmentally sustainable. This section provides a classified synthesis of identified themes and challenges.

Identified challenges

In total eight themes were identified. The coding logic was that the discussed data in literature shall have a thematic character (like managerial) or refer to an environmentally sustainable activity/issue (like developing new fossil-free fuels). In the follow, the identified themes are explained in detail.

Time restrictions – Delivery timing – Vehicle access time restrictions

These regulations – which are usually called access time windows – aim to restrict time of collection and delivery / loading and unloading of freight in urban areas. The most common form is night deliveries that may reduce: noise pollution, traffic congestion, vehicles fuel consumption, and GHG emissions as a result (Bhuiyan et al., 2010; Alvarez and de la Calle, 2011; Munuzuri et al., 2005; Angheluta and Costea, 2011) of freight distribution during the daytime. According to Alvarez and de la Calle (2011), nighttime deliveries have reduced the fuel consumption and CO_2 emissions by 15 to 20 per cent in some European cities.

Relaxation of time windows as well as their harmonisation among different municipalities can result in a relief of the environmental burden and a cost decrease for the retailers, too (Quak and de Koster, 2007).

Vehicle load capacity restrictions - Vehicle access weight /size/capacity restrictions

Restrictions on vehicle access weight and size are some of the most common mobility policies and legislations. The goal is to restrict entrance of large vehicles higher than a specific gross weight or longer-, wider-, and higher than a specific length, width, and height, respectively into urban areas. Such restrictions may lead to reduction of congestion, pollution, intimidation, safety concerns, vibrations, and noise (Anderson et al., 2005) in urban areas especially where pedestrians and other road users are present.

Another reason to introduce such restrictions is limitations in infrastructures of urban areas like height of bridges, width of carriageways, and dimensions of city squares.

Environmental zones / Low emission zones / Clear zones

Environmental zones – which are sometimes called low emission zones or clear zones – relate to geographical areas that can be entered by vehicles meeting certain emissions criteria/standards or below a certain age. The aim is to improve air quality in urban areas by encouraging the use of less polluting engine technologies (McKinnon et al., 2010) and more modern and cleaner vehicles (Anderson et al., 2005).

Urban Consolidation Centre (UCC)

The goal of UCC initiatives is to consolidate the freight before delivery in urban areas. As Browne et al. (2005) state: "a UCC is best described as a logistics facility that is situated in relatively close proximity to the geographic area that it serves, be that a city center, an entire town or a specific site (e.g. shopping center), from which consolidated deliveries are carried out within that area." UCCs are also called by similar phrases such as urban shared use freight terminals (Dablanc, 2007), city terminals (Munuzuri et al., 2005), city distribution centers (van Rooijen and Quak, 2008), and urban freight consolidation centers (Edoardo and Danielis, 2008). The main advantage of UCCs is reduction of traffic intensity (total number of operating vehicles) in urban areas by improving the load factor and empty running of vehicles. Such initiatives can also reduce- fuel/energy consumption per ton-km, vehicle emissions, and noise generation in delivering goods as well as making the area more pedestrian-friendly (Browne et al., 2005; Alvarez and de la Calle, 2011; Weber, 2003). According to Goldman and Gorham (2006), such initiatives have reduced number of truck trips into the city and truck operating times by 70 per cent and 48 per cent, respectively in some German cities.

Maximising capacity utilisation of existing infrastructures

Some literatures shed light upon some initiatives which aim to maximise the capacity utilisation of existing roads, parking places, load/unloading areas, and pedestrian/bicycle ways.

'*Multi-use lane*,' common use of 'public and private parking lots'– which are mainly used for passenger vehicles – or 'other reserved spaces (like taxi zones, bus lanes, motorcycle parking spaces, and parking spaces for disabled people)' during certain time intervals, are some of these initiatives that aim to adapt the use of public roads and spaces to the different freight distribution operational needs emerging during the day. 'Load zone provision,' 'Delivery zones,' and 'Dynamic allocation of loading and unloading places' – (reserved spaces to be used by delivery vehicles for loading or unloading freight in certain dense urban areas) –, as well as 'temporal individual load spaces' and 'short time double parking' (Munuzuri et al., 2005; Alvarez and de la Calle, 2011; Awasthi et al., 2011) are some other initiatives to mention. Although these initiatives may not reduce the number of vehicles during peak hours, they can reduce traffic intensity and congestion by facilitating parking, and loading/unloading operations.

Underground urban goods distribution

The aim of underground urban goods distribution initiatives is to utilise the underground links or network for distribution of goods among distribution centres around urban areas and receivers (like shops) inside the urban areas. According to Binsbergen and Bovy (2000), concept of underground goods transportation has potential feasibility for urban distribution of food products and consumer goods. It can also reduce noise levels, improve local air pollution, and decrease energy use for propulsion.

Managerial

Managerial issues are related to activities such as planning, control, measurement, monitoring, modelling, assessment/evaluation, cooperation/coordination/collaboration, and partnership that can contribute to sustainability of urban freight distribution.

Modelling activities are reflected in several articles ranging from multi-criteria decision making approach for location planning for urban distribution centres under uncertainty (Awasthi et al., 2011) to peak-hour urban freight movements with limited data availability (Munuzuri et al., 2010), and CO_2 emissions for different levels of congestion and time-definitive customer demands (Figliozzi, 2011). Modelling can also be found in Gao and Sheng (2008) who take advantage of simulation method combined with improved heuristic algorithm in order to solve the dynamic vehicle routing problem with time windows (DVRPTW) in real city environment.

Evaluating activities can be found in Awasthi and Chauhan (2012) who present a hybrid approach based on Affinity Diagram, AHP, and fuzzy TOPSIS for evaluating four city logistics initiatives; namely vehicle sizing restrictions, congestion charging schemes, urban distribution centre, and access timing restrictions. Hensher and Puckett (2008) present a choice-modelling framework for *assessing* the influence of distance-based charges on freight transporters. Route *planning* of delivery fleets (Zeimpekis et al., 2008) and *mapping out* the pattern of goods distribution (Ljungberg and Gebresenbet, 2004) in order to reduce financial costs, congestion, and environmental impacts are some other activities with managerial thematic character.

Cooperation, coordination, and *collaboration* are inseparable activities of sustainable logistics and supply chains. Urban freight distribution is not an exemption. *Partnership* between public and private sectors (McKinnon et al., 2010), inter-organisational cooperation among actors and stakeholders involves in city logistics (Petersen, 2006), cooperation in distribution channels, and coordinated goods flows are just few examples of managerial activities to mention.

Inter- and co-modality

Transferring the freight from urban roads to rail and marine (Dinwoodie, 2006; Pawlak and Stajniak, 2011; Goldman and Gorham, 2006) – which may have less energy intensity per ton-km – are among the discussed activities in making urban freight distribution sustainable. Co-modality, by combining different modes together, like cargo- trams and ferries combined with electric powered trucks (Angheluta and Costea, 2011), freight busses and metro (Petersen, 2006; Amico et al., 2011), and passenger and cargo trams (Munuzuri et al., 2005) are other initiatives to mention.

Inter- and co-modality by shifting to non-road modes of transport can reduce congestion on roads as well as costs of distribution operations.

Developing environmentally friendly vehicles

Designing, developing, and producing more environmentally friendly vehicles – with less energy and emission intensity – are inseparable parts of Zero-emission and Eco-mobility strategies. Using electric vehicles (Alvarez and de la Calle, 2011) like electric- lorries and vans (Zuccotti et al., 2011; Binsbergen and Bovy, 2000), zero emission vehicles powered by hydrogen (Rambaldi and Santiangeli, 2011), and gas and electricity-powered trucks

(Angheluta and Costea, 2011) can all contribute to environmentally friendly city distribution operations.

Technological developments

Developing clean/green/environmental technologies are permanent strategies towards sustainable development of city logistics, logistics, and supply chains.

Several literatures shed light upon Information and Communication Technologies (ICT) as some enablers of green urban freight distribution. They are also some major enablers of world-class infrastructure (Toh et al., 2009). Such technologies are also keys to integrated, connected, visible, adaptive, and intelligent supply chins. Tracks of ICT can be found in today and future of sustainable urban freight distribution in order to track and trace goods and resources of supply chains and take advantage of Global Positioning Systems (GPS), route optimisation, variable message panels, traffic management systems, identification tags, smart cards, computer software and hardware, emission calculators, parking monitoring tools, and on-line load zone reservations (Gebresenbet et al., 2011; Zuccotti et al., 2011; Qiang and Miao, 2003; Munuzuri et al., 2005), etc.

According to Weber (2003), “Bottom-up processes of strategic niche management with new emerging technologies have the potential to trigger regime shift towards a more sustainable supply of energy and transport services.”

Distribution services

Distribution services are complementary to sustainable physical freight distribution. Home service distribution – delivering the goods to the customer’s home – (Alvarez and de la Calle, 2011), neighbourhood drop-off points (Goldman and Gorham, 2006), and use of packaging automates in the distribution process (Pawlak and Stajniak, 2011) – other similar concepts are DHL pack stations and BentoBox (Amico et al., 2011) – are just some exemplary services that can reduce transport intensity, traffic intensity as well as congestion and emissions in urban areas.

Inefficiency in urban freight distributions is another factor that may make operationalisation of sustainable development challenging. To improve the efficiency of urban mobility while ensuring environmental quality and economic growth as well as maintaining liveable communities is fairly challenging (Figliozzi, 2011; Gebresenbet et al., 2011). Inefficiencies in urban freight transport can occur as a result of existing road layouts or traffic levels, unintended consequences of non-freight urban transport policies on freight transport operations (e.g. the introduction of bus lanes), variations in urban freight transport policy measures in different urban areas or different parts of a single urban area (McKinnon et al., 2010), and counterproductive institutional roles and procedures (Jönson and Tengström, 2005), etc.

Uncertainties

Another challenge is related to uncertainties inherited in different aspects of urban freight distribution and sustainability. There are several strategic uncertainties regarding production capacities and logistics of new fossil-free fuels, design/location and capacity planning/viability of supply chain static resources (like distribution centers, UCCs, terminals, facilities) in urban areas, construction of new infrastructures, and behavioural effects of congestion charging regimes, etc. (Angheluta and Costea, 2011; Marcucci and Danielis, 2008; Hensher and Puckett, 2008; Awasthi et al., 2011). There are also operational uncertainties due to unexpected/unforeseen incidents like order cancellation, delivery time changes, new customer requests, traffic congestion, road construction, flea markets, natural disasters, weather changes, accidents, mechanical failures, etc. (adapted from Zeimpekis et al., 2008). There are also uncertainties due to psychological reluctance of customers to buy clean technologies as they might not be fully convinced of their practicability and chance of survival on the market (Angheluta and Costea, 2011).

Finally yet importantly, there are uncertainties, dilemmas, and misunderstanding regarding paradoxical/ contradictory/ antagonistic effects of freight distribution activities/initiatives in urban areas. For example, Lean and Just-In-Time (JIT) may increase service level and efficiency of freight distribution while at the same time lead to small order problems and increase Less-Than-Truckload (LTL), empty running, costs, congestion, fuel consumption, and GHG emissions (Gebresenbet et al., 2011; McKinnon et al., 2010). There are also dilemmas in decision making for facility location of static resources. For example, locating distribution centres close to customers' locations may increase traffic congestion in urban areas while locating far from them may increase costs of transportation or destroy green fields (Awasthi et al., 2011; Toh et al., 2009).

Lack of visionary leadership

Today, there is a lack of visionary leadership in making urban freight distribution sustainable as visions and goals are vague, short-term market perspectives are in focus, and potential long-term benefits of initiatives and legislations are misunderstood (Petersen, 2006; Angheluta and Costea, 2011). This is a real challenge in construction and development of infrastructures as they last for several decades; it takes many years to plan, build, and equip them; and considerable investment will be needed (EU, 2011).

In addition, there are also tremendous difficulties in creating a new and innovative urban mobility culture that all stakeholders accept and follow the legislations and initiatives (Zuccotti et al., 2011; Pawlak and Stajniak, 2011). To change and shift the organisational culture is also tied with behavioural challenge, as there are very high inertia and resistance to change. Sustainable development brings significant challenges to traditional business models – which have clear focus on just financial aspects – and the ways that different stakeholders define their missions and strategies, and organise their work and operations (Jönson and Tengström, 2005; Goldman and Gorham, 2006; Weber, 2003; Browne et al., 2005).

The usage of public transit system has also been considered for urban freight distribution. However, there are no cost and logistically effective strategies to date. Urban transit is not well adapted to freight distribution and often involves additional load break and costs. Attempts at developing 'cargo-trams' have failed, such as the ambitious cargo-tram project in Amsterdam, which went bankrupt in 2009.

Urban areas remain congested areas where space utilisation comes at a premium and where the presence of many stakeholders impose concerted efforts to insure that urban markets remain serviced in an effective and environmentally friendly fashion. The future is indicative of a transition towards greener for greener forms of city logistics since the current situation appears unsustainable in many cities that are facing rising congestion and environmental externalities. Since each city represents a unique setting with its own prevalence of transport infrastructure and modal choice, there appears to be no single encompassing strategy to improve urban freight distribution, but a set of strategies reflecting challenges that are rather unique for each city. As underlined, a salient difference relates to city logistics between developing and developed countries.

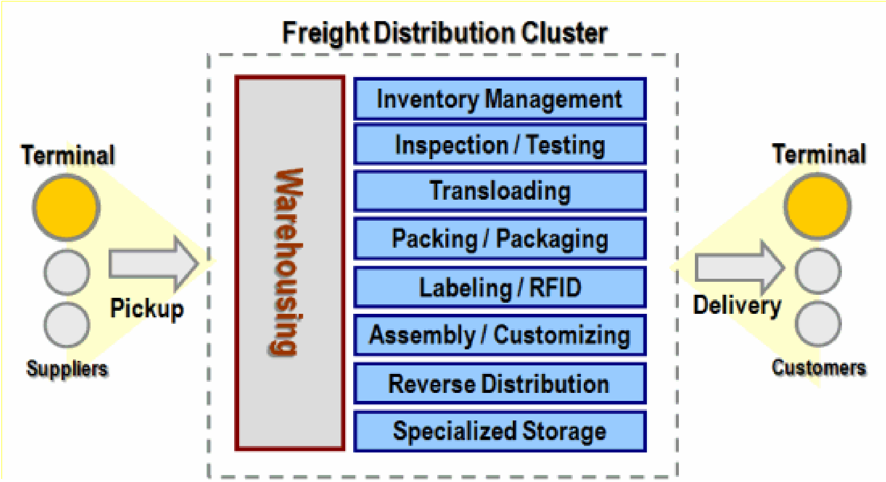

Figure 2: Value-added Activities Performed at Logistic Zones

The main value-added logistics activities are:

- Simple storage, distribution, and order picking part of the **inventory management systems** of manufacturers, distributors, and retailers.
- **Quality control** (inspection) and **testing** of products before being sent to customers.
- Receiving goods, breaking shipments, and **packing** (preparing for shipment). Can also involve **packaging** were goods are broken down into retail units.
- In part related with packaging, labelling provides information on the product for consumers such as brand and price. More advanced activities involve the tagging of units using RFID (Radio Frequency Identification) for distribution or retail purposes.
- Light manufacturing tasks such as **assembly** and **customising** to country-specific (or culture-specific) demands, adding parts and manuals.
- A variety of **reverse logistics** activities such returning empty packaging and the recycling of used goods back into the commodity chain.
- Providing **specialised storage** facilities, mainly to support cold chain logistics.

The transport activities of pickup and delivery are also part of the added value process since they support logistical activities and provide employment.

CONCLUDING DISCUSSION

Urban freight distribution cannot become sustainable with just one or two activity(s). Instead, a packet of activities and mixed strategies without antagonistic effects on each other are required. Taking a holistic view and systematic thinking to sustainable development of urban freight distribution is also essential in order to understand economic, environmental, and social effects of identified themes on each other and avoid sub-optimal, irrationalised, and based on intuition discussion and decision making. Taking a short-term perspective and/or considering urban freight distribution in isolation from their supply chains or other aspects of urbanisation will not make them sustainable.

It is also important to realise that 'one shoe does not fit all.' The packet of activities and strategies should be also adaptive as each urban area is unique. Differences among shape, size, nature, and society of urban areas have led to different types of freight distribution inside them. The urban freight distribution needs to be adjusted to the local context and user requirements as well as regulations and policies of a specific city (Gebresenbet et al., 2011) and adaptive to new clean technologies and infrastructures.

Three 'I's in making urban freight distribution sustainable

The platform needed for building a creative urban logistics solutions is based on the three I:s mentioned in the early part of the book. These three I's will also play an important role when City Logistics is configured to deliver sustainable performance.

Information

Educating the urban stakeholders and sharing information about freight distribution, supply chain, and sustainable development among them is a must. Today, there is huge gap and lack of knowledge and visibility as well as misunderstanding about city logistics and future trends that may influence their sustainability and development. Both researchers and media (mass media, social media, electronic media, etc.) have great responsibility and role in reducing the gap.

Integration

Sustainable urban freight distribution requires cooperation, coordination, collaboration, and alliance among all its stakeholders. There is a great need for having 'merging actors/agents' who can integrate and unite all the involved actors/stakeholders - who influence urban freight distribution at different levels (locally, regionally, state, continentally, and globally) – as well as their strategies, tactics, and operations. It is also important to close the loop of urban freight distribution by integrating both the forward and reverse flows of goods. Reverse logistical activities like recycling, reusing, and refurbishing of waste and packages are usually ignored in discussion and decision or policy making.

Innovation

It is clear that by current business as usual approaches and activities, urban freight distribution will not become sustainable; instead new strategies with innovation solutions are required. All incremental and radical innovative ideas that may optimise the mobility or decrease mobility by increasing accessibility should be in focus.

Recommendation for tackling the challenges

In order to tackle the identified and classified challenges, it is recommended that the complexity of such a complex socio-technical system (urban freight distribution) be harnessed, visionary leadership for transformation of this system towards sustainability be appreciated, and both top-down and bottom-up changes be considered.

Harness the complexity

Urban freight distribution is a complex socio-technical system with tremendous number of interconnected actors/stakeholders and activities that influence its sustainability and sustainable development. In order to harness this complexity, all these actors and activities shall be identified and classified, and their effects on sustainability of urban areas/cities (environmental protection, liveable human societies, and economic profitability) shall be measured, controlled, and managed. In addition, effects of current and future business and market trends on urban freight distribution must be fully investigated. For example, the role of: globalisation in distribution industries - and, vice versa, the significance of distribution in glopbalisation – (Markus, 2006), future of ICT (Information and Communication Technologies), and clean technologies deserve full investigation

Visionary leadership

Urban freight distribution calls for charismatic visionary leaders who can transform it towards sustainability and develop it sustainably. It is also necessary to shape a new culture of sustainable mobility among all the stakeholders where big and innovative ideas are heard, developed, and evolved.

Top-down and bottom-up changes

Both top-down and bottom-up strategies and initiatives must be considered for transformation of complex city logistics towards sustainability. Governmental subsidies, funding, and liberalised policies and restriction are some examples of top-down ones. Collaboration of local stakeholders and practitioners (like retailers, transport operators, shippers, and residents) by taking part in initiatives as well putting pressure on local- and central government are few bottom-up examples to mention. Combination of bottom-up strategies and initiatives with top-down ones may increase the chance of their acceptance and operationalisation as well as a regime shift towards sustainability.

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7. Sustainable Urban Distribution in the Øresund Region

Carl-Magnus Carlsson and Mats Janné

1 Introduction

City transport and logistics deal with the combination and conflict of interest between goods transport and people transport within an urban environment. People have to reach their destinations of choice, and in urban areas, these destinations are quite often trade areas, restaurants, and other places where day-to-day activities such as working and living are carried out. At the same time however, these are also the areas to which we need to deliver goods. In the city, where people work, live, and enjoy themselves, they also need to shop, consume, and get rid of waste. However, no one really appreciates heavy goods vehicles idling outside the bedroom window or goods vehicles in pedestrian areas during lunchtime or during the most hectic shopping hours of the day.

Goods transport in urban areas obviously contributes to many problems including congestion, emissions, and accidents. Approximately 75 per cent of Europe’s inhabitants are currently residing in towns and cities and the prognosis is that by 2020 as much as 80 per cent of Europeans will be living in urban areas (European Environment Agency, 2011). This implies that in future, most of the goods transports have to be carried out in cities.

So, what can be done in City Logistics? This chapter discusses new approaches to goods distribution in the Øresund region to ensure urban sustainability. The focus will be on goods consolidation by means of urban consolidation centres (UCC) from the viewpoint of the perceived problems in city shopping areas.

Traditionally, the consolidation of goods in urban areas around the world has been initiated and run by municipalities and city authorities (Browne, 2005). This implies that large-scale solutions and top-down implementation of consolidation centres and terminals have dominated the development. The focus has usually been on the transporters, forwarders and suppliers of goods, i.e. the supply side of urban distribution. Furthermore, costs of external effects, legislative measures and an inflexible logistical approach have overshadowed the views and needs of the end-users – the shops – and eventually the consumer, i.e. the demand side in planning as well as in operating. Experience has shown that the supply side strategy has faced difficulties in long-term economic sustainability.

This chapter argues that in order to ensure the prerequisites for long-term sustainability, the focus of implementing and running urban consolidation programs should shift, albeit not entirely, to the demand side: to the shop’s needs, to the consumers, to visitors, to tourists and to new forms of governance. Societal and social factors should be given more emphasis in the analysis as well as stakeholder involvement. The role of the authorities should be to enhance the benefits of new measures in distribution to increase city attractiveness – the positive external effects of urban consolidation – rather than focusing on pricing the costs of the negative effects of urban distribution. This would imply striving towards an optimal mix of mobility and resources; i.e. transport availability in relation to transport needs related to different activities in an area. New business opportunities for transport services should be developed. Social entrepreneurship initiatives and social enterprise should be encouraged by reassessment of rules and legislation in transport planning and the interaction of public, private, and goods transport, where trade is the interface, should be taken into account when planning for the urban transport system.

1.1 Challenges in Urban Distribution

During the last decades, people have become more aware of the environmental problems that humanity is causing. One can barely open a newspaper without reading something about how the climate is showing signs of irregular behaviour and that the cause of these irregularities might be human activity. Therefore, there is a need to reduce the environmental impact and emissions from various sources.

Goods transports do play an important role in making the urban environment alive and prosperous, but it also has effects that are less desirable. Currently, freight accounts for somewhere between 20 and 30 per cent of the kilometres driven in a city (Dablanc, 2007). Emissions can of course lead to numerous health problems for the population in densely trafficked areas and influence their overall quality of life (Dablanc, 2008).

What we can say with certainty is that due to increasing population in urban areas (European Environment Agency, 2011) goods transport is also increasing, as the inhabitants need their demand for commodities accommodated. This means that we as consumers have to share the limited space available with heavy goods vehicles and other goods distribution vehicles. We also need to move around in these areas to be able to go to work, drop our children off at school, and for general leisure purposes. This creates a conflict between our wish to consume and our wish to not have goods traffic close to our homes and workplaces; we face a potential decline of our cities attractiveness and in the long run we may even face a decline in economic growth if people hesitate to go to the city centre to do their shopping.

1.2 The Attractiveness of a City

The problems mentioned previously are often seen as drawbacks of transport in general, but one has to bear in mind that they have a relatively higher impact in urbanised areas. This is connected to the fact that urban areas have limited space and most people living in these cities or towns need to be able to move around in the city. The congestion problem has a great impact on the mobility of people as well as goods. The bottom line is that in urban areas we have a conflict between the needs of people, goods transports, and city planning. In essence, one might say that the conflict really is a conflict between living, working, producing, shopping, and visiting. Yet, all of these activities are vital for the cities in order to retain their attractiveness and in the long run – their competitiveness.

However, why is attractiveness so important? A safe bet is that many of us wish to have a vibrant and prosperous environment surrounding us with a wide range of activities like workplaces, restaurants, shops, and a healthy environment. In the urban setting, this definition of attractiveness implies a potential conflict between public, private, and goods transports. It also implies a conflict between social, environmental, and economic sustainability[1]. What attractiveness means is of course different for each individual, some of us actually do enjoy discarded industrial buildings with their raw romantic attraction, whereas others prefer to live in a suburban area with neatly mowed lawns and picket fences. We are all attracted to different things. Therefore the question remains – why is attractiveness so important?

It all boils down to economic growth. Richard Florida fathered the theory of the creative class and creative capital, and argued that this, the human capital, has replaced natural resources and efficiency of physical labour as the key factors in creating wealth and economic growth (Florida, 2005). This implies that the bottom line in achieving economic growth is the creativity of humans. To Florida, attractive cities are the melting pots where new ideas can grow into fruition and this has become one of the main components in a city's competitiveness.

On the other hand, many researchers, including Chandler and Freeman & Louçã, propose that economic growth in an area largely emanates from the improvements in the transport and communications sectors. Particularly the introduction of railways, the telegraph, and the telephone, were important prerequisites for mass production and the late 1800s so-called second industrial revolution (Chandler, 1990; Freeman & Louçã, 2001). In this tradition, and translated into modern times, it is a city's geographical location and financial and economic climate that is the stimulus for companies to establish their operations in that particular city. Cities offering close proximity to well-designed transport systems, allowing operations to run smoothly, can and do act as a magnet for companies to establish operations in a given location. When there are businesses, jobs are created and in turn, jobs attract new inhabitants to that city.

What Florida advocates is that there is more to the decision to move to a certain city than just the possibility of employment. He stresses that people have two things in mind when relocating – lifestyle and economic factors. It is the optimal mix of these two that makes a region or city as attractive, and that draws the human capital that Florida defines as the creative class. (Florida, 2005)

However, is it that simple; Infrastructure vs. attractiveness? Can we just assume that in creating the proper conditions to attract the creative class and the creative capital everything will work out just fine and that the infrastructural needs of our industries will pop up out of the blue at the right time? Could it be that one of the prerequisites, or at least a contributing factor for attractiveness, is proper infrastructure?

Florida's view teaches us that economic growth is achieved through attracting knowledge and capital, whereas the more conventional view is that physical environment and infrastructure are the most important factors. However, the position of this chapter is that in order to achieve an increase in economic growth, good infrastructure, such as an environmentally sustainable transportation system, in combination with knowledge, is also needed. We need the physical environment as well as the creative capital. These factors build the foundation for economic growth, but are also dependant on economic growth, thereby creating a cumulative process depicted in Figure 1 below.

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[1] These three pillars of sustainability have been derived from the sustainability definition proposed by the Brundtland Commission in 1987.

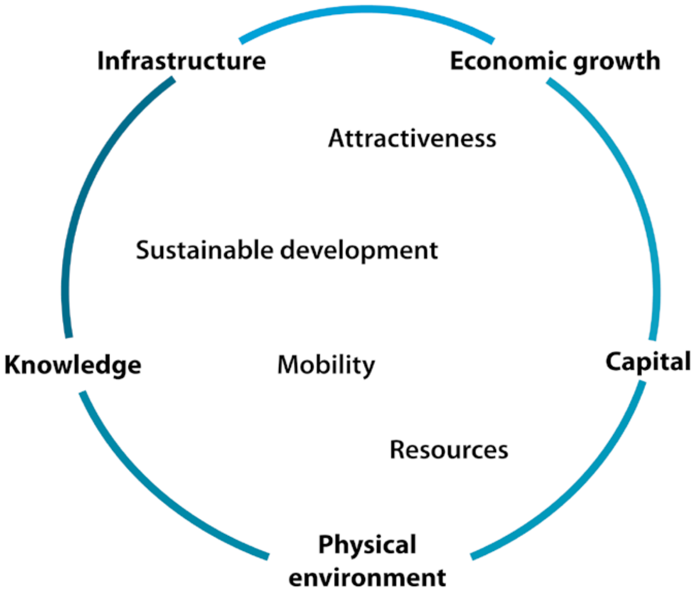

Figure 1: Factors for urban attractiveness

Eliminating one of the factors might not lead to negative growth, but it might slow down the growth rate. These factors are important to achieve an attractive and sustainable future, and the key to achieving this cyclical flow is through mobility and accessibility. Attractiveness is thus one important prerequisite to sustainable urban development and economic growth.

1.3 Resources and Mobility in Sustainable Urban Transport

It is often said that we live in a culture of mobility, and that we are dependent on cars to get where we need to go, or even to enjoy our leisure time. Breaking our dependence on motorised private vehicles, and starting to use mobility management and public transport, to a higher degree than we currently do, are key if were are to aim for an *accessible* world rather than a *mobile* world. If we have access to work and leisure time activities in close proximity to our homes, we do not need to be as mobile as we are right now and instead focus could be shifted towards developing other communication forms to allow us to work in a more virtual way. So, might increased accessibility save the world?

A common definition of accessibility is "…potential interactions between places…or importance of a place based on available sets of opportunity" (Boschmann & Kwan, 2008 p.149.). In this chapter, accessibility in a transport system will be defined as ease of reaching destinations or simply – availability of resources[2]. Resources in this sense include everything from natural resources, capital, labour, commodities, services etc., and

[2] This applies both to transports of goods as well as to transport of people. In practice, an urban area is more accessible than a rural or peripheral area regardless of the intensity of transport and infrastructure.

in the urban context for example work places, shops, hotels, cinemas, restaurants, and even residential housing. Mobility in a transport system can be defined as access to the possibility to change spatial position or creating the means that make resources available. A higher degree of mobility makes it is easier to reach a certain destination. Examples of very high mobility would thus be ports, airports, railways, and motorway junctions with unlimited means of transport, not necessarily in places with abundant resources. This would imply that accessibility is crucial for achieving attractiveness in urban areas by allowing citizens and visitors to reach desired destinations and resources. Furthermore, this means that accessibility and attractiveness both are integral parts in sustainable urban development.

In order to see what mix of mobility and resources could contribute to balanced accessibility, which in turn leads to increased attractiveness and sustainable urban development, one could depart from the conceptual node-place model based on the research of Professor Luca Bertolini of the University of Amsterdam. The node-place model was based upon a multi criteria analysis and was originally used for mapping and developing the public transport systems of Amsterdam and Utrecht. The model was comprised of numerous variables such as proximity to the transport system, the number of directions served, daily frequency, and amount of stations reached within 45 minutes. This is the node factor. The place factor in the Bertolini model is related to the intensity of activities of a place, measured as e.g. number of work places, shops, restaurants, and hotels. Bertolini weighted and indexed these factors in order to see the relationship between railway stations and travellers in the two agglomerations. The weighting and indexing also meant that the same scale could be used on both axes. The weighted and indexed factors can be seen in relation to standard values (i.e. desired normative relations between factors) for the system that is being investigated.[3] This implies that along a 45° line in the node-place model the studied weighted and indexed factors for a certain place fulfil the desired norm and pertains to the standard value. This indicates for example that if we have standard values for place at index 0.4 and for node at 0.4 as well, you have the optimal mix of node and place, and you are in fact located on the diagonal line. This in turn means that the mix of node and place for a certain city or area is optimal, in the sense of 'it's as easy to get there as you would want it to be'. If the indexed values of node and place differ, we get a situation where we have either excess capacity in the system or an indication that we need to increase the capacity of e.g. public transport (Bertolini, 1999).

To be able to use the conceptual node-place model, the authors have adapted it to fit the purpose of this study and chapter. The thought put forth in this chapter is that an optimal mix of mobility and resources is vital to increase city attractiveness, accessibility, economic growth, and sustainable urban development. If we view mobility as nodes and resources as places, the two factors that can contribute to city attractiveness and accessibility, and assign these to the x- and y-axes, theoretically, a diagonal line would indicate a balance of resources in relation to mobility, and would contribute to sustainable urban growth. That however only holds true if both resources and mobility are weighted in accordance with what Bertolini did in his original model.

[3] The standard values in per cent (%) of one facility in relation to another facility or factor indicate the optimal provision of the studied facility. Such a value is related to the probability function of utilisation. For bicycle parking in proximity to public transport stations, this standard value is for instance 10%, indicating that for every 100 commuters, the need for bicycle parking spots are 10.

The adapted node-place model in Figure 2 shows us different ideal situations; the further along the diagonal line one reaches, the intensity and diversity of transport in urban areas is increased. Above and to the left of the diagonal line, we have a situation where mobility and infrastructure outweighs the need of transport in relation to resources – we have an excess of transport supply which, inevitably, leads to low load factors and non-effective transports. Below and to the right of the middle diagonal line, the situation is the opposite – the number of resources outweighs mobility and infrastructure. In this case we have a transport deficiency, implying that demand for transport is greater than the supply. At the same time, as this is a place with a high level of resources like leisure time activities, work places, and residential housing, the deficiency will affect attractiveness negatively.

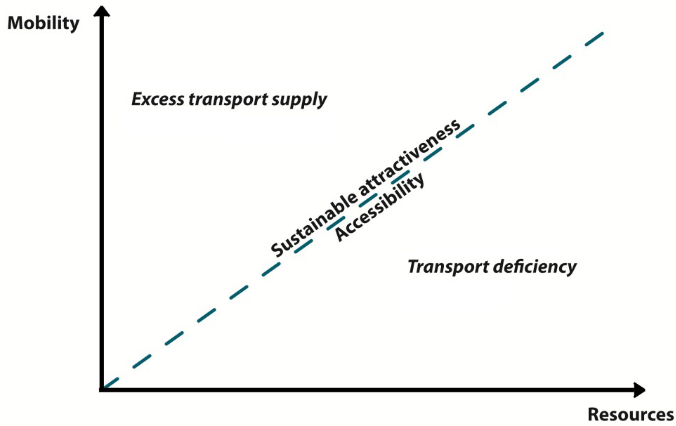

Figure 2: Sustainable attractiveness and accessibility as a function of mobility and resources

What we aim for is to find an optimal mix of resources and mobility that would position us along the diagonal line in the node-place model. Along this line transport supply is in long run equilibrium with transport demand, leading to attractiveness, accessibility, and sustainable urban development. In order for shops and businesses in the attractive urban areas to receive goods, new measures and correct infrastructure is needed for urban goods transports. How could this work in practice? One way of obtaining the optimal mix of mobility and resources in the urban environment, in order to achieve attractiveness and sustainable urban economic growth, could be found in new concepts for city goods logistics such as UCCs. In order to adapt a UCC to the needs, a first measure should be to identify those indicators[4] for resources and mobility that are needed to be used in the Bertolini analogy in order to create the optimal mix. The Bertolini model would then be a useful tool for authorities as well as stakeholders, and would help to create legitimacy in decision-making.

[4] A few examples of useful resource indicators could be; number and structure of shops, amount of goods delivered, number of residents, inhabitants in the area, visitors and tourists, hotels, restaurants and theatres. On the mobility resource side we find flow of public and private transport, number and structure of transport companies and forwarders, fill rates, traffic and transport regulations, fuel in use, and infrastructure etc.

2 The Complexity of the Urban Transport System

If we focus on what goes on in the urban areas, we find that there is more to transport than just roads and vehicles. There are two main sectors competing to use the infrastructure: (i) public and private transport and (ii) goods transport.

Traditionally, researchers and infrastructural planners alike have focused on *either* the public and private transport sector *or* the goods transport sector as depicted in Figure 3 below. However,, if we deal with the mobility of goods and/or the mobility of people, the space and city infrastructure available to those two purposes is one and the same. We cannot build separate roads to accommodate goods transports alongside the roads used by commuters who are trying to get to work; therefore, we need to find a way to consider both sides and their needs.

If we take a closer look into what defines the transport needs for the two different sectors, we see that the public and private transports mainly consist of work travel, shopping travel, and leisure travel. Further, this sector is dependent on having good infrastructural planning that caters to an average-sized personal car, that provides proper public transport, or that allows the individuals to go by bike or foot to wherever they need to be. Regardless of the purpose of mobility, we need infrastructure that enables these types of movements in our urban areas.

The goods transport side on the other hand is dependent on having infrastructure that allows raw materials and components to be delivered not only to the point of production but also to be deliver as finished goods from the point of production to the point of consumption, e.g. a wholesaler. In addition, we often seek to manage the end-of-life of used materials with rules and regulations that stipulate that discarded goods have to be taken care of by the wholesalers,[5] thereby giving us a return flow from the consumer side back to the point of production that also needs to use the same infrastructure. With the increased environmental awareness amongst people, return flows of paper, glass, aluminium, and other material gives us a recycling flow that also affects the overall urban transport system. In Logistics, large roads with as few stops as possible, in order to ensure that the heavy traffic has as smooth a journey as possible, is desireable.

[5] This is the case when it comes to discarded goods that are harmful to the environment such as oils, chemicals, refrigerators and similar products.

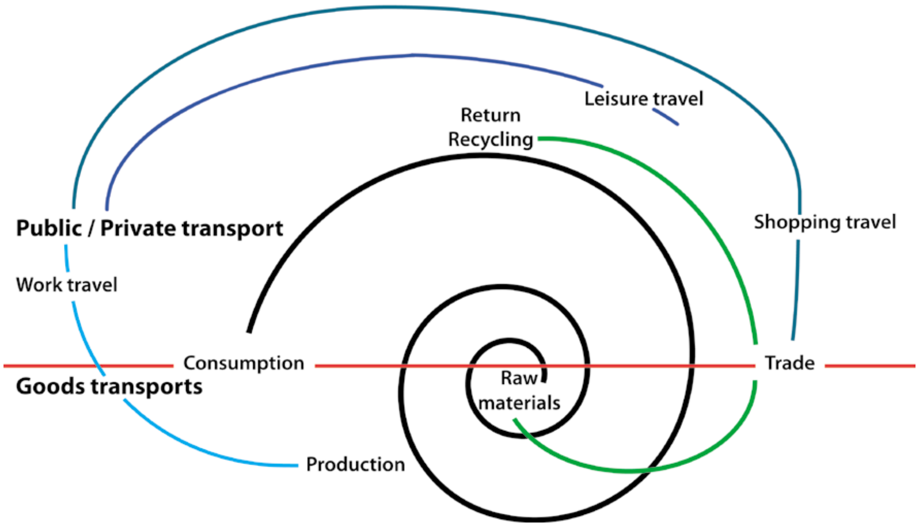

Figure 3: The complexity of the urban transport system: The two sectors of the transport system; public/private and goods transport are dependent on each other and interact most intensely at the point of trade and consumption

As we can see from the two previous passages, the transport system is complex and both sides need to use the current infrastructure. The picture gets even more complex when we consider that the two sides actually are closely interlinked with each other. Work travel on both the public and private side is connected to the production sites, as the workers need to be in place for a company to produce, sell and deliver goods. Shopping travel, to the point of consumption, is conducted in order to purchase the goods that are being produced and some of the products might be used during our leisure travels. Yet, somehow, we seem to not consider both sides in our research or planning endeavours; there is a barrier between the two disciplines and it is a barrier that needs to be viewed as more of an interface.

2.1 Trade as Interface

Based on the complexity of the urban transport system described and depicted above, trade, or rather the point of consumption, can be seen as the interface between goods transports and public and private transports. This is where the interaction between industry and everyday life occurs and is where we find the greatest conflicts of interest between shoppers and delivery vehicles.

Today, a small shop in a city centre can receive numerous deliveries per day from different suppliers. However, the quantity of goods received in every delivery may not be very large for each delivery. It is for instance not that uncommon for a small shop to have upwards of ten smaller deliveries per day. The reason is of course that different suppliers use different delivery companies in order to deliver to their customers. However, at the same time that same little shop might not have that many customers per day, implying that there might be an excess of delivery transport to the shop in comparison to the shopping travel undertaken by consumers. This is a good example of the ‘excess transport supply’ area in the previously presented Bertolini-model analogy.

From an attractiveness perspective, the situation where numerous delivery vehicles deliver to the same shop over the course of a day might lead to that shop feeling crowded and simply being rendered unattractive. Consider the following; what is more appealing, a shop that has delivery vehicles parked outside during a large portion of the day or a shop where you can actually see what is on display in the window? A majority of us would probably prefer the latter situation, where we can see what is being sold. The conundrum is of course that in order for a shop to sell goods, deliveries are crucial but at the same time, the shop needs to attract customers.

Another dimension to the interface is that consumers need to reach the shopping areas. In Sweden and Denmark, we find two different approaches to how this is done. For instance in the central parts of Copenhagen there are a lot of smaller shops but also large gallerias and not many external shopping malls in the greater Copenhagen area. Most of the city is accessible by public transport. In Sweden, to some extent, the situation is different. Of course, there are shops in the central parts of Swedish cities as well, but establishing external shopping malls on the outskirts of cities is something that dates back to 1980's and has become the norm in Sweden (Vägverket, 2003). This leads to smaller, centrally located city shops struggling to compete with the larger malls on the periphery. In fact, many of the same shops that are found in the core of Swedish cities can also be found at the external shopping malls. The shopping malls, to a high degree, cater almost exclusively to those who have access to personal motorised transport, whereas city centres are connected to the public transport system.

Regardless of what shop system is established people need to get to the shops, which means that we have conflicting interests between delivery vehicles, public transport, and private transport. In this situation, all vehicles are trying to utilise the same spatial resources. One way of reducing the conflict, which has been tried and shown to work, is to reduce the amount of private vehicles that enters city centres through different toll systems. Another way is to make it more difficult for private vehicles once they have reached the city centres by blocking streets or making them one way only. In addition to the previous examples, goods delivery vehicles in many cities can only enter the central parts during certain hours to deliver their goods. In order to reduce negative external effects like pollution and congestion of goods distribution and transport in cities, the most commonly used tools have historically been different legislative measures dealing with traffic like delivery-time windows or prohibited entry in central areas for certain types of vehicles as mentioned previously. More recently, however, the use of societal marginal cost pricing of the negative external effects have come in practice. This involves using the price mechanism to achieve reductions in e.g. emissions, by raising prices on fuel, on distance driven, or on entering the city via congestion charges and road tolls. Usually a combination of the two policies, legislation and societal marginal cost pricing, are used when addressing the issue.

These interventions usually do have the desired effects, at least in the short run. However, the long run effects on economic growth are not always measurable. Interventions such as these are sometimes inflexible and fail to effectively allow for differing needs in different areas of the city both spatially and temporally. This inflexibility can sometimes counteract the original intention of the regulation. Another way of approaching the issue may offer a solution. If we can adapt the number of goods transport vehicles (mobility) in the urban environment to the needs (resources) by means of new approaches to urban transport planning, the transport intensity could be optimised thereby resulting in increased attractiveness of the city in accordance with the Bertolini-analogy.

