Future CO_2 savings from on-line shopping jeopardised by bad planning

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Topic area: Panel 3, Mobility and transport

1 SYNOPSIS

Transport represents a very large part of our total energy consumption. More rational behaviour concerning household purchases can lead to a lower energy consumption and lower release of greenhouse gases. However, this puts large demands on logistics and planning. Any deficiencies here and the effect can be the opposite, namely, higher energy consumption and release of greenhouse gases.

2 ABSTRACT

Enormous amounts of energy are used to transport groceries and other daily household goods from producers to end-users. The share of energy use in transport is about equally divided between transport from producer to retailers and from retailers to end-users. Models show that given a smoothly operating web-shopping system at a penetration level as low as 10% of purchased daily household goods, the transport-energy consumption and CO_2-emissions can be lowered by 7%, and NO_x-emissions by 10%. Should the market penetration of web-shopping reach 50% in an area, energy and CO_2 consumption should decrease by 36% and 34%, respectively, and NO_x-emissions by 48%[1)]. Today in Sweden 0.8% of all daily household goods is purchased on the net.

However, bad planning in several senses jeopardise the potential savings. Some of the risks:

- "Creating" a need for a second set of fridge/freezers per household for reception of goods
- Bad (distributor) logistical routines and planning
- Lack of standardisation (distribution methods, sizes of reception facilities, etc)

The new Stockholm city district, Hammarby Sjöstad, is planned to be extremely energy-efficient and designed to stimulate environmental awareness. Ecological efficiency matters are carefully incorporated into not only new building construction logistics and future web-shopping, but for goods-delivery logistics (including planning of a local logistical centre) for the commercial and industrial life already existing in Hammarby Sjöstad. Totally new living conditions may change the consumption dynamics faster in new areas such as this (when compared to the national average) meaning that energy savings might be more easily realised here.

This paper gives a brief description of the overall savings through selected logistical solutions, and a more in-depth study of the savings foreseen through encouraging web-shopping through town planning, building design and other measures.

3 BACKGROUND AND OVERALL PROJECT DESCRIPTION

3.1 Background of the LIP-Council Logistics Project

The City of Stockholm Local Investment Programme (LIP-Council) has the task of reducing environmental impact in the city, with a special emphasis on Hammarby Sjöstad and the Östberga and Skärholmen city districts. This occurs through a variety of projects including technology procurements, general (co-operative) procurements and development and demonstration projects.

Transport is one sector generating large environmental impacts and is therefor prioritised by the LIP-council. One logistics project is being run with the aim to make transport more efficient by developing the existing – and creating new – logistic services in the following areas:

1. Construction logistics
2. Residential logistics
3. Business logistics

Areas one and three (construction logistics and business logistics) will be presented in overview, while the second area, residential logistics, will be discussed in more detail. The project primarily concerns Hammarby Sjöstad, although some collaboration will occur with the ongoing renovations project in the Skärholmen City District via the *Suburban Investment Programme*[2)], and the city as a whole via The Stockholm City Environmental Administration. On the national level, a collaboration with the Swedish Energy Administration is planned.

3.2 Hammarby Sjöstad

Hammarby Sjöstad is an entirely new environmentally accommodated city district being constructed with, among other features, its own bio-cycle model and local waste treatment facility. The district will have a downtown feeling and new, exciting architecture. Its waterfront location and accessibility to both the city centre districts and a nature preserve create unique opportunities and qualities. This environmental project also includes the opportunity to create conditions for cleaner traffic, and Hammarby Sjöstad will have several public transport options, such as the “Cross-town line” (tramway), commuter boats over the Hammarby Canal and access to a rental car fleet. In addition, Hammarby Sjöstad will have first-class pedestrian and bicycle pathways. The goal is to make Hammarby Sjöstad an international model of sustainable development. This district’s ecological performance characteristics are to be twice as good as the best applied technology used in new production today (based on 1990 statistics).

4 PURPOSE AND SCOPE

The purpose of the project is to increase the environmental efficiency of transport by developing (and creating new) logistical services for the construction companies, residents and existing businesses active in Hammarby Sjöstad.

Via this project, the district’s businesses, residents and building contractors in Hammarby Sjöstad will be assisted by using general procurements or, as an alternative, new technology procurements of logistical functions. The project shall be carried out objectively with respect to systems and products, but based on solutions that are not tied to any specific producer. The technical solutions shall be characterised by a comprehensive view of the environment, systems operation and maintenance, safety, user-friendliness, and so on.

The goal is to reduce transport in Hammarby Sjöstad (and eventually Stockholm) by 50 percent within this project during a ten-year period.

5 REALISATION

In general, Hammarby Sjöstad's logistical needs can be divided into the three areas Construction logistics, Residential logistics, and Business logistics.

Measures for reducing the environmental impact within each of the three areas must be defined and applied; similarly advantage must be taken of the opportunities for co-ordination and measures for acting on a larger aggregate level. The project concerns technology and general procurement of services for a more efficient use of logistical resources. This effort is divided into three stages: pilot studies, technology or general procurement, and implementation.

The pilot studies conducted so far indicate that there is a potential for further efficiencies in all three areas, but that it is currently most efficient from the resources point of view to invest in the areas of construction logistics and residential logistics.

5.1 Construction logistics

Residential construction is in full swing in the city district and will continue for another decade. Construction will reach its maximum in mid 2001 and hold this high level for five years. Afterwards, construction and its associated traffic will successively ease off. A delivery by heavy transport during the most intensive construction period is calculated to arrive at a construction site within the district every 40th second each all day from early morning to late night. Furthermore, the traffic net is also being overloaded by the arrival of goods in lighter vehicles at the construction sites, the construction of a high-speed tramway in the area, and the traffic generated by the approximately 4000 employees coming to work at the 400 businesses active in the area. Developers, contractors and subcontractors will have a great need to co-ordinate services to meet the established time schedules and environmental goals.

Large environmental gains are possible if efficient control of construction and goods can be carried out in Hammarby Sjöstad. In addition to environmental gains, time-savings are required from contractors and others active in the area.

A logistics centre has been initiated to facilitate and co-ordinate the construction process. Its purpose is to increase the transport load ratio via collective consignment of direct deliveries when the lorry load ratio would otherwise be low. As a complement, a technology procurement contest of traffic direction systems has been conducted. Experience from the extensive reconstruction of Potsdamer Platz in Berlin, where a traffic direction system was implemented, shows that environmental gains are possible via efficient control of construction and goods traffic. In addition to environmental gains, significant time-savings will be expected from contractors and others actors in the area. A task force has been formed with representatives from all contractors, the LIP-Council and The Stockholm City Real Estate, Streets and Traffic Administration Office to collaborate in these issues. This part of the project is expected to produce a reduction of energy use by 500 litres vehicular fuel per day, which corresponds to 6% of the total energy use in transport.

5.2 Residential logistics

Residents began moving into the district in December 2000, and within a 10-year period the city district will expand to 15 000 residents. According to the time schedule, the last residents will move in in 2012. A total of 8 000 flats will be built, and 10 000 persons are estimated to find work in the area. The residents have several logistical needs including transport to and from work and school, and the purchase of daily household goods (there are no food retailers planned for the area).

Transport of people represents a large yearly consumption of energy. And not least, a large amount of energy is used by the distribution of daily household goods. An increased share of on-line shopping should be able to significantly reduce this energy consumption. However, doing so requires good planning, otherwise there is a large risk that energy consumption will increase instead. The risks include:

- A need of duplicate refrigerator-freezers per household; one in the flat and one in the goods deliveries entrance for daily household goods requiring refrigeration and freezing (concerns both the contractors and residents).
- Poor planning of logistics routines (distributors)
- Lack of standardised distribution methods, package sizes, etc (retailers, wholesalers, contractors)

The proposals discussed for well-functioning logistics are:

- The establishment of a logistics centre for the residents, including the handling of the goods and services ordered. The intention is to arrange a competition for the direction of deliveries of goods, where the City of Stockholm is the purchaser and formulates requirements for contents, environmental goals, level of service, etc. The competition details will be handled according to the law on official procurements (LOU[3)]). There are currently a number of actors expressing strong interest in running a logistics centre.
- Initiate a technology procurement for deriving standard packaging for shipment of daily household goods. This procurement covers the packaging's function throughout the entire distribution chain, from filling it at the e-business warehouse or retailer, transport to the logistics centre, and until being opened by the customer.
- Launch a technology procurement project for environmentally friendly delivery vehicles for distributing the goods from the logistics centre to the final customer.

Initially, a seminar will be arranged for retailers, distributors, contractors and other local actors where pre-conditions will be discussed for realising the above-named proposals. Within the project framework, meetings and discussions have been conducted with a number of retailing representatives, logisticians, refrigerator-freezer manufactures and contractors. There is an expressed interest for some form of co-operation for leading development forward in these areas.