3 City Transport and Logistics

In the urban environment, we are inevitably dealing with emissions and limited space. Emissions can be reduced through modernising vehicle fleets and by making a transition to new technologies and renewable energy sources, whereas space utilisation might require other measures that ultimately reduce the number of vehicles in our urbanised areas. Reducing the number of vehicles will of course also contribute to decreasing emission levels.

Freight deliveries account for a significant portion of emissions in cities, which means that the potential for environmental gains through alternative ways of distribution is large. One way to go about solving the environmental problems connected to goods deliveries in cities might be through a higher degree of goods consolidation that could reduce the number of delivery vehicles in the cities. Another positive aspect of this would be if consolidation could be a means of phasing out the older vehicles, as these have the greatest negative impact on the environment (Dablanc, 2007; Dablanc 2008).

3.1 Urban Consolidation Centre

An urban consolidation centre is a terminal where goods arrive from different suppliers, are sorted and consolidated, in order to ensure that right quantities are delivered to the right customers (i.e. shops) in a specific urban area. Deliveries from UCCs are often consolidated in such a manner that a number of nearby customers receive their goods from the same delivery vehicle, thereby reducing the delivery mileage within an urban area. What distinguishes a UCC from an ordinary private transporter run terminal, is the scale of operations, scope of delivery area, and often the form of financing.[6]

In Freiburg, the establishment of a UCC led to 33 per cent fewer trips by heavy goods vehicles, and a 48 per cent reduction in the time that these vehicles were in the city. Fill ratio also increased from 45 per cent to 70 per cent. The same pattern can be witnessed in Kassel, Germany, where the number of kilometres driven in the inner city decreased by 60 per cent through using the UCC. The use of cargo space in Kassel increased by 100 per cent and a reduction of total traffic also occurred (Browne, 2005).

In theory, the advantages of a UCC are mainly attributable to the environmental benefits associated with increased efficiency in goods transport, better warehousing facilities and inventory control, but also include the value added services for the end-users i.e. the shops. Potential disadvantages associated with UCCs, however, can include high fixed and operating costs, reduced efficiency by increasing the number of reloads of goods, and increasing the length of the supply chain. One further consideration is the potential conflict between non-UCC solutions already operating between large retailers and

[6] For a thorough discussion of the urban consolidation centre concept, see chapter 6 by Abbasi and Johnsson in this book. For inventory control and warehousing in sustainable distribution, see chapter 11 by Axsäter, Howard, Marklund and Stenius.

forwarding companies that might be damaged if new regulations were introduced (Allen and Browne, 2010.

In the view of this chapter, there are in principle two approaches or models when it comes to implementing urban consolidation centres that, to some extent, have proven to be successful. Of course, there are variations on the models, but the bottom-line when implementing a UCC is normally one of these two. In the following section, the two models are described as two extremes; a large-scale approach and a small-scale approach to implementing an urban consolidation centre.

3.2 Large-Scale Approach

Traditionally when starting an urban consolidation centre, the initiative has often come from municipal authorities or from a freight forwarding company. The reasons for starting and supporting urban consolidation centres often differ between municipalities and companies. Municipalities often seek to reduce the number of transports through an area by increasing delivery vehicle load factors, whereas, large delivery companies try to gain market shares by providing consolidated deliveries from numerous suppliers. From a municipality point of view, the reasons for supporting and starting urban consolidation centres are often environmental, as consolidated goods transports are believed to reduce emissions, and increase accessibility of a particular area. Delivery companies too are seeking to reduce their carbon footprint, but this might be more out of marketing reasons.

We refer to this implementation model as large-scale approach or top-down implementation. Often the large-scale approach to urban consolidation centres is built on sound logistical values, creating efficiency in the operations through good use of warehousing, packaging, and delivery service elements[7]. Capital tie-up and logistics costs are minimised and route planning is used in order ensure the best possible delivery system. Unfortunately, it often focuses on transporters, not really taking the end-users or the market into account.

Many of the schemes have been founded through European Union grants and once the initial pilot phase has ended, a majority of the projects have been disbanded as it has been difficult to reach financial sustainability (Browne, 2005). Commitment has often been at a low level, and responsibility is somewhat shunned due to unclear structures; is the company or the municipality responsible? Concerns have been raised that these top-down implementation models run the risk of becoming biased by favouring certain companies, and thusly would not adhere to the rules of competition.

As mentioned earlier, there is always a certain level of environmental awareness when it comes to city logistics schemes, especially in the cases of municipality initiated consolidation centres. Some reductions in carbon dioxide levels have been reached in most cases, but it is difficult to know whether the reductions are due to the urban consolidation centre or other CO_2 reducing measures implemented by municipalities at the same time.

[7] These delivery service elements are focus points for logistics service providers and suppliers in order to bring goods to the user in the best possible way. The service elements vary from company to company, but the following gives us a hint of what can be considered as important; *delivery lead time, delivery reliability, delivery accuracy, information, flexibility and customer adaptation* and lastly *stock availability*. (Oskarsson, Aronsson, & Ekdahl, 2006)

3.3 Small-Scale Approach

The other extreme when it comes to implementing urban consolidation centres is the small-scale approach. Often a small business owner [8], or rather a conglomerate of small business owners, identifies a need for deliveries to be consolidated to their particular area. The identified need does not necessarily relate directly to environmental issues such as emissions, but rather to relieving the workload of the business owner or to raise the attractiveness of the area. The reduction in emissions that might accompany the consolidation of goods is more of a positive side effect and not the primary goal. This model is referred to as bottom-up implementation as the initiative is taken by the end-users.

This model is not as common as the top-down implementation of urban consolidation schemes, so this process does not figure prominently in current research. One of the more successful examples of UCCs that has grown from a bottom-up initiative is Binnenstadservice[9] in the Netherlands, which has grown from one person's active commitment to a multi-location operation in several cities. The objective of Binnenstadservice is to meet the needs of suppliers, transporters, retailers, and consumers, in a socially, economically, and environmentally sustainable way (Binnenstadservice, 2010).

One of the main objectives of the small-scale approach is to relieve small business owners' workload and increase their sales. By consolidating goods to a single shop from numerous suppliers or from a supplier to numerous shops, or from numerous suppliers to numerous shops, the number of deliveries could be reduced. This would, according to what has been expressed previously in this chapter, raise the attractiveness of that particular shopping area, as this reduction of deliveries would mean that the number of delivery vehicles would decrease as well. This in turn will render the individual shops more attractive to visit, as the shop is not "blocked" by a delivery vehicle and the personnel have more time to attend to prospective customers, thus increasing their sales. In addition, some value-adding services can be provided to the end-users by small-scale UCCs. These services can be anything from price tagging, removal of packaging materials, postal services to additional warehouse space, or having goods delivered all the way on to the shop floor. In addition, safety and security aspects could be jointly handled by several shops, e.g. splitting costs of expensive electronic solutions like RFID with track & trace features and monitoring. Not least, shops that join the UCC programme would get a reputation of being environmentally friendly. These additional services are of

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[8] The small businesses mentioned are often shops run by one or a few people, or restaurants located in crowded areas with a high concentration of businesses and passers-by.

[9] Binnenstadservice was founded in April 2008 through the initiative of Drs Birgit Hendriks, a shop-owner on a busy street in Nijmegen (NL), a city with approximately 200 000 inhabitants. She was fed up with the amount of delivery vehicles frequenting the area, delivering small consignments to different shops at different times, and as a shop-owner thought that there must be a better way. Together with eleven other shop-owners, she formed Binnenstadservice, a consolidation scheme that could lessen the burden of traffic around their shops, running environmentally friendly delivery vehicles and offering value-adding services. One year after it was founded, 98 shops in Nijmegen had joined the scheme and two years after the first Binnenstadservice, the concept had spread to six more cities in the Netherlands and the concept was about to be launched in Belgium. The financing of the Binnenstadservice-scheme was threefold; the municipality of Nijmegen supported the scheme, the EU supported the scheme and delivery companies paid for the mileage that they did not have to drive. For the shops, it was free of charge to join, but any additional services that they wanted to use they had to pay for. (Hendriks, 2010)

great importance in raising the end-users experience, as they can prove to increase economic gains as well as save time for the shop's personnel (van Rooijen & Quak, 2009).

As is the case with the large-scale approach, there have also been signs of positive environmental impacts from the small-scale approach to urban consolidation centres, however, the same problem is apparent here; are the reductions measured due to the UCC or some other measures implemented by the municipality? These UCC operations are often small and therefore the impact from them might not be as large as anticipated. However, a reduction in driven freight kilometres and number of stops made by delivery vehicles has been proven in some of these small-scale cases, for instance the aforementioned Binnenstadservice[10]. As one of the aims of the small-scale approach is to increase the attractiveness of a shopping area, this is a desirable outcome, but what happens if one of the businesses grows too large and demands more deliveries? The worst-case scenario is that the entire UCC scheme ends due to a lost member of the consolidation family, depending of course on the size of that member from the beginning. If this happens, deliveries will go back to how they used to be and the attractiveness will decline once again.

3.4 Proactive or Reactive Approaches to Planning?

In essence, one can say that the large-scale implementation of urban consolidation centres is a proactive approach to dealing with environmental issues, as it is often the case that a municipality wants to limit the impacts of transportation in a certain area before the problem becomes too large. The main concerns in the proactive approach are planning, economic growth, and mobility where planning implies the possibilities that exist to reducing negative impacts on society. Economic growth of course takes into consideration that a municipality cannot run and support a failing business model, especially if it turns out not to be that influential in the reduction of environmental issues. The mobility in this case must take the infrastructural environment and its limitations into consideration, as this is something that influences operations on a daily basis.

If the large-scale implementation of urban consolidation centres is a proactive approach, then the small-scale implementation can be said to be a reactive approach driven by end-users in dealing with urban sustainability issues. The need for a UCC is identified by end-users as a solution to a perceived problem; it is a reaction in order to increase their own productivity and efficiency. The key words in the reactive approach are market, city attractiveness, and accessibility. The market sets the rules for what can be done through a simple demand driven function; in this case, there is a demand for a smarter distribution system with increased utilisation of freight delivery vehicles. The result of the reactive approach might well be increased city attractiveness that could lead to an increase in trade. Accessibility in this context is ease of reaching ones shopping destination or activity of interest, taking into account the limitations of urban infrastructure and utilisation.

[10] After the first year of operations, the number of driven freight kilometres in the city centre was reduced by 5 per cent and the number of stops made by distribution vehicles was reduced by 7 per cent. The project had also shown a decrease in CO_2 emissions, whereas a possible reduction in noise and NO_2 levels could not be proven due to the rather small extent of the Binnenstadservice in comparison to the overall traffic situation in Nijmegen. (van Rooijen & Quak, 2009)

Neither of these 'extremes' exist or could be considered realistic. Of course, a mix of good planning and adaptability – visionary realism – is an ideal approach.[11]

4 Making Urban Distribution Sustainable

The concept of sustainability includes social, economic, and environmental sustainability. Today some even speak of cultural sustainability as an upcoming forth pillar in the sustainability temple. Especially in cities, considering all goals of sustainability at the same time can lead to conflicts of interest. Visible effects of these conflicts are the positive and negative external effects traceable to the urban transport system, where public, private, and goods transports have to co-exist on limited space. Are there ways to overcome these conflicts? In this section, the authors will present a tentative solution for making urban distribution sustainable.

4.1 Social Entrepreneurship

Social entrepreneurship can be described as the making of socially responsible companies that work together across sectors in order to reduce social problems. Further, social entrepreneurship helps create solutions to social problems through mobilising ideas, resources, and arenas necessary for sustainable social transformation.[12] By making use of the driving forces within economic entrepreneurship, social entrepreneurship strives towards meeting social objectives by combining social values with innovation[13] and risk taking. Social entrepreneurship is thus different from traditional entrepreneurship in that it focuses on ethics, morality, and responsibility, and not primarily on creating economic value. (Mair & Marti, 2004) The goal of social entrepreneurs is to combine business and profit with social benefits, thus creating both social and economic value (Peredo, 2006).

There are several somewhat differing definitions of social entrepreneurship, social enterprise, and social economy. A common denominator though, would be the voluntary, non-profit orientation to solve a social or societal issue that the mainstream market economy or the public sector has failed to fully solve; like poverty and social exclusion by e.g. employing from groups that have normally had problems in finding jobs. Examples of these kinds of organisations are the Scandinavian cooperatives, often emanating from the labour movement.

According to the EMES European Research Network[14], the social enterprise is characterised by a continuous production of goods or services, is exposed to economic risk, and has a smaller portion of employees on payroll. Furthermore, a social enterprise has an aim to benefit society, is started by a group of citizens, and has a decision-making (board) process not connected to financing (e.g. equity). Finally, the governance should

[11] Differences within the Øresund Region regarding these planning approaches are discussed in (Carlsson 2006).

[12] The modern concept of social entrepreneurship could be traced back to the early 1800s when the British industrialist and social reformer Robert Owen started a cooperative movement. One of the most well known social entrepreneurs in the 1800s would probably be Florence Nightingale who among other things founded a nursing school in London. (Seelos & Mair, 2005).

[13] For a general discussion of innovation in logistics, see Gammelgaard and Prockl, chapter 10 of this book.

[14] EMES is a "European corpus of theoretical and empirical knowledge, pluralistic in disciplines and methodology, around 'Third Sector' issues." See: http://www.emes.net/index.php?id=7

have a high degree of autonomy and participation, i.e. including the stakeholders and a limited distribution of profit. (Hulgård, 2008)

In this chapter, the authors agree with the EMES definition of social enterprise. A tangible example from transport is the aforementioned Binnenstadservice in the Netherlands, an enterprise that actually labels itself a social company.

4.2 Public-Private Partnership

Partly due to lack of public finance, the boundaries between the public and private sectors have increasingly relaxed during the last decades, opening up new arenas and opportunities for collaboration and partnerships between the two sectors of society (e.g. municipalities, private companies and non-profit organisations). This type of cooperation is usually called Public-Private Partnerships or PPP, and also allows for non-profit organisations to participate in projects. Non-profit organisations often have wide networks and are knowledgeable in how to bring private and public parties together. It is often persons in the non-profit organisations that become the social entrepreneurs, by facilitating the public and private sectors to work together for society to benefit.

Freight transport in an urban environment involves a wide range of public and private actors with sometimes competing interests. To create and facilitate efficient transport of goods, all the way from suppliers to end consumers, it is essential that there is cooperation between the stakeholders through the value chain; carriers, trade associations, retailers, municipalities, property owners, residents, and end-users. PPPs within urban transport, consolidation and distribution can help implement policies that contribute to create conditions for sustainable transport and ensure long term profitability of a project. Experience has shown that many previous urban goods consolidation projects entirely run by municipalities or other public bodies, have had very limited success and economic viability (OECD, 2003). One way to promote economic sustainability in urban freight transport projects would thus be to highlight the mutual interests of stakeholders; public, private, and non-profit, in promoting city attractiveness, environmental awareness, congestion and CO_2 reduction, to ensure the proper project design within a PPP, thereby making it legitimate and in different ways beneficial to all involved parties.[15]

In the Netherlands, a special form of this policy has been adopted in urban goods transport since the late 1990s, involving co-financing and altered regulations from the authorities by the signing of covenants that guide the behaviours of the stakeholders; i.e. the public and the private.[16] These kinds of policies exist also in Britain. There they are called freight quality partnerships or FQPs, and consist of partnerships involving stakeholders from the private and public sectors set up to identify best practices in urban transports that relates to the needs of the different groups. (Allen and Browne, 2010)

[15] In chapter 8 of this book, Hvass and Teilmann present an identification of shop characteristics in central Copenhagen, important for UCC interest.
[16] For a Swedish discussion on this matter in infrastructure planning, see Cars (2010).

4.3 Urban Consolidation Centres as a Social Innovation

It has previously been pointed out that neither urban goods consolidation nor social entrepreneurship is a particularly new phenomenon. During history, goods consolidation has probably been more prevalent than it’s opposite in the urban development, albeit to different extents, with different financing and of course, with different success.

In general, it was not until the 1900s that direct deliveries from producers to shops and retailers became increasingly common. The reason for this is the growing importance of major retail chains and external shopping malls, as well as increasing delivery volumes. From the shops point of view, as well as from the producer’s perspective, it has been logistically efficient to let a centrally procured freight carrier distribute goods from the producer to several stores within the same chain in a loop. A good example would be dairy products. In this case, the consolidation concerns the goods and producer; not the shops’ location and due to the large volumes to be delivered this system has proven logistically efficient. It also implies generally high load factors in such transports. Thus, deliveries of small volumes to smaller shops in the same urban area, and from several producers, would be those deliveries that logistically gain the most from an urban consolidation centre. This type of consolidation, though, is rather similar to traditional freight forwarder activities, where suppliers have contracts with the forwarder. The difference would be that also the receivers or shops would sign a contract with the forwarder. This would create larger volumes, making it possible to get profitability for the transporter in such a UCC operation. In the traditional case, without a UCC, there would probably not be any freight forwarder who would sign for carrying several small volume deliveries to several different stores.

So, from the carrier's point of view, load factors could be significantly increased for several types of goods deliveries to several different stores with a UCC in place. This could also reduce the number of deliveries for the store and thus it would primarily be independent and privately owned stores with many suppliers, who would be the beneficiaries of an urban consolidation centre from a user perspective.

However, this means that there needs to be a fairly mixed group of shops that must agree on consolidating their goods deliveries; not necessarily an easy challenge for e.g. competitors on the same street. External pressure and "top-down initiative" would hardly create enthusiasm for goods consolidation in such a situation and perhaps this is where large-scale and community-initiated UCC initiatives have come to fail; either the right users have not been properly engaged or the wrong users have joined the project. In this context, social entrepreneurship could make a difference for city retailers with smaller volumes in the inner urban areas.

Social entrepreneurship in this case would mean that someone, e.g. a shop keeper, encourages and convinces other shop keepers, or even commercial chains in the area, to jointly launch a goods consolidation centre based on individual needs and where all participants would benefit from the business, as well as the urban and natural environment. This in turn, would affect the city's attractiveness and eventually the profitability of all shops in the area. This type of social entrepreneurship however, does not necessarily arise by itself; municipality engagement is important not only to visualise, but also to enable and permit alternative solutions to the many problems related to urban goods distribution.[17] Traffic and transport is surrounded by many rules, not least in the urban environment. Therefore, the municipality's role should largely be to allow, ease and to a much smaller extent, initiate, own or actively run a consolidation centre. The municipality also should not influence the scale of operations, which has been the case in many of the now closed down UCC projects. The aforementioned Binnenstadservice in Holland is a good example of this type of social entrepreneurship. In this case, one could talk about a kind of PPP between municipality and a social company.

An urban consolidation centre that is based only on social entrepreneurship would probably not have anymore of a chance to survive in the long term, than one operated totally by the municipality. Efficient logistics is required to create sustainability also in small-scale solutions and here, the volume of goods is a key issue; it takes a certain number of participating stores with a minimum volume of goods to logistically and economically justify a consolidation programme. As previously mentioned, for a single shop with very large volumes the most reasonable solution, logistically speaking, would be direct deliveries. This means that the logistical challenge is to find the volume and the number of participating stores that are optimal for a successful UCC implementation, and to continuously monitor the volume development. If a participating store would, for example, greatly expand with increased delivery volumes as a result, it could mean that the store would be more lucrative and logistically effective with direct deliveries from a producer or wholesaler. Likewise, if a store were removed from the cooperation, the volumes would become too small to maintain the UCC business efficiency. This implies that a UCC, in order to be economically sustainable, has to be very dynamic and continuously flexible. This in turn can be facilitated by the above described social entrepreneurship; to put focus on the common utility and prosperity that goes beyond one's own business' short-term profitability, may be the key to more free entries and exits to and from the cooperation in order to balance the delivery volumes. Doing so would increase city attractiveness, and would thereby benefit all activities in the area.

It is of utmost importance to identify needs, preferences and volumes in the group of shops that would be most suited to join a UCC-cooperation. A problem is of course, who should be in command of the identification process? This question implies an important balancing act for the municipality; balancing such considerations as large scale vs. small scale solutions, legislative interventions vs. letting social entrepreneurs act freely, top-down vs. bottom-up implementation, focusing on costs of negative external effects vs. valuation of benefits of e.g. increased attractiveness and reduced environmental impact. All this is related to finding the perfect mix of proactivity and reactivity; the visionary realism.

Initially, the municipality's role should be to identify the needs and volume-related preconditions for establishing an UCC and if they are present, then actively facilitate the social entrepreneurship through a "bottom-up drive," allowing for a private or public-private initiative to implement goods consolidation. Once again a good example is the Binnenstadservice in the Netherlands and the British FQP.

Combining social entrepreneurship, public facilitation, and not excluding initial project financing and logistical efficiency related to delivery volumes, would most probably be a strategy for the successful balancing of large-scale top-down implementation and small-

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[17] This is referred to as *metagovernance* by Khan in chapter 1 of this book.

scale bottom-up momentum – together creating a social innovation that could be referred to as the “Sustainable urban distribution in the Øresund region”.

4.4 Sustainable Urban Distribution

In neoclassical economic theory, market failures refer to sub-optimal resource allocation due to lack of some, or several, of the prerequisites for perfect competition that, theoretically, is needed for the price mechanism to work. The presences of externalities, i.e. unpriced external effects of an action, are examples of such failures. The external effects can be both positive and negative. In transport, the positive (unpriced) effects would be e.g. that transport allows people to meet and exchange ideas and culture, allows people and goods to reach new markets, allows for labour division, specialisation and trade, and thereby contributes implicitly to both social and economic growth; in short, let us call this attractiveness of an urban area. Negative effects are the all too well known problems of congestion, pollution, CO_2 emissions and climate change, and transport accidents etc.. It is not surprising that the negative effects garner more attention by policy makers in the debate. The reason for this is probably to be found in the fact that they are more visible, threaten urban attractiveness, and thus are more urgent to handle. They may also be easier to put a price to (internalise) by introducing e.g. road-tolls (marginal cost pricing), congestion charges as in the cases of London and Stockholm, or the introduction of CO_2 tradable permits for transport. Perhaps these measures just have more of a political momentum. At the same time it could be argued that positive external effects already are priced by the market – or will be. If an urban area has a lot of attractive features, someone will make business out of it. However, and argued in this chapter, within parts of urban distribution this is not the case. Due to the complexity of the urban transport system and the vast amount of stakeholders involved, the perception of positive and negative external effects are not the same for the different sub-systems or stakeholders, and might cancel each other out. However, where sticks have failed in the past, perhaps carrots might succeed.

To mitigate between these conflicting interests, a mix of large-scale and small-scale approaches when planning, implementing, and operating UCCs, of top-down and bottom-up, proactive and reactive, and of economic as well as social entrepreneurship, would be the solution. The latter manifesting itself in social enterprise – the institution guaranteeing the visualisation of the previously unpriced positive external effects and benefits of a socially, economically and environmentally sustainable UCC.

One effect of this is that the right mix of mobility and resources would take the urban transport system closer to an attractive and sustainable city with an optimisation of transport capacity to transport needs and adapted to the size of the city; not small scale, not large scale, but right scale.

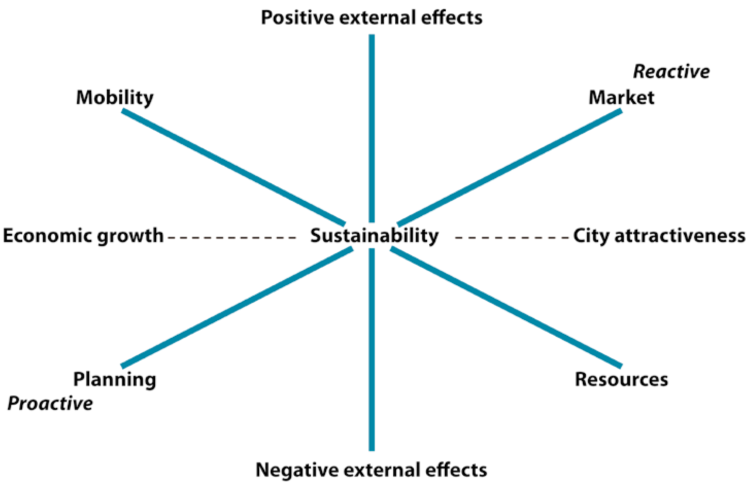

Figure 4: Mixing for sustainable urban transport

5 Conclusion and Recommendations for the Øresund Region

The Øresund region has not escaped the development that has long plagued Europe's major cities. Increased congestion, noise, emissions and climate impacts, that to a large extent can be attributed to transport of goods and people, have become increasingly evident. This means that in the long run, a city's attractiveness may be affected in a negative way. Trade, tourism, and residents' well-being, health, and sense of security may be damaged. One measure to reduce this impact would be consolidation of goods in the urban environment.

The basic idea of urban goods consolidation is that several deliveries to shops in the central areas of a city is consolidated and re-loaded into smaller, environmentally friendly vehicles and delivered in logistically efficient loops. The expected result would be fewer deliveries, shorter transportation distances, and higher fill rates in the vehicles, which in turn would lead to reduced environmental impact like emissions, CO_2, noise, and improved traffic safety due to fewer heavy vehicles in the city. It could also mean increased city attractiveness that would benefit the entire community and potentially business profitability.

Historically, municipalities or public authorities have administered the set-up of UCCs and they have often been short-lived. One of the reasons that previous attempts have had less success is that they focused on the supply side of goods transport and large-scale solutions instead of making thorough analyses of end-user needs, volumes of goods, and of adjusting legislation, in order to allow for social entrepreneurship and bottom-up commitment. To avoid future mistakes, it is necessary to involve the shops and other users of an urban goods consolidation program. Without the commitment of those who will be the most influential group of beneficiaries, the shop owners, and the general public i.e. the consumers, a municipality-run UCC is sooner or later bound to fail. This means that the users should be given the opportunity not only to influence the development of sustainable solutions for city distribution of goods, but also to actually have a leading role in the planning and implementation of such a programme. Of course, data on the needs of all stakeholders and resource indicators must be gathered in order to identify the optimal mix in accordance with the Bertolini analogy. A number of tentative recommendations for achieving sustainable urban distribution in the Øresund region are:

1) Thinking in terms of new business opportunities – of new products and services – in urban distribution. Such new services, like e.g. un-wrapping and postal services, would preferably be run by private or public-private bodies. New services, in combination with increased city attractiveness due to reduced congestion and pollution, would contribute to increasing trade, and increasing profitability of the shops. By being part of a UCC programme, the single shop can thus make staff available to handle an increased number of customers visiting the store, and in turn is one of the results of the programme.

2) Another way to approach the issue of involvement and participation is to depart from the concept of social entrepreneurship. Social enterprise is a new form of association within urban transport and logistics that should be encouraged and facilitated and initially partly co-financed by the authorities. Here public private partnerships (PPP) between a city and a social enterprise could be fruitful. An important issue is also to allow new forms of association in transport. The prime example of a successful social enterprise within transport is Binnenstadservice in the Netherlands.

3) Active involvement of all stakeholders, policymakers and authorities, suppliers and shops, transporters, consumers and citizens, in the planning process is crucial. One system, presented in Allen and Browne (2010) that has gained momentum is the FQP in England. One essential tool for creating such involvement, but also to highlight the needs, is the Bertolini analogy presented in Figure 2. If all stakeholders could agree on the indicators to be used in order to find the optimal mix between mobility and resources, this would facilitate the process of establishing a sustainable urban distribution system.[18]

4) Urban transport and traffic is subjected to vast amounts of regulation. An open attitude towards new solutions in urban traffic and transport planning requires thinking outside of the box. The municipality must not be reluctant to changing old patterns, and perhaps even in some cases reinterpret local traffic regulations. Instead of handling negative external effects of urban distribution with regulation or prohibition, the municipality should focus on allowing and enabling. Examples of this could be allowing environmentally friendly delivery vehicles to drive in the bus lane during rush hours, or to give permission to deliveries of goods in the evening for better utilising the existing infrastructure, or even mutualising public transport with goods transport capacity. This would mean that public transport is opened up also for goods transport. The authorities must reconsider rules and regulations for transport planning, financing, transport accessibility like environmental zones, loading areas, and time windows in order to allow and enable new smaller-scale logistical solutions. The Dutch covenants between authorities and other sectors, described by Allen and Browne (2010), may serve as role model. In this process it is important to find an operational mix between proactive and reactive planning strategies: Visionary realism.

[18] One way of achieving this would be to arrange decision conferences as presented Vestergaard Jensen, Ambrasaite, Bang Salling, Bruhn Barfood and Leleur in chapter 9 of this book.

5.1 Summing Up

In urban areas, the negative effects of transport of goods and people are particularly visible, complex and threatening. In this chapter, we have studied different new approaches to making urban distribution sustainable in order to develop the attractive city. A common denominator for these approaches is involvement, participation, and thinking in terms of new business opportunities. All stakeholders, users and beneficiaries, and also those who are negatively affected by urban transport, should participate in the development of new urban transport systems. The public, private, and goods transport systems should be developed with a holistic and resource efficient mind-set in order to provide sustainable city attractiveness. This involves the recognition of co-existence of transport means for goods and people in order to ensure sustainable growth. The interface in this process is the trade, or the place of consumption. By promoting the emergence of social entrepreneurship and social enterprise, new societal benefits can be detected and capitalised. This however calls for the authorities in municipalities and regions to embrace a less prescriptive approach to urban transport, UCCs, and new forms of associations and partnerships. Combining these new approaches, however, is not an easy task. The first step must be to gather the data that can help us identify an optimal mix of mobility and resources in urban goods distribution in the cities of the Øresund region. In the city that succeeds, we would be witnessing a social innovation for sustainable urban distribution in the making – a social innovation that could adapt mobility to resources and reduce negative environmental impact of urban transport.

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8. Shop Characteristics that Determine UCC Interest

Kristian A. Hvass and Kasper Aalling Teilmann

Introduction

Heavy goods traffic in pedestrian urban areas has various negative impacts on a city's attractiveness, branding, environment, including poor air quality (see e.g. Dockery et al (1993)), urban residency, and the economy of goods' transport price (Rooijen, Quak 2009, Allen, Browne 2010). Various attempts have been implemented to avoid or diminish these negative externalities, including increased pricing of freight transport in urban areas, restricting the time span open for freight transport, and enforcing particle filters to reduce negative health issues from exhaust emission (Anderson, Allen & Browne 2005). These initiatives have, in many cases, had limited effect on urban traffic concentration and environmental impact (Anderson, Allen & Browne 2005, Knoop 1998). Recently, the establishment of urban consolidation centres (UCCs) has emerged as a contribution to the solution of these problems. In addition to the main activity of consolidating goods and coordinated delivery to the participating businesses, UCCs often provide additional services, such as the opportunity to carry and dispose of packaging and pallets on return trips, marking of goods with price, stock-keeping unit, and security tags, as well as the opportunity for participating shops to purchase extra storage (Rooijen, Quak 2009, Quak 2008).

The UCC appears as an apparent and optimal solution to a rather concrete problem of diminishing the negative consequences of urban freight. However, UCC establishment is often supply-side driven and relies on a top-down approach (see e.g. the chapter contribution by Carlsson and Janné for a greater exploration of this topic), and long-term success is often reliant on the purchasing of extra services by participating shops. This may be attributed to the financial challenge of operating a UCC; the limited revenue generated through participating shops must be complemented with the sale of extra services (Rooijen, Quak 2009, van Rooijen, Quak 2010). This suggests that a small-scale, demand-side driven approach is more appropriate. For example, it is argued, that potential businesses that might benefit from UCC participation are determined by the type of goods sold (e.g. garment, food, small or medium sized specialised shops) and shop size (Marcucci 2008). However, the authors believe that looking at these two factors alone is too limited to entail an assessment of the potential usability of a UCC. The desire for UCC participation and demand for extra services varies among businesses depending, for example, on the back-office set up of their supply chain system, existing storage facilities and needs, and the types of goods sold in the shop. This implies that a broader set of characteristics at the shop level influence the potential success of a UCC.

Through a study on the potential of establishing a UCC in the city centre of Copenhagen, the authors identify among six shop characteristics their unique combinations that are in favour of a UCC and the provided extra services. The study thereby seeks to answer the question: which combination of shop characteristics determines the attractiveness of participating in a UCC and utilising extra services? It does so based on a mixed method approach combining case study and qualitative interview data with a method new to logistic studies, multi-value qualitative comparative approach. The results suggest that those shops that are interested in UCC participation lack a systematic delivery system, are dissatisfied with their current delivery system, and often have poor storage facilities, which are similar characteristics of those shops interested in extra services. The comparative method utilised identifies several combinations that lead to the same outcome (i.e. UCC participation and purchasing of extra services), therefore it would benefit the reader to review all possible combinations presented by the authors.

Urban consolidation centres are one solution

Many attempts are made to decrease the negative externalities from urban freight transport. UCCs have the key function to reduce the need for an abundance of goods vehicles to deliver part loads in dense urban areas (Allen, Browne 2010). This function is achieved by establishing storage facilities close to the urban area where deliveries are consolidated for coordinated delivery to participating businesses. This increases the load degree of the vehicles and hence decreases the aggregated fright impact in the urban area. In addition to the core function of coordinated freight, many UCCs offer additional services to the shops (Rooijen, Quak 2009, van Rooijen, Quak 2010). Extra services are offered to assist the shops on different parameters that ease the daily management of their shop and products, and provide additional revenue to the UCC. This indicates that the key function of the UCC, from a public policy perspective, is to decrease transportation in dense urban areas, while the key function from the demand side (i.e. the end users) are the potential benefits it might have on shop management.

Despite the promising impact of UCCs on the local economy, air pollution, and traffic congestion, the record of failed UCCs exceeds that of successes. In a comprehensive study of 66 operating and not-operating UCCs in Europe (and one from the US), 39 are not operating while 27 are still in operation (Browne et al. 2005). Various reasons are highlighted to explain the high rate of failures. Duin et al. (2010) argue that success is dependent upon the actor who started the initiative (i.e. top-down implementation versus small-scale approach), number of participating shops, organisation of the UCC, type of distribution vehicle, and UCC location are regarded as the most important factors for success. An analysis of supply-side versus demand-side instigation supports the latter; a top-down approach is seldom as successful as a small-scale approach. The focus on the end-user has been the driving force in one recent and successful UCC implementation. Starting in 2008 in Nijmegen, Netherlands, the Binnenstadservice reached 98 shops within the first operating year and the numbers are still increasing (Rooijen, Quak 2009). This UCC took its point of departure from the needs and requirements of the shops rather than what has been the prevailing approach, the logistics companies (i.e. a top-down approach). Since the implementation of the UCC in Nijmegen, the Binnenstadservice has spread to nine cities in the Netherlands.

Demand-side driven

Previous studies argue that two factors explain the demand for a UCC: types of goods sold and shop size (Marcucci 2008), while Rooijen and Quak state that, "…deliveries with high frequency, low volume and that certain simple products are potentially interesting for consolidation centre initiatives" (2009 p. 2). While these factors are relevant when investigating end-use demand for UCC participation, the authors believe that there are more underlying characteristics that have yet to be investigated. Therefore, in this study the authors seek to add additional perspectives to previous observations. This is done by conceptualising the present supply and storage systems of shops and identifying what characteristics of these systems increase the likelihood to participate in a UCC. The following section provides a framework developed to illustrate differences in shop supply and storage systems.

The study takes its point of departure in the shops and their potential demand for UCC participation. Therefore, the study concerns itself with the final supply chain link between the supplier and the shop, and hence the logistic services that tie them together. Investigating the entire supply chain would involve product production and its transport through several supply chain links. Related to this research the supplier can be a producer, middleman or wholesaler and product transportation can be managed either by the producer or by a third-party logistics provider (Harrison, Hoek 2011). In this final supply chain link, there are several requirements that must be met from both the transport provider and the in-shop perspective.

Shops have different requirements and needs in relation to delivery from their suppliers and their in-shop handling of goods. In the present study, the authors distinguish among these differences by focusing on various requirements. These requirements are grounded in previous research focusing on UCCs (e.g. Marcucci (2008), Rooijen and Quak (2009), Browne et al. (2005)), logistics operations (Harrison, Hoek 2011)), and from informal discussions the authors had with various shop owners and logistics providers. The requirements can be seen from two perspectives: the supplier and the shop, which can be regarded as the supply and demand perspectives. These requirements are the foundation for constructing the characteristics that the authors chose to investigate in depth for the analysis; these characteristics are introduced in a subsequent section.

In relation to the supplier, four requirements are identified as being important by the authors: weekly delivery frequency, number of suppliers, and fixed or flexible delivery time requirement. Some shops are reliant on many deliveries and suppliers whereas others might suffice with deliveries from one or few suppliers. The delivery requirements may vary in relation to the importance of having new goods displayed in the shop, the in-shop storage facilities, and among shops with a lover product turnover. Shops that have special opening hours, few employees or bad storage facilities might benefit from a fixed time for deliveries, since this can help managers plan the handling of their goods. Lastly, some shops are dependent on the possibility to receive their orders very quickly in order to meet customer requirements. In such cases, a flexible delivery time to accommodate shop and customer needs may be required. Such solutions are challenged by third-party logistic provider services and current delivery processes in the Copenhagen city centre.

In relation to the in-shop perspective, two UCC proposals are included to meet customer requirements: storage facilities and waste disposal. These requirements can be understood as extra-services that can allow businesses to differentiate themselves among competitors. Differences in the requirements for these services related to the transporter and the in-shop goods handling yield different characteristics that consequently yield differences in the demand for a UCC. Table 1 provides a summary of the requirements from the two requirement perspectives.

Perspective	In-shop requirement	Definition
Supplier/ transporter	Many/few deliveries	The frequency of delivery
	Many/few suppliers	Need products from many or few suppliers
	Fixed delivery time	Demand fixed delivery time i.e. certainty in deliverance e.g. delivery in the morning time
	Flexible delivery time	Demand for quick delivery to the shop
In-shop	Storage facility	Need for storing products in the shop
	Waste disposal	Demand for disposal of accumulated waste

***Table 1**: Requirement summary*

Comparative analysis as a method

This research is built upon the case study method and comprised of qualitative interview data that is analysed using multi-value qualitative comparative analysis. Case study methods have grown in importance in management research (Öz 2004) and enable researchers to delve deeper into content complexity. When contemporary events that are beyond the control of the researcher wish to be researched, a case study may be best suited (Yin 2009). This paper relies on the multiple, holistic case study typology proposed by Yin (2009). There are nine cases under study in this paper, each of which is populated with data from semi-structured interviews. The unit of analysis for each case are the supply and demand-side requirements of shops in central Copenhagen.

The nine cases are all non-food retail outlets in the city centre of Copenhagen, Denmark. The cases were identified using two methods. The first method relied on contacting shops that were respondents in an online survey distributed in the second quarter of 2011 to all small and medium sized non-food businesses in the city centre. There were 1031 surveys distributed online and 272 respondents. Six per cent of the respondents replied that they would be willing to be contacted to participate in a working group related to the further development of the UCC concept. These shops were invited to participate in one thirty-minute semi-structured interview concerning their requirements and experiences with their current logistics. In addition, relevant extra cases were contacted in collaboration with the City of Copenhagen municipality. These cases were identified due to their relevance to UCC development or expressed desire to participate. A total of nine cases were secured. Interviews were conducted individually by the authors at the shop site. Each interview was electronically recorded and field notes were taken. The interviewee was the owner or person responsible for coordinating purchases, deliveries, and logistics. Interviews were semi-structured (Kvale, Brinkmann 2009) based on 15 standard questions which asked interviewees to respond to questions such as: describe the current ordering, delivering, and logistical arrangement, rank the services provided by current providers, rank the desire for extra services, etc. All interviews were conducted in Danish and the interviewed shops will remain anonymous; in the text they are referred to as ID and numbered one through nine. Grounded in the dual perspective requirements discussed previously, the authors identified six independent characteristics to characterise a shop's desire to participate in either the UCC scheme or extra services. These characteristics are described further on following the presentation of the analytical method.

Case studies fall into the realm of qualitative research and are useful in theory development (Glaser, Cohen 1969, Eisenhardt 1989, Birks, Mills 2011) and generalisations grounded in theoretical propositions (Öz 2004, Yin 2009). However, analyses of qualitative data is often challenging due to a lack of systematic methods, which makes analyses less developed than other aspects of qualitative research (Yin 2009). Systematic methods (e.g. structured content analysis, multiple discriminant analysis, case survey) that are robust and grounded in logic, are likely to advance research (Yin 2009). Qualitative comparative analysis (QCA) is a systematic method developed by Ragin (1987) that is case oriented (Berg-Schlosser et al. 2009, Ragin 2009), relies on Boolean and Mills logic, and is supported by the belief that case study logic is configurational. This is to be interpreted that a case study's parts, in relation to a whole, are understood in relation to one another and the total picture (Öz 2004). QCA regards each case as unique and comprised of a combination of characteristics (Berg-Schlosser et al. 2009, Ragin 2009). QCA allows the researcher to reduce information from multiple cases into a parsimonious Boolean equation that represents the combination of characteristics that lead to a particular outcome; the method seeks conjunctural causation across the cases and accepts that there are several "paths," all which are relevant, that lead to a desired outcome (Berg-Schlosser et al. 2009, Ragin 2009). QCA comes in various forms; crisp set QCA (csQCA) (Ragin 1987, Ragin 2009, Rihoux, Meur 2009), fuzzy set QCA (fs/QCA) (Ragin 2009, Ragin 2000), and multi-variate QCA (mvQCA) (Cronqvist, Berg-Schlosser 2009). This paper relies on the mvQCA method due to its ability to better capture case details and software availability, and is analysed using the Tool for Small-N Analysis (TOSMANA) (Cronqvist 2011).