Behaviourally, it is probably easier to adopt new habits and patterns when moving into a new environment. The possibilities of affecting a faster increase in purchasing daily household goods via on-line shopping must therefor be deemed as significantly larger in an entire new city district of Hammarby Sjöstad's character than for the nation as a whole. An opinion questionnaire administered to the future residents will be conducted for the purpose, and to discover which services they are most interested in (above and beyond daily household goods). These can include dry cleaning, mail-order companies, library, home-help and other services.

5.2.1 On-line shopping — pre-conditions and possibilities

"Shopping on the net", "electronic shopping" and so-called "on-line shopping", is currently undergoing lively debate in various forums. Most actors seem to agree that this market has come to stay. The discussions are more concerned with how quickly this will increase and what its market share will be, than whether it will occur or not.

In a report from the Swedish Environmental Protection Agency[4)] it is stated that the energy consumption of transport and the release of greenhouse gases can be considerably reduced by planned on-line shopping of daily household goods. The potential reduction of energy usage and greenhouse gases is equally divided between transport from the manufacture to retailer and from the retailer to the customer. According to the report, simulations show that well-planned on-line shopping, assuming 10% of all purchases of daily household goods take place via the net, would reduce transport energy and CO_2 emissions by 7% and NO_x emissions by 10%. If household on-line shopping increases to 50% of all daily household goods, transport energy and CO_2 emissions would reduce by 36% and 34%, respectively, and NO_x emissions by 48%. Currently, 0.8% of daily household goods purchased in Sweden takes place over the net.

In fact, on-line shopping is no big news. It is the modern version of mail-order. But, on-line shopping puts higher demands on IT-strategy and control. On-line shopping reduces the significance of analysing the competition, while increasing the significance of the knowledge of what the customer does. In B2C (Business to Customer) – as the name implies – the customer is the most important, and this is only made possible by IT. The database and its informational content (information provides statistics which in turn provide knowledge) is on-line shopping's most important factor.

It is essential to keep in mind that on-line shopping is several different phenomena with different underlying motives. Lack of time, limited local choices, the "hip" factor, exclusivity, etc. This great variety places large demands on choice in logistics. The largest motivation for on-line shopping in cities is lack of time, while a shortage of stores is the more important factor in the countryside.

Another aspect to keep in mind is that on-line shopping does not give instant gratification, which is why it is easy for people to go back to previous shopping habits. Old habits stand in the way of new habits.

There is no longer any established purchasing patterns in B2C (Business to Customer), the customers hop wildly between shopping at malls, petrol stations and on-line, to name but a few.

Any attempt to reach efficiencies in cost would see wholesalers, and not food retailers, getting into on-line purchasing. Thus, a probable restructuring of the market will occur just here. This requires further development within wholesaling. Changes in the outside world are taking place due to globalisation, shorter product cycles, more mature Internet technology and increased competitive pressures due to deregulation. On-line shopping will provide commerce with a new structure, which creates new competitive advantages and reduction in transaction costs. New actors need to arise and old ones change. Accordingly, it follows that the logistics branch must change too. The logistics branch will be transformed from a push to a pull structure. But the changes are taking place more slowly than anticipated.

Change in the ambient business climate lead to change in customer needs, which in turn leads to change in transport need (a transformed transport industry) with environmental considerations as one of the many parameters.

A strong logistics concept is needed for success with on-line shopping. Simultaneously, volume is needed for helping to build a strong logistical concept for on-line shopping. Thus, volume is decisive for financial strength in on-line shopping and e-business logistics. This is a dilemma for new on-line shopping businesses.

Many on-line shopping companies have overlooked that a purchase is a process. B2B (Business to Business) developments have been proceeding for many years, while B2C (Business to Customer) development is relatively new. Therefore, we see many mistakes from e-business. Another reason that B2B works better than B2C is that B2B has a well-defined demand.

There is always a return flow of purchases that must be handled by on-line shopping companies. But this is not a new problem; mail-order firms have always wrestled with this. Up to 70% of a good's costs are comprised of logistical costs.

Chalmers University of Technology (Department of Transportation and Logistics), in Gothenburg Sweden, has carried out a conjoint-analysis over what people are willing to pay for home delivery of the daily household goods they have ordered. The break-point according to this survey lies at 50 SEK ($5 USD, 5 Euros), which is 4% of the average purchase price in the survey.

Finally, a factor that must be further developed if on-line shopping is to have a large breakthrough are the purchasing routines. There are many aspects to consider here, not least are questions about security.

5.3 Business logistics

The approximately 400 companies already operating in Hammarby Sjöstad represent many diverse types and sizes. One pilot study has been conducted on the businesses' logistical needs. Unfortunately, the practical possibilities of co-ordination of the businesses' need for transport is relatively small as a consequence of this large diversity. However, some gains from potential co-ordination have been identified. Continued efforts with business logistics will be concentrated on the following three areas:

- A logistics centre for businesses
- Co-ordination with logistical efforts in other parts of the city's administration.
- A transfer of knowledge from an international logistics project, such as the Elcidis-project[5)].

6 SIMULATIONS

6.1 Preconditions for simulations

We are unaware of any project that has actually tested how to direct the needs for transporting daily household goods based on environmental impact data. However, among others, there is a project currently underway in Borlänge, Sweden, about co-ordinating transport of groceries[6)]. Here the municipality co-ordinates all deliveries of daily household goods to their schools, day care centres, nursing homes etc.

The model combining a logistics centre with on-line shopping of daily households goods for the residents originated in the effort to examine any possible measure that might reduce the environmental impact of Hammarby Sjöstad. In order to get an idea of how on-line shopping can reduce environmental impact, we conducted simulations using *Miljöbelastningsprofilen* ("Environmental Impact Profiles"), a computerised calculation model developed by the City of Stockholm (funded by the Ministry of the Environment). Thus our model is based on statistics on annual use of private cars for shopping, emission data for various makes of vehicles, assumptions on requirements for on-line shopping etc, from Statistics Sweden (SCB), background information from the Swedish Environmental Protection Agency (SNV), the Swedish National Road Association (SNRA), and the assumptions presented below based on the expected demographic profile for Hammarby Sjöstad. Other assumptions on shopping habits for daily household goods, transport needs, emissions from transport of these goods, etc, come from the report *Logistik och e-handel av dagligvaror i Hammarby Sjöstad 2001*[7)].

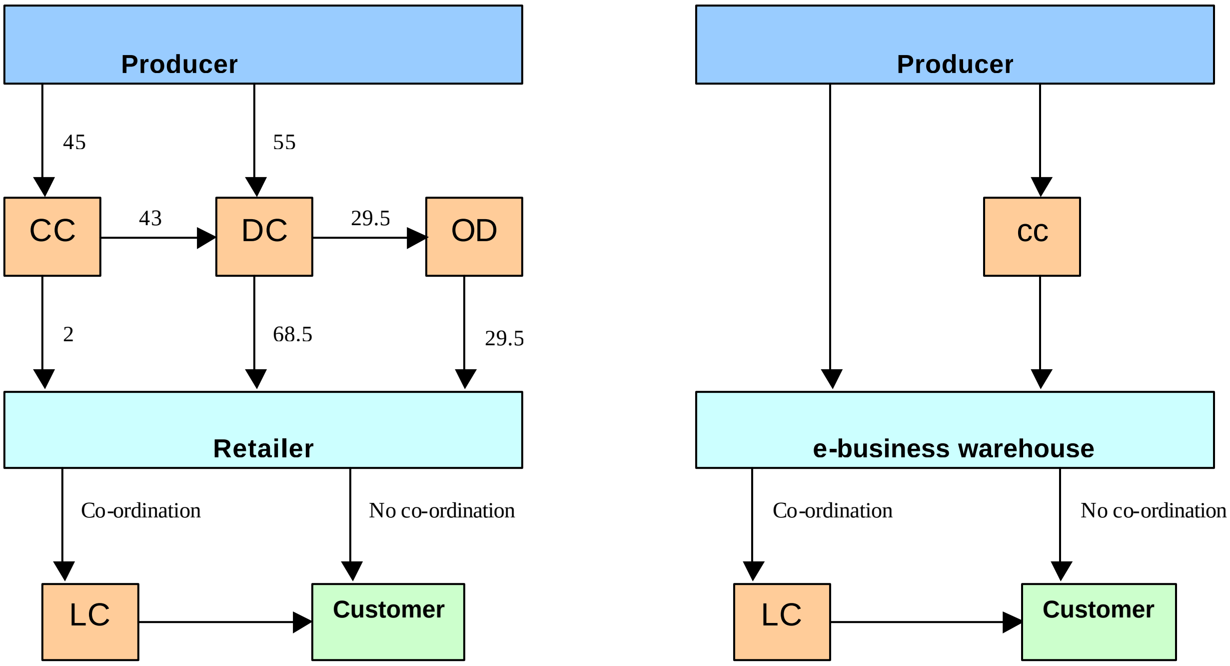
The environmental impact from the transport of daily household goods can roughly be divided into two parts, where the first accounts for transportation from the producers to the retailers, and the second incorporates transport from the retailers (i.e., groceries) to the consumers' homes. According to reports from The Swedish Environmental Protection Agency[8)] the environmental impact from transport of daily household goods is approximately the same for either part.