The authors have identified six independent characteristics that capture a shop's desire to participate in two dependent characteristics, the UCC scheme and extra services. These characteristics have been identified in literature (e.g. Marcucci (2008) and van Duin, Quak, Muñuzuri (2010)) and through interviews with participants and the municipality. Their type, independent and dependent, can identify these characteristics and mvQCA will identify the combination of independent characteristics that lead to the dependent characteristic. One of the characteristics, delivery/supplier ratio, is a ratio scale characteristic based on data supplied from the interviewee. These data are raw numbers that are converted to multi-variate data using the threshold setter in the software, which is shown in the table. The Storage characteristic is tri-variate and relies on qualitative interpretation by the interviewer of interview data. The remaining variables are dichotomous in nature. The Location characteristic was coded by the interviewer based on the location in the city centre compared to experience with pedestrian density. The Extra Services characteristic is a summary of whether shops ranked extra storage and waste disposal among the top three desires on an interviewer-provided list. If both services were ranked among the top three, the case data was coded as a one. The remaining variables are based on interview data collected from the shops.

Name	Description	Type	Measurement
Delivery/supplier ratio	Ratio of weekly deliveries to number of suppliers	Independent	Ratio Thresholds: 0 = 0.0 – 0.74 1 = 0.75 – 1.4
Storage	Assessment of current storage facility	Independent	0 = poor 1 = average 2 = good
Supply system	Shop has a current supply system that is comparable to a UCC (e.g. own warehouse and delivery system)	Independent	0 = no 1 = yes
Location	Location in dense pedestrian area	Independent	0 = no 1 = yes
Delivery time	Shop has a negative perception towards the current delivery time	Independent	0 = no 1 = yes
Independent	Shop is independent or part of a chain	Independent	0 = no 1 = yes
UCC	Desire to use UCC	Dependent	0 = no 1 = yes
Extra services	Prioritize extra services	Dependent	Ordinal Thresholds: 0 = 0.0 – 1.49 1 = 1.5 – 2.0

Table 2: *Characteristics*

UCC demand

Based on a brief introduction to the UCC concept and a discussion about the shop's current logistic operation, interviewees were asked if they would be interested in using a UCC if it was established in Copenhagen. Seven out of the nine interviewed were interested in UCC participation for varying reasons. Among these seven, all of them showed interest for the opportunity to get flexible deliveries, while four were interested in the opportunity to have extra storage. All except one were interested in the service of waste disposal by the UCC operator. This indicates that one of those not interested in the UCC saw the waste disposal as beneficial though not interested in the core ideas of the UCC. None of the interviewed highlighted the environmental benefits as a determining factor influencing their interest in UCC participation. Table 3 shows a summary of the interview results.

	UCC	Flexibility	Extra Storage	Environment	Waste
Interested	7	7	4	0	8
Not interested	2	2	5	9	1

Table 3*: Interview summary - variables*

The characteristics of shops' current supply chain and their daily management of shipments were identified through the interview. The results show great variation between the number of weekly deliveries (i.e. between one and 25) and number of suppliers (i.e. between one and 200). The in-shop storage facility was characterised on a three-point likert scale by the interviewee. As the UCC attempts to address deliveries in a central urban environment, four shops were located in dense pedestrian areas while the remaining five were not located in dense pedestrian areas. Two of the nine respondents were part of an already-established and optimised supply chain system (e.g. their own arrangement). Six shops were independent while three were not. Finally, five respondents experience the current time of deliveries as a problem whereas four did not. Table 4 is a summary of the values obtained during the interview.

Variable	Measurement	Value
Deliveries	Average Range	12.34 1-25
Suppliers	Average Range	60.45 1-200
Storage	Poor Average Good	3 1 5
Shops	Average Range	3 1-5
Location	Dense Not dense	4 5
Supply system	Supply system No supply system	2 7
Independent	Independent Not independent	6 3
Delivery time	Problem No problem	5 4

Table 4: *Interview summary - values*

Shop characteristics that determine UCC interest

The TOSMANA analysis allows the authors to identify the unique combinations of independent variables (i.e. the shop characteristics) that lead to a demand for UCC participation and the extra services (i.e. waste disposal and extra storage). The authors tested for the combinations of characteristics for an additional characteristic, flexibility, which was questioned during the interview. The intent of this characteristic was to identify which characteristics would lead shops to utilise a UCC due to flexibility. However, the TOSMANA results for overall UCC participation and flexibility were identical; indicating that general interest in UCC participation is to gain greater flexibility in the supply and delivery process. The TOSMANA results regarding UCC participation will cover the flexibility results so as to avoid duplication.

The TOSMANA analysis regarding the demand for a UCC and the flexibility, presented in interpreted form, is shown in table 5, followed by an analysis:

	Delivery / supplier ratio	**Storage**	**Pedestrian location**	**Supply system**	**Problem with delivery time**	**Independent**
Number of cases	Low, Medium, High	Poor, Average, Good	Yes, No	Yes, No	Yes, No	Yes, No
1	Low	Poor	Yes	No	No	No
2	Low	Good	Yes	No	Yes	Yes
2	Low	Poor	No	No	Yes	Yes
1	Low	Average	No	No	No	Yes
1	High	Good	Yes	No	Yes	No

Table 5*: Combinations of characteristics that demand a UCC*

Six unique combinations of characteristics lead to participation in a UCC and hence also the demand for a more flexible supply and delivery solution. The analysis indicates that all interested shops do not have a systematic supply system. This is the one reoccurring characteristic that is identical to all cases analysed. This is likely due to the possibility of a UCC providing such a structured solution for those who currently are not participating in such a scheme. The relation between flexibility, the demand for a UCC, and being part of an established supply system, also became apparent and further nuanced during the interviews.

Many shops in the inner city of Copenhagen are small and have only a few employees to handle goods at the time of delivery, and the time of delivery appears in the interviews as a recurring problem. This is exacerbated by the current time and weight restrictions on truck deliveries in the centre of Copenhagen (Knoop 1998). With an uncoordinated delivery system, the shops are unaware as to when they will receive their orders. Expressed by one interviewee (ID 4):

“We don’t know when the delivery arrives. While we are talking right now a delivery of two pallets of lamps from Spain, that we expect one of these days, might arrive. Then we have two pallets that we need to do something with. […] so the biggest problem for us is that we don’t get any warning. The different logistics companies cannot give such a warning because suddenly the goods are here” [translated by authors].

Or, as one interviewee (ID 5) stated regarding the current delivery time:

“I would like not to get deliveries Friday afternoon at 17.00. They do that categorically” [translated by authors].

These quotes, together with the high degree of interest among the interviewees, indicate that shops’ present delivery logistics could be enhanced from their present state. This becomes evident among those shops that already have a coordinated supply system and hence do not see the benefits of improved flexibility system or certainty in time of delivery. This is expressed by one shop owner (ID6):

“Our main supplier is situated [close by] and sometimes we have the delivery one hour after we order – that’s nice [...]. From our main supplier, there is a carrier that drives when we order” [translated by authors].

This indicates that shops that already have an optimised supply system which meets their requirements which makes a UCC delivery system appear less dynamic and slow. In the above case, the interviewee has one main supplier and the shop is a major client, which gives them advantages regarding their deliveries. Another example comes from a small chain of shops that has already established a coordinated delivery system for their own shops which exceeds, in their opinion, a UCC offering:

“We have a central storehouse in [a city 16 km away]. It is here all our goods from the suppliers are delivered. The shops in the city centre get two deliveries per week, typically one or two pallets at a time” [translated by authors] (ID 1).

In summation, this indicates that there are various reasons for either benefiting from flexibility or on-time of deliverance which are embedded in the UCC solution. A part of this difference can be explained by the utilisation of an existing enhanced or coordinated supply system, as is the case with two of the interviewees.

Lack of UCC-comparable system is key

From the TOSMANA analysis, it appears that nearly all shops interested in participation have a low delivery/supplier ratio (i.e. five out of six combinations). This suggests that these shops can have a low number of physical deliveries, however, a high number of suppliers. Shops that have a low ratio often have storage facilities that are rated poor to average (i.e. four out of six combinations).

Looking at the TOSMANA results there is one combination of characteristics where a shop has a high delivery/supplier ratio. This combination stands out, as there are good storage facilities, in a pedestrian location, and a non-independent shop. However, the shop is dissatisfied with their current delivery time and inflexibility in changing the delivery time to match the needs of the shop.

The authors’ proposition that those shops interested in UCC participation are those with poor storage facilities and dissatisfaction regarding current delivery time is partially confirmed, however other results are also valid. There are cases with shops that have good storage facilities that are dissatisfied with their time of delivery. The reverse case may be true, such as poor storage facilities with satisfaction in delivery time. This suggests that shops can benefit from two primary aspects of the UCC: greater storage capacity or improvement with regard to deliver time (i.e. flexibility or precision).

Shop characteristics that determine interest in extra services

The UCC concept can provide additional services beyond consolidation and distribution. Extra services can come in various formats limited only by the innovative cusp of the UCC. The authors asked interviewees to rank additional services and two extra services stood out: extra storage capacity and waste disposal. These two characteristics were aggregated into a single characteristic: extra services. Analysed in TOSMANA and the interpreted results for those cases that prioritise both extra storage and waste disposal are shown in table 6:

Number of cases	**Delivery / supplier ratio** Low, Medium, High	**Storage** Poor, Average, Good	**Pedestrian location** Yes, No	**Supply system** Yes, No	**Problem with delivery time** Yes, No	**Independent** Yes, No
1	Low	Poor	Yes	No	No	No
2	Low	Poor	No	No	Yes	Yes
1	High	Good	Yes	No	Yes	No

Table 6: *Combinations of characteristics that demand extra services*

These results appear to be similar to those combinations of characteristics that describe willingness to participate in a UCC scheme; however, there are combinations that differ. Common for all combinations is that no shops currently participate in a supply system. This indicates that interest for extra services is grounded in a current lack in existing processes regarding handling of goods. Three combinations lead to extra service interest. Two have a low delivery/supplier ratio and poor storage facilities. The low ratio may indicate that a large volume of supplies is delivered and there are inadequate storage facilities to accommodate this.

Interview statements supported these observations. Among respondents that prioritise the storage facility, the demand was founded in their lagging storage facilities:

“We only have what we can dig out in the backyard of weird small storage solutions” [translated by authors] (ID 4).

In addition, shops that already have existing external and adequate storage to accommodate the volume also prioritise the service:

“I do have external storage facilities. But, mainly due to man power, it doesn’t pay off to go there more than once a week. This means that sometimes it looks like this [referring to the sales area in disarray], but it is not bad now. Half of the room was filled with boxes during Christmas last year. […] it is the purpose, that it should be a sales area and not a storage room” [translated by authors] (ID 8).

It is therefore the impression that the extra storage facilities are valued not only by shops that have bad storage facilities but rather when the in-shop storage is inadequate.

The reasoning among respondents that did not prioritise the storage offer is diverse and includes both those shops where the existing storage could be improved and those that have good and optimised storage facilities both in-shop and externally. One interviewee

(ID 6) stated that a good storage facility alone is not sufficient, knowledge about contents and location are also relevant.

“We have a small garage here and a storehouse close by [11 km]. If we should ascribe to the storage service, it would cost us money and we should leave our storage to external people. We have an external storehouse with approximately 10 000 different products. Our boss, who has worked with [the shop products] his entire life, has difficulties in finding his way around. And if some external should do this – it would simply not be possible” [translated by authors].

This quote indicates that it is the great diversity and complexity of the storage that makes the external storage service unattractive for the shop. Another perspective deals with the flexibility and ease of having the storage close by:

“It gives us a lot of flexibility to have our main storage right here. We have discussed moving it, but we are not big enough for that yet. It would not pay off” [translated by authors] (ID 3).

In this case, there is an Internet shop affiliated to the shop and the packaging and shipment of ordered products are maintained from the well-ordered storage facilities of the shop.

In relation to the waste disposal solution, the interviewees gave the impression that the present packaging and waste disposal situation in the city centre is poor.

“We have a huge pallet problem here in the city centre. A huge problem. I put all my pallets in my car and drive them out to the recycling station once a week. I have to do that. […] I can tell you, that some people have started to dispose of cardboard in the bins, and I do it myself once in a while when there is nothing to do at all” [translated by authors] (ID 5).

This suggests that the UCC may offer a service that is pertinent to several shops in the centre. However, the service offered must surpass that offered by the city to command a price premium.

Another respondent (ID 7) highlights the inefficiencies of the system:

“Think about that someone drives in, emptying their carriers and drives out again. We unwrap the boxes and then another carrier picks it up and drives it away” [translated by authors].

In addition, one of the two respondents that did not show interest in the UCC sees potential in the waste disposal. This indicates that there is a disposal problem among the shops in the Copenhagen city centre and that the UCC might hold the potential in solving part of this problem.

Conclusion

This paper is a contribution to the field of urban logistics and urban consolidation centres. Through the analysis, the authors have added to the research in potential UCC participation. Potential UCC participation is not determined solely by the type of products sold but connected to several characteristics that UCC operators must account for in their analysis. These aspects include the number of deliveries, the number of suppliers, the current supply system, the shop location, perception of the current logistical service, and ownership structure (i.e. independent or non-independent). This implies that assessing the potential of establishing an UCC requires a thorough evaluation of the underlying characteristics of the shops in a particular area. The results indicate that analysis of these characteristics alone is not sufficient as they interact in several different combinations. Common for both analyses, UCC participation and demand for extra services, is the current lack of an established supply system. Those businesses that have an in-house or alternative solution that is comparable to an UCC supply system are not interested in participation. In addition, most businesses that show interest for the UCC have a low weekly delivery to supplier ratio, which may indicate few deliveries but large volumes. Such deliveries can strain shop resources, and these businesses are UCC-interested. The remaining characteristics have a large variation and it would not be appropriate to summarise the results for fear of simplifying a complex issue.

The characteristics of shops showing interest in extra services are similar to that of UCC participation. Common for all cases is the lack of a comparable supply system. In addition, the majority of cases also have a low delivery to supplier ratio and poor storage facilities. This may reflect the fact that several businesses in the city centre have insufficient facilities to deal with their delivery volume which, in turn, is partly driven by customer and shop requirements, third-party logistic providers' resources, and the municipality's administration of regulations concerning city centre deliveries. Again, the remaining characteristics have a large variation and the authors refer to the analysis for a more nuanced discussion.

The Boolean method has proven its value in identifying the shop characteristics that increases the attractiveness of the UCC in the small N sample based on qualitative interviews. This research relied on six variables. Alternative variables may strengthen future research, such as the physical volume of delivered goods, types of products sold, actual storage space currently available, logistics expenditure, number of employees, or time spent by personnel handling deliveries. However, users of the Boolean method should be wary of using too many variables. The objective of the method is to identify common characteristics across cases; however, use of an abundance of variables can lead to each case being unique. In addition, the method is challenged by the transformation of some data into numerical notation. This requires a close dialogue with other researchers, an intimate knowledge of the data, and a structured approach to interpretation. Finally, this research is supported by nine qualitative interviews; the addition of several more interviews and shops would strengthen the results.

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9. The EcoMobility Modelling Framework for Sustainable Transport Planning

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1. Introduction

Addressing the sustainability issues in contemporary decision making is a topic of growing concern. The concept of sustainability necessitates the revision of traditional decision-making processes, where the generally acknowledged cost-benefit analysis (CBA) is used for a systematic quantification and comparison of the various benefits and costs generated by a project (Banister and Berechman, 2000). Decision making based on CBA is often found to be inadequate to incorporate and assess multiple, often conflicting objectives, criteria or attributes like environmental or social issues, which are usually intrinsically difficult to quantify (Thomopoulos et al., 2009; Beukers et al., 2012). Therefore, it is necessary to broaden the decision-making process beyond the consideration of merely economic factors. The ultimate implementation of such a decision-making framework, under the multiple criteria, will require multi-disciplinary and multi-participatory approaches, especially when there is need for assessing a decision problem from different perspectives, e.g. a sustainability perspective (Banister, 2008). These issues are of great concern for the EcoMobility project, which seeks to reduce the environmental impact of transport while increasing economic growth and accessibility in the Øresund region.

This chapter introduces the EcoMobility (EM) modelling framework developed within the decision-modelling group of DTU Transport for the evaluation of complex transport infrastructure decision problems. The EM modelling framework consists of two parts: namely, a decision conference, and an Excel-based software model (entitled the EM-model). The latter employs the use of two multi-criteria decision analysis (MCDA) techniques, REMBRANDT (ratio estimation in magnitudes or deci-bells to rate alternatives that are non-dominated), which is based on pair wise comparisons, and SMARTER (simple multi-attribute rating technique exploiting ranks), which is based on criteria rankings. The concept of a decision conference (DC) is introduced in order to formalise and operationalise group processes that enable the assessment of non-quantifiable impacts/criteria within a decision support context.

For illustration, the application of the model is presented by a case study in the Øresund region considering the alternatives for a new fixed link between Helsingør (Elsinore) in Denmark and Helsingborg in Sweden (referred to as the HH-connection), where a sustainable solution for the connection was found. The case study has proved the decision support system to be a valid and useful tool for making decisions under complex circumstances of multiple objectives, conflicting interests, and involvement of different stakeholders.

The chapter is organised as follows: after this short introduction the overall modelling framework is introduced more specifically in terms of small introductory paragraphs to the various methodological approaches of decision conference, REMBRANDT and SMARTER. Hereafter, the case study is presented and used to demonstrate the applicability of the EM modelling framework for sustainable decision making. The chapter ends with a discussion on how the model can support and validate the research findings about sustainable transport in the Øresund region as well as the main conclusions and perspectives for the future research and application tasks.

2. The EcoMobility modelling framework

The main scope of the EM modelling framework is to assist the decision-makers in assessing complex decision problems, which usually involve multiple and often conflicting objectives. The main aim is to allow for stakeholders' involvement in order to obtain informed and transparent decision support. The EM modelling framework is illustrated in Figure 1, where the decision conference and the EM-model are separated into two independent items aggregating into a set of resulting total scores for a given set of alternatives within a project scope.

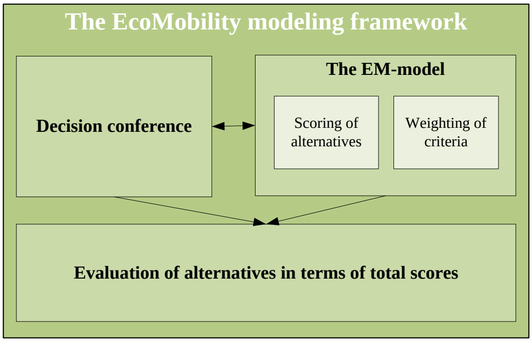

Figure 1. The EcoMobility Modelling framework

From Figure 1 it is given that the decision conference and the EM-model are interacting in terms of producing a set of total scores i.e. prioritisation between a set of pre-defined project alternatives. The following paragraphs summarise, in short, the approach of respectively the decision conference and the EM-model containing of the two subsequent techniques REMBRANDT for scoring of alternatives and SMARTER for weighting of criteria.

2.1. Decision conference

The overall purpose of a decision conference (DC) is to combine technical and social aspects for solving different types of complex decision problems. It enables a structured debate between the participants that are either involved in and/or affected by the decision problem. The debates, evolving between the participants representing different perspectives on the problem, are able to enrich the basis on which the decisions have to be made. The goal of a DC is to develop a common understanding of the decision problem between the participants, to create a sense of common purpose, and achieve a group commitment (Phillips, 2007). A decision achieved in consensus at a decision conference has a higher possibility for being implemented than e.g. the results from a complex decision analysis that only involves one decision-maker who later has to justify his decision to an organisation or to the general public. However, the final decision is still in the hands of policy-makers and based on many other factors (Zurita, 2006).

The concept of a DC consists of three main components: group processes, decision analysis, and information technology (the EM-model). An impartial facilitator who is guiding the participants though the DC assists the group processes. The main task of the facilitator is to ensure that all the participants get a chance to express their opinions (Franco and Montibeller, 2010). The decision analysis is supported by the software model, which is constructed, and run by a decision analyst who, in real time, collects the relevant data and judgments of the participants (Phillips and Bana e Costa, 2007). In principle, the model represents the collective view of the group at any point of time along the process, allowing the participants to understand each step such that no black-box process/solutions should occur and only confident results be achieved.

The five-step procedure contained within the DC is formulated in Figure 2 in order to lead the participants through the decision process and motivate them to produce the input needed for the assessment. The arrows pointing back from step 5 indicate that it is possible to go back in the process and redo the assessments made in step 3 and 4 if a shared understanding has not been achieved (Barfod, forthcoming).

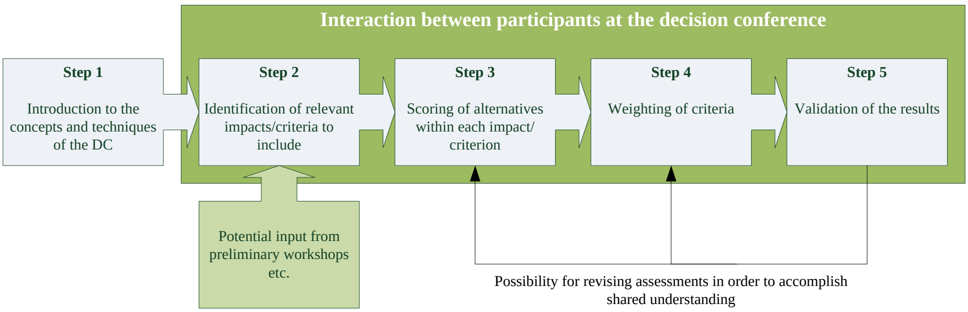

Figure 2. The five steps in the decision conference (adapted from Barfod (forthcoming))

In detail the steps are as follows (Ibid):

1. *Introduction to the concepts and techniques of the DC*. It is very important for the quality of the decision conference that the facilitator starts by introducing the concepts and methods being used in simple terms. When the participants know the basic characteristics of the model, they will be more comfortable with the later process.

2. *The identification of relevant impacts for the assessment*. Before any ranking can be carried out, the alternatives have to be characterized by a number of decision criteria, e.g. technical, economic, and environmental, etc. In this respect, it can be very useful to conduct a workshop already in the initial planning phase, where issues regarding the project can be discussed and criteria with influence on the

decision making can be developed. It is up to the participants to structure and reduce the criteria into a number of relevant criteria which all contribute to the differentiation between the alternatives. However, it is up to the facilitator to ensure that no criterion overlaps with other criteria in order to avoid double counting.

3. *The scoring of the alternatives within each impact/criterion*. The relative scores of alternatives are determined through the pair wise comparison mechanism, where the alternatives are compared two by two under each criterion and assigned with numerical values based on preference intensity.

4. *The weighting of the criteria*. The criteria are weighted using rank order distribution weights (ROD) embedded within the SMARTER approach. It is considered to be very difficult to make the participants agree directly upon a weight set of criteria. Instead, the model contains the possibility to examine all the different weight sets provided by each participant individually.

5. *Validation of the results*. The participants will after this process be able to make their choice based on a broader basis of knowledge, as they now are aware of the other participants' viewpoints and can take them into account.

Consequently, DCs are conducted "here-and-now" preferably without any formal presentations. Each DC may proceed differently and have different outlines/outcomes; however, the four basic stages that typify most of them can be outlined as follows (Ibid):

1. Broad exploration of the issues
2. Construction of the model based on each participant's judgments about the issues
3. Exploration of the model
4. Summary of key issues, conclusions and agreement about the way forward

At the beginning of the DC, the data are introduced and the issues are tackled in line with the different opinions actively sought to encourage the debate. Based on that, input is given to the model and participants examine the results and their realism and consistency. New perceptions about the issues might lead to successive revisions. This iterative and interactive process proceeds until a shared understanding of the issues is obtained. Finally, the commitment of the participants to the way forward is agreed upon.

2.2. The EcoMobility-Model

As presented, the third component within the settings of a decision conference are the application and introduction of a software system capable of arranging, and ultimately assessing, the inputs brought forward by the various participants of the DC. The EM-model is capable of handling up to eight alternatives with up to ten criteria. During the interaction with the participants, the alternatives are compared two by two assigning them with a score within each criterion. The criteria are then assigned with weights according to their relative importance, and the results are found by aggregating the preference information. Figure 3 presents the flow of the model embedding the five steps presented in the DC procedure (Figure 2).

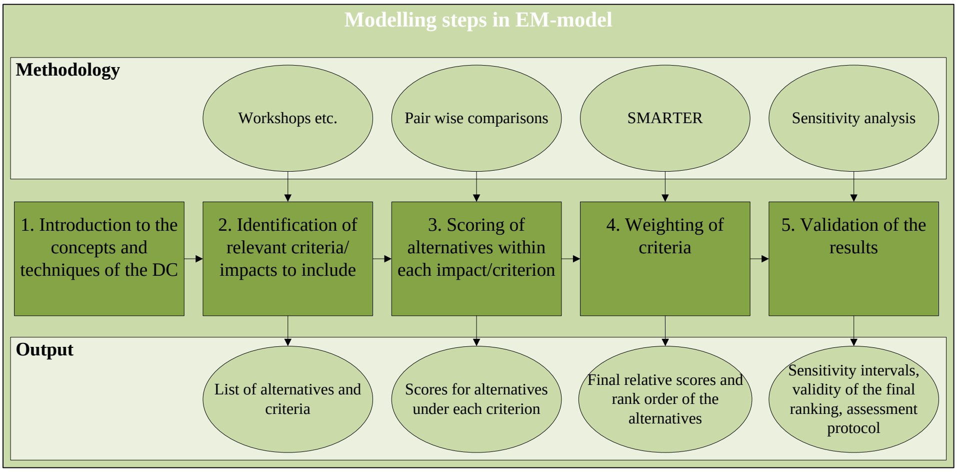

Figure 3. The modelling steps of the EM-model

The process-related steps to be followed in the EM-model in order to conduct the assessment are shown in Figure 3. After the introduction to the DC, the information in relation to the alternatives that are formulated to remedy the problem and the criteria that are developed relevant to the assessment of alternatives is firstly fed into the model. Secondly, the alternatives and criteria to include in the assessment are listed. Thirdly, the EM-model makes use of the REMBRANDT approach (see section 2.2.1) for scoring the alternatives and measuring the contribution of each alternative to a specific criterion. The relative score given to each alternative is determined by comparing all the alternatives pair wisely under each of the criteria. Fourthly, the EM-model requires the determination of the criteria weights, which currently are performed by the use of the SMARTER approach (see section 2.2.2). Fifthly, the information is aggregated into single value measures resulting in the total scores, thereby making it possible to define a prioritised list of the alternatives. These total scores indicate the degree to which the alternatives contribute to the problem solution. Finally, the EM-model performs sensitivity analyses where it tests whether the final ranking would be different if the weighs of the criteria are changed.

The REMBRANDT approach

The EM-model involves the use of a structured hierarchical technique named REMBRANDT by Lootsma (1992) that is designed to evaluate a finite number of alternatives under a finite number of conflicting criteria by a single stakeholder or a group of stakeholders.

In order to assess the project alternatives (make a prioritised list of preferred alternatives), the REMBRANDT approach for pair wise comparisons has been applied. The approach is a multiplicative version of the Analytical Hierarchy Process (AHP) developed by Saaty in (1977), which attempts to overcome some of the theoretical difficulties associated with the original AHP (Belton and Stewart, 2002; Barfod, forthcoming). The applicability of REMBRANDT is based on three parts: decomposition, comparative judgment, and synthesis of priorities.

The decomposition part requires decomposing the decision problem into a hierarchy that reflects the essential elements of the decision problem dealt with: an overall objective or goal at the top level, the criteria (sub-objectives) that define the alternatives at the middle level, and finally, the competing alternatives at the bottom level of the hierarchy. The principal structure of such a hierarchy is presented in Figure 4.

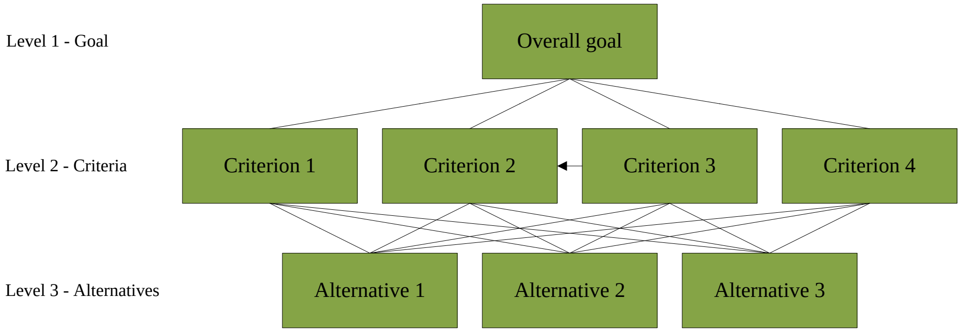

Figure 4. A decision hierarchy

The comparative judgment principle requires pair wise comparisons between the decomposed elements within a given level of the hierarchical structure with respect to the next higher level. Thus, the pair wise comparisons have to be made between the alternatives to determine their impacts under each criterion and between the criteria to determine their relative importance to the overall goal (Figure 4).

Finally, the synthesis principle requires aggregating of the results derived at the various levels of the hierarchy in order to construct a set of priorities for the elements at the lowest level of the hierarchy, allowing a rank ordering of the alternatives.

When the decision problem in hand is to be assessed using the REMBRANDT approach, it is beneficial to have a group (participants of the DC) to make the assessment. A finite number of pre-selected alternatives A_1, A_2,…, A_n (Level 3), thus, are pair wisely compared against a set of predefined criteria (Level 2). During the process, participants are presented with each pair of alternatives A_j and A_k under a specific criterion and asked to express their preference for one alternative over another. The strength of such a procedure lies in the preference information that is collected in terms of verbal statements as denoted in Table 1 that in turn are corresponding with a numerical value to be entered in the EM-model, and processed using the mathematical principles behind the REMBRANDT approach.

Table 1. The REMBRANDT intensity scale for comparing two alternatives A_j and A_k (Lootsma, 1999)

Verbal description	Numerical value
Very strong preference for alternative A_k	-8
Strong preference for alternative A_k	-6
Definite preference for alternative A_k	-4
Weak preference for alternative A_k	-2
Indifference	0
Weak preference for alternative A_j	+2
Definite preference for alternative A_j	+4
Strong preference for alternative A_j	+6
Very strong preference for alternative A_j	+8
For the compromise between the neighbouring values	-7, -5, -3, -1, +1, +3, +5, +7

All the information about the pair wise comparisons conducted and the participants' arguments regarding them during the decision making process must be documented in an assessment protocol. This can be valuable to justify the decision and in addition can be useful if the process is going to be repeated after some time.

When the relative scores of the alternatives under the criteria are determined through the pair wise comparisons, the criteria should be weighted in order to synthesise all the scores. The criteria can be weighted using different techniques, such as pair wise comparisons or the SMARTER (simple multi-attribute rating technique exploiting ranks) technique with the ROD (rank order distributions) weights.

The SMARTER approach

In order to simplify the process of eliciting criteria weights, the SMARTER approach has been proposed by Edwards and Barron (1994). Using SMARTER, the participants of the DC place the criteria into an importance order: for example 'Criterion 1 (C1) is more important than Criterion 2 (C2), which is more important than Criterion 3 (C3), which is more important than Criterion 4 (C4), and so on, C1 ≥ C2 ≥ C3 ≥ C4... The SMARTER approach then assigns surrogate weights to the criteria based on this ranking. A number of methods that enable the ranking to be translated into surrogate weights have been developed. These are among others, Rank Order Centroid (ROC), Rank Sum (RS), RR Rank Reciprocal (RR), and Rank Order Distribution (ROD) weights. Roberts and Goodwin (2002) have examined these methods in details and found that ROD weights seem to provide the best approximation of the participants' preferences.

ROD is a weight approximation method that assumes that valid weights can be elicited through direct rating. In the direct rating method, the most important criterion is assigned a weight of 100 and the importance of the other criteria is then assessed relative to this benchmark. The ROD weights for between 2 and 10 criteria are shown in Table 2.

Table 2. Rank Order Distribution (ROD) weights (Roberts and Goodwin, 2002)

Rank	Criteria								
	2	3	4	5	6	7	8	9	10
1	0.6932	0.5232	0.4180	0.3471	0.2966	0.2590	0.2292	0.2058	0.1867
2	0.3068	0.3240	0.2986	0.2686	0.2410	0.2174	0.1977	0.1808	0.1667
3		0.1528	0.1912	0.1955	0.1884	0.1781	0.1672	0.1565	0.1466
4			0.0922	0.1269	0.1387	0.1406	0.1375	0.1332	0.1271
5				0.0619	0.0908	0.1038	0.1084	0.1095	0.1081
6					0.0445	0.0679	0.0805	0.0867	0.0893
7						0.0334	0.0531	0.0644	0.0709
8							0.0263	0.0425	0.0527
9								0.0211	0.0349
10									0.0173

The use of ROD weights goes some way to reduce the value problem of having criteria with very low weights in the assessment. However, it can be argued that the inclusion of criteria with very low weights, e.g. 0.02, does not contribute in any way to the overall result and, therefore, should be omitted from the analysis, see Barfod et al. (2011) for a discussion of this.

It should be noted, that the four decimals that are shown for the ROD weights in Table 2 express a much higher accuracy in the weights than should be expected in practice. Normally, the participants assign weights with not more than two decimals, as this seems to be the limit to what can be comprehended by the human mind without difficulties. Thus, the weights in Table 2 should be presented with only two decimals to the participants if this technique is used in the decision process.

2.3. Evaluation of alternatives: Results

After deriving the separate scores for the alternatives within all the assigned criteria and furthermore determined weights for the criteria – it is possible to produce a result based upon the participants at the decision conference.

It should be noted, that if the participants in the DC do not agree with this result, it is possible to go back in the process and, hence, revise the assessments or perhaps test the various weight settings applied.

On this basis, decisions made in consensus at a DC seem to have a fairly higher probability for being implemented when compared to results from another more standardised evaluation approach only involving one decision-maker, who then later has to justify the choices or causes of action during the calculations. Moreover, decisions made by group effort have better terms for working in practice both in terms of operability (since the group somehow is committed) but also in light of project ownership.

The following section enhances the perspective of the EM modelling framework in terms of a presented case study with respect to a second fixed link between Denmark and Sweden, the so-called HH-Connection.

3. The case study: HH-connection

Eleven years have passed since the Øresund fixed link connecting Copenhagen in Denmark with Malmö in Sweden opened to traffic (see Figure 5). The fixed link between Zealand and Scandinavia has led to a strong increase in traffic across Øresund as a whole. In 2009, an average of 19,500 vehicles and 184 trains crossed the link per day, corresponding to 141 per cent and 125 per cent increase respectively compared to the first full year of operations in 2001 (Øresundsbro Konsortiet, 2010). Moreover, the fixed link across Fehmarn Belt between Denmark and Germany, which is expected to open in 2018, will increase these numbers due to more travellers from central Europe through Denmark to the rest of Scandinavia (Sweden and Norway). In particular, the number of freight trains through Denmark is expected to grow significantly, turning the Øresund fixed link into a bottleneck, due to the existing capacity already being close to the limit.

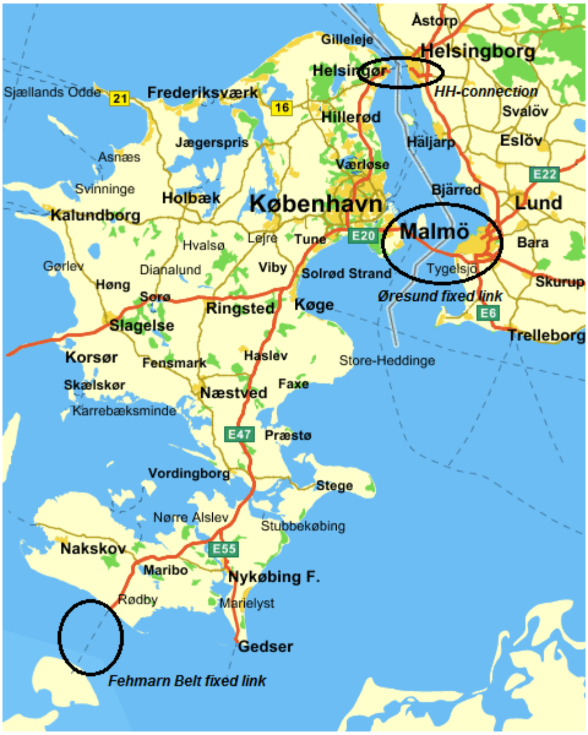

Figure 5. The proposed new fixed link (HH-connection), the Øresund fixed link and the forthcoming Fehmarn Belt fixed link (from map.krak.dk)

The proposal of a fixed link between Helsingør (Elsinore) in Denmark and Helsingborg in Sweden – referred to as the HH-connection – has been considered since the 1980s, however, the opening of the Øresund fixed link postponed the planning and implementation. The case is now re-actualised in order to cope with the increasing traffic across the Øresund and the planned Fehmarn fixed link. A new northern fixed link would reduce the travel time between Zealand and Scandinavia, relieving the Øresund fixed link for some of the car and railway traffic. In the autumn of 2011, three tunnel alternatives are considered as main alternatives for the HH-connection. The alternatives are listed in

Table 3 with indication of type of construction, type of traffic, and total costs (in mill. DKK).

Table 3. The three proposed alternatives for the HH-connection (Larsen and Skougaard, 2010)

HH-connection	Description	Cost (mill. DKK)
Alternative 1	Tunnel for rail (2 tracks), passenger trains only.	9,500
Alternative 2	Tunnel for rail (2 tracks), passenger trains only + tunnel for vehicles (2 × 2 lanes).	24,500
Alternative 3	Tunnel for rail (2 tracks), passenger trains + tunnel for vehicles (2 × 2 lanes) + tunnel for rail (single track), goods trains.	32,500

The alignments of the different alternatives depending on the type of traffic are shown in Figure 6.

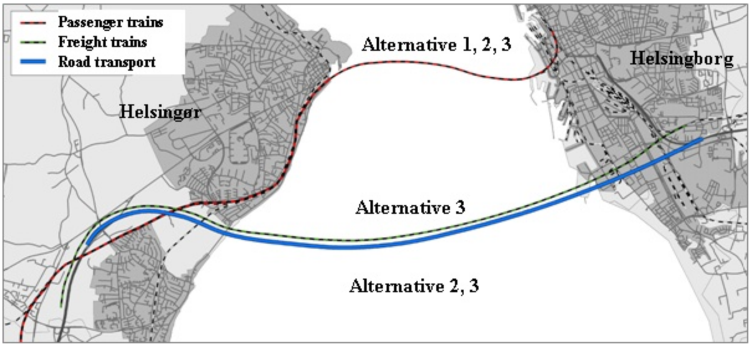

Figure 6. The alignment of the alternatives

The overall goal of this case study is to find not only the most socio-economically sound, but also the most sustainable alternative for both passenger and freight transport. Based on this, the alternatives have been assessed against a set of decision criteria as follows:

- *C1: Socio-economic robustness*. The criterion embraces the overall economic performance of the alternative. The main indicator is the certainty value (CV) calculated based on the results stemming from the cost-benefit analysis (CBA). Risk analysis (on construction costs and time savings) is applied to the CBA and the resulting CV describes the certainty for obtaining a benefit-cost rate (BCR) above 1 (Salling and Leleur, 2012). A high CV is, therefore, preferable.

- *C2: Improvement for passenger cars and public transport*. The criterion emphasises the accessibility for both cars and public transportation. This is represented by the increased mobility potential that the commuters obtain (they can cover more geographic space using the same time as previously).

- *C3: Impact on towns and land-use*. The criterion primarily emphasises the visual environment in the towns of Helsingør and Helsingborg. The form of the land-based facilities and their geographical placement will, for this reason, be in focus. Moreover, the housing prices in the towns will most likely be affected as well, especially, for the houses close to Øresund and the land facilities.

- *C4: Impact on regional economics*. The criterion considers the alternatives potential for contributing to the economic development in the Øresund region. In order to obtain economic development in the northern part of the Øresund region, the area should become more attractive to both housings and businesses. If more businesses are located in the area it becomes more attractive to live there, which also creates the basis for more shopping opportunities. In this way, the potential for gathering businesses and creating a specialised business life increases. Moreover, a new connection should make it more attractive for students to live in the area, as it will become easy to cross the sound and for that reason the universities in Helsingborg, Lund, and Copenhagen will be within a reasonable travel distance/time.

- *C5: Impact on flexibility in logistics*. The criterion covers the impact on the efficiency, punctuality, security, co-modality, and risk in the logistic chains. Relocation of warehouse facilities reflects the benefits that arise when companies reduce e.g. their number of warehouses because the new infrastructure makes it possible to serve customers from fewer warehouses. Moreover, a new connection can help to expand companies' clientele, and at best, it can result in that some companies can close down a production area, thereby, saving money.

- *C6: Contribution to the EU green corridors*. The criterion emphasises the alternative's potential for promoting the green transport corridors. According to the Danish Transport Authority (2011), Green Corridors are a European concept denoting long-distance freight transport corridors in which advanced technology and co-modality are used to achieve energy efficiency and reduce environmental impact. Launched in the Freight Transport Logistics Action Plan (2007), Green Corridors support the EU's agenda towards decarbonising transport while emphasising the need for efficient logistics. The existing Øresund fixed link is, at the current time, a part of the EU east-west green corridor. However, a north-south green corridor is also going to pass through Denmark and Sweden, and the only way to relieve the pressure on the Øresund fixed link, in order not to exceed the capacity limit, is to place a new connection between Helsingør and Helsingborg.

3.1. Application of the EM modelling framework to the HH-connection study

A decision conference was conducted concerning the HH-connection decision problem, where the purpose was to locate the most attractive alternative amongst the three presented in Table 3. Four experts joined the group from DTU Transport on 6th October 2011 in order to conduct the decision conference and ultimately create a decision support base with regard to the prioritisation of the alternatives. The conference was guided by a facilitator and supported by a model analyst using the EM-model, in order to perform on-the-spot modelling of the information obtained from the participants.

After the introduction and the information regarding the alternatives and criteria was presented, the first task for the participants was to rate the alternatives under each defined criterion. The ratings were done using pair wise comparisons, where the participants had to state their preferences for one alternative over another in a comparison under the criteria one by one. The verbal information was then converted into numerical values based on the intensity scale from 0 to 8 (see Table 1) and filled into the comparison matrices in the model. An example of such a matrix is shown in Figure 7, where the results of the pair wise comparisons of the alternatives for the socio-economic robustness criterion are presented as they were agreed upon by the four participants.