The current transport flow for daily household goods from the producer to the customer is shown as Case A in Figure 1 below. The flow of goods from the producer to retailers goes through various steps, via collection centres, and distribution centres and nodes before reaching the retailers. The numbers in the figure below are percentages showing the relative size of the flow taking each path. These shipments take place via several means of transport, however at the national level heavy trucks predominate. The environmentally harmful component of the present retailer-to-home transport involves private cars.

The future scenario (Case B in Figure 1) involves an increased share of on-line shopping of daily household goods. This will most likely lead to a restructuring of the daily household goods branch in several ways. Firstly, on-line shopping of daily household goods will very likely be restructured such that that percent of on-line orders for these goods will be filled from special e-business warehouses which, in this case, supersedes the retail shops[9]. An e-business warehouse centre is not open to regular customers, is larger than an average retailer, and are fewer in number than regular daily household goods retailers (in comparison rather more like a wholesaler than a retailer shop). Secondly, transport to the e-business warehouse can provide a more direct route from the producer to the warehouse, perhaps even via a distribution centre. Thus there is a possibility of reducing the need for transport between the producer and the retailer of daily household goods, which in turn can generate a decreased environmental effect.

Deliveries from the retailer to the customer (Case B) can occur in several ways, and the consequence in terms of environmental effect varies primarily due to whether, and in which case which, instrument of control is used to determine the method of distribution.

Figure 1. Flow of goods from the producer to the customer. **A)** From the producer to the retailers the goods pass through collection centres (CC), distribution centres (DC) and other nodes of distribution (OD). The data represent the percentage of total transport volume[10]. **B)** The flow of goods from the producer to the e-business warehouse goes more directly, because the e-business warehouse is larger and less numerous than retailers (more comparable with wholesalers), which means that the transports can be co-ordinated to a higher degree. From the retailer or to the e-business warehouse, the goods go either directly to the customer via traditional shopping or on-line shopping delivery services, or via a logistics centre (LC) in the residential area.



CASE A ***CASE B***

We have chosen in this study to focus on how the environmental impact from transport of daily household goods in the links between daily household goods retailers and the customer are affected by an increase in on-line shopping. Some simulations have also been performed for the transport links between producers and retailers of daily household goods; these results also point to a reduction of environmental impact for transport of daily household goods in this link due to increased on-line shopping. However, unreliability of source data are currently too large to allow a dependable review of these calculations. Further research is required into the availability and quality of source data.

6.1.1 Four different scenarios

As mentioned above, 0.8 % of daily household goods purchased in Sweden currently takes place over the net. Although this shopping includes some e-business warehouses, so far on-line shopping concerns larger, regular retail groceries.

Four different scenarios have been calculated for 2 200 and 8 000 households. The scenarios propose different shares of on-line shopping: 0, 10, 25 and 50%. Each scenario contains six cases (see Table 1) depending on whether on-line shopping concerns shopping from regular household goods retailers or e-business warehouses, and whether transport occurs with or without co-ordination. In the no co-ordination case there are two subcases, delivery in refrigerator-freezer or at the customers door (including several deliveries per day, know as "time windows" for delivery).

Table 1: The six different cases in the scenarios.

	1) Retailers	2) e-business warehouses
A) With co-ordination	A1	A2
B) Without co-ordination (refrigerator-freezer)	B1	B2
C) Without co-ordination (“Time windows”)	C1	C2

Co-ordination means that there is a so-called logistical centre (LC) in the near area. All deliveries of daily household goods from retailers and e-business warehouses ordered over the Internet will arrive here. Each distributor delivers once daily. The logistics centre will store all goods in cold-storage rooms or freezers. The customers later choose whether they want to pick up the goods themselves or have them delivered with the environmentally friendly vans.