Criterion 1:	**Socio-economic robustness**			
	Alt1	**Alt2**	**Alt3**	**Score**
Alt1	**0**	-6	-4	0.10
Alt2	6	**0**	3	8.00
Alt3	4	-3	**0**	1.26

Figure 7. The comparison matrix for the socio-economic robustness criterion

The idea of incorporating an economic criterion in the MCDA is based on the SIMDEC (risk simulation and multi-criteria decision analysis in combination for decision support) approach (Leleur et al., 2010; Leleur, 2012). In SIMDEC, the MCDA includes the results of the risk analysis on the possibility of not obtaining socio-economic feasibility examined for each of the project alternatives as one criterion. This criterion concerns how each alternative is affected by the uncertainties underlying the two major impacts of every large transport infrastructure project: construction costs and travel time related benefits (Salling, 2008).

Afterwards, the participants were asked to rank the criteria, first, individually, then as a group. The criteria were then assigned with the surrogate ROD weights based on the rankings, see Table 2. The group's joint ranking of criteria and the assigned weights are shown in Table 4 below. Note that the ROD weights are only shown with two decimals here.

Table 4. The DC participants' joint ranking of the criteria

Criteria	**Rank after importance**	**Weight**
C1: Socio-economic robustness	2	0.24
C2: Improvement for passenger cars and public transport	3	0.19
C3: Impact on towns and land-use	6	0.04
C4: Impact on regional economics	1	0.30
C5: Impact on flexibility in logistics	5	0.09
C6: Contribution to the EU green corridors	4	0.14

All the information fed into the model was aggregated to obtain the resulting total scores for each alternative. The results are shown in Figure 8 with alternative 3 as the most attractive, while alternative 1 only achieved a very low score.

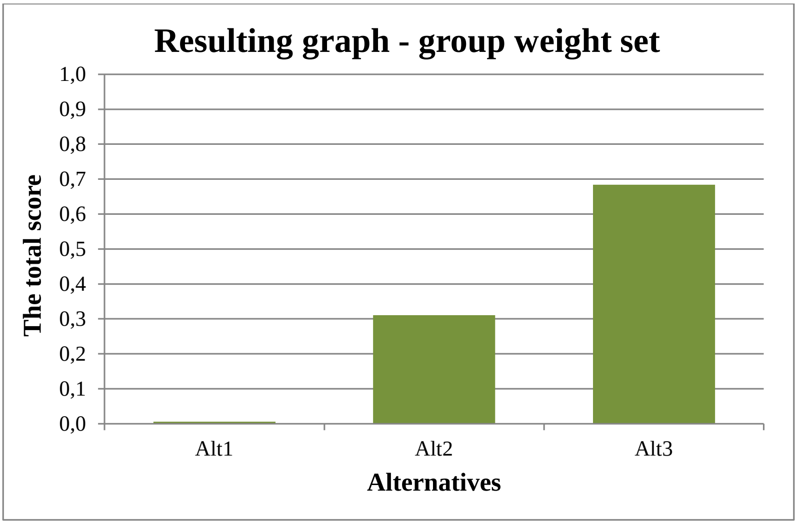

Figure 8. The resulting graph showing the total scores for each alternative

It is worth noticing that similar results were produced applying the four individual weight sets, even though the participants had very different perspectives on the weighting of criteria. Three of the participants had the socio-economic robustness criterion as the most important criterion, but one participant had the criterion ranked as the least important criterion. The argument for the low priority of this criterion was that all of the alternatives were socio-economically feasible and, therefore, this criterion was not given a high priority. A sensitivity analysis revealed that the weights of all the participants were within the interval for the socio-economic robustness criterion and, thereby, it made no difference for the overall ranking of alternatives which weight profile was applied. This also applies to the other criteria weights. This means that the participants at the DC achieved a common vision on the decision problem with alternative 3 as the most preferred for the HH-connection.

4. Discussion and conclusion

The modelling framework described in this chapter attempts to encompass a wider set of criteria in transport planning than a traditional cost-benefit analysis. Sustainable transport planning in the Øresund region necessitates a broader decision support tool that is capable of taking into account and assessing the multiple and often conflicting criteria and objectives which are difficult to measure in monetary terms. Thus, the use of pair wise comparisons (REMBRANDT) makes it easier for the participants to assess how the alternatives perform under each criterion and assign them with values enabling a ranking of alternatives. By selecting appropriate criteria, it becomes possible to express sustainability in operational terms for actual decision support.

The case example shows that it is possible to take into account a wide range of criteria such as environment, economic growth, and accessibility in the same decision support model. The EM-model is not only a multi-disciplinary, but also multi-participatory decision support model. Several stakeholders can be included in the assessment as recommended by e.g. Musso et al. (2007) and Macharis (2007) and in the case study, four different participants in the DC gave input to the EM-model. The setup of the DC should obviously depend on the involved participants, but more importantly be based upon the decision problem to be investigated. Therefore, a major obstacle is the ability to convey appropriate methodological approaches that provide a theoretically approved course of action while at the same time maintain its transparency and applicability.

It is planned that the EcoMobility modelling framework should also be used for the localisation problem of an Urban Consolidation Centre (UCC) in Copenhagen. An UCC initiative for Copenhagen has been proposed aiming to remedy the urban freight transport in the city centre of Copenhagen. Hence, the localisation of such an UCC is a multi-disciplinary and multi-participatory decision problem, since technical, social, economic, and environmental criteria are all important for the choice of localisation. The technical criteria consist of logistics, level of service to be provided, volume, and the trip effectiveness. The social criteria are mobility, accessibility, quality of life, and traffic safety. The economic criteria are related to the direct influence on benefits and costs, while the environmental criteria cover congestion, air pollution, and noise and energy consumption. These numerous and often conflicting criteria together with a range of different stakeholders and their different preferences make this localisation problem an obvious task for the future application of the EM modelling framework.

A key concern within the EcoMobility project is to identify the effective means for sustainable transport planning in the Øresund region. This complex challenge can be met as concerns assessment methodology with the multi-faceted EM-model, which involves risk analysis on the socio-economic part of the decision problem, MCDA to embrace various and often conflicting criteria and sensitivity analysis for taking into account the interests and preferences of different stakeholders. To optimise the use of the EM-model customised decision conferences become essential where the engagement of stakeholders and their different preferences provide a common platform for understanding a decision problem and for seeking out the most attractive decision alternative.

Overall, the EM modelling framework provides a theoretically sound, and at the same time, practical and effective decision support tool for planning sustainable transport in the Øresund region.

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10. Innovating for Green Supply Chain Management: The logistics service providers´ perspective

Britta Gammelgaard and Günter Prockl

Introduction

Environmental sustainability is an issue high on the political agenda in the European Union. The transport sector is a main ‘target’ for reducing greenhouse gas emissions as the transport sector is the source of approximately 8 per cent of the annual emission energy related greenhouse gasses (Kahn Ribeiro and Kobayashi, 2007, in McKinnon, 2010). Reducing the emissions, however, will to a large degree, depend on how transport is organized and managed.

When organising for sustainable transport, ideally the whole supply chain, from raw material to end-user, should be taken into account in order to prevent sub-optimisation of the transport network. From a sustainability perspective, this could mean that initiatives to improve the sustainability score in one part of the supply chain can create increased emissions in other parts of the chain. In contrast, if initiatives can be coordinated throughout the supply chain, real improvements may take place. Managing supply chains from end-to-end is a complex task, and in many cases will not be possible. However, from the transport and logistics service provider perspective, innovating for sustainability in collaboration with the customer is one place to start this endeavour. Creating sustainable supply chain solutions are in essence an innovative and collaborative effort.

As logistics service providers (LSPs) carry the consequences of customers´ decisions regarding transportation on their CO2 emissions, these companies are important actors in the creation of sustainable supply chains, often referred to as *green supply chain management*. These companies often react to customers´ demands on sustainable logistics services; however, a proactive approach on behalf of LSPs themselves in looking for environmental savings may create cost savings and increased business for LSPs. Such savings demand careful supply chain process analysis and thinking out of the box; in other words innovative thinking and action. An example of such a supply chain innovation is the Supply Chain Carbon Check™; a computer programme that can calculate the carbon footprint of specific logistics solutions including in-country transportation, international transportation, warehousing operations, and port operations. These calculations were proven more accurate than the industry standards that are most often used by customer companies (Blanco and Craig, 2009).

However, a supply chain management approach to solving problems of lack of sustainable transport is seldom taken into account and linking green supply chain management and process innovation is even less thought of. Moreover, innovation in itself seems to be much less applied in the transport- and logistics sector than in other sectors (Wagner, 2008). Pagell and Wu (2009) do, however, clearly link innovation capability with sustainability performance.

Initiatives that emphasise the combination of sustainability and innovation are, however, now emerging. In Denmark, the so-called EFFIE award granted by the Danish Freight Forwarders´ Association in collaboration with Danmarks Transport-Tidende was established in 2010. Excellent performance on the criteria of efficiency, innovation, and energy use are awarded. In North America, the LQ´s Third Party Sustainability Study and Awards Program was initiated and promoted by the Canadian trade magazine Logistics Quarterly as recent as in 2011. This programme emphasises supply chain collaboration between logistics service providers and clients and requires excellence on all triple bottom lines, namely the economic, environmental, and social bottom line (Closs and Goldsby, 2011).

This chapter looks into how logistics service providers may innovate for more environmental sustainable logistics solutions. The purpose of the chapter is to inspire logistics service providers to think about sustainability in a business and innovation context rather than 'just' a regulatory issue.

After this introductory section, the concept of green supply chain management is presented and discussed. Next, sections on sustainability and innovation in relation to logistics service providers specifically outline the present knowledge on these two issues. Thereafter, three cases - two winners of the Danish EFFIE award and one runner-up - are presented as examples of how logistics service providers can be proactive in innovating logistics services in a green supply chain management context. These cases are then analysed and discussed in order to create more general reflections on learning points and how to proceed with green supply chain management efforts from the logistics service providers´ perspective. The conclusion summarises the important learning points that can be drawn from the case analyses.

Green Supply Chain Management: What is it?

McKinnon (2010) presents Green Supply Chain Management (GrSCM) as the most recent theme within the discourse of *green logistics*. Other themes are *reducing freight transport externalities*, *city logistics*, *reverse logistics*, and *logistics in corporate environmental strategies*. He further builds on Klassen and Johnson´s (2004) definition of

Green SCM as the alignment and integration of environmental management within supply chain management. In their study on the impact of green supply chain management on economic performance, Rao and Holt (2005) found a positive relationship in a South East Asian setting.

Supply chain management is by CSCMP defined as "… the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies" (www.CSCMP.org). All logistics and therefore green logistics are seen as a function that differs from for example the function of purchasing. What makes the concept of GrSCM different from the other themes mentioned above - and even the concept of green logistics - is the collaborative, strategic, and long-term orientation of supply chain management. Supply chain management, involving at least three companies is, however, also systemic (Mentzer et al, 2001), meaning that whenever change is taking place at one place in the system, it influences the other parts of the system. Therefore, changes such as environmental improvements should be evaluated on a system/supply chain level in order to be sure that improvements one place in the system does not lead to worsened performance in another part. If supply chain members collaborate and exchange information, this should ideally be avoidable. Mentzer and colleagues (2001) also point to supply chain orientation as a necessity for making supply chain management work. This means that the individual member of the supply chain should be willing to sacrifice short-term individual profit to obtain long term individual and supply chain profit.

Carter and Rogers (2008) elaborate the definition above further by incorporating the idea of the triple bottom line into the SCM sphere. To achieve sustainability – *environmental*, *social*, and *microeconomic* performance should be integrated to allow for long-term economic viability[1]. This integration approach contrasts the more traditional approach to the triple bottom line as a three dimensional trade-off that has to be taken into consideration (McKinnon, 2010). A trade-off implies potential conflicts in obtaining all three sustainability goals at the same time as obtaining one goal may hamper the performance on another to a degree that outweighs the improvement of the first. A considerable problem in this respect especially regarding social and environmental aspects is measurement (Pagell and Wu, 2009; Closs and Goldsby, 2011).

Closs et al (2011) also build on the idea of the triple bottom line (sometimes referred to as people, planet, and profit) by proposing *dimensions* of sustainability. They extend, however, the understanding of the concept to include education of employees in sustainable working behaviour. The point of departure of this framework is a company

[1] This thinking builds on the much-cited definition of the so-called Brundtland Commission Report from 1987 where sustainable development is defined as "… development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987)

but the aspects of the dimensions are largely transcending company borders. The focal company in this model is probably not thought of as being a logistics service provider but by taking that perspective, it is possible to apply the framework to the analysis of what sustainability means for a logistics service provider and how they can approach their customers regarding development of sustainable logistics services. The dimensions are the following:

Environmental sustainability: Includes conservation of resources such as rain forests, usage reduction of for example fossil fuels and business practices such as packaging for transportation rather than marketing and sustainable sourcing.

Economic sustainability: Includes internal management such as strategic sourcing and transport optimisation as well as external management such as supplier management and customer relations (market creation).

Ethical sustainability: Includes employee relations, community development, or support as well as business practices such as product traceability. Only if the product can be traced back to its origin can the customer be sure that it is produced on sufficient ethical conditions along the chain of operations.

Educational sustainability: Includes employee relations that emphasise sustainable behaviour; talent development and business management practices such as education of own and suppliers´ workforce in environmentally sound behaviour.

The ethical and educational aspects of sustainability can be categorised in the same bottom line, namely the social but what is interesting about having a separate dimension for educational sustainability is that it emphasises that sustainable behaviour is not just a decision to be made; it has to be learned by the actors in the supply chain. This observation is confirmed by Mamic (2005) who especially mentions the learning process from multinational companies to suppliers in emergent markets. This educational dimension thereby leads to a dynamic perspective of sustainability in supply chain management.

In conclusion, GrSCM is a strategic concept that may affect the supply chain design as opposed to the operational concept of green logistics (Shrivastava, 2007). GrSCM does focus on alignment and integration of environmental aspects in supply chain management, but focusing on improvement of this aspect alone without taking changes in economic and social aspects into consideration, is meaningless. We therefore suggest the term Sustainable SCM (SSCM) is used as an overall term to GrSCM. The recent MIT/Sloan Management Report on sustainability confirms this as the leaders in sustainability see improvements here also as a source of improving both competitive power and recruitment of talent (2011). The main focus in this chapter is however GrSCM, as this is the overall idea of the Øresund Ecomobility project.

Sustainability in the logistics service industry

Lieb and Lieb´s 2008 and 2009 surveys reveal that 40 large logistics service providers in the North America, Asia-Pacific, and Europe have sustainability on their corporate programme. The reason is partially that they think it is important, partly because their customers ask them to do so, and finally, that they want to attract "green" customers (Lieb and Lieb, 2010). The demanded sustainability capabilities were (Lieb and Lieb, 2010, p. 529):

- Support customer effort to reduce carbon footprints
- Enhance existing return logistics programmes
- Reduce fuel, water, and electricity consumption
- Help customers comply with various industry certification programmes
- Dispose of hazardous material
- Develop recycling programmes
- Improve performance of customer vehicle fleets; and
- Develop renewable energy sources, especially at customer facilities

Wolf and Seuring (2010), however, did not find in their US and European cases of six transport buyers and three transport providers support of specific customer emphasis on sustainability issues. They conclude that sustainability performance at present do not overrule more traditional buying criteria such as price, quality, and delivery reliability; at best it is considered as a minimum requirement for doing business. Anderson et al (2011) confirm the focus on economic criteria in selection of logistics service providers in their study of logistics customers in Asia Pacific; sustainability is not even mentioned here.

Both studies point at economic and environmental aspects in the buying criteria for transport and logistics services even though it seems like the economic aspects of logistics provider selection are the most important. The reason behind this situation is possibly that economic sustainability is considered the basis of business and further that the environmental and social aspects are viewed as 'add-ons,' not at least because it is difficult to quantify the value of these aspects at present. Another reason could be that historically manufacturing companies have been occupied mainly with their internal sustainability and are just starting to think more about requirements for their logistics and transport services. Finally, the lack of integration of sustainability data in the supply chain could be a major issue in preventing sustainability to an order winner (AlfaLaval, conversation 2011).

Innovation in the logistics service industry

Innovation in the logistics industry has not been a prevalent topic (Busse and Wallenburg, 2011). According to Wagner (2008) investments in innovation in this industry has lagged considerably behind other important sectors such as vehicle construction and electronics. The explanation of this phenomenon is that innovation in the field of logistics often takes place together with customers in specific customer relations and is therefore not disseminated throughout the organisation (Wagner and Franklin, 2008).

Wallenburg (2009) proposes that innovation in logistics can be categorised in two classes. The first is innovations taking place internally in the logistics company in order to increase internal operational efficiency and the second is customer-related innovations where those directed towards individual customers rather than multiple customers have the highest potential for increasing competitiveness. Therefore, when this second class of innovation customer loyalty is increased, the relationship has a higher propensity of becoming long-term. As service complexity increases, the likelihood of strategic customer relation due to innovation increases. According to Wallenburg, innovation in specific customer relationships is therefore an important aspect to retain a customer. This is important, as the cost of capturing new customers is increasingly high compared to on-going relationships. Wallenburg´s (2009) analysis further shows that German LSPs do not fully exploit this potential of innovation and customer loyalty.

Chapmann et al (2003) argue that innovation may take place in relation to products, services, and processes. In relation to all three elements, there are three levels of innovation where the most basic is *incremental* – ‘small step’ innovation - and *architectural* innovation comes next. Architectural innovation imply novel configuration of existing systems. The next level is *radical* innovation that redefines the way we think of or use a service. Finally, *transformational* innovation is the highest level of innovation that covers completely new products, services, or processes (Chapmann et al, 2003: 632). An example of a transformational logistics process innovation is McLean´s container as mentioned in f. ex. Grawe (2009) that made integration of logistics flows efficient. Specifically for the logistics industry, which Chapmann and colleagues consider being a service industry, technology, knowledge and relationship networks are seen as the most important sources of innovation. In addition, Cui and Hertz (2011) emphasise network as important characteristic of logistics service providers. Further, Cui et al (2009) point out that the character of logistics innovation varies according to the geographical region they operate.

Wagner (2008) suggests that product/service innovation in the LSP sector is taking place when the customer is offered new or improved services, and new performance promises are realised. Moreover, when implementation of new techniques, methods, or procedures with the goal of continually improving the quality of a service or reduce the cost of providing a service, a process innovation is taking place.

The logistics innovation process model deals with innovation processes in customer related logistics (Flint et al, 2005; Flint et al, 2008; Busse and Wallenburg, 2011). Ideally both product/service innovation and process innovation may be the outcome of a deliberate approach in innovation but process innovation is probably the most straightforward result of a collaborative innovation effort as depicted in the logistics innovation process model. Su et al (2011) showed that the logistics innovation model is also valid in supplier relations meaning that if the initiative to innovation is the customer´s it will work as well.

Flint and colleagues define innovation as “an idea, practice or object that is perceived new to an individual or other unit of adoption” and thereby drawing on Rogers, (2003, p12). In this particular context, we use the same definition acknowledging that these users may also be co-creators of innovative solutions. These solutions may be new in the specific context where they emerge but may not be new to the world.

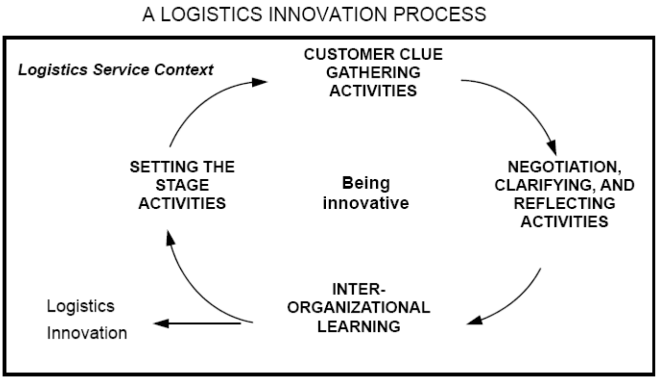

Figure 1: *The Logistics Innovation Process Model (Flint et al., 2005, p. 127)*

The logistics process innovation model is the basic point of departure in describing and analysing how logistics service providers innovate sustainable logistics services and processes in collaboration with suppliers or customers. Sekerka and Stimel (2011) further point to inter-firm relationships as a way to obtain sustainability, particularly in times of economic recession. The starting point of logistics innovation is “setting the stage,” meaning that the process has to be conscious, thought through, and prepared. Next, “customer clue gathering,” means that knowledge about the customer´s needs has to be obtained. Then the development starts in the “negotiation, clarification, and reflection” phase. If successful, it can lead to inter-organisational learning and logistics innovation. The “Logistics Service Context” in the model is firstly GrSCM with detours to the idea of sustainability as a triple bottom line. The sources of the logistics service or process innovation outside the specific supply chain relationship will be technology, knowledge, and/or network relationships. The logistics innovation will be incremental, architectural, radical, or transformational as understood by the users and/or co-creators.

Secondly, the logistics service context consists of the leadership approach to GrSCM innovation. Closs et al (2011) outline three different approaches to sustainability: the true *innovator,* who takes the lead in sustainability issues and where sustainability is a strategic priority; the *contributor,* who prefers to look to industry best practice for ideas to improve; and finally, the *reactor,* who responds to requests from the outside world and primarily is interested in the economical consequences of improvements for sustainability.

GrSCM innovation cases

The EFFIE award is granted for excellence in efficiency, energy/environment, and innovation. The award has been granted in 2010 and 2011 on the basis of proposals from regions of Danish Freight Forwarders' Association. In each of the two years there were three nominees and all six nominees were given the opportunity to participate in the Øresund Ecomobility project. Three accepted the challenge and are therefore case companies in this chapter. The award does not in itself talk about supply chain management, but this is implicit, as the freight forwarders think of themselves as supply chain integrators (www.dasp.dk). Further, it does not emphasise social aspects of sustainability, however, green and innovative approaches are combined, which makes it relevant in relation to this chapter´s idea of the need for innovative approaches to establish GrSCM and even sustainable supply chains.

The case companies are logistics service providers with Nordic roots: one Norwegian, one Finnish, and one Danish. All three companies are located in the Øresund region, although none are headquartered there. The following case studies and chapter draws upon input from an Øresund Ecomobility workshop for LSP executives in the Øresund region that was held at CBS in Copenhagen in September of 2011. The focus of the workshop was on transcending barriers for sustainable development and how to further develop sustainable strategies.

The cases are further chosen on the basis of the anticipation of them having an *innovator leadership approach* or a contributor approach to sustainability as opposed to a *reactor* approach (Closs et al, 2011), which is necessary in order to be inspirational to others.

The innovation case descriptions take their point of departure in the particular cases that made them win or run up for The EFFIE award. These cases are documented in articles on Danmarks Transport-Tidende and supplemented by Internet sources. These cases were then followed up by interviews of the winning companies about innovation and sustainability, as documented and discussed in Tveit, Dahle and Thomassen (2011), which also is the basis for the description of the companies´ approach to sustainability and the innovation processes.

***Fresh goods on rail from Scandinavia to Verona Italy* by BringFrigo (EFFIE winner 2010)**

BringFrigo (formerly BringFrigoscandia) is a leading company in the Nordic region providing transportation of fresh goods such as meat and fish. The company is owned by Posten Norge (Norway Post) and is present in Scandinavia as well as Finland, France, the Netherlands, and UK. The company offers temperature controlled supply chain solutions including cold stores. They have daily departures of full loads, batch goods, and general cargo to Scandinavia and the rest of Europe (TT, week 51, 2009, p.6).

The innovative solution that was recognised with the EFFIE award in 2010 was an intermodal connection from Norway, through Denmark and the European continent, to Verona, Italy, in order to provide fresh goods. In this intermodal solution, a rail connection via continental Europe was established through collaboration with a German rail operator that provided priority rights on the German railways. Where rail is usually considered slow and inflexible compared to road transport, this solution worked because of the collaborative relationship, electronic surveillance through GPS, and constant telephone connection to the locomotive driver. Also, a system of temperature surveillance was established so that it became safe to transport fresh goods through a long distance. Surprisingly, the time needed for the railway solution was shorter than for road transport. Rail transport is more sustainable than road transport and further reduces congestion on roads thereby limiting its impacts on sensitive European nature. BringFrigo´s estimation of the reduction in CO2 emissions of this connection is 1.200 tons in 2007 and 2.600 tons in 2008 (Bring presentation for the EFFIE award, 2010).

This particular innovation case emphasises the environmental issue over economics; at least the solution is not cheaper than the more traditional road transport solution. BringFrigo looks for opportunities to expand individual solutions to as many customers as possible and preferably to a 'standardise' service. Bring seeks to have environmental friendly logistics as part of their brand.

Bring has an overall goal of reducing CO2 emissions by 30 per cent by 2015. This is partly done by establishing close connections to individual customers in BringFrigo. The initial "setting the stage" phase is not formalised, as the company fear that this will restrict the necessary creativity. Customers presenting their challenges or problems mostly create ideas for innovative solutions. Sustainability is not a prominent topic at this time due to the economic crisis; however, the company anticipates that this will change in the future. As the current economic situation makes business highly volatile, innovation is not something that can be planned as the situation may change from day to day. "Clue gathering" is taking place on an on-going basis through telephone, mailings, and not at least, personal meetings every other month. Sometimes information through channels external to the relationship is obtained. In the "negotiation, clarifying, and reflection" phase, sustainability is often not an issue brought forward by the customer. BringFrigo on the other hand is eager to do so because of its formal strategy that emphasises environmental sustainability. It is, however, a challenge to make employees aware of environmental sustainability polices. BringFrigo sees a trade-off between economic and environmental sustainability where priority is most often given to the first mentioned. "Inter-organizational learning" is taking place specifically in relation to big customers. Learning in general is considered important for developing future business both in relation to large and small customers.

Increased truck loads with Itella Logistics A/S (EFFIE runner-up 2010)
Itella Logistics A/S is a logistics service company with a presence in Finland, the Baltic States, Russia, Norway, Sweden, and Denmark. The services offered are customised logistics and supply chain solutions including contract logistics (www.itella.dk/logistics). The company is owned by the Finnish Post (TT).

The specific case in action is a customer relationship with a packaging company in Denmark. Itella offered a 100 per cent tailormade solution including national transport, warehousing at two facilities, and an IT system controlling the flow of goods and communication between LSP and customer. Itella posted employees at the customer´s facilities in order to secure efficient integration of the flows, so that the two parties together could find the best possible solutions exploiting the knowledge of both companies. Together they developed solutions that increased truck load utilisation, thereby reducing CO2 emissions. The expectation is that future innovative logistics solutions will emerge out of this close collaboration (Danmarks Transport-Tidende, 2009, week 49).

Itella Logistics as being a part of a state-owned company must adhere to regulations on sustainability, and these requirements are communicated via their website. Sustaianability is, according to Tveit et al (2011), considered as a prerequisite for doing business in the future, however, at present environmental sustainability is not the most prominent theme or order qualifier in daily business. Not at least due to the economic crisis, as economic sustainability is at the forefront of customer relations and sales. The postion of the firm is that the basic precondition for both environmental and social sustainability is economic sustainability. If that is not present, nothing else is. At the time of the interviews in the spring of 2011, sustaianbility was not integrated in the innovation setup of the company, as they were not yet ready to formalise such processes.

The innovation process of Itella largely followed the logistics innovation process model. *Setting the stage* for logistics innovation is, for Itella, the creation of trust between themselves and the customer. In Itella's understanding this is crucial due to the character of logistics as a service that cannot be evaluated before purchase. *Customer clue gathering* is done by informal conversations, but Itella employees are trained in asking the right questions to the customer. So despite the informal character of much of the dialogue with customer, the process is not random. More formal meetings with important customers are also arranged and information from networks and written public sources is also gathered. When the stage of *negotiation, clarification and reflection* is reached, data analysis of customer data forms the basis of such processes. Sometimes customers put specific problems forward or ask for specific solutions to problems. Internal discussions, negotiations, and analysis of the problem, which might turn out to be a different one than anticipated by the customer, is an important part of this stage. These three stages are all preparation for implementing a new customer contract and are considered to be the foundation of a successful relation. *Inter-organizational learning* is the outcome of a good relationship and this close interaction with customers is highly valuable to Itella and is also important for future innovations. Itella also spend time in considering how new and innovative solutions emerging out of one relationship can be dispersed into others. Generally, the process of developing new customised solutions together with the customer is, despite the informal character of the relationship, quite formalised. As environmental sustainability is not at the forefront of the agenda in negotiating new solutions with customers at present, we consider the Itella leadership to be *contributor* regarding sustainability.

"Harmonica curtain" trailers for load size flexibility at Freja Transport & Logistics (EFFIE winner 2011)

Freja Transport & Logistics is a Danish company with representation in Denmark, Norway, Sweden, and Finland. The company offers transportation and logistics services, preferably as a strategic partner customising services to individual customers. Environmental responsibility and advanced IT solutions for integrating solutions are their primary competitive focus areas.

This case is about Freja, regarding their transportation of broad steel plates over several years to Sweden and Germany for their customer, Dansteel (Danmarks Transport-Tidende, 2011, 7). The unique problem with this contract was that the trailers had to be open due to the oversized nature of the goods being transported. Due to the open trailers, it was very difficult to obtain return goods from the destination country, which made both the price and environmental impact of the transport very high. In 2009, Freja became aware of a trailer with a harmonica curtain. With this curtain, the trailer could be open or closed depending on the size of the goods. This meant that return goods could now be loaded on the trailers after bringing the steel plates to their destination. Empty truckloads were thereby reduced by 20 per cent. Freja provides this customer (and others) with a customer specific CO2 emission report that makes it possible for them to measure performance improvements.

When Freja became aware of this opportunity, they informed their customer and thereby deliberately made it possible for them to let their competitors know about it and embed it in the upcoming tender. Freja did however, win the tender and continued their long-term relationship with Dansteel. The consequences of this new solution were that it now became possible for Dansteel to expand their markets to Poland, France, and Benelux. Freja had to reduce their prices, but at the same time they expanded their business with this particular customer through this innovation.

Sustainability is highly prioritised at Freja; apart from the customer specific emission reports, Freja has been ISO 14001 certified since 2000. For Freja, environmental sustainability is to a high degree a question of reducing CO2 emissions, and the optimisation of truckloads in order to minimise empty spaces, is the most important way to do so. Further, Freja´s new IT fleet system makes it possible to improve optimisation of truck loads. Freja sets new goals for truckload optimisation every year and emphasises optimisation of economic and environmental sustainability at the same time.

Embarking on innovation processes, Freja does not always set up goals in the "setting the stage" phase, but an open-minded dialogue with employees, especially those close to customers, about creating new and innovative solutions for them and potentially the supply chain, is an on-going process. Management challenges the employees in their approach and encourages them to listen to the customers to find new collaborative solutions; the process is, at this stage, not formalised, and management´s position is that innovation cannot be taught. “Customer clues” are gathered in on-going dialogue with customers and with the larger ones, there are strategic meetings every year with the purpose of evaluating where the partners can discuss new initiatives, tools, and processes. Most attention is given to customers who themselves see the value in innovation. “Negotiation, clarifying and reflecting activities” consists of analysing data in collaboration with customers. Freja highlights trust and confidence as critical in this part of the process. Freja tries to push for environmental concern in new solutions; innovations do, however, not always lead to improved environmental sustainability but in many cases they do. Freja also emphasises “inter-organisational learning” as well as intra-organisation learning from these innovation processes, and has overall a developmental oriented approach to their processes. Interaction with big customers or niche customers with a high level of complexity is a source for creating new solutions that also applies and benefits smaller customers.

Cross-case analysis

All three companies had incorporated environmental sustainability to a certain extent in existing innovation processes, although the emphasis of this from customers was not great. The overall impression is that the logistics service providers largely struggle with environmental sustainability themselves at this point in time because of the international financial and economic crisis. Environmental sustainability was clearly accepted by customers as long as it increased economic sustainability, for example by increasing truckloads. The case companies were, however, all future oriented as they anticipated that times would change in direction of demand for sustainability. The innovation processes were moderately formalised; the case companies seemed worried that formalisation would lead to less creative solutions. The three case companies emphasised interaction with customers as an important source for innovation logistics processes.

What also appeared from the cases was that there might be a trade-off between the sustainability aspects and economic aspects. Despite customers seeming not willing to let economic sustainability trade-off against environmental sustainability, the inverse did not appear to represent a big issue with customers. This should, however, be based on the fact, that all case companies lived-up to basic environmental regulations. Therefore, the trade-off should be evaluated against extra environmental efforts not required by government. As mentioned this was not specifically in demand from customers. But when economic and environmental sustainability went hand-in-hand, in for example increasing truckloads and thereby creates savings for the customer, it was considered a good thing. The problem for the logistics service provider though, is that they lose business, which means that increased environmental sustainability can be expected only when more business can be developed by the customer and hence the LSP, now or in the future. Integration of economic and environmental sustainability therefore makes a lot of sense in these particular situations, whereas integration of social aspects did not play a role in the innovation cases. The reason for this could be that these issues are handled in other parts of the company; that it is not considered a problem or that a potential problem is ignored by the LSPs as well as the customers. We anticipate that social issues are well taken care of in the reputable case companies presented herein, but in general they should play a role in relation to the sustainability aspect also in Scandinavian companies, not at least when using subcontractors. The social aspects in the innovation processes are however, integrated in considering employees as actors in the innovation processes. These are the ones that should be creative and innovative in dealing with customers and therefore should know about polices and practical aspects of environmental sustainability. This means that including *educational sustainability* in the social aspects is meaningful. Integration of all three sustainability aspects, with the economic aspect being the foundation, therefore makes a lot of sense. The implication of this is that we see the concept of sustainable supply chain management as more suitable than GrSCM focusing solely on environment.

The innovation processes in the case companies were highly structured even though the phases of the logistics innovation process model could not be identified. Innovation processes seem to be highly integrated in the on-going customer relations, specifically with larger customer companies. The case companies seemed to be worried about formalising the logistics innovation processes, either not to prevent creativity or simply because of the conviction that innovativeness can not be learned by procedures or at all. This anticipation could very well be reconsidered given the findings of Daugherty et al (2011) that formalised decision structures lead to higher levels of logistics innovation. Decentralised decision-making is, however, important, so creativity seems to be harmed by centralised decision making rather than formalised procedures, again according to the findings of Daugherty and colleagues. Formalised procedures in logistics innovation can of course be a result of centralised decision-making but need not be.

Level / Type	**Incremental**	**Architectural**	**Radical**	**Transformational**
Service		BringFrigo-case		
Process		Itella-case		Freja-case

Table 1: *Logistics innovation in supply chains; types and levels*

In comparing the cases and case companies in relation to innovation type and degree, we find that both BringFrigo and Itella cases are architectural innovation types. The innovations are, however, different, as the BringFrigo case is a general integrated logistics service offered to all relevant customers, whereas the Itella-case is an architectural innovation, as the division of labour between Itella and customer is changed as new logistics processes are installed in their relationship. The collaborative relationship between Itella and its customer created new business for Itella by an innovative solution that allowed Itella to increase full truckloads, thereby saving money. Likewise, we have categorised the Freja-case as a transformational logistics process innovation. This is not due to the hardware used in transporting oversized goods one way and normal sized good back. This is rather due to supply chain approach offered by Freja to its customer. The approach sacrifices short-term earnings for potential long-term gain in helping the customer serving new markets. Had this approach not been use, we would have considered the innovation to be incremental. Both Freja and their customer expanded their business due to this innovation. It is then important to acknowledge that it is not the ‘harmonica curtain trailer’ as such that is the innovation, but the way it is adapted in a specific situation. The innovation is not transformational in the sense that it transformed a whole industry as McLean´s container did in the 1950s but it transformed one or more supply chains. A question that could, however, be asked is whether environmental sustainability was improved on an overall level as it increased truck transportation at the expense of short sea shipping. An answer to this question is, however, out of the scope of this analysis.

Table 1 creates an overview of not only the specific cases and their ‘parent’ companies, but also an approach to how logistics innovation could be elaborated and systematised further in addition to the logistics innovation process model. When it comes to logistics innovation in sustainability, all types of innovations matter. In this process more innovator leadership styles will have to come into play. In our case collection only Freja had this approach. Integration of at least economic and environmental aspects of sustainability is presumably a necessity, not at least in difficult economic times. One problem seems, however, to be that there is no particular incentive for exceeding regulatory requirements so that it pays to do more than asked for by government. According to the MIT/Sloan Management Research Report (2011), a possible future trend will be that companies will demand sustainability and that will have implications for the whole supply chain including the logistics service providers. Another problem is how the supply chain can benefit from ‘voluntary’ improvements made by a LSP, as no standard performance sustainability measurement system exists today.

The case studies also showed that collaboration with supply chain partners were important in developing innovative supply chain solutions. They also showed that in addition to what most literature emphasises, namely customer relationships as the source of logistics innovation, supplier relationships represent another potential source of innovation.

Conclusion and outlook

This chapter has focused on LSPs’ logistics innovation for sustainability in the supply chain. The point of departure was that an innovative leadership approach to developing sustainability in the supply chain is necessary. We further suggested that a green supply chain management approach should be expanded to include economic and social sustainability, and that the three aspects should be integrated into a *sustainable supply chain management approach*. The economic aspect of sustainability is the basis for operations and without economic considerations, green supply chain management is not likely to happen. The social aspect should, in addition to ethical considerations, include education of employees about sustainability issues, as employees often are the actors that can make environmental sustainability happen. However, this is often quite complicated, therefore education is needed. Further we propose that not only logistics services offered to all customers but also logistics integrated processes with customers, are objects to innovation. These innovations may have four levels of sophistication, namely incremental, architectural, radical, and transformational innovation. A somewhat formalised model to achieve sustainable logistics innovation is suggested; using the logistics process innovation model (fig. 1), LSPs may look for the whole range of innovation options in a systematised way. Recent research reveals that logistics companies do not have to fear the formalisation of processes as a 'killer' of creativity.

Three cases and case companies were presented and analysed to learn about logistics innovation for sustainability. From these cases, it became clear that environmental sustainability is an important issue but at this point in time, it is rather something expected than a factor that can create orders in concrete customer relations. If improvements in environmental sustainability create economic sustainability it is appreciated, however, economic sustainability is viewed as the basis for business. All three companies emphasise environmental sustainability in their marketing material, which leads us believe that this is something they expect to be a driver of competition in the future. In addition to the economic and environmental sustainability, future customers may also want to know about social issues not only in the contracting company, but also in subcontracted companies. Of these specific cases we had the opportunity to dig into, only one used a supplier to develop a new service. We anticipate that the future will show that this will be more the rule than the exception. Transparency in the transport and logistics chains will be a 'must.'

Finally, we saw adoption of supply chain management thinking in the Freja case. Here supply chain management principles (mutual trust, information sharing, and long-term approach) were creating a so-called 'win-win' situation for Freja and its customer. It is hard to say if this is always an option in concrete customer or supplier relations, but on the other hand, both this case and the Itella case, showed synergy effects in collaboration with customers as theory proposes. In this chapter we have only revealed a very, very small portion of what is going on in relationships between LSPs and their customers. Our final proposition is that there is much more to gain in the Oresund and Nordic logistics service industry by opening up to innovations for sustainability in relation to both customers and suppliers and the supply chain as a whole.

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11. Design and Control of Sustainable Supply Chains

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Introduction

In striving towards a more sustainable society, logistics can have a major impact. By shifting to more sustainable transport modes, without giving up on the logistical requirements, CO_2 and other emissions can be reduced. Together with a growing environmental awareness, increasing fuel prices, and the introduction of climate related taxes and regulations, the need for sustainable supply chain solutions that recognise the importance of freight transportation systems is accentuated.

In order to be more environmentally friendly, distribution systems should favour shorter shipments, less handling, reduced number of trips, more direct routes, and better space utilisation. Moreover, possible strategies to achieve this involve shipment consolidation, larger batch quantities, lateral transshipments, and combinations of different modes of transportation. However, these strategies may have negative effects on productivity, customer service, and/or inventories from a supply chain perspective. Therefore, as also discussed in Chapter 10 (Gammelgaard and Prockl), a competitive and sustainable solution that avoids sub-optimisation requires that the transportation system is carefully coordinated with upstream and downstream supply chain inventory and production decisions. Another aspect of this problem is that because of poor coordination many distribution systems today fail to meet the required service levels without extensive use of express deliveries, typically by air, at high environmental cost. A growing number of companies are realising these issues. However, a challenge is that there are few conceptual models and software tools available to aid in the design, control, and evaluation of these complex systems.

In this chapter we discuss how this challenge may be addressed using new models and methods developed at the division of Production Management, Lund University, Faculty of Engineering. We focus particularly on methods for: better inventory control of multi-stage distribution systems to avoid emergency deliveries by air, efficient use of emergency orders and express transshipments, and shipment consolidation in supply chain inventory systems. The results in terms of conceptual and analytical models, as well as software tools, can be of direct use for companies that aspire to achieve cost efficient and sustainable supply chain solutions. Many such firms are found in the Öresund region and many more ship goods through the area affecting its environment.

The chapter is organised such that the remainder of this introduction is devoted to an overview of the challenges and results associated with the focus areas presented above. Four sections where the methods and results for each focus area are explained in more detail follow the introduction. More precisely, Section 2 explains the methods for improved inventory control of divergent supply chain distribution systems. Section 3 deals with efficient use of emergency ordering. Section 4 describes how transshipments/express deliveries from a regional warehouse can improve supply chain performance, when the inventory decisions at the warehouse and the retailers are coordinated. Finally, Section 5 further explains our developed models for shipment consolidation in supply chain inventory systems. Section 6 concludes and summarises.

From an EcoMobility perspective, our interest in methods for better inventory control of divergent multi-stage supply chains stems from discussions and collaboration with several large companies including, Volvo, Tetra Pak, Lantmännen, and the supply chain management software provider Syncron International which, in turn, has a substantial client base of large companies. An issue raised in these discussions is the costly use of emergency airfreight due to the inability to maintain promised service levels. In particular, for expensive and critical products like spare parts, the cost of not having the item in stock when the customer demands it can be very high. This means that whenever a situation such as this arises there is an economic rational to use emergency deliveries by air. However, with better inventory control methods much fewer emergency situations will occur. A concrete example of the impact these emergency airfreight deliveries can have is found in Gertsson and Ling (2009). They studied the distribution system at Lantmännen Maskin and concluded that emergency airfreight was responsible for about 85 per cent of the systems total CO_2 emissions. Lantmännen Maskin distributes agricultural machinery and spare parts from their central warehouse in Malmö to local warehouses and service providers in Sweden, Norway, Denmark, and Finland. Regular shipments are almost exclusively transported by truck, and emergency orders either by truck or by air depending on which mode of transport is the fastest. Here the distance to Malmö is the determining factor.

The model we have analysed considers a central warehouse and an arbitrary number of local warehouses or retailers. The latter replenish their stock from the former, which in turn replenishes from one or several external suppliers. A key feature in our model is that it jointly optimises the reorder points at the central warehouse and at the retailers to coordinate the inventory control for the entire system. The model is designed to be computationally feasible for direct implementation in real systems. It was developed in close collaboration with Syncron and one of their customers, a global spare parts provider (with headquarters and a central warehouse in the Öresund region) from which we have had access to real data. Our simulation results show that the model is accurate and achieves the service targets much better than the current system. From the simulations, based on real case data, we can see that for low demand items our new method on average increases the fillrates from 12 per cent below target, with the current solution, to an average fillrate of 0.6 per cent above target. At the same time, the average total inventory is reduced by about 12 per cent. Assuming that emergency airfreight is used to cover all shortages, and knowing that the average target fillrate is 92 per cent, these results suggests that using our method could reduce the emergency airfreight volume by about 60 per cent. For items with higher demand, the reduction in emergency airfreight is a little less, about 45 per cent, while the average reduction in total inventory is much larger, about 30 per cent. Thus, our model can offer substantial reductions of costs as well as emissions. The model is under implementation in Syncron's supply chain software.

Turning to the efficient use of emergency ordering, further explained in Section 3, the EcoMobility importance is fairly obvious as it involves the choice between different modes of transportation. The model we consider consists of a single inventory location that can replenish its stocks using regular orders or emergency orders. The regular orders are associated with longer lead-times (slower more environmentally friendly transportation) and lower delivery costs. The emergency orders have shorter lead-times (faster less environmentally friendly transportation) and typically higher delivery costs. At each replenishment opportunity, the inventory location needs to decide if a regular or emergency order should be placed. The replenishment costs must be balanced against the costs of holding inventory and the shortage costs associated with unsatisfied demand. Our work results in a decision rule with a performance guarantee. This means that applying this rule can never increase the costs over the alternative where only regular orders are allowed. Thus, it provides a tool for combining the use of different transportation modes, and balancing the associated delivery costs against the resulting inventory costs.

Our work on how express deliveries (transshipments) from a regional warehouse can improve supply chain performance (further described in Section 4) stems from close collaboration with Volvo Parts, a spare parts provider of Volvo AB. On most markets they have a distribution system consisting of: (i) dealers that sell spare parts and typically perform service on vehicles made by Volvo AB, (ii) a regional support warehouse that can provide fast (typically overnight) deliveries to the dealers on the same market, and (iii) a central warehouse (which for the European markets is located in Gent). Under normal circumstances, the dealers replenish their inventory from the central warehouse. However, in case of shortages, the dealer can turn to the regional support warehouse and receive an express delivery. The support warehouse replenishes its stock from the central warehouse. From an EcoMobility perspective the support warehouse structure is an interesting alternative to express deliveries by air from the central warehouse. The express deliveries from the support warehouse are typically made by truck. The distances are such that biogas or electrical vehicles can be used, although today this is not the norm. Thus, they do involve extra transportation costs and emissions, albeit to a much lower extent than direct deliveries by air from the central warehouse. In a sense, the support warehouse structure represents a way to position safety stock closer to the market and thereby enables slower more environmentally friendly freight transportation. There are many companies besides Volvo Parts that have recognised these benefits, for example Tetra Pak Technical service (with their central warehouse in Lund), which are changing to the support warehouse structure in order to reduce the need for air transports. However, within the support warehouse structure an important issue is to coordinate the inventory control decisions at the dealers and at the support warehouse to achieve a sustainable cost efficient solution. Our work on this has focused on two slightly different models, which are both computationally feasible to implement in practice.

The first model is a flexible approximation that allows batch ordering at the dealers, and at the support warehouse (see Axsäter, Howard and Marklund (2011)). It assumes that as soon as a dealer experiences a shortage, it will order a unit from the support warehouse. This reflects the current behaviour in Volvo Parts' system. From our simulation studies, based on real data from the company, we can see that our model offers large potential savings and improved sustainability. On average, the new method reduced the costs of holding and distributing inventories by 29 per cent while maintaining dealer service levels above targets. The average inventory was reduced by 43 per cent, and there were about 30 per cent fewer express deliveries from the support warehouse. The latter is particularly interesting from an EcoMobility perspective as it means environmental benefits in terms of reduced emissions. Thus, our model offers Volvo Parts an opportunity to both reduce their costs and be more environmentally friendly.

The second model focuses on incorporating real-time information about incoming deliveries into the decision of whether to order from the support warehouse or not. An additional feature is that in case the support warehouse is out of stock, dealer requests that materialise can be satisfied by express deliveries from the central warehouse directly to the dealer in question. The decision about initiating an express delivery or not is based on the time it takes until the request can be satisfied by an incoming delivery to the support warehouse. A simulation study based on data from Volvo Parts show that, by using our model, stock keeping and distribution costs may be reduced by 12 per cent, on average. The study also illustrates that, for most items, the new policy avoids express deliveries from the central warehouse all together.

The EcoMobility motivation for our work on shipment consolidation (further explained in Section 5) is of course that it offers ways to better utilise the transportation capacity, and thereby reduce the number of load carriers (i.e., trucks, boats, planes etc.) needed to transport a given volume. This clearly is one way to achieve more sustainable supply chains, which is also discussed in Chapter 7 (Carlsson and Janné) from a city transport and logistics perspective. However, an important aspect to recognise is that consolidating shipments typically leads to longer lead-times. Longer lead-times mean increased inventories in order to maintain the same service to the end customers. Thus, it becomes important to balance the costs associated with the shipment consolidation decisions against the costs associated with the inventory control decisions. With this as the starting point, our work to date has focused on models for joint consideration of inventory and time-based shipment consolidation decisions. Moreover, we consider these decisions in supply chain inventory systems consisting of a central warehouse and an arbitrary number of retailers. This means that shipments from the central warehouse are consolidated to groups of retailers by only allowing shipments at regular intervals, for example once a week. The time between shipments to each retailer group is referred to as the shipment interval. The models we have developed provide exact mathematical characterisations of these types of systems under various assumptions, for example, regarding demand structures. They also provide viable tools for joint optimisation of the shipment intervals and reorder levels for all stock-points in the system. An important feature is that they are applicable both to single-item and multi-item systems. In the former, there is a single product that is distributed to the retailers, and in the latter, there are multiple items that are distributed from one or several central warehouses to the retailers. The multi-item system is of course more prevalent in practice, although there may be situations where items cannot be mixed on the same load carrier (container, truck etc.). The models are useful both for firms with a private transportation fleet, (i.e., they own and control their own trucks, planes etc.) and for third party and fourth party logistics providers (3PL and 4PL). In all these cases, the same firm is in charge of the inventory and transportation system, and it is the total cost that is of importance. However, the models can also be of use for transportation carriers as a tool for determining how large economic incentives they can/must offer their customers in order to convince them to use more regular shipment patterns. Without a reasonable profit sharing scheme, the carrier would reap all the benefits at the expense of higher inventories at their customers upstream and downstream in the supply chain.

In the following sections our work in the different focus areas are further described and elaborated upon. Detailed descriptions and technicalities are carefully specified in the underlying reports, and scientific articles referenced in the following sections are listed in the references at the end of this chapter. Unpublished reports and other material are available from the authors upon request.

It is worth emphasising that in this chapter we deal with quantitative models that can support and improve supply chain planning and control. Such models are especially useful in connection with short-term operational decisions. Other chapters in the book consider related topics in different contexts and from different perspectives. For instance, Chapter 10 (Gammelgaard and Prockl) considers strategies of logistics service providers. Such strategies are important particularly for long range planning. Moreover, Chapter 6 (Abassi and Johnsson), 7 (Carlsson and Janne) and 8 (Hvass and Teilmann) deal with distribution in urban areas. The transportation in urban areas is growing rapidly and the associated planning problems become increasingly important. Shipment consolidation is one of many important issues in this area.

Methods for better inventory control of multi-stage distribution systems

The distribution system we consider, consists of one central warehouse and an arbitrary number of retailers, see Figure 1. In the inventory literature, this is often referred to as a one-warehouse N-retailer system. There exist a large number of models and approaches for analyzing different aspects of this problem, but still there are few reported applications of these integrated models in practice. One reason for this is that most existing models are difficult to directly apply because of restrictive model assumptions and/or conceptual and computational complexities. Our work has therefore been focused on developing simple and flexible approximation models that can be directly implemented in practice. The purpose of these models is to coordinate the inventory decisions in the system by joint optimisation of the reorder points at the central warehouse and all retailers.

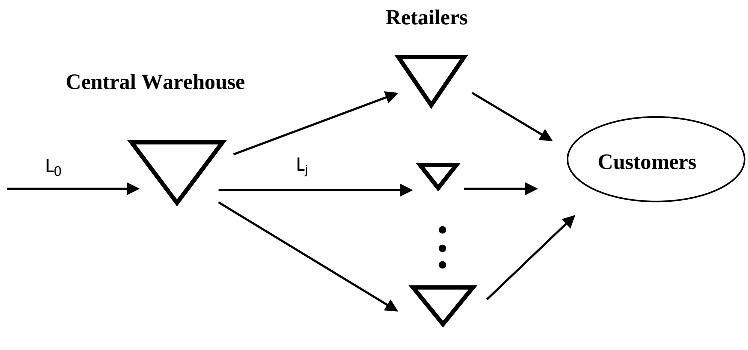

***Figure 1**. The structure of the considered multi-echelon inventory system*

The work is based on close collaboration with a supply chain management software company, Syncron International, and one of their customers, a global spare parts provider (with headquarters and central warehouse in the Öresund region). Important requirements posed on the model are that it should: (i) handle reorder point policies with batch ordering, backordering, and partial order deliveries, (ii) jointly optimise and coordinate the reorder points in the system to meet target service levels for the end customers, while minimising the inventory costs, (iii) be applicable to realistic demand distributions, also where customer orders varies considerably in size, (iv) be able to deal with transaction data, i.e., continuous review information, (v) be computationally feasible for large systems in practice, and (vi) be conceptually simple enough to be understood by the end users.

Based on these requirements the two models we have developed are characterised by continuous review installation stock (R,nQ)-policies at all locations, First-Come-First-Served allocation, and complete backordering. Under the (R,nQ)-policy, an order of nQ units is generated as soon as the inventory position (= stock on hand + outstanding orders – backorders) reaches or drops below the reorder point R. n is the smallest integer such that the inventory position just after ordering is above R. The main difference between the two models is that one is based on normally distributed customer demand (Berling and Marklund 2011a) and the other assumes compound Poisson demand with general compounding distributions (Berling and Marklund 2011b). The model framework is the same for both models, although the technical details differ. Because the framework is the same, it is easy to combine the two models into a complete heuristic that can adequately deal with just about any type of demand, i.e., high and low demand with high and low variability and with small and large order sizes. The combined heuristic, which is in the process of being implemented in Syncron's supply chain management software, is explained and detailed in Berling and Marklund (2011a,b), and to some extent also in Berling et al. (2010).

The model framework is based on heuristic coordination of the reorder point decisions by decomposing the multi-echelon system into solving N+1 single-echelon models. The decomposition is achieved by introducing a near optimal induced backorder cost at central warehouse. This induced backorder cost captures the impact that its reorder point decision has on the retailers, and it is obtained from applying the results in Berling and Marklund (2006). The decomposition framework makes it possible to obtain a very flexible model that is able to meet the requirements listed above. It also allows for optimisation of reorder points both with the objective to minimise expected inventory holding costs while meeting specified target fillrates, or minimisation of total expected holding and backorder costs for specified backorder cost rates.

Conceptually, the proposed approximation model can be divided into the following five steps. Recall that the objective is to find near optimal reorder points at the central warehouse and each of the retailers.

Step 1: Estimate a near optimal induced backorder cost at the central warehouse

Step 2: Determine the lead-time demand at the central warehouse,

Step 3: Determine a near optimal reorder point at the central warehouse,

Step 4: Estimate the lead-time demand at each retailer i,

Step 5: Determine a near optimal reorder point at each retailer.

The quality of the proposed models is analysed by extensive numerical studies reported in Berling and Marklund (2011a) and Berling and Marklund (2011b), respectively. These studies encompass comparisons with existing methods in the literature, and with optimal solutions. The results show that the developed models perform very well. An important aspect of our work is also the evaluation of our models' performance when using real case data. As indicated above, the case data has been obtained from one of Syncron's clients, a global spare parts service provider. The detailed analysis of this data together with associated simulation results are presented in Callenås and Lindén (2010). The simulation results are also summarised and further analysed in Berling et al. (2010).

Looking closer at the numerical results for the Normal demand model in Berling and Marklund (2011a), they show that the developed model provides better solutions than existing heuristics in the literature in terms of reaching target fillrates at a low cost. In the generated test series of small problems, which can be solved exactly for compound Poisson demand, the average increase of the total cost is only 0.9 per cent. This is achieved despite that the assumption of normally distributed demand in these situations may be less appropriate. Still, an additional improvement potential for the presented model can be observed for slow moving items with intermittent and lumpy demand. Compared to the current method used at the case company, the simulation study shows that the model brings the realised fillrates substantially closer to the targets. On average, the fillrates increase by 6.5 per cent. At the same time, the inventory cost is reduced by over 30cper cent on average.

The numerical study in Berling and Marklund (2011b) for the compound Poisson demand model (specially designed for slow moving items with lumpy demand) shows that it performs very well. It renders total cost solutions that are on average within 1 per cent of the exact solution that is optimal for the given system. As expected, it is more accurate than the method in Berling and Marklund (2011a) (and thereby also more accurate than the other approximation methods from the literature that they investigated) in meeting target fillrates, and it offers significant improvements to the case company. In the simulations based on real data, the fillrate on average increases from a current 12 per cent *below* target (the average fillrate target for the considered items is 92 per cent), to 0.6 per cent *above* target with our model. At the same time the average holding costs were reduced by about 12 per cent.

Under the assumption that all shortages are satisfied by emergency airfreight from the central warehouse, which is what the case company states, the simulation results suggests that applying our models can reduce the emergency airfreight volume by about 60 per cent for the low demand items studied in Berling and Marklund (2011b), and about 45 per cent for the broader range of items studied in Berling and Marklund (2011a). Thus, our combined heuristic for better inventory control of multi-stage distribution systems renders a much more sustainable solution.

Efficient use of emergency orders

Consider the inventory system in Figure 2. There is a single stock point facing random customer demand. Demand that cannot be met from stock on hand may be backordered or lost.

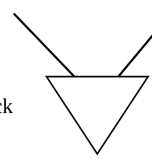

Figure 2: *A single stage inventory system with two supply modes*

Replenishment orders can be placed using two different supply modes, a situation, which is quite common in practice. Typically one supply mode is relatively cheap, but has a long lead-time, the other is expensive but has a short lead-time. The long lead-times may be due to slow boat transports, and the short lead-times due to fast but expensive deliveries by air with very different environmental (CO_2) footprint.

One possibility is to use one of the transport modes for all deliveries. We then simply need to evaluate the system for both transportation possibilities and choose the cheapest alternative. This is relatively easy to do.

However, there is also another possibility, which is usually more interesting but also more difficult to evaluate. We can use the slow transport for normal deliveries and the quick deliveries for so-called emergency deliveries. In the Öresund region, there are many large companies that face the considered problem (we have for example had discussions with Tetra Pak, Lantmännen, and Alfa Laval regarding this). In many cases, the companies feel that they use emergency deliveries too much, which results in high costs and a negative impact on the environment. Large improvements both economically and environmentally are possible with a better mix of the two modes of transportation. For a general overview of problems with different transportation modes, see Minner (2003).

We note that the considered questions are directly related to the problem of using so-called lateral transshipments in an efficient way. This is when we have several local stock points that can help each other by sharing inventory through emergency transshipments. For more details, see Axsäter (2003, 2006) and Olsson (2009). Another related system structure is considered in Axsäter, Howard and Marklund (2011) and further described in Section 4.

As part of the EcoMobility project, we have in the division of Production Management designed and evaluated new techniques for decisions concerning emergency replenishments. One of the methods was originally suggested for decisions concerning lateral transshipments (Axsäter 2003) but later modified for emergency replenishments in Axsäter (2007, 2011) and Huang et al. (2011).

Let us first sketch the basic technique in Axsäter (2007). We assume complete information about the inventory system, e.g., when outstanding orders will be delivered. For mathematical details, we refer to the original paper. Consider Figure 2. We have stochastic demand and different constant lead times for the two replenishment alternatives. The costs for the emergency replenishments may reflect both transportation costs and environmental costs. A standard reorder point system is used for the normal replenishments. Emergency replenishments are evaluated under certain assumptions, for example, when a demand occurs and there is no stock on hand. The idea is to first assume that only a single emergency replenishment is possible. It is then possible to determine the optimal decision. This rule is then used repeatedly as an approximation. The decision rule has two important qualities. Our decision rule is not optimal but it has a performance guarantee. Each time we order based on the decision rule, we get a reduction of the expected costs. Consequently, application of the decision rule gives, in the long run, an outcome that is always better than without emergency replenishments.

The method in Axsäter (2011) describes a further development of the considered technique. We now have a periodic review system with period T. We consider an additional decision alternative. The additional alternative considered is to wait one period (T time units), and after this delay order an emergency replenishment. In addition, this technique has a performance guarantee.

Simulation tests show that both methods give significant savings compared to the case without emergency replenishments. Furthermore, the technique in Axsäter (2011) performs significantly better than the technique in Axsäter (2007). The cost reduction obtained with the original technique is about 6 per cent. The new technique reduces the costs by about 11 per cent. For details, we refer to the original papers.

The paper by Huang et al. (2011) is based on the approach in Axsäter (2007) but considers a different situation. If a demand is satisfied within a so-called service time, no additional costs are incurred. However, after this service time, if the demand has not been satisfied, there are two possibilities. Either the demand is satisfied by an emergency order that takes no time or it is backordered.

Another technique for evaluation of emergency replenishments is suggested in Howard et al. (2010). This method is further described in Section 4.

Improving supply chain operations by transshipments from regional warehouses

We have previously discussed how many businesses today are struggling to reach desired customer service levels without extensive use of express or emergency deliveries. In many cases, this leads to an unnecessary loss of supply chain efficiency. However, when implemented correctly an express delivery system can offer opportunities for improved supply chain operations, both from an environmental and monetary viewpoint. Hence, finding optimal strategies regarding these deliveries is of high importance for many companies. One such company is Volvo Parts Corporation, a spare parts service provider with headquarters in Sweden. Volvo Parts is responsible for the distribution and stock keeping of spare parts for vehicles and engines made by the Volvo Group, including: Volvo Trucks, Mack, Renault Trucks, Volvo Busses, Volvo Construction Equipment, Volvo Penta, and Volvo Aero. They have distribution points in over 120 different countries and over 600,000 different articles are stocked globally. Focusing on the European market, the Öresund region is of high strategic importance for Volvo Parts. Firstly, the company has dealers (that are responsible for service and sales to the end customer) situated in the region. Secondly, a large part of the shipments between the Swedish and the remaining European market pass through the region by truck and air. For the worldwide distribution of spare parts, Volvo Parts uses a mixture of truck, boat, and airfreight. Needless to say, the strategies used for transportation and stock keeping have a major impact on their environmental footprint.

Looking more closely at Volvo Parts' distribution system, it consists of a number of central warehouses, positioned around the world, each one responsible for supplying spare parts to several local markets. On each local market, they have a number of dealers that, in turn, serve the end customers. As mentioned above, this includes both service and repairs of the customers' vehicles, as well as direct 'over the counter' sales of spare parts. Most local markets also have what is referred to as a support warehouse. The purpose of the support warehouse is to provide transshipments or express deliveries in the event of a stock-out at a dealer. That is, the dealers place regular replenishment orders with the central warehouse, but if extra items are needed quickly, an express transshipment order is instead placed with the support warehouse. The support warehouse also replenishes its stock at the central warehouse. The system is illustrated schematically in Figure 3.

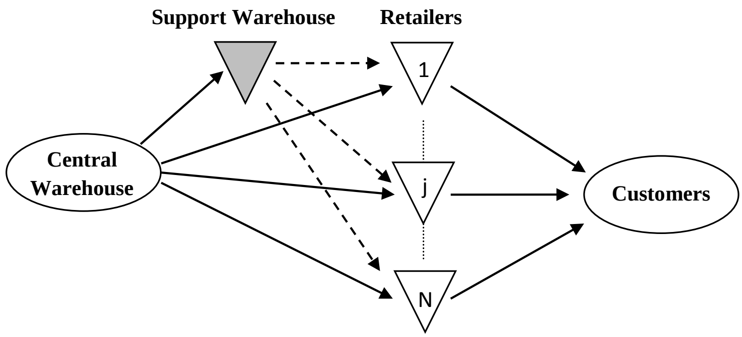

***Figure 3**: The considered distribution system for one local market*

An express delivery from the support warehouse is more resource consuming and costly than a regular delivery from the central warehouse. This is because of the extra handling and transportation involved, that is, the transportation of items from the central warehouse to the support warehouse, and then on to the dealers, compared to direct transportation from the central warehouse to the dealers for the regular orders. On the other hand, express deliveries from the support warehouse (typically by truck) are generally much cheaper and environmentally attractive than the alternative of express deliveries from the central warehouse directly to a retailer (typically by air). Hence, there is an economic and environmental rational for using a support warehouse structure.

For placing regular orders, all stock points use reorder point policies with fixed batch quantities (so-called (R,Q) policies). This means that when the stock level reaches or drops below the reorder point, R, a batch of Q units is ordered. It follows that the choice of reorder points (at the support warehouse and at the different dealers) greatly affects supply chain performance. For instance, a low reorder point at a dealer implies a low inventory holding cost at that location, but requires frequent use of the support warehouse to maintain a sufficient service level to the end customers, and vice versa. Therefore, developing a method for jointly determining the optimal values of these reorder points, and thereby improving current operations, has been the aim of the first part of our collaboration project at Volvo Parts. The second part of our project involves potential changes in supply chain design and the use of extended information.

Currently, Volvo Parts determines reorder points at each inventory location separately; using tables based on price and forecasted demand. These tables are constructed based on achieving target service levels set by management (for more information on current operations at Volvo Parts see Borowiec and Liedberg, 2009; Alfredsson and Hansson, 2010). However, several shortcomings can be identified with the current method used. The most obvious problem is that there is no coordination between the choice of reorder points at support warehouses and the dealers. That is, inventory decisions are made at one location without regards to how it affects other locations. In particular, the extra amount of resources needed when ordering from the support warehouse, compared to a regular replenishment, is not taken into account when determining reorder points at the dealers. This makes it impossible to weigh the potential benefits of using express deliveries against the potential downsides. Other problems identified are that the current method tends to result in rather large over-investments in stock, and that the price/demand tables cannot be updated automatically (see Borowiec and Liedberg, 2009; Alfredsson and Hansson, 2010).

In the first part of the project, a mathematical optimisation model of the described distribution system was developed, the purpose being to determine the best possible reorder points for the support warehouse and all dealers on any given local market. The model considers the extra resources needed for express deliveries along with other input data (for instance demand variability) that are not reflected in the current approach used by Volvo Parts. The modeling technique used is based on concepts within probability theory, statistics, inventory control, and optimisation theory (see Axsäter et al. 2009, and Axsäter, Howard and Marklund, 2011 for further details). For effortless implementation in the company's current IT system the model was developed in Excel®, which is a software used at all installations in Volvo Parts' supply chain. In combination with the optimisation algorithms that were developed, this means that new reorder points can be automatically generated for a large number of articles in a matter of seconds. This also holds true for high demand articles, a class of articles for which solution times can be quite long in general.

Given the nature of spare parts inventories, it usually takes several years to evaluate changes in inventory policies. In order to provide Volvo Parts with a tool for faster (and less costly) evaluation of the reorder points proposed by the optimisation model, a computer based simulation model was also constructed. Designed in the simulation software Extend®, the model mimics the real systems in greater detail than the optimisation model. A simulation study of representative articles revealed that the optimisation model outperforms the current method used by Volvo Parts (see Axsäter et al. 2009, Borowiec and Liedberg 2009, Alfredsson and Hansson 2010, and Axsäter, Howard and Marklund 2011 for details). On average, the new solutions reduce costs of keeping and distributing inventories by 29 per cent, while staying above the required end customer service levels. The average inventory reduction was 43 per cent, but through better coordination between the support warehouse and the dealers, this can actually be combined with high customer service and 30 per cent fewer express deliveries from the support warehouse. Consequently, by using the new optimisation model Volvo Parts has the opportunity to reduce their environmental impact, reduce costs and still provide their customers with competitive service.

The second part of our project was aimed at investigating how Volvo Parts can benefit from investment in more advanced IT systems and inventory control policies. We focused particularly on expensive low demand articles, which are notoriously difficult to manage. In this case, our model also includes the option of requesting express deliveries by airfreight from the central warehouse; a service currently provided for expensive articles if both the dealer and the support warehouse are out of stock. As in the first part of the project, new optimisation and simulation software was developed, this time to evaluate a new type of inventory control policy (see Howard et al. 2010 for details). The new policy utilises information about the exact geographical position of incoming orders, and the time until they arrive, before determining whether to place a regular order or an express order. Such real-time information can for instance be obtained by use of RFID technology. A second simulation study, encompassing 70 representative articles, discovered a large potential for cost reductions. Results indicate that using real-time information can lower stock keeping and distribution costs by 12 per cent, on average. The study also revealed that, if the new policy was implemented, the expensive and environmentally taxing express deliveries from the central warehouse could be avoided altogether for most articles.

In summary, the current project has resulted in optimisation and evaluation models that can be directly implemented into Volvo Parts' systems. The developed software tools can be used to determine how much stock there should be at each inventory location and when it is best to use express deliveries. Two different simulation studies show that there is a large potential for Volvo Parts to optimise its current operations, as well as to invest in new technology that will give them additional competitive advantages in the future. This will be of direct benefit for the Öresund region, because of the shipments passing through and the dealers situated in the area. Furthermore, although the software was developed based on the specific conditions at Volvo Parts, the modeling assumptions are quite general. This means that it is relatively easy for other companies within the Öresund region to use the developed models and software and achieve more efficient and sustainable supply chain operations.

Achieving sustainable supply chains through joint consideration of inventory and shipment consolidation decisions

In efficient control of supply chain distribution systems, the main goal is typically to achieve high service to customers while minimising the costs. The costs include; inventory costs (for holding stock and placing orders), and transportation costs in various forms (picking, loading, dispatching, transporting, receiving etc.). Ideally, all decisions are considered simultaneously when optimising the system. Still for reasons of complexity and lack of information availability, the control problem is traditionally separated into two hierarchical problems; an inventory control problem, and a transportation problem. Generally, the inventory control problem is solved first, the transportation planning is then carried out under given conditions on lead-times, quantities to be shipped etc. Under the assumption that the transportation costs are fairly low and can be included in the ordering costs, the inventory control problem is usually split into one problem for each individual item or SKU (Stock keeping unit). Because of lack of coordination between items, and the different transportation modes in use, the timing and sizes of orders to be shipped may vary significantly. This leads to difficult transportation planning problems, which may result in low fillrates in trucks, containers etc. The transportation costs and the environmental impact will therefore be unnecessarily high when controlling distribution systems in this manner.

With increasing transportation costs, the economic incentives for considering the transportation decisions at an earlier stage in system design and control are growing. At the same time, many companies are prioritising environmental and sustainability goals in their supply chain strategies in order to be prepared for future regulations, and to meet customer requirements. One of these environmental goals in the supply chain context is often to reduce the environmental (or carbon) footprint of the distributed products. One way to achieve this is of course to increase the fillrates of load carriers (i.e., containers, trucks, ships, planes etc.), and thereby reduce the number of shipments needed to distribute a given volume. Other obvious ways include shifting to more environmentally friendly modes of transportation, and to combine modalities.

In striving to address these issues, we have, at the division of Production Management at Lund University, worked on developing new models and methods to control distribution systems that explicitly incorporates both inventory and transportation decisions. The overarching goal of these methods is to determine effective ways to consolidate shipments from a central warehouse to groups of retailers and to determine when and how much to ship in order to minimise the total inventory, transportation, and environmental costs. Figure 4 provides a schematic illustration of the considered system with shipment consolidation for two groups of retailers.

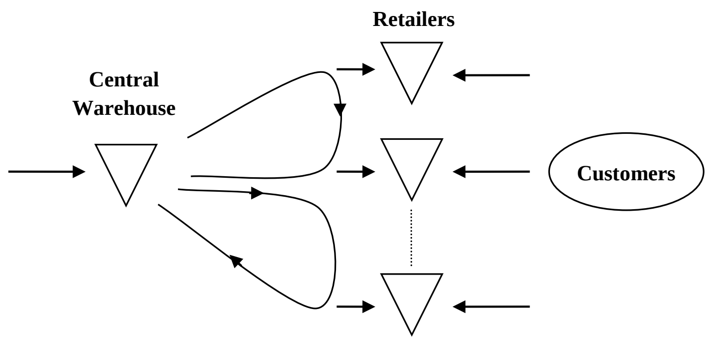

Figure 4*: Illustration of the considered distribution system with two different retailer groups*

The methods are general in the sense that they can handle SKUs with different types of demand and different kinds of transportation modes. Based on discussions with industry, the focus has been placed on developing models for time-based shipment consolidation. This means that deliveries from the central warehouse to the retailers are consolidated by use of periodic shipments. More specifically, the retailers are divided into retailer groups so that shipments leave at regular time intervals to each retailer group, consolidating both the demand from different SKUs but also the demand from different retailers. The time between shipments to a given retailer group is referred to as shipment intervals. In practice, this could mean that a truck leaves from the central warehouse once every second day to deliver goods to a group of retailers in the same geographical area, while there is a train that is used to ship goods to another retailer group in a different area once a week. The shipment intervals in these two situations are then two days for the truck deliveries and one week for the train deliveries. The challenge is to determine how often these shipments should leave and how much of different SKUs that should be shipped to each retailer every time.

A concrete motivation and source of inspiration for our work has been the EU funded Marco Polo project "Scandinavian Shuttle 100% reliability" coordinated by the Malmö-based fourth party logistics provider (4PL) UBQ. The Scandinavian shuttle project focused on establishing a shuttle train for freight transport from central Europe to different destinations in Sweden via the Öresund Bridge and the Öresund region. The project was managed by UBQ, and developed together with Øresund Logistics, Øresund Environment Academy, van Dieren, and the VinnExcellence centre Next Generation Innovative Logistics (NGIL) at Lund University. Apart from the infrastructural, political, and strategic challenges encountered during the project, there were also two operational challenges identified when changing to rail transports; (i) there is a restricted capacity on the railways, resulting in a need to reserve capacity in advance, and (ii) the shipment quantity needs to be large enough in order for it to be economically competitive. The latter creates a need for consolidating shipments of different SKUs but also to different customers (retailers) in Sweden. Several of the clients UBQ has worked with have a main warehouse in central Europe and a number of retailers or local warehouses in Sweden. Specific operational issues that need to be investigated when switching to freight transportation via shuttle train are: How often should the trains leave in order to guarantee reasonable fillrates? How much capacity should each customer reserve on the train? For given shipment intervals, how much should every retailer order to fulfill customer service requirements while keeping the costs for holding stock low? What should the replenishment strategy at the central warehouse be?

The models we have developed deal with different aspects of these problems with the common feature that they allow for joint optimisation of the shipment intervals to each retailer group and the reorder points at all retailers and at the central warehouse, see Marklund (2011), Stenius et al (2011) and Axsäter, Marklund and Stenius (2011) for details. The models consider a central warehouse that order batches of units from an outside supplier or manufacturer. The central warehouse in turn serves a number of retailers that is divided into retailer groups (for example, based on geography) to enable shipment consolidation. Different retailer groups can use different modes of transportation or combinations of transportation modes. The goal of the optimisation is to minimise the costs of the whole system while assuring a high service to the customers. The customer demand is random, and we assume that stationary stochastic processes may adequately describe it. In the work of Marklund (2011), the demand is assumed to follow a Poisson process. This is a common assumption that works well for many SKUs with low demand, and customers that typically order one unit at a time. In order for the model to be able to handle a wider range of SKUs, it is generalised to compound Poisson demand in Stenius et al. (2011). In practice, this enables the model to handle SKUs that have more variable demand, in relation to its mean. The compound Poisson process is well equipped to deal with situations with uncertain customer order sizes.

One key idea behind the modeled system is that information is shared within the distribution system. Recent technological development has decreased the costs of sharing information, which also has been noticed by many companies. This opens up for new opportunities to optimise larger systems but also requires for the optimisation models to be up to date. These kinds of settings where operational information, such as stock levels and point-of-sales information, is shared can obviously be seen in situations where all retailers and the warehouse are owned by the same company. However, it has also become more common for industry partners to agree upon information sharing in order to be able to control supply chains more efficiently. Common settings where this kind of information sharing can be seen are so called Vendor Managed Inventory (VMI) systems, where the suppliers get access to point-of-sale data, under the agreement that they provide a certain service to their customers. The information sharing in our models mean that sales information at every retailer is immediately transferred to the central warehouse, so that the warehouse can decide on replenishments instantaneously and also allocate units to every retailer based on their demand. A key assumption in both Marklund (2011) and Stenius et al (2011) is that the central warehouse allocates the units to the retailers according to a First Come First Served (FCFS) policy. This indicates that the retailer that experiences the demand first will get his demand fulfilled first. This allocation policy is very common in practice as it is simple and considered as fair, but it might not be optimal.

In a separate study, different allocation strategies were investigated in order to evaluate the performance of the FCFS assumption. In this study (see Howard and Marklund 2011 for details) the FCFS policy was compared to more advanced, state dependent myopic allocation strategies, in fact two different strategies were considered: one where reallocations were performed at the central warehouse, and one where reallocations also were allowed during transports. In the first case, the allocation of the available units at the central warehouse is determined when the truck is loaded just before it leaves the central warehouse. In the second case, a new reallocation is performed every time the truck stops at a retailer to drop off goods. The main result of this study was that the FCFS policy performed well compared to the more advanced allocation policies. Compared to the policy where reallocation was performed at the warehouse, FCFS only increased the inventory holding costs by on average 1.6 per cent. However, in some cases where reallocations were allowed during transportation, the costs could be reduced more significantly (over 10 per cent). This occurred primarily when the transportation times from the central warehouse to the retailers were rather long. It should be stressed that these reallocations during transport are difficult to execute in practice, as it requires that the transporter is flexible in how many units to unload at each retailer during a transportation run. The conclusion is therefore that FCFS is a good policy to use.

Another assumption made in both Marklund (2011) and Stenius et al (2011) concerns the transportation cost. It is assumed that there are two types of costs associated with shipping; a fixed cost for every delivered unit, and a fixed cost associated with every scheduled shipment leaving from the central warehouse. The second assumption can be criticised because it does not consider the fillrates on different transportation modes. Moreover, it implies that the transportation cost is incurred even if there are no units to ship on a scheduled shipment. This may be appropriate in some situations (e.g. when outsourcing entire logistics functions to 3PL firms), but may not be adequate in others (e.g. when a private fleet is used for transporting the goods). To better evaluate the overall effects on emissions, and in order to implement more accurate transportation costs in the model, the distribution of the shipment sizes are needed. In a study by Axsäter, Marklund and Stenius (2011) this aspect is included in the model. As a result, the model can deal with: (i) Fixed transportation costs dependent on the shipment size, (ii) Determination of the environmental footprint of a certain shipment consolidation strategy (when the probability of a certain shipment size is known, the expected fillrate of every shipment can be determined and thereby also the associated environmental footprint), (iii) Decisions regarding transportation capacity reservations (for instance on a shuttle train).

From the numerical examples we have looked at, it is interesting to see how the system behaves if the costs for transporting goods increase. Note that new costs associated with environmental impacts of the distribution system (e.g. emission taxes) can be modeled as a transportation cost increase, as the effect of these two scenarios are almost equivalent; the use of half empty trucks can be assumed to have proportional effects on the transportation costs and on the environment. We have found that an increase in the transportation costs will (of course) increase the optimal shipment intervals. Another result is that as the transportation cost increases the importance of coordinating the inventory and transportation decisions increases, i.e. it becomes more important to consider the inventory parameters when deciding the shipment intervals (see Marklund 2011). Finally, we can see that as the shipment cost increases (and the shipment interval becomes longer) the available inventory at the retailers increase while it decreases at the central warehouse. This means that as the transportation costs increase, the time between shipments will increase. In addition, more of the available inventory will be pushed out to the retailers and the central warehouse will serve more as a cross-docking facility, redistributing stock rather than holding it.

A general finding when optimising distribution systems is that the central warehouse should be relatively low on available inventory, with optimal service levels (fillrates) to the retailers not seldom in the range of 50-70 per cent. This result is known to be emphasied in systems where the transportation times to the retailers are fairly long and, as we can see, also when the shipment intervals increase. With the analytical models in place, the next step is to apply them to real cases to investigate what savings they can offer economically and environmentally for companies in the Öresund region.

Summary and concluding remarks

This chapter has focused on methods and models that can be used for evaluation of various supply chain structures. The considered techniques have been developed at the division of Production Management at Lund University. The methods can be used when evaluating costs as well as sustainability characteristics for different supply systems.

Summarising the main focus areas, we first considered a common distribution system structure with a central warehouse replenishing a number of retailers that face random customer demand. All facilities are allowed to carry stock, but the question is how much? New efficient approximation methods for evaluation of such system structures have been developed and can be used when choosing between different transportation modes. Fast transportation by air is usually more expensive both economically and environmentally. On the other hand, the need for local stock at the retailers is reduced. By better inventory control the need for emergency air shipments from the central warehouse can be reduced significantly with positive effects on costs and emissions. We illustrate this by simulation studies based on real data from a company operating in the Öresund region.

Next we discussed how so-called emergency orders can be used in an efficient way. For this analysis we consider two supply modes with different transportation times, for example boat and air. The idea is to use the slow transportation mode as the basic option, but when needed temporarily switch to the fast mode. By using such a policy we can reach more or less the same low inventory costs as a system which is exclusively based on fast transports by air. Still, we obtain a system with substantially lower transportation costs and better environmental qualities.

A related topic that is also discussed in this chapter is the use of emergency orders or transshipments delivered from adjacent local stock points instead of the normal supplier. A system of this type at Volvo Parts Corporation has been evaluated. The considered system has a regional support warehouse on each local market, which is exclusively used for providing express deliveries to dealers on that market. The dealers as well as the support warehouses replenishes from the central warehouse using regular orders. A numerical study has shown that considerable improvements can be obtained by using the suggested system structure.

Finally, we considered how shipment consolidation can be used for reducing the environmental footprint of distributed products. Our work in this area has mainly focused on time based shipment consolidation. In the study, different shipment intervals are evaluated. For example, in a practical situation the shipment interval may be two days for truck deliveries and a week for train deliveries, and we can compare the efficiency of these two possibilities. The shipment consolidation models can also aid in the evaluation and optimisation of combinations of different types of transportation modes such as train and truck.

The purpose of this chapter has been to give a general overview of problems and solutions considered in the work partly financed by the EcoMobility project at the division of Production Management at Lund University. In this chapter, we have avoided all technical details and instead refer interested readers to the original articles and reports. From our analysis, we conclude that the developed models and tools can offer significant opportunities to reduce costs and emissions and thereby achieve more sustainable supply chains. We can also conclude that much remains to be done in this area.

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12. Sustainability Models in the Øresund Region in the Transport Sector. Teachings for SMEs from Large Corporations

Lise Lyck, Jakob Kiel and Mads Granborg

1. Introduction

Since the book *Our Common Future* was published in 1987, sustainability has been on the world agenda. The core message presented in the book was the principle of meeting the needs of the present generation without damaging and reducing the opportunities for future generations. The discussion on the requirement of understanding and following of this principle has continued for years.

The Koyto protocol text was agreed upon in November 1997 and it was open for signature 16th of March 1998 to 15th of March 1999. Article 25 paragraph 1 reads; "… that the protocol shall enter in to force the ninetieth day after the date on which not less than 55 parties to the convention, incorporating parties included in Annex 1 which accounted in total for at least 55 percent of the total carbon dioxide emission for 1990 of the parties included in Annex 1, have deposited their instruments of ratification, acceptance, approval or accession." The conditions were fulfilled on the 16th of February 2005. The US never ratified it. Article 26 further reads; "… no reservations may be made to this Protocol." It has proved to be a strong international binding agreement and further more Article 27 reads that after three years from the date of which the Protocol was entered into force, a Party may redraw from the Protocol by giving written notification to the Depositary and with effect up on expiry of one year from the date the Depositary was notified.

When the Stern Review (2006) first was published, it became clear for most that something had to be done about GHG emissions at a global level. The Kyoto Protocol (2007) included binding targets for GHG reduction with duration up until 2012 for 37 industrialised countries. China, India, Brazil etc., having the status of non-industrialised countries, did not have any binding targets on sustainability for their economic development.

In Durban in December 2011, the future of the Kyoto protocol was discussed at the COP17. The result was that only targets for EU countries and other developed nations would continue to be binding until 2015. At that time, new negotiations should have been initiated with the purpose of having a new regulation from 2020. As a consequence, only 11 per cent of the world's CO2 emissions will be included in the international binding agreement. Therefore, this implies that the three dimensions of sustainability (environmental, social, and economic) will have different priorities in the coming years in the EU and in other parts of the world. However, due to the recent economic crises it is expected that the EU member states will not be able to offer much economic support to sustainability and that their main support will be through regulations, i.e. not via economic support. It also implies that the main driver for sustainability progress will be the way corporations, big-, small- as well as medium-sized enterprises (SMEs), can achieve increased competitiveness and having economic advantages through implementing sustainability as a guiding principle for their production and investment. Customers are seldom a driving force for sustainability, as although they often respond positively towards corporate sustainability initiatives in practice do not change their behaviour.

2.The role of SMEs in the sustainability development

The vast majority of attention and responsibility on sustainability has so far been placed on the largest and most well-known corporations, meaning that very little attention has been paid to the role of small- and medium-sized enterprises (SMEs). This is in part due to SMEs having a less developed division of labour, as most SMEs do not have a specific department or resources for dealing with sustainability.

In Denmark, SMEs play a large role in the industrial economy of the country. SMEs employ 40 per cent of the Danish workforce and account for between 30 and 45 per cent of the total CO2 emitted by firms (Concito, 2007). For quite some time the SMEs' role in the climate debate has been neglected, which is highly problematic. For this reason, this chapter will pay attention not only to sustainability in large corporations but also on how SMEs can include sustainability in their business activities.

There are many aspects regarding sustainability in SMEs that are still in need of further research and one of the most underexplored areas is sustainable transportation. The significance of transportation, in relation to making SMEs more sustainable, is highlighted by the fact that one third of Danish firms' CO2 emission comes from their transportation (Concito, 2007). Furthermore, a recent study from the Danish environmental think tank Concito, shows that Small and Medium Sized enterprises, (SMEs) consider transportation as the area where they are most willing to invest in sustainable solutions. SMEs do this both by themselves and by cooperating with third parties. Concito's study was based on 250 respondents of management level personnel in Danish SMEs, and is cross-sectorial with various degrees of third party transportation usage. The report showed that transport users (companies and corporations) want their transport suppliers to be green in order to contribute to their own image, and because of this transport providers are trying to make their product greener. Information from the Concito investigation show that not only do emissions from transportation account for the highest proportion of CO2 emitted from SMEs, but also that they are willing to make investments to improve their performance in this area.

3. Problem Formulation

From the introduction and the focus on SMEs, it is clear that implementing sustainable transportation in SMEs is essential for a sustainable transportation development in the Øresund region. It is therefore a relevant problem to study and attempt to identify efficient instruments for SMEs to apply sustainable approaches to their transportation activities.

The main problem dealt with in this study is the following:

This study is based on the hypothesis that SMEs can learn from big corporations by utilising the knowledge those companies have gained in the area of sustainable transport and through adjusting their own demands and requirements for sustainable transportation as set out by larger corporations. In doing so, it opens the possibility for a transfer of knowledge from large corporations to SMEs, and can be viewed as an indirect impact of the investments large corporations make in order to improve sustainability.

The question then becomes this, how can sustainable transportation, especially amongst SMEs in the Øresund region, be achieved?

4. Driver and barriers for greening the transport needs of SMEs

Large corporations are in the media's spotlight and have therefore developed extensive sustainability programmes, while most SMEs outside the media's scrutiny, are lagging far behind in this area (Lyck, 2011). When considering the status of the SMEs sustainability programmes, along with the fact that the SMEs account for quite significant amounts of the total CO2 emissions, there is a huge potential for GHG reductions for SMEs. There are however two significant barriers that have to be overcome in order to realise this potential. The first and perhaps greatest challenge facing SMEs when working towards making the company more sustainable is that they have limited financial resources and often-tight budgets. This presents itself as a larger barrier as the benefits resulting from sustainability often are intangible, difficult to measure, and have little short-term pay off and therefore do not show the same short term pay off on the bottom line as other investments. Consequently, sustainability projects, although they may reduce costs, are difficult to finance. The other major challenge is that most SMEs do not have the knowledge and competences required to successfully develop and implement a sustainability strategy. This is highlighted by the Concito study that shows that 26 per cent of SMEs when asked, think they lack knowledge on the subject of sustainable transportation, and therefore small firms cannot afford to make investments without having the required knowledge. [1] It is crucial that the SMEs are able to overcome these challenges if they are to become more sustainable in the future.

Although these barriers often hold SMEs back from investing in sustainable solutions, some SMEs are however already in the progress of greening their organisation. TaxiNord, which will be covered later in this chapter, is an example of an SME that makes it a business asset to be sustainable. Their move towards more sustainable business practices is motivated by key factors in the business environment in which they operate. The Concito study shows that there are three main motivating factors for SMEs such as TaxiNord to become more sustainable:

The first motivation is the prospect of economic profitability. The Concito study showed that 61 per cent of the SMEs would only invest in sustainable initiatives with a positive payoff. This fits with the main barrier explained above, however, sustainability can also be seen as motivation for firms. Primarily because being sustainable often means using

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1 The Analysis Institute Interresearch ran for the research and analysis of the data. The data collection has been done with a random selection of companies with 250 or less employees with a representative geographical and sectorial spread of Denmark. The respondents were employed at a management level with overview of the company's activities and strategies in sustainability. The data was collected between the period of 23-02-2010 to 17-03-2010 by Interresearchs electronic survey tool defog.net®. The report was co-authored by Michael Johansen and Martin Lidegaard for the CONCITO institute.

fewer resources or using resources in a more efficient way, and this can by itself reduce operational costs thereby increasing profit.

The second motivation for SMEs is the pressure from customers, from other corporations that buy their products, or from investors. In a business-to-business (B2B) context, some customers, especially large corporations, are placing demands on their suppliers. The Concito study shows, however, that only 16 per cent have experienced pressure from customers or investors to implement sustainability in their strategy. It should be noted that many firms believe that the focus on sustainability will increase in the future, which would indicate that this number is likely to grow.

The third motivation for SMEs is the brand value of being sustainable. In recent years, being a green company has been one of the most important aspects of a company's brand (Thomas White, 2011). As SMEs' sustainability programmes, for the most part, are not as well developed as large corporations', it might lead one to believe that SMEs would not be capitalising on sustainability in their branding and marketing. However, 54 per cent of the SMEs in the Concito study answered that they think sustainability is an important aspect of their branding.

In this chapter, the challenges expressed above and how they may be overcome will be investigated, in order to better understand the potential benefits of sustainable transportation achieved through the inclusion of sustainability in the management strategies of SMEs will be explored.

5. Methodology

This chapter is based on thorough review of the literature on sustainability, with a focus on sustainable transportation. The literature review includes articles and studies from various journals, academic books, and business related material that is used to draw a practical picture of sustainable transportation. Furthermore, several interviews with sustainability experts from different industries have been conducted.

To gain an in depth understanding of how corporations are operating in the Øresund region and how they approach the issue of sustainable transportation in a contemporary context, a multiple case study approach will be applied. These case studies consist of five large corporations operating in the Øresund region from Denmark and Sweden, namely Maersk, Novozymes, SJ AB, DSB, and IKEA, as well as the case of TaxiNord to gain an SME perspective. The selection of the cases in the study was based on the relevance they have in relation to the topic and the potential they have for educating other firms about sustainable transportation. This means that the choice of cases was not based primarily on the amount of work regarding sustainability issues that the large corporations were engaged in, but rather on the uniqueness and originality of their initiatives, along with how applicable the activities and principles are for other firms. This will help to ensure the practical relevance of the chapter. The reason for studying large corporate entities is - referring to our hypothesis- that experiences from large corporations can be an important factor for promoting sustainable transportation in SMEs. The reason it is beneficial for SMEs to look at the larger corporations is that they have more resources to spend on developing sustainable transport solutions in the corporation. Although it is not possible, and at times feasible, for most SMEs to copy a particular corporation's methods for handling sustainability, there is much to be learned from the way large corporations approach sustainability and some of the more simple initiatives are directly transferable.

In order to have the experiences from large corporations implemented in the SMEs, SMEs must have incentives for a transfer of knowledge. This can be achieved through requirements and standards set forth by corporations that must be met by SMEs in order to fulfil the terms of a particular subcontractor contract. Sustainability measures can also be spread through the sharing of information to SMEs regarding the experiences of big corporations. The later requires an awareness of the problem in SMEs and/or transportation organisations interested in making use of the knowledge.

The cases studies have been chosen both to give the perspective of the transport provider (Maersk, SJ AB, DSB and TaxiNord) and the transport buyers (IKEA and Novozymes). Furthermore, the case companies were chosen so that both Danish and Swedish companies are represented in both categories.

With regard to the transport providers, Maersk was chosen because it is the largest transport provider in the region and sustainability is key part of their overall strategy to compete on the global market. DSB and SJ AB are respectively the Danish and Swedish national railroad companies, which are both owned by the state. These two cases provides the perspective of state-owned companies and shows how they working on greening their services. Lastly, the case of TaxiNord demonstrates how a smaller transport provider is working on creating competitive advantage through greening their service.

With regard to the transport buyers, IKEA and Novozymes were chosen because they are some of the most ambitious companies with respect to sustainable transport and because they have two different approaches to achieve this (Novozymes SAM Yearbook 2011, IKEA sustainable brands 2011 study).

The aim is not to describe all principles and activities in the case corporations but instead to focus on what is the most beneficial as seen from a learning perspective.

Before any contact was made with the selected corporations, extensive desktop research was conducted to gather as much knowledge about the potential cases as possible. This was done through studying the corporations' publications on their work with sustainability. This includes anything from newspaper articles to corporate sustainability reports. Furthermore, the development in the field of EcoMobility and other issues related to sustainable transportation was followed very closely throughout the process of the study.

A qualitative approach was applied to conduct the empirical research. The primary method was the conduction of informal interviews with managers from the corporations' sustainability departments. These interviews were conducted in order to gain clarification and enlightenment on the activities related to sustainable transportation as well as their current challenges and the future direction of their work.

A descriptive framework was applied for organising the analysis of the case studies. This means that the analysis was not organised in terms of theoretical proposition but rather on the general descriptive characteristics of the individual case. The intent is that the case studies shall serve as knowledge sharing between the participating corporations as well as inspiration for other firms that are interested in the topic. For this reason, the case studies are primarily explorative and descriptive with little focus on comparative analysis of the different cases. Instead, the insights from the cases are gathered and analysed to induct findings.

6. Case studies

The first five case studies presented consist of three large Danish corporations: AP Moeller Maersk, Novozymes and DSB, and two Swedish corporations; IKEA and Statens Järnvägar.

What is presented in the following part are the key teachings from each case that illustrates how SMEs can learn from what the largest corporations are doing. This means that each case will be presented from an angle that SMEs would find most interesting in a learning perspective and therefore doesn't include all the corporations work with sustainable transportation. The last case that is presented is that of the Danish taxi company TaxiNord. This is a relatively small company compared to the other case companies and this case study will be presented in a more comprehensive form than the other cases to show how a smaller company in the Øresund region is working strategically with sustainable transportation in a very ambitious manner.

6.1 Maersk - the strategic approach

One of the most important projects in terms of sustainable transportation for Maersk is in the Low-Carbon Leaders Project, developed under the UN Global Compact Caring for the Climate initiative. This is an interesting programme in many ways. The first reason is that it is very advantageous for Maersk in its nature. This is because the aim of the programme is promote low carbon transportation through a modal shift in transport away from road and air-freight to the transportation of goods by ships. This makes it a win-win project for Maersk to participate in as they are able to both promote their organisation as working towards reduction of CO2 emission, while at the same time promoting their core business of container shipping. The second aspect that is very interesting about this programme is the close collaboration with the UN. This is interesting because it gives Maersk several advantages compared to developing such a programme in-house. Firstly, they can draw upon the expertise of the UN and in the process learn from working with them. The second advantage is that in working with an international non-profit organisation, such as the UN, third party credibility is added to the programme.

Working with NGOs to gain credibility is something that is not only possible for large corporation but is also possible for SMEs. It is something that is relatively simple to do and SMEs can gain the same advantages, especially the expertise that such organisation can provide. This outside expertise can be extremely valuable for SME that do not have the necessary knowledge and competences to implement solutions for greening the transportation themselves.

Another initiative that is worth highlighting in this context is their *slow steaming strategy*. The idea with this strategy is that the vessel operates a lower average speed on certain legs of a particular route. This means that the vessels have lower fuel consumption and therefore emit a lower amount of CO2. However, not only is this initiative good for the environment but it also helps Maersk's operational efficiency as it has helped them deliver with greater reliability. Furthermore, lower fuel consumption also helps to reduce costs significantly as fuel is one of the main cost drivers of sea transport. This makes it what Maersk calls a 'win-win-win' project as it is beneficial for 'people, profit, and planet.' This initiative clearly exemplifies that programmes designed to make a company's transportation greener do not have to be costly and, quite the contrary, can actually help to improve both operational efficiency as well as cut costs.

6.2 Novozymes - measuring the environmental impact of transportation

As already discussed one of the major challenges of working with sustainable logistics in a strategic manner is measuring the environmental impact of transportation. In recent years, Novozymes has worked systemically to overcome this challenge and are now one of the pioneers within the area.

The first step Novozymes took in order to address this challenge was to create a database containing all relevant data on their transportation. This may sound relative simple but is in fact quite a challenge. One of the major challenges is that Novozymes uses many different transportation firms that all employ different systems for measuring their CO2 emissions. This can most easily be illustrated using a concrete example:

Novozymes asked their suppliers the following question: *What is the CO2 emission of transporting 24 tons from Bagsværd to Munich.*

The following numbers were received:

677; 773; 886; 922; 1096; 801; 1010; and 782 Kg of CO2

The numbers provided show a variation of more than 60 per cent from the lowest to the highest. These differences do not necessarily reflect the real difference in CO2 emissions between the suppliers but rather are a result of different preconditions and methods for measuring CO2 emissions. This creates major challenges when evaluating suppliers.

In order to overcome this problem, the application of key figures is vital for Novozymes. The idea behind using key figures is to measures the emissions of all transportation in the same way. This alone does not provide a 100 per cent objective way of evaluating the suppliers' environmental performance but it makes it a lot easier to compare amongst the different suppliers.

The most important key figure for Novozymes when it comes to measuring a suppliers' environmental performance is the TonKiloMeter (TKM). The TKM is weight * distance, where one TKM is one ton transported one kilometre. Novozymes uses the TKM to measure the environmental performance of their transport based on how much CO2 is emitted per TKM (the CO2 emissions are measured based on TKM).

With these challenges, it might seem like a daunting task for a company with Novozymes' complexity to solve the problems that lie in trying to measure the environmental impact of transportation. So for a company like Novozymes this raises the question, *how do we begin the process?*

As discussed early, the first step is to create a database on emission data from suppliers. Novozymes devised three key rules on how to handle this data collection:

1. Keep it simple
2. Use methods that are partly based on existing models
3. Method and reporting-scheme as a demand for the Novozymes-suppliers

If a company were to consider all of these dimensions when evaluating the impact on their transport, it would be a very difficult and time-consuming task. Furthermore, it woud make the process of comparing different suppliers even more difficult than is already the case.

For these reasons a key demand for Novozymes in the data collection process is to keep it simple. The main idea behind keeping it simple is not to avoid measuring on crucial dimensions just because it might be difficult, but rather to keep focus on what is most important and not make the process more difficult and time consuming than it needs to be by including relatively unimportant details in the data collection.

Data collection can be a complicated process; a well thought out method is crucial for a successful outcome. Coming up with a successful method can be a difficult task in and of itself. Luckily, however, there already exist a number of sufficient methods for collecting key data on emissions from cargo transportation. Among others, the methods used at Novozymes are “ITD” for truck and “Sascargo” for air-freight. Probably the most important advantage of using an established method is the time and resources saved when compared to developing your own method. Other important advantages include that the method already is tested and that the data collection is conducted in a uniform manner across the organisation. For these reasons it is a demand at Novozymes that the data collection is based on existing models.

Using these methods is something that can be employed in SMEs as the methods are public available for free.[2] This makes it an easy and way to start measuring CO2 emissions of transport activities.

A majority of Novozymes cargo transportation is handled by their suppliers or external transport providers and as such they are dependent on their cooperation for data collection. This may prove problematic for Novozymes as their suppliers’ enthusiasm for sustainability initiatives may not align with their own and if they do they are likely to have a different method for measuring environmental performance, which makes the data difficult to interpret. In order to overcome this problem, Novozymes has made it a requirement for suppliers to fill out a reporting scheme on the emissions from transportation. This allows Novozymes to gather data from their suppliers in an easy and standardised way.

Another important facet in Novozymes’ approach to reporting on the environmental performance of their transportation is keeping track of what aspects they can influence and what is out of their hands. In order to do this Novozymes uses simple reporting tables for each type of transportation. By always having in mind what can be influenced it makes easier it for Novozymes to focus their efforts in the right area where it is possible to measure and improve performance. An example of this type of table can be seen in table 1.

2 The ITD method can be found at [http://www.itd.dk/Miljo/Em.aspx?ID=168] and Sascargo can be found at [http://sasems.port.se/EmissionCalc.cfm?lang=1&utbryt=0&sid=cargo&left=cargo].

Table 1. Factors that can be influenced, experiences from Novozymes

What can be influenced	Car	Ship	Plane
Demand for the transportation type		no	no
Distance to the customer	no	No	no
Order size (Novozymes can suggest optimal size of order)	no	No	no
Packaging/type/weight	yes	Yes	yes
Incoterms	yes	Yes	yes
Choice of transportation method (when possible)	yes	Yes	yes
Optimization of internal transportation between warehouses	yes	Yes	yes

Creating tables to determine the areas that a business can influence is also something that is relatively easy for an SME to apply. Doing so will help SMEs to identify the areas that they can make changes in.

As the majority of Novozymes' CO2 emissions are production related and only approximately 6-7 per cent of its emissions come from their logistics activities, sustainable transport has not been their main focus in the past. Although Novozymes' work with sustainable transportation dates back to 1998, it has only been since 2007 that they have started to collect emissions data on a global basis and consequently have only recently developed a greater understanding of their CO2 emissions from transport.

6.3 DSB Case – sustainability and politics

The DSB 'Miljørapport 2010,' the 'Årsrapport 2010,' and the interview with Head of CSR Malene Kingo Christensen provided insights into DSB's sustainability and CSR activities, and made this case possible.

DSB stands for "Danske Statsbaner," which is the former name of the corporation. DSB is a state corporation that operates train traffic on the state-owned railroad net in Denmark. DSB is owned fully by the Danish government, and it is important to understand the special political environment that DSB works in. The impact of political decisions plays a major role for DSB, due to the significant importance (and regulation) of rail transport in Danish politics. Thus, DSB is in many ways affected by political decisions, both in general and on the specific route, but although owned by the state, it is operated as an independent company (Transportministeriet, Bekendtgørelse af lov om den selvstændige offentlige virksomhed DSB og om DSB S-tog A/S, 2010). This means that the politicians, through the board of directors, still directly influence the company. However, the government has examined the possibility of completely privatising the company (Laine, 2007).

Political aims for the goal of infrastructure to benefit society are stated through contractual laws, e.g. the law on railroads stating:

“… the railroad corporation must operate to research the goal in terms of society’s need for transportation on a sustainable foundation, in terms of environment, economy of society, safe traffic, accessibility and social considerations…” (Lov om Jernbane, 2010)

Such contracts might lead to a forced economic non-sustainability. For a regular corporation this problem is often created by stakeholders’ ambitions of increasing growth rates, while the society demands a more sustainable business model. Therefore, DSB must take an economic view on their environmental and social initiatives. In the interview, it was pointed out that all projects at DSB are evaluated on their economic return on investment, but that a social cost-benefit analysis cannot be left out-of-sight. What makes DSB interesting for SMEs is that they face the same barriers as mentioned in the fourth section of this chapter. As DSB is a state corporation, its business losses are paid through the Danish tax system. As a result of this model, DSB suffers from strict monetary policies keeping them from pursuing green investments with poor return of profit, while at the same time the society demands sustainability from them. For this reason, DSB has come up with a number of sustainability initiatives that are cheap and provide an economic return.

The first initiative deals with their supply chain management. Similar to other large corporations (IKEA, Maersk, Novozymes etc.), DSB manages their supply chain, but while for example IKEA refuses to collaborate with firms that do not live up to their IWAY programme, DSB works with their suppliers to help them to become more sustainable instead of immediately turning them away. Since changing suppliers often results in hard work leading to extra expenses, helping their suppliers meet their demands is often a better way, as it creates shared learning and a basis for further cooperation.

One of the more applicable sustainable solutions DSB has implemented is their “Green Team.” The Green Team consists of 19 Employees spread throughout Denmark and is an enthusiastic network that voluntarily works to point out environmental flaws at DSB and propose solutions for them. A Web-portal serves to collect and share ideas from these employees, and in addition, it serves as a marketplace where spare parts can be listed and reused by various departments in the organisation. This is a practical example of how a firm can reuse spare parts in other parts of the organisation where workers need them. In SMEs, one could imagine that this Web-Portal could be replaced with monthly sustainable meetings. The main idea is to create a sustainable mind-set amongst the employees of the organisation so their goal is not only to create profit but also to do it in a sustainable way. This way of motivating employees to act independently, in order to reduce the environmental footprint of a firm, can result in valuable knowledge about smaller changes that influence emissions (DSB Miljørapport, 2010). Using the internal knowledge of its own employees is a good way to learn about sustainability in a firm perspective.

Overall, DSB’s sustainability work is still quite new, but due to the organisational structure and the Green Team, DSB is on the way to create a knowledge pool and become a front running corporation from which others can benchmark. This is especially applicable for the social dimension of sustainability at DSB, which is impressively far developed. Their method of supply chain evaluation and their consumer-friendly reporting should also be taking into account as strong sustainable initiatives.

6.4 IKEA – IWAY

IKEA is the world's largest furniture retailer, selling all kinds of furniture from ready-to-assemble furniture such as beds and desks to kitchens and paintings. IKEA is known for their attention to cost control, operational details, and continuous product development. This focus has allowed IKEA to lower its prices by an average of 2-3 per cent over the decade to 2010, while continuing to expand on a global level.

Due to the size and economic power of IKEA, the organisation has comprehensive bargaining power; this is often not the case for SMEs. Despite this however, SMEs can learn from their larger peers and can increase their competitiveness and competences, which can make them attractive partners.

IKEA is keen to show off their sustainability in all aspects of the corporation, and their main strategy is to use sustainability as a tool that encompasses all aspect of their business operations. This means that IKEA, rather than undertaking small sustainability initiatives in various departments of the organisation, opts for a wide-reaching overall approach. Within the company, transportation represents a large share of IKEA's CO2 emission, and it is therefore a key area of focus in their sustainability work. In order to ensure that the logistic suppliers of IKEA are doing their job in a responsible way, IKEA has implemented IWAY into their business model. For a firm to work with IKEA they must meet the criteria and standards set forth in the IWAY policy. SMEs able to adapt their business practices to meet the sustainability demands place upon them by larger organisations benefit not only from their ability to do so, but can also incur increased competitive advantage in different aspects of their business when compared to their SME contemporaries. An example of this increased competitiveness is illustrated in the following excerpt from an IKEA presentation.

> … we had our 16 biggest suppliers in Älmhult to discuss product improvement in a huge workshop. And then we also discussed IWAY, so I sat down with some of the suppliers and asked what they thought about IWAY, if it was just hard work or what they thought about it. And they thanked thank us. Last year the authorities in China had decided on a new law, forcing all suppliers to take their water treatment to a completely new level. And all of the non-certified had to shut down for 2 months to fix this while the IKEA suppliers which have had IWAY for 10 years already fulfilled these new standards. (Jeanette Skjelmose, former Sustainability Manager at IKEA of Sweden, Copenhagen Design Week 2011)

Being in front of the competition in sustainability can sometimes lead to business opportunities that one would normally not have presented themselves. Sustainability is therefore seen as a way to stand out of the crowd – especially for SMEs, which do not have as much competition concerning sustainability. One of the key teachings from IKEA is also the return of profit. As stated above IKEA focuses heavily on cost control, which means that they want all of their investments to be profitable. This mind-set makes IKEA a great company for SMEs to benchmark from, since they can reflect on their business model at a smaller scale. The main teaching from IKEA is that SMEs are able to look at the IWAY programme, analyse what they want from their suppliers and business partners, and try to implement it in their own sustainability programme.

6.5 SJ - Statens Järnvägar – sustainability through technological development

SJ AB is the Swedish state railroad corporation. SJ AB has an extensive sustainability programme with many interesting aspects that will be presented here. The focus of this example will be on how updating technology can increase the level of sustainability in a corporation's operations.

SJ AB depends on the constant development of technology in order to increase the energy efficiency of the transport it provides. Although SJ AB does not engage directly in the development of such technology, they continually invest in new systems to lower costs and CO2 emission.

SJ AB requires just as high of standards regarding sustainability in their supply chain, as they do for themselves, since less than 1 per cent of the CO2 emissions of running a passenger train comes from the actual movement of the train, the remaining comes from maintenance.

Many of the firms in SJ AB's supply chain are former parts of Statens Järnvägar, (Swedish Railways) and this is for instance the case for the areas regarding mechanical and daily maintenance of trains and stations. Therefore, for SJ AB one of the main areas of sustainability development is in their supply chain.

One of the major technological developments SJ has adopted is regenerative breaks. These breaking systems are designed to recover energy created while slowing or stopping the train between and between 8-18 per cent of the train's consumption of energy can be regenerated. As energy is recovered, it is fed back on the electrical grid, thereby allowing other trains to benefit from it.

SJ AB has also made the decision to buy all its electrical power required to run its transportation network from renewable energy sources in Sweden and Denmark. In Sweden, this energy is mainly from hydroelectric sources, while in Denmark windmills provide the preferred source. This initiative plays a major part in minimising SJ AB's overall CO2 footprint.

6.6 TaxiNord – The 'green taxi' project

TaxiNord is a relatively small Danish taxi service firm located north of Copenhagen. The Firm has more than 480 vehicles. They cover most areas in the north of Zealand and the greater Copenhagen area. The firm was founded in 1937 under the name 'Lyngby Taxi' and has since then merged with a number of other taxi firms including Holte Taxa (1974) and Taxa Nordsjælland (2008). What makes TaxiNord an interesting case is that they are one of the few taxi firms in Denmark that actively presents themselves as a green firm (TaxaNord.dk, 2011).

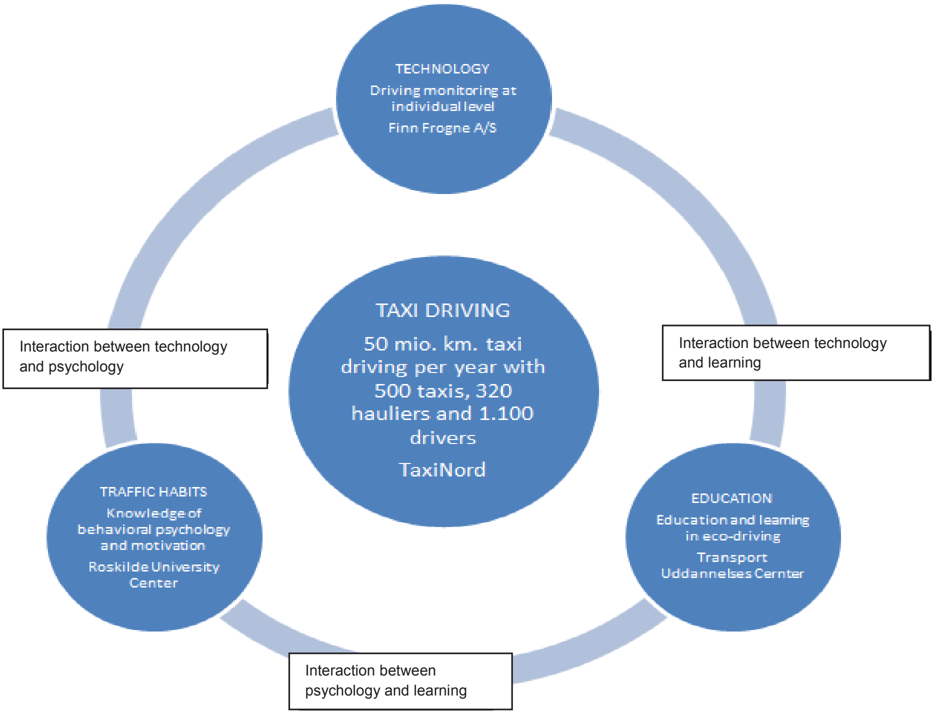
The case studies of the corporations operating in the Øresund region clearly shows that they all place a high emphasis not only on their internal processes and behaviour but also work actively with their suppliers in order to improve their environmental performance of their transportation. TaxiNord is very well aware of this trend and is adapting their strategy to satisfy the need for ecofriendly transportation that many of the large corporations in the region have. This case study will explore what TaxiNord has done to become a green firm and how they use this strategically.

6.6.1 The "Green Taxi" project

In cooperation with 'Trafikstyrelsen,' TaxiNord has entered an ambitious project called "Green Taxi" which aims at drastically reducing CO2 emissions and saving millions of Danish kroners. See figure 1

To run the project, a consortium consisting of TaxiNord, Roskilde University Center, and the Transport Education Center has been established by the traffic management firm Finn Frogne A/S. The main objective of the project is to change the driving behaviour of the chauffeurs and thereby significantly reduce the CO2 emission from the taxi industry.

Figure 1. The organisation of partner roles in project 'Green Taxi'



Source: inspired by, Finnfrogne.dk, (2011)

One of the major problems of the taxi drivers' behaviours is that an average Danish taxi drives close to 100,000 kilometres per year. Almost half of this driving takes place with the driver as the only passenger. This costs fuel but does not contribute to the actual purpose of taxi driving, namely transporting passengers from A to B. In addition, the increased fuel consumption caused by unsuitable driving such as idle running, unnecessary accelerations etc. makes up a fifth of total consumption; this represents a significant cost. For TaxiNord, running a fleet of 500 vehicles, this expense can cost millions of extra DKK a year. It was therefore not just a concern for the environment that made TaxiNord's CEO, Carsten Aastrup take initiative in the project as he explains:

TaxiNord contacted Finn Frogne with the purpose of develop a technology that can both monitor the running fuel consumption and open opportunities for the CO2 emission all the way down to the individual trip. However it quickly became apparent that the chauffer's motivation was a key factor that had to be thought into the technological solution. Shortly described the idea of the project is therefore that the technology that the vehicles are monitored with delivers information to the chauffer partly on his driving behaviour, such as speed, acceleration and breaking and partly on his fuel consumption and CO2 emission.

Chauffeurs educated in energy efficient driving, can on the background of such information adjust their driving in a way that reduces the fuel consumption. The information on CO2 emission will be collected centrally and be included in a motivation programme that can reward the chauffer and carries that are to change and maintain a behaviour that reduce fuel consumption.

6.6.2 Cooperation with external partners

Compared to a large corporation, a firm such as TaxiNord is relatively limited in resources and expertise needed to develop a programme like Green Taxi on its own. By entering into a partnership with Roskilde University, Finn Frogne, and Transportens Uddanelse center, TaxiNord benefits from a large pool of capabilities and resources that did not exist internally in the company.

Furthermore, TaxiNord was able to take advantage of the political engagement in environmental issues. Trafikstyrelsen has more than 200 million Danish kroners, to provide financial support for experiments within energy efficient transportation. Trafikstyrelsen has granted the Green Taxi project with 1.5 million DKK. As TaxiNord is the sole taxi firm involved in the consortium, they will benefit greatly from knowledge imparted as a result from the education and consulting on sustainable taxi driving behaviour generated in the project.

6.6.3 Gaining a competitive advantage by being green

Like most other firms, it is not just out of environmental concern that TaxiNord has become engaged in sustainability. Beside the positive impact on the environment, there are two main advantages of participating in the Green Taxi project: (i) cost reduction, and (ii) they separate themselves from the competition by marketing themselves as a green firm.

6.6.4 Cost reduction

As previously discussed, TaxiNord spends millions of Danish kroner on fuel consumption that does not contribute to the core service of the company, namely, to transport customers from A to B. The cost of the driver aside, fuel consumption is the highest variable cost for a taxi company. If TaxiNord is able to reach their goal of cutting fuel consumption by 19 per cent, they will be able to cut their marginal costs significantly. This, of course, will lead to a significant increase in profitability.

As reducing the wages of the drivers is not an option for TaxiNord, reduction in fuel consumption is the area where they can reduce their costs the most and thereby make the firm more competitive while being more sustainable at the same time.

"We expect to create sustainable fuel savings of up to 19 percent compared to the current driving pattern. In total this gives a realistic estimate of a reduction in CO2 emission for TaxiNord of 1,75 ton per vehicle per year and 875 ton for the whole vehicle group – equal to reduction in fuel cost of around 12,000 Danish kroner per vehicle per year." (Carsten Aastrup, CEO 4x48 TaxiNord)

6.6.5 Increased brand value

Today it has become a necessity for any large corporation to have an extensive sustainability programme, including working on environmental issues. When large corporations began working actively with sustainability, programmes designed to address sustainability issues tended to be inwardly focused. However, as these same corporations became increasingly ambitious, in an attempt to brand their corporations as sustainable, their scope on sustainability issues widened and they started to look externally through the whole supply chain as well. This means that they do not just work with their own sustainability issues but also look at their suppliers and business partners. For many corporations this includes evaluating their transportation providers on multiple criteria other than the price and quality of service, including environmental performance.

With the large corporations' demand for green transport, superior environmental performance plays a significant role in gaining a competitive advantage over competitors and TaxiNord is starting to become quite successful in this respect. TaxiNord has landed a number of big contracts based on their green profile; among these are some very high profiled corporations and organisation such as Novo Nordisk and the 'Miljøministeriet.' Regarding TaxiNord as their choice of taxi firm Novo Nordisk says:

> *Taking social- and societal responsibility is important for Novo Nordisk. One of the biggest challenges on the environmental area is global warming. For this we have set long term goal to reduce CO2-emission and apply green energy. It is therefore natural for us to consciously look at the firm and evaluate what we can do to make a difference for the environment. We have chosen TaxiNord as taxi firm, as the company as well as having good service have the greenest profile on the market and systematically works at making environmental improvements. It is great that TaxiNord as the first taxi firm in Denmark has developed an environmental strategy and set ambitious goals to reduce the environmental impact with specific consideration on CO2. (Susanne Stromer, Corporate Branding & Responsibility, Novo Nordisk, TaxiNord.dk, 2011)*

This statement demonstrates how TaxiNord has differentiated their service through their green image and how the company can co-brand their company with other strong and well-known corporations.

The demand for green taxis is currently strongest among corporations and other organisations that have a green profile, and consider environmental concerns in all business decisions in order to build a strong green image. However, TaxiNord believes that the trend is that an increasing amount of customers will take environmental considerations when choosing their taxi provider.

"We can already provide documentation for our business customers that we deliver ecofriendly driving. We believe that soon it will be a demand for all types of customers that they can order an 'ecofriendly driver' and to get a CO2 report for the individual trip." (Carsten Aastrup, CEO TaxiNord)

Whether this will be the case or not, only time will show, however, the case studies we have conducted certainly indicate that there is a trend towards higher demands on environmental performance from both corporations and consumers.

6.6.6 Good PR

With high competition, it is very important for taxi firms to have a highly recognised and strong brand. As SMEs have limited resources to spend on marketing, good public relations (PR) due to sustainability is very valuable. To gain good PR as a taxi firm, it is required that they have an interesting story to tell. As environmental issues are something that has been a very hot topic in the recent years, although slightly overshadowed by the global financial crises, it makes sustainability a very good area to gain PR. This combined with TaxiNord being the first serious mover within green taxi driving in Denmark has given TaxiNord a perfect platform for exposure in the media. It is therefore not surprising that TaxiNord has received a lot of attention in the media. This includes everything from articles in local newspapers to a report on presented on the News of one the largest national TV-channels.

7. Summing up the learning from the cases

A number of different examples of how SMEs in the region can work with sustainable transportation have been presented. These examples will now be summarised in the table 2.

Table 2. Summing up the learning from the cases

Company	How to gain knowledge	Cutting cost	Meeting the needs of partners	Building image
Maersk	Partnership with The UN-climate programme	Decreased fuel spending in the shipping business	Many of Maersk’s customers have high demands of environmental performance these initiatives helps Maersk to meet these demands- e.g. close collaboration with IKEA	A good fit to “constant care- take care of today, prepare for tomorrow,” which is a guiding principles for Maerk’s activities
Novozymes	-Participating in “*Transportens, Innovationsnetærk*”, and “*Rbenet*” -Working actively with creating a database on emission data	Establish effective value chains	Some customers with green profile ask specifically for their environmental performance of their transportation	Can show a holistic approach to sustainability

Company	How to gain knowledge	Cutting cost	Meeting the needs of partners	Building image
DSB	Gaining knowledge from employees by creating a sustainable mind-set	Cutting costs where economic efficiency and sustainability can work together	Meeting the needs of the people of Denmark by keeping their budget and at the same time being sustainable	Attempt to create image via creative trustworthy employees
IKEA	Experience is key, and SMEs have to learn from the more experienced corporations like IKEA	Solutions like IWAY makes for cheap cost, efficiency, and sustainability initiatives	Teaching partners to use standards for sustainability by using the IWAY as a guideline	Being sustainable in the whole company is crucial to the strategy of IKEA, they cannot have any working areas that lack behind.
Statens Järnvägar	Working with universities and knowledge centres	More efficient trains save costs	Teaching partners more efficient technologies	Gaining awards for green production
TaxiNord	Entering partnership with Finn Frogne, RUC and Transportens uddannelses center (education centre for transport)	Reduction in fuel consumption significantly reduces operational costs	Meeting the demands of Novo Nordisk, “Miljøministeriet” etc.	Are perceived as green by many customers as well as media because of the ‘green taxi’ project. –Has gained a relatively large amount of positive PR due to their sustainability initiatives.

8.Findings

From the case studies, it is clear that there is not one right way to handle the implementation of sustainable transportation initiatives in a firm. There are many different factors, including the industry in which the firm operates, the overall culture of the firm, and the company's overall sustainability strategy, that will determine how a firm will integrate sustainability into its operations. Furthermore, the size of the firm also has an important influence on what a firm should do in the area of sustainable transportation. Through the cases it is clear that there are still both general teachings and concrete initiatives that can be learned and applied in SMEs. The main learning that can be taken away from the case are; *collaborate with a broad spectrum of partners, sustainable transportation can cut cost, and use sustainable transportation as a marketing instrument in B2B and B2C; firms and people notice it.*

8.1 How to gain knowledge

The main reasons for SMEs lack of knowledge on how to identify, implement, and work with sustainable transportation in their organisations is a lack of experience and resources. A small firm with fifty employees simply cannot afford to have a sustainability department dedicated only to sustainability issues. Therefore, it is not possible for SMEs to generate knowledge and competencies the same way corporations do. What SMEs can do is learn from the cases presented and collaborate with external partners in order to gain expertise in the area; this is something that all the case corporations have benefitted from in the past. The case that perhaps illustrates this best is the case of TaxiNord.

As many SMEs, TaxiNord lacked the knowledge of how to operate in a sustainable way, however, by participating in the Green Taxi project they are now building great expertise in the area through collaboration with experts in the different fields that are necessary to succeed in the project and in the business world. The main learning from this is that it is possible to gain expertise virtually free of cost, even as a smaller firm, by entering in collaborations with researchers etc.

Another learning that can be made from the cases is that it is important to have data on the environmental impact of transportation. Such data can provide an SME with very important knowledge about which areas they can improve. The data needed is often already recorded, like ton/km numbers, but not used to set goals for sustainability.

It worth noticing that all corporations, not only the SMEs, can learn from the experiences presented.

8.2 How to cut cost

As the Concito study showed, the most important criteria when developing a strategy for sustainable transportation in SMEs is that it is also economically sustainable. Quite a few managers have the perception that integrating sustainability into their organisation will be costly, compromise the quality of their product and service, and is a burden. This is an unfortunate misunderstanding as being sustainable itself means saving resources and can translate into to cost reductions. An example of this was demonstrated by decreasing fuel consumption in the TaxiNord case, which led to a decrease both in the emission of polluting particles and in costs. Furthermore, decreasing fuel consumption does not have to compromise the quality of service. By teaching and motivating drivers to drive in a more environmentally friendly manner through using simple measures such as breaking in more efficient way, the performance of the drivers, in terms of other parameters, was not affected in the case of TaxiNord. The IKEA case also demonstrated how cutting costs can become the primary strategy of a firm – while sustainability as a side effect becomes equally important.

8.3 Meeting the needs of partners

The main learning from the cases in this study is not directly associated with how they meet the need of their customers, but rather the demand they themselves place on their own suppliers. This is very important for SMEs, as many large corporations are often very important customers. From talking to the sustainability managers of large corporations in the region, it is apparent that they all have the impression that there will be increased demand and importance placed on suppliers regarding their environmental performance in the future.

The case of TaxiNord shows how a medium sized firm has been able to satisfy the demand of the big corporations. Through dialog with Novo Nordisk they have been able to meet the demands for greener Taxis and thereby by secure continuous collaboration with a major client.

8.4 Building image

For larger corporations operating in the Øresund region it is a necessity to operate in a sustainable manner. This is however not the case for SMEs and is one of the reasons why many SMEs do not put as much emphasis on sustainability as the large corporations in the region do. Sustainability for SMEs is, however, a growing concern and the new Danish government (2011) has enforced the strengths of green policies. Although this means that many of the smaller firms do not have the same motivation as the larger corporations have, it also creates an opportunity to differentiate themselves from the other SMEs in the market.

The case of TaxiNord shows how a firm was able to gain a vast amount of PR, because they were the first in their sector to take sustainability to the next level. The IKEA case demonstrates how sustainability change can be managed and developed in a coherent way, in order to brand the organisation and unite the firm under a single goal. Another important learning regarding image is from the DSB case. Due to DSB being divided between cost optimising and image building, they are the perfect corporation to study in order to learn the balance of being sustainable in an economic way.

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Part III

Travel behaviours & mobility management

13. Mobility Management – background, progress and state-of-the-art in Sweden and Denmark

Joanna Dickinson, Madelene Håkansson, Christer Ljungberg & Björn Wendle

1 Introduction

Mobility Management (MM) is a range of measures designed to influence transport demand before the trip or transportation actually begins. MM in some cases, replaces more costly solutions such as infrastructure development, additional parking spaces, and provides a more efficient use of existing infrastructure. MM for the past 10-20 years has established itself as a complement to more traditional transport planning in Europe. At the European level, the European Platform on Mobility Management (EPOMM)[1], a network of governments to promote the use and distribution of MM, has been established.

In its infancy, work on MM Sweden was primarily driven from the bottom up by actors at the local level, although a number of national and regional studies and projects did helped to highlight the importance of this type of action. As support for MM grew, a national aid furnished by the Swedish Road Administration, (SRA) sector work and Swedish Platform on Mobility Management (SWEPOMM).

In Denmark, unlike in Sweden, top-down national support for MM existed from the start, although this has declined in the proceeding years. Despite this, support for MM at the local level has continued. Recently strong regional initiatives on MM have taken shape in Denmark including Gate 21/Formel M. Regional MM projects currently underway in the Copenhagen area, cover a wider range of applications when compared to regional cooperation related to MM in Sweden. An example of this can be seen when comparing BET in the Stockholm region with Gate 21/Formel M.

The environmental impact of transportation has been the main driver for actors to work with MM in Sweden, while in Denmark, overcoming accessibility problems resulting from road congestion, in addition to environmental considerations, has provided the main impetus for MM. In both countries however, recent debate involving climate change has led to a renewed interest in working with measures to reduce demand for car use and to encourage a change in travel behaviour.
Today, in both Sweden and Denmark, there is a range of activities both locally and regionally, and to some extent nationally, concerning MM. The question then becomes, how has MM, as a concept, established itself in transport policy both within Sweden and Denmark?

Swedish transport policy at present, in terms of sustainable transport, is heavily focused on energy efficient vehicles and renewable fuels. This is reflected not only in the overall policy documents but also in the actual investment in the transport system, which is largely aimed at

[1] www.epomm.eu: ”EPOMM is the European Platform on Mobility Management, a network of governments in European countries that are engaged in Mobility Management (MM). They are represented by the Ministries that are responsible for MM in their countries.”….”The main aims of EPOMM are: To promote and further develop Mobility Management in Europe and o support active information exchange and learning on Mobility Management between European countries”

increasing mobility and not work devoted to create alternatives to it.[2] In Sweden, the idea of MM influencing demand for transport, thereby reducing road traffic, has been toned down in the recent national transport policies. In Denmark, there exists a tendency, especially in the past infrastructure bills, to promote measures that favour modes of transport that are seen as less polluting and that reduce congestion more than other modes of transport.[3] In recent years, Denmark has instituted a number of national policy decisions and initiatives that contribute to the promotion of MM-oriented work, even though the concept of MM is not mentioned explicitly.

In both Sweden and Denmark, although MM has influenced, at least to some degree, regional and local transport planning decisions, the goals and aims of MM are still not implicitly enshrined or fully embraced in either country's overall national transport policy.

1.1 So what is Mobility Management?

Current models for traffic planning are structured in such a way that the high mobility, by definition, is positive. However, high mobility also leads to reduced availability, when distances increase, and this in turn only further increases mobility. Therefore, transport planning becomes a self-reinforcing feedback loop. The more we expand the road network to increase mobility, the smaller the availability, leading to a demand for further increases in mobility. Likewise, this is the same for improvements in road capacity derived from other objectives, as for example in the case of safety. When we build better roads to improve safety this often results in increased speeds. This creates the need for safer roads, and so on.

The important conclusion from this, and one that is becoming more clear to traffic planners and policy makers, is that it is impossible to eliminate traffic problems such as congestion by simply building more infrastructure. From this insight, the impetus to provide and promote alternatives to single occupancy car use is born. As a precursor to MM, Transport Demand Management or Travel Demand Management (TDM), was initiated in the United States following the 1970s oil and energy crises. Since the development of TDM, a number of cities including Curitiba, Brazil; Portland, Oregon, USA; and Vancouver, Canada have applied TDM measures to traffic and urban development planning. TDM is defined as "a general term for actions that encourage more efficient use of existing transportation systems" or "a general term for an approach that encourages more efficient use of existing transportation systems."[4] In Europe, the Netherlands also embraced the idea of 'travel management' from the United States beginning in the 1980s.[5] MM, however, was not established as a concept in Europe until the 1990s. MM is a broad term to describe various measures aimed at influencing the demand for passenger and freight transport, and is complementary to traditional transport planning.

Within the European research project MAX 2006-2009 an updated definition of MM was developed, which has subsequently been approved by EPOMM. MAX/EPOMM define MM as:"… a concept for promoting sustainable transport and car use by changing travelers' attitudes and behaviours. The cores of Mobility Management are 'soft' measures, information and communication, organisation of services and coordination of various partners' activities.

[2] Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system.http://ec.europa.eu/transport/strategies/2011_white_paper_en.htm
http://www.regeringen.se/sb/d/11181

[3] "Transportpolitik 2010 – hvad kan mobility management bidrage med?" Presentation by Tine Lund Jense, Ministry of Transport 24th Mars 2010 at a seminar about Gate 21.

[4] http://ops.fhwa.dot.gov/aboutus/one_pagers/demand_mgmt.htm

[5] Kramer, Hans & Posch, Karl-Heinz: European State-of-the-Art in Mobility Management. 15 years of Mobility Management. Review and Conclusions. Presentation på ECOMM 2008.

"Soft" measures most often enhance the effectiveness of "hard" measures in city traffic (such as new tram lines, roads or bike lanes). Mobility Management measures (compared to "hard" measures) do not necessarily require large financial investments and are characterized simultaneously by a good cost / benefit ratio."[6]

The purpose and defining characteristic of MM is thus to influence the travel or transportation even before it begins. The difference between traditional transport planning and MM is essentially that the former is primarily occupied with meeting demands for mobility through, in many cases, large-scale infrastructure development, while MM seeks to influence and intervene on the demand side thereby eliminating, or in the least, reducing the need for the creation of new physical infrastructure.

2 Mobility management in Sweden

Up until the mid-1990s, the concept of MM was unknown to most people involved in transportation planning in Sweden. The lack of awareness of MM was, in part, attributable to a generally poor understanding of the environmental impact of transportation (Ljungberg, C. 2008). However there are many examples of projects and activities where mobility management where applied without always being called mobility management.

2.1 Emergence of Mobility Management locally and regionally

MM began to emerge as a municipal policy tool in some pioneer communities beginning in the mid-1990s. Karlstad Municipality opened the first mobility office in Sweden in 1996, in the form of the transport advice office. The mobility office in Karlstad provided, and continues to provide, information and assistance to individuals, companies, associations, and schools that want to improve their travel and transport.[7] As an early pioneer, Karlstad and its mobility office had developed a green traffic plan by the end of the 1990s.[8] Following in Karlstad's footsteps, Lund started Sweden's second mobility office in the late 1990s, proceeded by the City of Gothenburg in 2000 with their local mobility office in Lundby; the Lundby Mobility Centre.[9] Further to these developments, the municipality of Eskilstuna developed a transport policy for an environmentally friendly transport system in 2002.[10] Examples of actions undertaken under the policy include City bus (Eskilstuna city traffic), cycling initiatives, and the European Mobility Week. Despite a number of efforts in MM up to this point, in general it was easier for municipalities and regional governments to implement and gain support for traditional physical or hard measures when compared to soft/behavioural impact measures championed in MM (Trivector 2010).

A number of municipalities began working on projects incorporating MM and MM was discussed during this period in a growing number of meetings, seminars, and conferences (Ljungberg, C. 2008). Swedish municipalities' work with sustainable transport and MM often had its origins in the context of the local Agenda 21 work that was outlined at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in 1992. Concurrent to local Agenda 21 work, a national collaborative project on environmentally adapted transports driven by the Swedish environmental protection agency, called MaTs projects (environmentally friendly transport systems), was initiated in the mid-1990s. The work involved the Swedish Road Administration (SRA), Swedish National Board

[6] www.mobilitymanagement.nu

[7] www.mobilitymanagement.nu

[8] http://www.karlstad.se/apps/symfoni/karlstad/karlstad.nsf/$all/6F7318C63835B40DC1257433003D916F

[9] http://www.visionlundby.goteborg.se/

[10] http://www.eskilstuna.se/templates/Page____102461.aspx

of Housing, Building and Planning, Swedish Rail Administration, and various associations in the transport sector. MaTs resulted in several reports on the steps to greening transport at the national, regional, and local levels, as a basis for e.g. the Communications Committee. The MaTs project steps to greening transport were divided in five areas:

- Measures to influence transport needs.
- Measures to influence the modal split of transport and intermodality between modes.
- Measures to affect the operation of the various modes.
- Technical measures on vehicles and fuels.
- Infrastructure measures e.g. construction, operation, and maintenance of infrastructure.

The first two areas outlined in MaTs are in fact the same as mobility management, although the term was not used (Ljungberg, C. 2008).

The reports from the MaTs project sought initiatives from municipalities to develop their own plans for the greening of transport of local transport networks. By this point, Lund had already taken the initiative for such a plan, developing Lunda-MaTs. It was in this context that the concept of MM was introduced in Sweden by Trivector, which was responsible for producing Lunda-MaTs in 1997. Lunda-MaTs is an integrated traffic plan that has attracted attention both in Sweden and internationally (Ljungberg, C. 2008). Lunda-MaTs includes measures in urban planning, traffic and parking, public transport, walking and cycling, as well as MM.

Free bus service in Ockelbo, ‘Kuxa buses,’ introduced in 1995,is an early example of MM thinking in Swedish municipalities. The expansion of local public transportation was ‘paid’ for through the coordination of school trips, elderly transportation, and regular transit. Line routes quadrupled, ridership increased by 400 per cent, and although there was an increase in service, the expenses for the operation of the public transportation system remained the same as before.[11]

Another example of a regional initiative is Skåne-MaTs, a regional cooperation project on environmentally adapted transports between municipalities, the county administration, industry, and universities/colleges in the Skåne region in the mid-2000s. In the late 2000s, the Milore Centre was established in the Öresund Region, as a knowledge centre to encourage the development of environmentally friendly transportation in the region. The Milore Centre spread information and ran projects on carpooling, public transport, car sharing, eco-driving, and more to different companies, universities, and other organisations. Milore Centre also received a regional successor in Sustainable Mobility Skane, a regional centre for green transports.[12]

2.2... and nationally

The Swedish Government addressed MM in their infrastructure bill in 2001, under the heading “sustainable travel" (Government, 2001). The government of Sweden outlines in the bill that the term “sustainable travel” includes a wide range of activities aimed at influencing demand for transport in the direction of an economically efficient and long-term sustainable transport system. Amongst these includes initiatives aimed at the reduction of demand for transport, e.g. through planning of community development and settlement, reducing individual car travel, and increase efficiency in car use through car sharing and car pools,

[11] http://www.ockelbo.se/Invanare/Kollektivtrafik/

[12] www.hmskane.se

flexible working hours, or repatriation of goods. The government stated in the bill that the SRA should work with the measures affecting the demand for transport in a push towards sustainable travel.[13]

In 1999 Sweden took part in ECOMM (European Conference on Mobility Management) for the first time, and in the same year joined EPOMM. In November 2000, the first national MM conference was organised in Lund with more than 150 participants from all over Sweden. SWEPOMM, one of the SRA funded network to support MM in Sweden, was formed.[14] A Swedish Internet site for MM, www.mobilitymanagement.nu, run by Trivector Traffic for several years, brings together examples of MM from Sweden and internationally.[15]

With encouragement from the Swedish Environmental Protection Agency (EPA), work with MM began in the early 2000s in several regions around the country. The EPA believed that a regional approach was necessary in order to allow for joint action of several municipalities on issues concerning MM. With regional collaboration, MM measures could be discussed and implemented to reduce the environmental impact of commuting across municipal boundaries, and to enable municipalities to jointly affect and influence the design and implementation of policy measures and incentives for environmental adaptation of transport that is outside the municipality's own decision area (EPA 2001). In addition to Skåne-MaTs, as previously mentioned, such regional cooperation projects in sustainable mobility were conducted in Gavleborg (X-MaTs), Norrbotten, and Västerbotten amongst others.

In recent years, a wide range of publications with best practices for achieving more sustainable travel are issued by the actors at national level. These publications that guide Swedish planners' and decision makers' (e.g. SRA, SKL, National Rail Administration, Swedish National Board of Housing, Building and Planning 2007) work on issues concerning city traffic include Handbook TRAST (Traffic for an attractive city), "Sustainable Travel in practice,"[16] and "Guide for better municipal business trips."[17]

2.3 Mobility management in Sweden today

Today, MM is integrated into policies at many levels in Swedish transport planning, both explicitly and implicitly. A large proportion of all MM projects and activities in Sweden are linked to some form of planning process or to a physical task (Ljungberg, C. 2008). The driving force to work with MM in Sweden has often been born out of desire to achieve environmental goals – starting in the wake of Agenda 21, and in recent years mainly being driven by the goal of reducing transportation related greenhouse emissions (Ljungberg, C. 2008).

Local and regional

The process in Sweden of implementing sustainable travel and sustainable transport, both labelled MM and otherwise, are mainly still carried out at the local and to some extent regional levels.

At the municipal level, actions and work for sustainable travel is established and increasingly is rooted in many of the larger municipalities. In most cases it still is the larger municipalities who work with MM. Many of these larger municipalities are searching for ways to

[13] www.swepomm.se

[14] www.swepomm.se

[15] www.mobilitymanagement.nu

[16] Hållbart resande i praktiken. Trafik- och stadsplanering med beteendepåverkan i fokus. Trafikverket och SKL, 2010.

[17] Handbok för bättre kommunala tjänsteresor. Vägverket Publikation 2006:6.

incorporate MM projects and integrate the MM way of thinking into daily operations. In some municipalities, MM is integrated as part of the city's traffic plan, as for example in Lund and Helsingborg. Activities related to MM are often placed organisationally in the local traffic office or technical office (Ljungberg, C. 2008). Furthermore, there are a few examples of MM as an effective toolkit in some rural areas.

MM is slowly but surely becoming an increasingly integrated part of transportation and community planning at the regional level, in some parts of the country. Local and regional efforts with MM have, so far, often been in project form and with external funding by means of, e.g. KLIMP funds (Swedish EPA local climate investment). However, some progress is needed before sustainable travel and sustainable transport is a natural part of the regional transportation planning. The regional county transportation plans have traditionally included only measures related to rebuilding or the building of new infrastructure. Measures to influence behaviour and demand, and to better utilise existing infrastructure, have not been included in such plans, since the rules and directives for the State funding have been earmarked for infrastructure development only (Regional Association of Sörmland, 2009). Despite this exclusion of MM funding from state authorities, some regional county councils have provided funding money for measures related to MM. One example is in Gävleborg, where money has been made available to finance personnel working with ‘this important field’ in connection to the regional MM project X-MaTs.

Many Swedish cities are working on sustainable transport strategies, corresponding to the EU initiative Sustainable Urban Mobility Plans (SUMP). In many of municipalities, MM measures are included as an important part in order to achieve more efficient travelling within their community (Ljungberg, C. 2008). In the long-term traffic plan adopted by the Helsingborg City Council's in 2006, MM is included as field of work. Helsingborg’s traffic plan is linked to a traffic strategy designed to improve air quality in Helsingborg and was developed by the County Board on behalf of the government.[18]

Activities related to MM are, as mentioned before, often placed organisationally in the local traffic office or technical office (Ljungberg, C. 2008). Örebro municipality has for some years established a MM unit in the municipal office of sustainable transport.[19]

Out of the Sweden’s three largest cities, Malmö and Gothenburg were the earliest to start with measures to obtain sustainable transport through working with MM. Malmö has, since 2001, been working actively with behavioural measures to promote more sustainable transport and has implemented a number of different campaigns trying to raise awareness amongst its citizens of the effects of car usage on environment, health, and economy.[20] The Mobility Office in Lundby, Gothenburg, called Lundby Mobility Center,[21] was, as previously mentioned, one of Sweden’s first. The Transport Authority in Gothenburg currently operates the campaign, "New road-rules" with the purpose to get dedicated car drivers to break their routine and instead make active daily choices related to carpooling, driving less, taking public transport, cycling, or walking.[22] "Profitable road-rules" is a similar campaign devised by the Lundby Mobility Center targeting companies.
At regional level there are a few examples of coordinated efforts for more sustainable transport. As previously mentioned, in southern Sweden there is Sustainable Mobility Skåne,

18 Handbok för bättre kommunala tjänsteresor. Vägverket Publikation 2006:6.

19 http://www.orebro.se/240.html

20 http://malmo.se/Medborgare/Stadsplanering--trafik/Trafik--hallbart-resande/Hallbar-trafikmiljo.html

21 http://www.visionlundby.goteborg.se/

22 http://www.nyavagvanor.se/daligaursakter

HMSkåne, which is a regional centre for greener transport.[23] Co-operation is performed through projects with municipalities, companies, and authorities in Skåne in the following areas: the door-to-door perspective and regional commuting; behavioural change for better health and the environment, cycling, alternative fuels, green and fuel-efficient cars, information technology, and telecommunications and video conferencing. Östsam in Östergötland runs as part of a climate investment project, Climate Coach Östergötland, which together with the municipalities is working to reduce the environmental impact of travel and transport. The aim is to get more people to choose more sustainable options. Local authorities are offered support in knowledge, which sets the foundation for long-term work with sustainable transport.[24]

Many Swedish public agencies have used MM as part of their marketing (Ljungberg, C. 2008). Examples include Stockholm Public Transport, with targeted transport advice and marketing to major workplaces in England, and Skånetrafiken in southern Sweden.

While MM has formed a part of traffic planning in several major Swedish cities for more than a decade now, including Malmö and Gothenburg, the concept has only recently attracted interest amongst traffic planners in Stockholm. The previous low activity could in part be due to the fact that traffic planning in the Stockholm region has been focused heavily on bringing about new infrastructure.[25] MM has recently attracted interest in the Stockholm region when planning new residential areas and in the construction of infrastructure projects, in order to reduce disruption during these works.

Out of concerns that the large number of planned road and rail construction projects over the next 20-year period will disrupt road traffic, there are now several projects in the Stockholm region to encourage car users to travel by other modes of transport, at other times of the day, or by other routes during the construction period. Regional collaboration started in Stockholm a few years ago with ResSmart[26] and SATSA[27] with targeted MM measures. MM is thus seen here as a temporary solution while waiting for new transport infrastructure, rather than a real alternative to new transport infrastructure. To deal with traffic problems during the construction period, SRA Stockholm Region has decided to develop a procedure for how MM measures will be integrated both in construction and in the renovation of infrastructure.[28]

In Gothenburg, SRA together with the City of Gothenburg has also tested mobility management measures for road works. Measures were introduced during construction on Route 155 and included enhanced public transport, dedicated lanes for heavy traffic, public transportation, and carpooling, as well as "trial"-offers for public transport. In a MM telephone campaign of roughly 3600 households, local residents were informed about the planned road construction and alternative travel options. Measurements of the campaign's results showed a decrease in the amount of traffic in peak hours by 15 per cent from 2009 to the corresponding week in 2010.[29]

23 http://www.hmskane.se/

24 http://www.ostsam.se/article.asp?id=33

25 Dennispaketet, Stockholmsberedningen, Stockholmsöverenskommelsen m fl

26 http://www.ab.lst.se/templates/proj_startpage____8659.asp

27 SATSA - *samverkan för effektivt transportsystem i Stockholmsregionen* or Cooperation for an effective transport system is funded by the European Union and includes the Swedish Transport Administration, County Administrative Board, the Office of Regional Planning, Stockholm Public Transport and Stockholm City.

28 ResSmart nyhetsbrev nr 1 2011.

29 ResSmart nyhetsbrev nr 7 2010

Nationally

SRA, now the Transport Administration, has for a number of years been obliged to work with the so-called four-stage principle in national and regional infrastructure planning. The four-stage principle is an established approach in the planning of transport infrastructure in order to save resources, both environmental and economic. The first two steps are to influence attitudes, and to highlight as well as promote sustainable travel modes.[30] MM is included as a tool to be considered in transportation planning at the national and regional level, although not explicitly mentioned. The first step in the four-stage principle is, "activities that may affect transport demand and modal choices" and step two includes, "measures that provide more efficient use of existing road network and vehicles,"[31] which, although not described as MM, clearly are influenced by the underlying principles, goal, and aims of MM.

The Transport Administration, former Road and Rail Administration, has for years had the governmental directive to work with sector measures or sector activities. Sector measures meant various forms of cooperation for sustainable development and efficient freight and passenger transport. The sector measures included activities that the SRA and now Transport Administration have pursued, which were clearly of mobility management character (Ljungberg, C. 2008).

In 2011, the government of Sweden released the Transport Administration from the responsibility to work with so-called sector activities. This means that the already modest operation with sector activities should cease, so that the Transport Administration will no longer be working with general demand and attitude affecting activities or provide financial support to such activities, as before. The Transport Administration will cooperate with "municipalities that the Transport Administration continues to regard as essential in effort to solve common issues and problems." Responsibility for behavioural aspects concerning transport has thus been transferred to the local level. This despite the fact that the motive for working with MM is the major cost savings that often can be achieved if a change in transport behaviour leads to more efficient use of existing infrastructure, thereby avoiding investment in new transport infrastructure.

In the latest national and regional infrastructure plans adopted by the government and parliament in 2010, there are a few small vestiges of hope for MM. Among the proposals for road and rail investments, are a couple of pioneering projects in which alternatives to new investments in infrastructure should be examined. In Mora and Ludvika, it has been decided that a package of measures under the four-stage principle steps 1-3, including measures to influence the transport behaviour and modal choice of citizens, should be implemented instead of an expensive investment in new road infrastructure. The projects are called "Passage Mora" and "Passage Ludvika" and can be said to be the first examples where mobility management is a part of an alternative to investment in transport infrastructure at national and regional level.[32]

[30] www.trafikverket.se

[31] www.swepomm.se

[32] The Swedish Transport Administration, http://www.trafikverket.se/Foretag/Planera-och-utreda/Planer-och-beslutsunderlag/Nationell-planering/Nationell-plan-for-transportsystemet-2010-2021/Beslutsunderlag-till-Nationell-transportplan-2010-2021/Beslutsunderlag-i-atgardsplaneringen-20102021---vag/Region-mitt/Objekt-i/

3 Mobility management in Denmark

The car in Denmark has, as elsewhere, taken increasing market shares from other modes of transport. In the last twenty years, personal trips by car have increased by 60 per cent, while rail travel increased by just over 20 per cent. Bus travel has fallen by over 20 per cent, as has moped and bicycle trips by the same amount over the time period. The car dominates in mileage proportion already at distances of 3-4 km and upwards, as in other western countries. The downside of this development is an increased inefficiency in the transport system, through increased congestion in cities - the average speed of road traffic in Copenhagen during the same twenty year period decreased by 34-27 km/h (Krag, 2005).

3.1 Emergence of Mobility Management nationally

MM as a concept is not well known in Denmark. The implementation of MM is limited and does not constitute an integrated part of the national Danish transport policy. However, in the 1990s and early 2000s there was an active national policy on mobility management in Denmark. In the 1990s, the Danish government focused on road traffic environment and introduced MM as a planning tool. Between 2000 and 2003, the Danish environment and transportation departments supported the European campaign "In Town Without My Car!", also known as "European Car Free Day." In addition, the campaign was expanded to not just a day but a whole week, know as "Mobility Week", and meant that local projects received financial and other support from a central campaign secretariat (Botoft & Høj 2008).

The government's national MM initiatives supported several local projects at municipal level that took place around Denmark (Botoft & Høj 2008). Other examples of Danish MM activities include the campaign "National Bicycle City," which took place between 1999 and 2003, and a national "bike-to-work" campaign that attracted 85,000 participants. In addition, a similar "cycle-to-school" campaign has been implemented (Botoft & Høj 2008).

Despite this initial enthusiasm, national support for MM in Denmark has decreased in favour of Intelligent Transport Systems (ITS), with a recent example of a proposed introduction of a national "smart travel card" for travel with all public transport in Denmark (Posch, 2008). In 2006, a Commission on infrastructure was established by the Danish government, with the task of strengthening the national investment in transport infrastructure (roads and railways) for the period between 2007 to 2030. MM was not specifically mentioned as a part of this work. The national agenda therefore focuses on the provision of enhanced infrastructure in Denmark, especially in road transport (Botoft & Høj 2008). Danish transport policies states that the expansion of transport infrastructure should be done whenever possible, while the need to manage and control the transport demand though is recognised (Krag, 2005).

Although not officially set forth in national transport policy many aspects of MM still have been used in the transport sector both in urban and regional planning in Denmark.

3.2... locally and regionally

In Denmark, knowledge of MM is established at the regional and local level, rather than national level. Several local MM projects have been implemented over the past two decades. This trend is predicted to continue as a result of a large local governance reform that saw the merger of municipalities and the abolishment of counties, starting in early 2007. This has helped to strengthen local expertise in transportation planning, as municipalities have taken over governance of roads from the regional authorities and have been made to share responsibility for public transport (Botoft & Høj 2008).
Danish activities in MM conducted since the 1990s include (Botoft & Høj 2008):

- Campaigns design to market cycling as a safe and healthy means of transport, combined with improved cycling infrastructure including parking.
- Improvement of public transport, including park&ride as well as marketing (at the same time, however, rates have risen).
- Campaigns for a more healthy and active lifestyle, but where transport has not been in focus.
- Specific mobility management-oriented activities, carpooling, travel plans etc.
- Projects related to the annual European Mobility Week, including the Copenhagen area.

Copenhagen aims to be 'cyclists' city' through the integration of bicycle traffic in the general traffic planning. Physical measures implemented are signal systems that give priority to bicycle traffic with a "green wave," and bike sharing systems. Car sharing in Copenhagen is also on the rise with about 4000 users of 190 cars (Posch, 2008).

Danish efforts for sustainable travel have had a strong focus on promoting increased cycling. Odense has been the "national cycle city" of Denmark and has tried to improve public health through various measures to increase cycling. Studies show that travelling by bike in Odense has increased by 20 per cent through the implemented bicycle campaigns in conjunction with various improvements to cycle infrastructure. Other MM measures implemented in Odense to promote bicycle travel included a plan to integrate pedestrian and bicycle traffic in land use planning so that these users are given priority. Odense is also working with car pools and the promotion of public transport.

Aarhus in 1995/1996 conducted the cycle project "Bike Busters," which involved 175 people. The participants' task was simply to commute to work each day during the year by bicycle. The criteria for participation in the project was that they would have 2-8 km distance between home and work and that they usually took the car. Participants were provided with a bicycle each, equipment, and bus tickets. Health surveillance of participants was conducted during the project and transport behaviour was studied in depth. The project was driven by a staffed secretariat and the total cost of the programme amounted to €385,000.00. Over 60 per cent of the participants were measured to have improved health after the project. An important conclusion was that the travel time by bike turned out to be less than what the participants thought in advance. As a result of the project, the proportion of bicycle travel increased while reducing modal split for car travelling. In 1996, the proportion of car trips decreased by about 80 per cent compared with 1995 before the project’s started. The share of bicycle trips increased at the same time from almost 10 per cent to about 25 per cent. The effect lasted also after the project had concluded according to the measurements carried out in 1997 (Krag, 2005).

Another strong focus in Denmark has been on more sustainable commuting. Hovedstadens Ud-viklingsråd (HUR) in Copenhagen started a special commuting office in 2002 with the aim to help public authorities and private companies find alternative more sustainable modes of transport for staff commuting. Measures included were carpooling to work or train stations, increased use of public transport, and to replace the car with bicycle.[33]

[33] http://www.nfo.nu/index.php?obj=b9a000c&base=1f8f2776&SearchLogID=0

3.3 Mobility Management in Denmark today

Local and regional

Region Hospital Randers, a large workplace that generates large transport volumes, and where the expansion of the hospital results in increased pressure on surfaces for car parking, has recently developed a strategy for the employee and visitor travel (Höj 2010). Based on surveys of travel behaviour and availability analysis for the different modes of transport, an action-strategy has been developed containing concrete measures to improve bicycle infrastructure and bicycle parking, improved public transport stops, traffic information at key spots, as well as campaigns in cooperation with the municipality.

In the city of Roskilde, a series of measures have been implemented to bring about a town where the densification of commercial, office, and housing is combined with a town centre that is car-free and where sustainable means of travel have the largest modal share (Höj 2010). To achieve this, a range of measures have been examined including MM in the form of transport plans for local businesses and hospitals. Other measures includes amongst others, bike sharing system, the possibility to carry bicycles on the bus, company bicycles in municipal operations, route planner for cyclists, bus lanes and improved bus stops, and a stated goal of encouraging densification to take place in locations near public transport.

For a number of years, the Copenhagen region has offered a public transport card for companies called "Erhvervskortet." By the end of 2008, around 1,000 private businesses in the region as well as seven municipalities were connected to the card, translating to roughly 10,000 people who have bought the "Erhvervskort" card. Follow-up studies show that nearly half of those who choose to purchase the Ehrvervskortet card for the first time were people who were not habitual user of public transport before. In addition, a further 13 per cent were dedicated car drivers who never used public transport. It is estimated that the Erhvervskortet card between the years of 2008-2010 generated approximately 2.5 million public transport trips, with almost half being completed by bus (Höj 2010).

A major initiative in MM that is currently running is Formula M and is run within the partnership "Gate 21."[34] Formula M is a two-year umbrella project on MM in the Danish capital region. The aim is to have state funding support a range of municipal traffic projects in full scale and to ensure that MM is anchored at all administrative levels in Denmark.[35] Behind Gate 21 stands a range of actors, the City of Copenhagen with several municipalities in the Copenhagen region, a number of companies including construction and property companies, and the University (Höj 2010). Gate 21 is thought to be a "driver of climate, energy and environmental solutions in Denmark." Emphasis is put not only on implementing projects designed to test different measures for sustainable transport in full scale, but also on strategic partnerships and the integration of expertise and research in the planning process.

Twenty-two demonstration projects in various areas, including (Høj 2010):

- “Green Mobility Office” that assists with the knowledge and practical help for local mobility activities and demonstration projects in Formula M's partner municipalities, and provides traction and support in the work of Formula M.[36]

34 http://www.formelm.dk/OmFormelM/

35 ResSmart nyhetsbrev nr 2 2011.

36 http://www.formelm.dk/OmFormelM/GrøntMobilitetskontor/

- Local mobility solutions for neighbourhoods and "Landsbyer." MM on commuting Copenhagen + Middelfart (Höj 2010).
- Mobility Plans for hospitals.
- Transport Policies for major workplaces: town halls in several towns and COOP.
- Transport Plans for local networks with a focus on commuting and business journeys. Mobility assessments of new areas and projects: objectives and measures for location planning.
- Development of Danish design practices and building permits.
- Development of methods for measuring results and evaluation, including green transport accounts for example, neighbourhoods, communities or clusters.
- Communication of impacts on national, regional, and municipal levels, to businesses and the public.
- Institutional support and knowledge transfer. Interchange of experiences into the demo projects.

Congestion pricing as a policy instrument for managing demand for travel by car has been discussed for many years in Copenhagen. Although city authorities have been working on introducing congestion charges, this has been made impossible by the national legislation that does not allow an individual municipality to impose such fees. A political agreement has not been reached yet (Botoft & Høj 2008).

There is also a currently on-going cooperation within the Öresund region with both Swedish and Danish participation in the project "Sustainable Travel in the Øresund Region" (Krag, 2005).

Information and best practices in regional and local MM work in Denmark is often spread through networks such as Agenda 21, various NGOs, and cooperation between municipalities (Botoft & Høj 2008).

Nationally

Has Mobility Management had an impact on the national transport policy in Denmark? In December 2008, a new national transport plan (Lund Jensen, 2010) containing infrastructure investments of 150 billion Danish crowns until 2020 and a proposal of an "infrastructure fund" of 90 billion Danish crowns, for continuous investments in infrastructure was announced.[37] The infrastructure fund will be expanded as new funding is achieved (Lund Jensen, 2010).

The plan includes a "green transport vision" where the main features are investments in public transport, cycling, shifting of taxes from the purchase of a car to use of car, in order to reduce carbon emissions. Two-thirds of the investments are allocated to public transport until 2020. In the short term, the plan contains a few actions relating to MM, even if the concept is not mentioned explicitly. Measures in the spirit of MM include campaigns and information on eco-driving, and information for shippers to increase "green procurement," as well as strategic partnerships with companies and municipalities about transportation plans.

Within the Danish national transport policy, there have also been some initiatives in recent years to promote MM. In 2007, the Transport Ministry presented a new cycling strategy with improvements in the national cycle road network and bicycle parking at railway stations as key ingredients (Botoft & Høj 2008). The Danish Ministry of Environment has recently

[37] ”Danmark vill satsa 150 miljarder på grönare transporter”. Article in Future Transport nr 1 2009.

introduced a new directive to regulate land use planning in the Greater Copenhagen area. The directive includes a localisation principle in order to ensure that new developments take place in areas well served by public transportation. This means that business developments, e.g. with an area greater than 1500m2 and other major attraction points, are located within walking distance of a maximum of 600m from a railway or subway station. The aim is to transfer modal shares to public transport travelling in the region and to reduce car traffic growth (Botoft & Høj 2008).

Denmark's climate goals include a decrease in carbon dioxide emissions by 25 per cent in 2030 compared to 1998. Meanwhile, CO2 emissions from transport have increased by 25 per cent since 1988. The transport sector is expected to decrease the current output levels by half, which needs to be done by 2030. The Department of Transport in Denmark has initiated a team, comprising representatives of various concerned departments to develop a catalogue of ideas for possible cost-effective measures to reduce carbon emissions from transport (Botoft & Høj 2008).

In November 2008, the Department of Transport presented the report "Green Transport Vision DK." The report describes an integrated plan for an environmentally friendly transport system consisting of three main parts: (i) the adjustment of vehicle tariff - so that less polluting vehicles are taxed less, (ii) more and better public transport, and (iii) sustainable technical solutions (Danish Government, 2008). A "Centre for Green Transport" has been formed within the Transport Ministry in order to boost the transition towards a more sustainable transport system, through initiatives to reduce the transport sector's CO2 emissions. These measures are under design and when implemented will seek to give an immediate effect through using existing transportation systems more effectively (Barfoed 2009). What role MM has in this work is unclear.

Through these initiatives, Denmark will reportedly be a ‘laboratory’ for the development of more sustainable transport technologies that may play a role in the transition to a sustainable transport system. The goal is that Denmark should be viewed as an attractive test site to try out new technologies, and pilot projects intended to launch in the coming years in order to identify opportunities and barriers to introducing new technology. These pilot projects will focus on energy efficient transport solutions such as energy-efficient buses and private or general vehicle fleets (Barfoed 2009).

4 Conclusions and discussion

Work on MM has developed differently in both Sweden and Denmark. In Sweden, work started on MM primarily driven by actors at the local level, although there were national and regional studies and projects pointing to the importance of this type of action. Eventually, national aid driven by the SRA sector work and SWEPOMM grew. In Denmark however, national support was highly developed from the start but has declined ever since. Meanwhile, local activity with MM continued, and in recent years, strong regional initiatives such as Gate 21 have taken form.

In Sweden, environmental objectives and environmental impact of transportation has been the basis for actors to work with MM. Most Swedish examples with MM to this date concerns influencing the demand for passenger transport, for example when commuting and leisure trips.

In Denmark, the original driving forces for MM were environmental issues as well as to address accessibility problems related to congestion, caused by a sharp increase in road traffic. In both countries, the recent climate debate has led to a renewed need to work with measures to reduce demand for car use and encourage a change in travel behaviour. Regional cooperation projects, as for example the ones now taking place in the Copenhagen region, cover a wider range of applications compared with the regional cooperation that can be observed in Sweden, such as SATSA.

Both in Sweden and Denmark a range of activities are conducted locally, regionally, and even nationally on MM. The question is how has MM as a concept has established itself in transport policy?

The research programme TransportMistra noted that there are three elements that need to be met in order for transport to be sustainable and for the environmental objectives concerned with the impact of transport to be achieved (Smidfelt Rosqvist, L. & Ljung-berg, C. 2008). The three parts are:

- Transport demand and/or transport dependency must be reduced.
- Sustainable transport must be promoted so that the share of transport by these increases.
- Vehicles and infrastructure need to be made more environmentally friendly.

In Sweden, as in Europe, the focus of transport policy in terms of sustainable transport is on energy-efficient vehicles and renewable fuels. This is reflected in the overall policy documents, as well as in actual investments in the transport system, which is largely aimed at increasing mobility and not creating alternatives to it (Government, 2010, EU 2011). MM has simply not had an impact as an adequate component of the strategic thinking about how the transport system will be developed. The latest Swedish infrastructure bill assumes that citizens and companies should be able to choose between different travel modes, without controlling or influencing the choices made. The bill mentions the concept of MM only once. "Sustainable travel" is mentioned once, and "sustainable transport" twice, but not in connection with the strategies formulated in the bill (Government 2008).

Commissioned by the Ministry of Enterprise, Energy and Communications a new infrastructure planning process was proposed in spring 2010.

In Denmark, there is a tendency in the past infrastructure bill to promote measures that, at least to some extent, furthers travel modes that are seen as less polluting and congestion-creating, more than other modes of transport (Lund Jensen, 2010).

Denmark in recent years has experienced a number of national policy decisions and initiatives contributing to the promotion of MM-oriented work, even if the concept is not mentioned explicitly. In Sweden, the idea of influencing demand for transport and reduce car traffic travelling is rather toned down in the recent national focus and investment on transport policy. The four-stage principle emphasises the importance of giving priority to measures that reduce transport demand before deciding on the reinvestment in infrastructure. However, in practice, evaluations conducted in line with the four-stage principle so far, do not show to any great extent that this has been the case. Therefore, the planning process has not been greatly affected.

In 2005, a consultant team prepared, on behalf of the Nordic Council, recommendations on how MM can be promoted in the Nordic countries. In the report, the Nordic countries were considered to have a number of similar circumstances that justify a future cooperation of MM. One proposal arising from the report is to develop policy instruments where MM is an integrated part of planning activities and the decision-making process. One way might be the development of an environmental management system similar to EMAS and ISO, that could be applied to transportation policy. In the report Nordic countries are also recommended to: overhaul the rules for preferential taxation of employer subsidies supporting employee travel by public transport and cycling, to review the company car benefits, to favour taxing workplace parking, to increase the proportion of car-sharing in the workplace through e.g. carpooling, to favour shifts to less polluting company cars, to change travel deductions to favour time and economically competitive public transport alternatives, and to impose requirements that companies develop travel and transport plans in order to get their building permit.

Other key actions identified in the recommendations for the promotion of MM in the Nordic countries are to develop a common model for travel surveys and to promote the exchange and dissemination of information and best practices through websites, annual seminars, and the Nordic Network (Steen Ley et al, 2005).

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14. Mobility Management Moving In: the journey of integrating MM into decision-making processes in municipalities

Christian Brandt and Peter Arnfalk

1 Mobility Management in Sweden

Mobility Management (MM) is a relatively young but rapidly growing phenomenon aimed at shifting travellers' behaviour toward more sustainable transport modes. Since the mid-1990s, Sweden has increasingly been working with MM at both national and regional levels by encouraging local governments to establish sustainable transport plans (IIIEE, 2011). Presently several Swedish municipalities and regional authorities have established MM offices (mobilitetskontor) in order to promote and implement various MM measures.[1] In essence, the overall goal and objective of a MM office is to support municipal and/or regional efforts in promoting more sustainable travel patterns in order to reduce air pollution, accidents, and noise. Most measures applied by MM offices are so-called 'soft measures' such as promotion (e.g. advertising campaigns), education (e.g. providing MM courses for target groups) and information (e.g. providing info and trip advice services of the local mobility centre) (EPOMM, 2009a). These demand-side measures are most effective when applied in conjunction with supply-side or 'hard measures,' such as changes in physical infrastructure or economic incentives (EPOMM, 2009a). When used together, demand and supply-side measures offer a comprehensive and mutually reinforcing solution to stimulate behavioural change towards more sustainable modes of travel (see Figure 1).

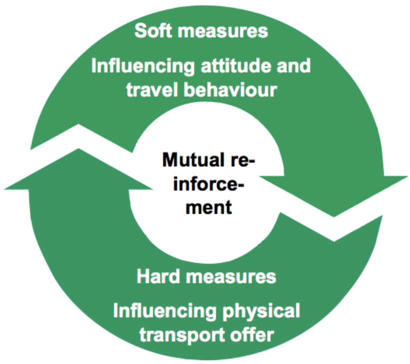

Figure 1*: Mutual reinforcement of measures*

[1] Currently there are roughly 15 to 20 Swedish cities with an established MM office and up to 50 cities are working with MM measures without having a dedicated MM office (EPOMM, 2009b). The selection of the six municipalities was based on the regional focus (municipalities in Skåne), being considered as MM leaders, possible access to staff for interviews, and the prerequisite for municipalities to have an established MM office.

Traditionally, transportation issues at the municipal and regional level have been managed through emphasising hard measures as opposed to favouring softer and often intangible measures. The development of soft, demand-side measures relating to MM were, at first, coolly received by planning authorities and their role in promoting sustainable transport first had to be proven. The acceptance of the objectives of MM within established units of a municipality or region was necessary in order for MM to receive financial and political support. Helping MM to achieve acceptance came via result-oriented campaigns that provided quantifiable measurements on changing travellers' attitudes and behaviour thereby demonstrating that MM measures can and do work. Early MM projects were often EU funded and MM units tended to work independently from other municipal units without any significant cooperation or integration. Although hard measures still dominate transport decisions at present, soft measures found in MM are slowly being adopted and are being shown to enhance the effectiveness of hard measures (EPOMM, 2009a). Nevertheless, the question remains of how to better integrate soft measures into the decision making process of municipalities and regional authorities when moving towards more sustainable transport systems.

The development of MM offices is often piecemeal due to the nature of the work being completed by MM units. Those engaged in MM primarily do so on a project basis with monies prevailingly provided by environmental and climate change funds on the EU, national, and regional government level (EPOMM, 2009b). Despite the recent trend of earmarking municipal budgetary funds in cities with established and integrated MM offices (EPOMM, 2009b; Vägverket, 2007), project-funded offices on the other hand often have limited contact with and influence on the day-to-day decision-making process regarding travel and transport issues within municipalities. One illustrative example of this isolation can be seen with the MM office in Umeå. Although Umeå's MM office has been successful in applying soft measures and attracting project funding, its work is often limited by the scope of the project funds and conducted independently from the municipal transportation planning authority. This has resulted in poor integration between the efforts of MM and the direction of the municipal transportation planning and decisions taken by city planning officials. In order to increase the effectiveness of the hard and soft measures undertaken by MM offices and the municipal departments responsible for public transport, an alignment of objectives and greater cooperation between the two is needed. In doing so, MM measures have an increased likelihood of being integrated into the decision-making and day-to-day planning activities of regions and municipalities. If this is not ensured, MM offices will not be able to influence the critical decisions that are necessary to be most effective with the given resources.

The following chapter will discuss the efforts of MM offices in moving toward greater integration with existing municipal planning authorities in order to influence the decision making process for city planning, road construction and other travel-related measures in a municipality. The findings are primarily based on a strategic environmental development project at the IIIEE (2011)[2]. In addition to collecting the MM experiences of three municipalities situated in the Öresund region: Helsingborg, Lund, and Malmö, the chapter will also build upon insights gathered from the MM efforts in Umeå, Mölndal, and Göteborg. The six municipalities were selected as they were considered to be among the MM leaders in Sweden.

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[2] Project Members: Elaheh Alasti, Peter Arnfalk, Christian Brandt, Maria Remstam, Emma Rogers and Antina Sanders.

2 Development of MM in six Swedish Municipalities – the evolution toward integration

In this section, an overview of the development of six different MM offices in Sweden will be provided. The section will outline the rationale for the establishment of the MMs, as well as provide details regarding their structure and funding sources and in conclusion will explore the numerous drivers and barriers related to their work.

The various mobility challenges cities face spurred the development of MM and for Helsingborg, Malmö and Umeå this included poor air quality caused by transport pollution (Table 1). In Umeå's particular case, the emitted levels of VOCs (Volatile Organic Compounds) and NO_x related to road transportation exceeded the EU standards and served as one of the decisive factors in the decision to establish a MM office in the city (IIIEE, 2011). In other municipalities surveyed, such as Lund, a combination of political will and public support for efforts to reduce car traffic in the city centre and a desire for a more sustainable transport system acted as major drivers for the development of MM. In Lund, the municipality's Comprehensive Plan (Översiktsplan) included a clause that sought to contain city growth and sprawl by limiting it to distances that could be reached by bicycle (Åqvist, 2011) and provided an overall objective that had major implications on transport planning (Åqvist, 2011; EPOMM, 2009b). Despite providing general guidance on the future development of transportation in the city, the Comprehensive Plan was missing concrete goals and targets as well as the specific measures and policies on how to achieve those goals (Åqvist, 2011). Within the implementation of the Comprehensive Plan in Umeå, the city's Planning Department has foreseen a more permanent role of the MM office (IIIEE, 2011). In order for the MM activities to 'take off,' several of the interviewed municipalities underlined the importance that key decision makers, political as well as administrative, recognise the significance of soft measures in shifting transport demand.

Without the extensive funding support from external partners, the success of MM offices would most likely not have been as significant as it is today. Those additional sources of funding enabled the MM team to thoroughly design and implement result-driven campaigns, allowing them to strengthen the role of soft measures internally and to demonstrate the added value of MM activities. In addition, municipalities that started their MM work at a later stage (e.g. Mölndal) must still progress through the early phase of establishing MM activities and finding sufficient financial and key decision makers' support, which has been proven to be extremely crucial (Månsson, 2011).

	Göteborg	Helsingborg	Lund	Malmö	Mölndal	Umeå
Drivers	- Political objective for public transport - Political support for MM	- Bad air quality - City environmental goals	- Environmental consideration - Political willpower	- Ensuring good air quality, especially when city is facing growth and development	- Political objectives to increase cyclists and public transport	- Need for improving air quality - Political support for MM

***Table 1**: Drivers for MM*

A pattern that emerged across the different municipalities was that MM offices became increasingly integrated with the municipal activities, planning, and funding. This was achieved after several years of nearly independent activities based on short-term activity planning and provision of external funding (IIIEE, 2011). Eventually, MM offices found themselves located physically close to municipal departments that were involved in transportation planning or traffic engineering (see Table 2). The common development, or evolution, of MM's role in a municipality seems to start out from a small unit to becoming more integrated into some of the departments of the municipality. Furthermore, MM offices started to receive permanent funding from municipalities and also changed their focus towards long-term projects more aligned with the activities of other transport relevant departments (Neergaard, 2011). Along with this development, the MM team took on a broader role as an internal advocate for alternative transport modes within the municipality, besides acting as an external communicator.

	Göteborg	Helsingborg	Lund	Malmö	Mölndal	Umeå
Structure	- 8 staff within Traffic and Public Dept.	- 2 staff working in City Planning (traffic planning occurs here)	- 3 staff in Street and Traffic Dept.	- 6 staff in Traffic Environment unit within the Street & Parks Dept.	- 3 staff in Traffic & Transportation Dept.	- 5 staff in City's Development Department
Funding	- Long-term funding - External funding at very beginning	- Long-term funding - Swedish EPA funding	- Long-term funding - Relied on external funding until 2005	- Began with EU funding	- Long-term funding - Swedish EPA funding at beginning	- Began in 2008 with base funding from City's Air Quality Program & additional funding from local, regional, and national organisations and EU

Table 2: *Organisation of mobility management in six municipalities and funding arrangement*

A unique development of MM can be seen in Lund's case where it introduced restrictions on car use in the city centre, complemented with parking fees in the 1970s. This was likely induced by the plans to build a highway through the centre of the city at the time and the citizens of Lund were very environmentally engaged and strictly against this project (Åqvist, 2011). Agreeing on maintaining the 'medieval' road network found in the city centre further supported those decisions and the long-standing support for alternative modes of transport from the community and politicians contributed to this development (Raeva, 2007). With the 1998 version of LundaMaTs[3], Lund introduced a comprehensive sustainable transport approach at an early stage. Despite soft measures being an important element of the transport strategy for the Municipality from the very beginning, the MM office operated, to a large extent, independently from the Traffic Department until 2005. Previous to then the MM office was physically located in a separate office building and was very much relying on external project funding (Åqvist, 2011). Finding themselves in a more integrated position today, in terms of location as well as activities, the MM team views this as essential for being able to influence sustainable transport behaviour of Lund's inhabitants. Increased integration has furthermore made more long-term planning and projects possible, and thus also the ability to influence how the physical structure of Lund is designed and developed (Åqvist, 2011).

Despite the different phases that the municipalities found themselves in, in regard to their development, differences in project focuses, and staff resources (see Table 2), each of

[3] LundaMaTs stands for the environmentally adapted transport system in Lund and is Lund's plan for an environmentally friendly transport system. In LundaMaTs II the vision has been extended to sustainable development of the transport system that is covering the environmental, economical, and social aspect of sustainability (Lund Municipality & Trivector Traffic AB, 2007).

them share a desired joint position inside the municipality. This desired position consists of:

- Long-term municipal funding;
- A permanent and dedicated MM staff;
- Organisation of MM in Traffic Department or equivalent;
- Partnerships with a wide-spectrum of external partners; and
- Formal cooperation procedures with other relevant departments, such as planning (IIIEE, 2011).

What we have seen is a slow evolution of MM offices. What once starting out as independent, EU funded units, have evolved into office increasingly integrated with municipal and regional planning authorities, with permanent funding that allows them to work on more long-term projects. In the studied organisations, this development is driven by the desire to be closer to decision-making processes, often supported by key decision makers, and driven by environmental concerns.

3 Integration challenges

The municipal actors interviewed stated repeatedly that the quantitative results and the high visibility of the campaigns launched, emphasised the strong impact of these projects. At the same time, several MM offices describe their poor integration with other municipal activities. The majority of MM projects are planned independently and are not aligned with the rest of the projects in the municipalities. In the case of Umeå, the MM team is located within the city's Development Department, a department responsible for applying for EU funds and contributing largely to the financing of the MM office. The cooperation with other departments was quite limited, only in case when specific projects demanded a cooperation with certain departments (Aschan, 2011).

A main challenge is the short-term character of many of the projects and campaigns arranged by these offices, at the same time as they attempt to change people's long-term traveling behaviour. They therefor strive towards more long-term project work, but they risk becoming stuck in the early phase and remain doing only short-term projects (Nordlund, 2011).

Furthermore, there seems to be a lack of basic understanding of MM among the different municipal departments. A structured and more formalised set-up would inherently enable better integration. In Umeå's case, having a MM Steering Committee (SC) with members from different parts of the municipality, they have not seized the opportunity to foster better integration since members of the SC do not seem to disseminate the concept of MM to their own municipal units/departments (IIIEE, 2011). In addition, the absence of an active position of the organisation responsible for public transport in the SC is suboptimal, especially due to the link of soft measures and public transportation. In some cases the MM team has not been consulted in key decisions affecting travelling (e.g. location decisions) because soft measures were not given a high priority when compared to infrastructure (Djärv, Neergaard, & Wendle, 2009).

As seen in Lund's case, the integration of MM into the Traffic department was a rather slow process, and there is still room for improvement for a closer cooperation with both strategic planners and traffic engineers (Åqvist, 2011). For MM teams, as well as any other part of an organisation, it is important to have a clear idea and perspective about their future role. The portfolio of projects implemented is often steered by the existing opportunities instead an overarching strategy that would support the decision-making process of choosing among the different projects (Aschan, 2011). In general, MM offices face the risk of getting involved in projects without a clear link to the overall goal of the MM office. Having clear objectives and budget (staff and resources) for each project can address those risks (Månsson, 2011).

In addition to the challenges described above, Table 3 outlines additional barriers for better integration of MM offices.

	Göteborg	Helsingborg	Lund	Malmö	Mölndal	Umeå
Barriers	- Power dynamics internally	- Power dynamics - Changing norms of planners	- Time wasted trying to secure money - Sceptical attitude from general public towards MM message - Focus on economic growth	- Ambitions sometimes colide with the courage of politicians and residents of a city	- Lack of relationship with public transport supplier	- Difficulties with quantifying objectives of soft measures - Differences among municipalities - Limits on the impact due to lack of resources - Knowledge of MM and awareness of the need MM of the municipal officials vary

Table 3: Additional barriers for better integration of MM offices.

4 Success factors for Integration

As mentioned in the previous section, a key to success for MM teams is to have a clear objective and strategy on what shall be achieved (Åqvist, 2011). This is not only important when deciding on the kind of projects to implement, and for what kind of funds to apply, but also to guide the day to day activities. Hence MM should contribute to decide what type of activities should be developed and what other units to cooperate with when designing campaigns alongside the traffic solutions that are developed (IIIEE, 2011). In addition, cross-departmental cooperation is crucial for promoting soft measures effectively. This includes aligning activities on the one hand, and on the other hand promoting the concept of sustainable travel internally. This can lead to a setting where MM, besides communicating it externally, takes on a bigger role in advocating alternative transport modes among actors within the municipality. This is a role that e.g. the MM office in Malmö found themselves in (Fahl, 2011). The internal communication might start by simply reaching out to other municipal departments and promoting aspects and benefits of soft measures. This in turn could then lead to the situation where the MM team is being consulted or asked for advice in regards to accessibility of new developments of cycle routes and public transportation infrastructure. Further advice could also ensure that the option of bicycle parking is being considered when debating about possibilities to reduce car parking space (IIIEE, 2011). Once the capabilities of the MM staff are recognised within municipal governments, they will have greater access internally, and could find themselves in a more integrated role within the municipality, as seen in Helsingborg, Lund, and Malmö. However, this role develops over time.

Additionally, MM offices share the desired position of being located in the department most closely related to transport planning or traffic engineering, and to focus on long-term projects aligned with department activities. In order to safeguard continuity and competence, it is naturally preferred to have staff with permanent positions funded by the municipality. Besides the previously mentioned considerations, common success factors that helped MM to evolve consisted of: early awareness building, active internal communication, and a strong and strategic promoter (IIIEE, 2011).

4.1 Early awareness building

Mobility management efforts lacking internal support and an understanding within the municipality, will likely fail. Therefore, building early awareness and support for soft measures in the establishment phase among internal stakeholders, including municipal administration staff and decision-makers, is essential when MM is first established (IIIEE, 2011, see also the contributions in Part II of this book). Very often, this has been achieved by result-oriented campaigns, which were funded by external sources. The results that were obtained via the campaigns served as demonstration material showing the value of soft measures and supported the staff's role in promoting MM on the long-term perspective. Amongst the cities studied, Lund and Malmö were advocating the long-term role across departments and on the political-level via the results obtained through short-term projects (Åqvist, 2011; Fahl, 2011).

4.2 Active internal communication

Beyond internally promoting the significance of soft measures at an early stage, it is crucial to continuously communicate the importance of MM up to the point where MM thinking is integrated into the planning, development, and activities within the municipality. Even when MM activities have wide political support and offices are fairly well integrated, as it is the case in Lund and Malmö, communication of MM aspects need to continue internally. Actively communicating the team's role and enhancing co-operation has been done through workshops with relevant departments in both Helsingborg and Malmö (Fahl, 2011; Nilsen, 2011). Various types of cooperation can be established ranging from informal networking to working groups linked to specific projects, as a means to regulated cooperation (Fahl, 2011). In order to provide input to other municipal departments (specifically the planning department), a certain level of regulated or formalised communication is desired. Common forms of cooperation found between departments such as working groups are seen in Helsingborg, Göteborg, and Malmö. Another form of cooperation found in Helsingborg was a steering committee consisting of members from the city management, environment, and planning department that is guiding the work of the MM team. Furthermore, simply by being geographically close, cooperation is naturally built by informal meetings and everyday interaction, hence reducing the need to formally communicate with relevant departments. Several of the municipalities, having the MM office located within the transport planning and traffic department, have stressed the value of this position as a key benefit.

4.3 A strong and strategic promoter

The component of strategic leadership is another factor for successful integration. For MM to evolve into a more integrated role, a top management commitment is critical. Until the desired position of the MM within the municipality is achieved, internal power dynamics such as the ones between long-term planners and creative mobility managers might need to be resolved. This could mean changing planning norms where results are less tangible and hard to measure. Such a move would require an influential actor to get approved of. Another aspect to consider is the way soft measures are framed. There are potential drawbacks of MM being too focused on environmental aspects when promoting itself, hence the MM team should emphasise its crucial role contributing to achieving the City's strategic objectives e.g. an attractive City and cost effective growth (Arby, 2011).

5 Future outlook

Part of the development of MM offices finding themselves in a more integrated municipal role, is that they tend to move their focus from solely independent projects towards more process-related work within the core activities of the municipality. This development includes shifting from external project funding towards other possible sources that ensure funding for continued work (Djärv, et al., 2009). The MM offices may face the situation in the future where EU funding is decreasing, as the MM concept moves from novelty to mainstream. It is therefore important to safeguard more long-term resources and interest within the municipality to support MM activities (Nordlund, 2011).

Despite the urge for MM teams to be physically closely located to traffic department and to be better integrated with the different units of a municipality, being fully integrated into the work of the city may not be optimal. MM offices should still retain their independence to some extent and should be working somewhat separately in order to maintain their focus (Söderström, 2011).

The Comprehensive plan can be viewed as one of the highest-level guidance documents for the entire municipality. Bases on this plan, different municipalities plan their projects, feeding into the overall stated objectives (Svensson, 2011). This guiding document will be of importance for the MM team when defining objectives and setting up future projects and identifying their role in those processes.

Moreover, MM offices are already working together with businesses on influencing travel behaviours and using this opportunity to increase the impact of their work. By cooperating with the department for entrepreneurs/businesses within the municipality, the MM office has another opportunity to promote their activities and from a strategic perspective MM could be part of a sustainable trademark of a municipality (Åqvist, 2011).

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15. User Perspective in Mobility Choices: The experience with leisure travel in the Öresund Region

Tareq Emtairah, Åke Thidell, Adriana Budeanu and Nils Boman

Introduction

The pursuit of leisure activities by most of us is evidently contributing to the demand for mobility services and infrastructure. This demand is destined to grow with increasing recreational opportunities as well as freed time from work. Focusing on travel modes, the distribution of leisure travel among various transport modes varies depending on distance and connectivity of attractions or destinations to various travel infrastructures. Still however, the car is by far the most popular mode of transport for Swedish and Danish leisure travellers when travelling domestically. In the case of Sweden for instance, three quarters of domestic leisure trips in 2009 were by car according to data from the Tourism and Travel Data Base (Terpstra, 2010). In the Öresund Region, the share of travel generated by leisure activities is estimated to be around 40 per cent of all road travel[1]. These trends, while troubling from an environmental perspective, highlight the opportunities for carbon efficiency in the transport sector through, for instance, modal shifts towards climate friendly transportation within the domestic leisure travel. In fact, these gains are more readily available to harvest in the Öresund Region compared for instance to commuter travel where there is near maximum utilisation of public transport capacity, especially during peak commuting hours[2]. Considering that most leisure travel is taking place at times when work activity is low e.g. weekends and nights, there is a a scope for shift to the under-utilised capacity in public transport system during these times.

However, motiving a shift in mobility modes is obscured by the intricacy of behavioural and choice determinants among heterogeneous travellers. Past efforts within the tourism and leisure industry to encourage a shift towards more sustainable life styles, including climate friendly transport choices, gave mixed, if not contradictory, results (c.f. Budeanu, 2007; Hares, Dickinson, & Wilkes, 2010; McKercher et al., 2010). Much of the critique is centred on the assumed associations between attitudes and values on the one hand and behavioural change on the other (c.f. Dickinson & Dickinson, 2006; Reiser & Simmons, 2005 and Garvill et al., 2003). This critique is in part a response to past efforts that focused on raising awareness or encouraging environmental responsible practices among travellers. These efforts apparently have failed to trigger noticeable shifts towards more environmentally friendly tourism and transport choices, despite evidence of increased awareness of environmental impacts from leisure activities (Barr, Shaw, Coles, & Prillwitz, 2010). While awareness and values are important predecessors of environmental behaviour, it is clear that their predictive power is limited (Wurzinger & Johansson, 2006, Bergin-Seers & Mair, 2009).

[1] C.f. Chapter 2, for detailed analysis of travel patterns in Sweden and Denmark.
[2] Ibid.

The noticeable gap, between expectations and outcomes, calls for better understanding of the underlying determinants of travellers' choices such as price, convenience, and availability. Verbeek and Mommaas (2008), in a study of the role of citizen-consumers in a transition process to sustainable tourism mobility, argue that even a focus on behavioural determinants is not sufficient without a *context-specific approach* to travelling behaviour. The point they make is that without giving greater consideration to the contextual dimension of leisure practices, this includes the specific context of travellers' motives, lifestyles, and routines as well as the public and private modes of provision; it will be difficult to effectively mobilise citizen-consumers as change agents (Verbeek and Mommaas 2008).

This chapter presents findings from an empirical study of leisure travellers and their mobility choices in five destinations within the Öresund Region, with the aim of shedding light on the revealed travel-choice motives. Further it critically examines those motives within the leisure experience context in the Öresund Region along the lines of the context-specific approach. The purpose of the study covers not only the effective mobilisation of citizen-consumers for sustainable leisure mobility, but also the potential role of upstream actors such as transport service providers and downstream actors such as attraction or destination managers in the transition towards more sustainable *leisure practice* with the Öresund Region. The remainder of the chapter is organised as follows. The next section defines and frames leisure travel for this study. This is followed with a brief description of the study design and findings. Finally, and building on the context-specific approach, the chapter concludes with a discussion of the findings and implications for other actors in the leisure practice in the Öresund Region.

Mobility for leisure

Leisure travelling is defined primarily by the purpose of the journey. This includes, for instance, travelling for shopping, sports, entertainment, culture, or the pursuit of nature experiences. Other defining features of leisure travel include trips that go beyond the traveller's ordinary area and often conducted off working hours. In addition to purpose and types of activities, other ways of segmenting leisure travellers are by the distance travelled and the duration of the trip. These characterisations are made in contrast to work related travel such as commuting to work or going to school. For the purpose of this study, we focus on leisure traveling for touristic and recreational purposes. Hence, we exclude trips for other purposes such as shopping or visiting family and friends. Since the focus is on the Öresund Region, with its short distances, we also include day-trip visitors; people travelling for recreational purposes or sports events.

A second clarification to make is regarding the notion of sustainable leisure travel. The Center of Sustainable Transport (2005) outlines the broad features of sustainable leisure travel patterns. These include travel activities that allow visitors to access destinations whilst minimising some of the perceived negative environmental impacts from mobility choices, namely congestion, accident risk, disturbance, visual pollution, noise, and emissions, which contribute to air pollution and global warming. Social objectives of a sustainable leisure travel include enabling individuals and families to pursue desires and needs for leisure experiences at an affordable price while offering a choice among a variety of transport modes. Moreover, there is a desire that sustainable transport modes should contribute to the local economy, increase networking, and reinforce the socio-economic fabric.

Two arguments are put forward for more attention to making leisure travel more sustainable within the Öresund Region. One is the high dependency on cars for leisure trips. The second is the spare-capacity in the public transport sector that can be utilised for leisure travel. On the first point, and taking Sweden as an example, GHG emissions from road traffic constitute nearly 64 per cent of all emission from the transport sector (Table 1). Given that the share of car-use for leisure trips is close to 40 per cent of all car trips, a shift of 20 per cent of leisure travel to the existing spare-capacity within the public transport system can lead to a reduction of nearly 10 per cent in transport related GHG emissions. The Öresund Region has a well-developed public transport system, particularly in the capital area of Copenhagen and in the more densely populated western parts of Skåne. The system facilitates convenient commuting with trains and buses that operate to virtually all places in the region. The rail system connects major urban areas on both sides of the straight through the Öresund bridge and ferries crossing the straight are available in the north. The public transport system also reaches into the more rural and remote areas in western Själland and eastern parts of Skåne with a developed bus system connecting to the major railway hubs.

Table 1: GHG emissions from Swedish transport of people, *Source: Data from Trafikverket 2010*

Transport mode	**Share of GHG emissions (%)**
Road traffic	64
International sea transport	24
International flights	8
Domestic fligts	2
Domestic sea transport	1
Rail	0
Miscilanious	1

In line with studies showing that the public transport system has spare capacity during weekends and off-peak hours when most leisure trips happen (c.f. Chapter 2), this study has its starting point in the idea that there is a great potential for shifting a good percentage of the leisure trips to the public transport system in the Öresund Region.

Patterns of leisure travel behaviours in the Öresund Region

Destinations

For this study, a total of five destinations and events were targeted for travellers' survey with regard to travel behaviours. The destinations were selected primarily based on popularity and accessibility via public transportation. The popularity test for the destinations on the Swedish side of the straight (Skåne) was based on the Brand Clinic investigation from 2010. That study found the *Swedish Open* in Båstad and the *Kivik's Market* in Österlen among the attractions that tourists know most of and have the greatest attraction factor (Brand Clinic AB 2010). In addition, the *Malmö Festival* in Malmö city was selected as a third destination randomly. On the Danish side, statistics from *Visit Denmark* (year 2008) showed that the theme park *Tivoli* is among the most visited destinations within the capital city of Copenhagen. As complement, the *Louisiana*

Museum of Modern Art was chosen both for its popularity and to broaden the profile of selected destinations. Volumes of visitors and accessibility by public transport for each of the destination are elaborated on in Table 2.

Table 2: Studied destinations and their profile

Destination	Brief description	Number of visitors (yearly)	Access by public transport
The Kivik's Market	The largest open air market in Sweden close to the town of Simrishamn in the eastern part of Skåne region. It is held during a couple of days in July every year.	Attracts close to **100,000 visitors**[3]	Bus connecting with rail network at Simrishamn
The Malmö Festival	An annual event that takes place in the City of Malmö over one week period during the month of August	The festival in 2011 attracts close to **1.4 million visitors**[4].	Train and bus
The Swedish Open	Located in the town of Båstad in the northwestern end of Skåne, the tennis tournament "Swedish open" is among the most popular attraction in the region with visitors from all over the world.	Båstad and the Swedish Open combined attracts close to **1.2 million visitors** every year. The Swedish Open alone attracted between 80-100 thousand visitors in 2011[5]. Close to 30% of those from the region.	Train and bus
The Louisiana Museum of Modern Art	Located in Humlebæk, 35 km north of Copenhagen is the most visited museum in the region.	Attract over **500,000 visitors** annually.	Train (+short walking distance) and bus
Tivoli Gardens	A theme park in the city-center of Copenhagen, often described as the most popular amusement park in Scandinavia.	The theme park attracted close to **3.7 million** visitors in 2010[6].	Train and bus

Respondents and data collection

A pattern of travel behaviours in the five destinations was elaborated through field surveys. Sample respondents consisted of visitors at the chosen destinations. A random selection of respondents for the sample was desired in order to meet a normal distribution; however, it was impossible to select the sample from a statistical probability principle since the respondents of the sample could not be randomised from the start. This implies strict requirements on the conduct of the interviews in order to make it as randomised as possible and in order to generalise conclusions from the results for each of the destination. Thus, strict criteria were applied in order to avoid skewed representation of the sample. At the point of selection, the sample was selected by personally approaching every fifth passing visitor or tourist of at least 15 years of age. In case the approached person was not a visitor or tourist or declined to participate in the survey the very next person was approach instead. Interviews were conducted during three days at each destination and at different time slots of the days in order to obtain best possible variety of the sample. In total, 404 respondents were included in the sample analysis (Table 3).

[3] Number from the Market Organisational committee: http://kiviksmarknad.com/
[4] Numbers from the Festival Organizing Committee: http://www.malmofestivalen.se/
[5] Numbers from the tournament organization: http://men.swedishopen.org/sv-SE/Functions.aspx
[6] Numbers from Tivoli A/S: http://www.tivoli.dk

Table 3: Number of respondents at each destination

Destination	Number of respondents
Swedish open, Båstad	142
Kivik's market	82
Malmö festival	88
Tivoli/Copenhagen	58
Louisiana Museum of Modern Art	34

The investigation was designed as interview surveys at each destination to obtain data on:

- choices of travel modes: train, bus, walking/biking, flight or car
- the frequency of use the same travel mode for leisure travel
- their reasons and preferences for choosing certain travel modes, including environmental reasons
- demographic data: gender, age, salary, and travel party
- starting point of the journey: inside or outside the region

The interviews were conducted through structured questionnaires with closed multiple-choice answers that had been tested out in previous works and in smaller surveys. The answers were coded and processed with the software Statistical Package for Social Sciences (SPSS) for statistical analysis and testing of relationships between different variables.

In terms of limitations, the investigation primarily represents the leisure travel patterns for the selected destinations, and the reader is asked for caution when generalising these patterns for the entire region. There are many other destinations in the Öresund region that receive fewer visitors and destinations with less access through public transport means. However, helping us here is the fact that the chosen destinations represent some of the most popular ones and thus reflect a good percentage of leisure trips in the region.

Travellers and profiles

Respondents were grouped by gender, age, income, and traveling party. In terms of gender distribution, on average, 60 per cent of all respondents were female and 40 per cent male. This might reflect a bias through greater willingness among female visitors to participate in the Survey experienced by interviewers. In terms of age, the majority of respondents were in the age segment between 18 and 30 years old (44 per cent). The second largest segment was 31 to 50 years (Table 4). The age distribution deviated significantly between the destinations. The *Swedish Open* and the *Malmö Festival* attracted primarily people in the age bracket of 18 to 30 years old. Most visitors to the *Kivik's Market* were in the age bracket of 31 to 50 years old while visitors to *Tivoli/Copenhagen* and Louisiana were evenly spread across all age brackets. Close to 26 per cent of respondents were traveling in families with children, and 55 per cent in groups of two or more.

Table 4: Age groups

Age (years)	Nr of respondents	Per cent of total respondents
Under 18	14	3.5
18-30	176	43.6
31-50	133	32.9
51-64	61	15.1
65-	20	5.0

In terms of the starting point of travel, there was a significant difference between geographical starting points and visited destination. Most visitors of the *Swedish Open* began their trips outside of Skåne but from within Sweden. Both the *Kivik's Market* and the *Malmö Festival* attracted primarily visitors from Skåne region while most visitors to *Tivoli/Copenhagen* and the *Louisiana Museum of Modern Art* came from Zealand (Figure 1). In total, close to 55 per cent of all trips were intra-regional, whereby the starting and ending points were within the Öresund Region.

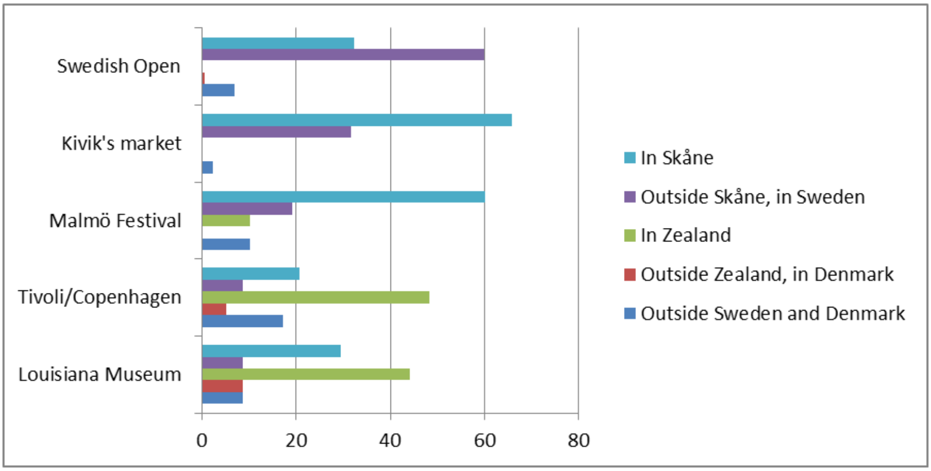

Figure 1: Starting points for visitors to the destinations

Transport Choices

The car seems to be the dominant choice among leisure travellers in the five destinations. Among the respondents, 56 per cent travelled by car and 35 per cent travelled by public transport (Table 5). Almost 79 per cent of the travellers claimed that they *often* or *almost always* use the same transport mode when travelling to other destinations, indicating habitual behaviour as opposed to destination specific conditions such as accessibility to public transport infrastructure. Only 4 per cent claimed that they did not at all use the same travel mode as the one chosen for this trip.

Table 5: Transport mode

Transport mode	Nr of respondents	Per cent of total respondents
Car	225	56
Train & bus	143	35
Flight & ferry	14	4
Bike & walking	21	5

The survey data also shows that there are significant differences in the choice of transport mode depending on starting points. Within the group whose journey began outside Skåne, but within Sweden, the proportion of car trips is highest (70.4 per cent), while those that started their journey Within Zealand, the proportion of car trips is lowest (28.8 per cent). Overall, travellers who started their journeys in the Öresund region tend to leisure travel more by train and bus, and much less by car compared to those who started their journey in the rest of Denmark or Sweden. As shown in table 6 below, all trips made by bicycle or on foot began within the Öresund region.

Table 6: Transport mode and starting point

Transport Mode	**Starting Point** (% of Category)	
	Öresund Region	Other Denmark/Sweden
Car	47.1	69.7
Train and bus	41.9	25.4
Flight and boat	1.8	4.9
Bike and walking	9.3	0

From the data, we can also identify differences in travel mode depending on final destination. A higher percentage has travelled by car to the *Kivik's Market* and the *Swedish Open* compared to the other destinations. A large proportion of respondents in these destinations started their journey in Sweden. It is tempting to say that travellers who started in Sweden are more likely to travel by car, but upon closer examination of these two destinations, other factors such as convenience might come into play including the fact that to reach the actual events require a bit of walking and/or an additional bus connection from the nearest train station.

There were no statistically significant differences in travel mode by gender, but moderate relations by age. The percentage of car users increases with age and reaches its peak for the age group 51-64 years. For people aged 65 and over this trend bends down and the proportion of motorists decreases. The opposite is true for train and bus passengers (Table 7).

Table 7: Transport mode and age

Transport mode	Age Groups (% within age group)				
	Under 18	18-30	31-50	51-65	65 & above
Car	35.7	50	60.9	68.9	47.4
Train and bus	57.1	42.6	26.3	24.6	52.6
Flight and boat	7.1	1.7	5.3	4.9	0
Bike and walking	0	5.7	7.5	1.6	0

Significant differences in travel mode by the size of the group were noticeable. The car is the most common alternative when at least two adults are included in the party. Trains and buses are more frequent among individual travellers or single parents with children. Some differences are also noticeable among income groups. The proportion of motorist seems to increase with income, where 76.5 per cent of the respondents belonging to the highest income group travelled by car. The opposite relationship prevail among travellers by train or bus where low-income earners account for the majority of travellers.

To summarise, the data shows interesting relations between transport mode and traveller characteristics. Primarily, habits, travelling party, and income variables need to be investigated more closely in relation to car dependency in leisure travel. On the other hand, destination characteristics in terms of accessibility or convenience to public transport infrastructure seem to also relate to transport mode choices.

Revealed motives

Table 8 below gives a comprehensive picture of passengers' revealed motives for the choice of travel mode. As the questions had multiple answers, respondents could choose to enter one or more options. The percentages represent the proportion of travellers who selected a particular option or aspect as one of their motives. Upon close examination, the data show clear differences among the highest-ranking motives in relation to different transport modes.

Table 8: Motivation for transport mode choices

Choice motivation (% of transport mode takers)	**Car**	**Train and bus**	**Flight and boat**	**Bike and walking**
Child Friendly	10.2	5.6	21.4	14.3
CO2 emissions	0.4	8.4	7.1	9.5
Flexibility	29.3	9.1	7.1	47.6
Convenience	14.2	36.4	28.6	19
No alternative	12	25.2	7.1	0
Campaigns	0.4	2.8	0	0
Comfort	66.7	27.3	42.9	23.8
Cost	13.6	49	7.1	27.3
Environment	4.4	18.9	14.3	42.9
Reliability	12	5.6	7.1	4.8
Parking	4	11.9	14.3	9.5
Saving time	39.6	25.2	64.3	52.4
Frequency	3.1	7	0	4.8
Habits/Image	14.7	2.1	7.1	4.8
Luggage	35.1	4.2	14.3	4.8
Other	2.7	1.4	0	14.3

In the case of car users, comfort is the single most important reason, 67 per cent of car users selected this as one of the reasons. Other motives for car users include the fact that the car is perceived as timesaving and provides smooth handling of luggage and flexibility. Among all options, cost factor was the highest selected reason among train and bus travellers, 49 per cent. Other factors of high ranking among train and bus travellers include connectivity, comfort, time saving, and, for some, the fact that there was no other option. Environment, nature, and carbon emissions featured low among the motives for car users and slightly higher among public transport users.

Significant differences in the underlying motives arise when comparing responses between different demographic groups. The results show that men, to a higher extent than women, believe that comfort is an important motive for choosing transport. The highest proportion of travellers that selected *child-friendliness* as a motive was among the age group (31-50) years, while the highest proportion that selected *Cost* as a motive was among the age group (18-30). The majority of travellers who find *luggage handling* as an important aspect belongs to the age groups (31-50) and (51-64) years.

Motives seem to also relate to the size and traveling party. *Comfort* reason scored highest among those traveling with another adult as well as *Child-friendliness* reason scored the highest among those travelling with children. The motives seem to vary even among income groups. Respondents in the high-income category were among the highest proportion stating *comfort* and *baggage handling* as motives, while respondents in the lower income category identified most with *Cost* motive.

On closer examination of the survey results, one is very tempted to conclude that these are self-evident. We can clearly anticipate for instance higher sensitivity among travellers with children towards *child-friendliness* aspect of the travel experience. Similarly among younger age groups and lower-income groups, we can anticipate higher sensitivity to *prices* when making transport mode choices. Although not uncommon in other studies on tourist transportation, it is perhaps among the surprising results is the fact that environmental motives do not feature prominently in leisure travel decisions in a region that pride itself as world-leading in terms of environmental awareness. However, the findings of the survey are useful for providing a starting point for a context-specific analysis of the leisure practices in the Öresund Region, as discussed in the next section.

Discussion and Conclusions

A context-specific analysis of leisure travel in the Öresund Region would need to account for the contextual dimension of leisure experience, the geography of the trip, the specific context of travellers' motives, lifestyles, and routines as well as the embedded transport infrastructure. In the field survey, we tried to underscore several of these contextual elements, those mainly related to travellers' motives, underlining travel choices to the five destinations described earlier. In this section, the analysis brings other contextual dimensions of leisure travel experience such as destination characteristics and how these might influence the broader objective of promoting climate friendly leisure travel in the Öresund Region.

The results of this investigation illustrate that habit, travelling party and income are important variables for leisure travellers' choice of transport. These results are in line with some of the specialised literature (Klöckner and Christian 2004); however these particular variables are rarely explored and seldom addressed by transportation providers or destination organizations. Considering that habits are among the toughest challenges for behavioural change, and peer pressure requires long time to take effect, public and private transportation stakeholders need complex skills and creative solutions in order to see a modal shift in leisure travel.

Trip and destination characteristics in terms of accessibility or convenience to public transport infrastructure also affect transport mode choices. As we saw earlier, from the survey results, the choice of transport mode varies depending on where the journey began geographically. Car is a more common means of transport for those passengers who started their journey outside the Öresund Region compared with those who started their journey in the Region. Although transportation options exist for travelers from outside the region as well, the quality of transport systems at the final destination has an impact on the choice of transport mode. Louisiana Museum, Tivoli in Copenhagen, and the Malmö Festival as end destinations attracted a higher proportion of train and bus travellers compared to the *Swedish Open* in Båstad and the *Kivik's Market*.

Malmö and Copenhagen are big cities easily accessible by train or bus, and provide good opportunities for moving around through public transport. Båstad and Kivik on the other hand had experienced the highest proportion of long-distance travelers (passengers who started their journey outside the Öresund region). Therefore, the results show that the *Swedish Open* in Båstad and *Kivik's Market* in Kivik are events that attract a relatively high proportion of long-distance travelers, which in turn results in a high proportion of visitors who traveled by car. Although

these later destinations can be reached by public transportation, the fact that their accessibility is not so easy or convenient may hinder their use by long-distance travelers. Therefore, it can be concluded that modal shifts by transportation users in the Öresund Region is conditioned by the accessibility of destinations, defined by the existence of public transport systems and by having them known, affordable and convenient for potential users beyond the region's boundaries.
The conclusion has implications primarily for destination managers and event organisers who have high stake in the discussion on climate friendly transportation to the destination. They represent an important stakeholder to involve with transport service providers in the design of customised, event-specific climate friendly but equally convenient transport options for visitors. This might involve, for instance, customized transport links between key public transport hubs and the destination coupled with easily accessible information about departure locations and timetable. The higher penetration of mobile applications should present an opportunity for this type of communication about alternative collective transport options.

The results of this study are only one illustration of how the contextual dimension can be factored into strategies for creating modal shifts in leisure travel. A second aspect of building on this context-specific analysis relates to having more accurate profiles of leisure travellers and motives by transport mode. Our data shows that leisure travellers choose to travel by car primarily for convenience. Passengers perceive this mode as a convenient, timesaving, and flexible option. Efforts at creating modal shifts need to work on altering these perceptions via a mix of measures. Back to the example above, offering a convenient alternative alone might not be sufficient to encourage modal shifts because of the habitual factor. As shown earlier, higher percentage of car users (close to 79 per cent) often, or almost always, use the same transport mode for leisure trips regardless of destination and identify with *convenience* factor as the primary motive. Destination managers can engage in, for instance, creating a level-playing field in terms of convenience factor, i.e. increase the convenience of public transport and lower the convenience of car use to overcome the resistance to switch. An example here would be restrictions on parking or prohibitive parking fees at the destination.

In summary, the Öresund Region is considered to be a cross-border region with extensive yet successful cooperation between the administrative and political parties on both sides, Swedish and Danish. It is also a region encompassing two countries known worldwide for the high levels of environmental citizenship and activism. However, as this study illustrates, environmental considerations rank very low among other criteria for individual choice of transportation, while convenience, comfort and cost rank very high. In order to successfully steer leisure travelers to choose public transport, attractive alternative offers must satisfy all functionality and environmental criteria. This investigation started with the intent of exploring the reasons why in an area well prepared to have an environmentally friendly transportation system, the majority of leisure travelers opt to use the car. As the results show, opportunities for shifting modes of transportation exist but require complex approaches, which are often overlooked by those in charge of managing and organizing transportation around tourist attractions. Private and public organizations involved transport management across the Öresund Region have good prospects to foster a shift towards sustainable transportation by joining forces with organizers of tourist attractions and specialists in demand management. A great deal of their success would depend on the persuasive power of novel transportation alternatives, and their ability to satisfy functional and comfort-related needs of their users. In the light of the national and European goals of reducing CO_2 emissions by 2020, there is sufficient scope and urgency in the Öresund Region to use existent experiences of cross-border collaborations to create, test and adopt sustainable transportation packages for leisure travelers.

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The Øresund Region is the largest hub in Scandinavia for transport of goods and people by sea, road, air and railway. Efficient transportation is a key factor for regional growth but it also contributes to many negative external effects like CO_2 emissions, pollution, congestion etc. This calls for knowledge.

Øresund EcoMobility contributes to knowledge creation for sustainable transport and green logistics, city transport, and energy systems with a specific focus on the conditions and needs of the Øresund region. In this book, long distance goods transport and strategies for green corridors are studied and multi-criteria models for analysis in transport and infrastructural planning are tested. Moreover, City Logistics and the challenges within urban areas are scrutinised, challenges for fossil free transport systems are analysed and mobility management in municipalities and use patterns in leisure travel are considered. In addition, the role of knowledge transfer between companies is examined. New energy systems are fundamental in creating a sustainable future, but are not enough – new forms of governance, planning, and stakeholder involvement to create sustainable supply chains are also needed.

Øresund EcoMobility aims at innovating for economic, social, and environmental sustainability by addressing issues of green logistics, city transport, travel behaviour, and renewable energy systems. Through using new approaches to transport policies and legislation, by exploring new strategies in decision making and demand management, and by allowing for new forms of association to induce better allocation and use of resources and infrastructure, this book provides some of the answers and paths forward to help achieve a more sustainable future.

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