In the case **without** co-ordination, either the goods will be placed in refrigerator-freezers in the residential building’s stairwells (case B) or directly at the customers’ doors (Case C). Case B requires only one delivery daily per distributor, while case C requires the customers to be at home at the time of delivery, which in turn requires several deliveries (“time windows”) per distributor and day at each address. Currently, three "time windows" per day are used for on-line shopping of daily household goods. Many of the daily household goods retailers have stated that they are prepared to increase these to five now or as soon as the total customer base is sufficiently large. We have assumed three "time windows" for our calculations.

Our calculations are based on these cases. Also, a sensitivity analysis has been conducted on selected “on-line shopping’s markets share” in relation to the degree that the vehicle is filled. The results are presented later in this chapter.

6.1.2 Assumptions

The study is restricted to Hammarby Sjöstad in Stockholm. The calculations incorporate a) 2 200 households, which corresponds to that part of Hammarby Sjöstad that will be completed by 2002, and b) 8 000 households which corresponds to the entire new city district when it is complete by 2012.

The calculation of emissions and energy usage are based on data from the Swedish National Road Association (SNRA), The Swedish Environmental Protection Agency (SNV) and Statistics Sweden (SCB). Assumptions about on-line shopping behaviour for daily household goods are based on information from both the major Swedish e-business companies and from The Swedish Environmental Protection Agency. All on-line shopping for daily household goods is assumed to take place from Monday through Friday.

In the case of co-ordination, the logistics centre is assumed to be located within Hammarby Sjöstad, and that all deliveries from there to the residents use either electric or other environmentally friendly vehicles, or are picked up on foot by the resident at the centre.

The no-co-ordination case using refrigerator-freezers in the stairwells (Case B) assumes newly developed intelligent refrigerator-freezers with built-in control for minimising the operational time. These refrigerator-freezers use less than half the energy-consumption than best available household fridge-freezers mainly due to the built-in control. The assumed fridge-freezers currently exist only as prototypes.

The case of no co-ordination but with multiple time windows assumes three deliveries daily per retailer, Monday through Friday.

6.2 Scenarios

6.2.1 Scenario 1: base line, 0% on-line shopping

The case of no on-line shopping of daily household goods is calculated as a baseline for comparing the environmental impact of deliveries for the remaining scenarios. In the diagram below, the starting point use no on-line shopping, and changes in the environmental impact are expressed as percentage change from this baseline.

Changes are reported in energy consumption, traffic, nitric oxides (NO_x), carbon dioxide (CO_2), hydrocarbons (HC), carbon monoxide (CO) and particulate matter.

6.2.2 Scenario 2: Possible short-term changes, 10% on-line shopping

Based on contacts with daily household goods retailers and distributors, we feel that a nation-wide average of 10% on-line shopping is a reasonable short-term estimate (5 to 10 years). We believe and assume that a higher percentage than this may be achieved faster as residents occupy a completely new-built district like Hammarby Sjöstad.

Diagram 1 shows the results of our simulations of the environmental impact for cases with and without co-ordination of transport at 10% on-line shopping for 2 200 households. Diagram 2 shows the corresponding results for 8 000 households.

Diagram 1 shows that if no measures are taken (i.e. on-line shopping continues to increase, but without taking any measures on the area's infrastructure), the environmental impact will increase dramatically (Case C1). All values calculated will thereby increase. The most striking increase is in the amount of particulates, which increase by fully 32%. Energy consumption is predicted to rise by 7%, while CO_2 emissions will rise by 3%. The increase in environmental impact as a consequence of on-line shopping would be less if restructuring took place from on-line shopping from traditional retails to e-business warehouse centres. However, 2 200 households represent too small a customer base to allow such a restructuring.

On-line shopping with co-ordination of transport via a logistics centre (Case A) is the most favourable case. Each environmental impact is calculated to reduce, for example reduced energy consumption of 5% and CO_2 emissions of 7%. (Should shopping occur via e-business warehouses instead of from traditional groceries, the corresponding reduction becomes 6% of energy consumption and 8% for CO_2 emissions.

In addition, the extra refrigerator-freezers in the stairwells (Case B) gives very good results at 10% on-line shopping of daily household goods. In this case, the release of particulates increases, but the other estimated environmental parameters decrease. Energy consumption is estimated to go down by 3%, and CO_2 emissions will decrease by 6%.

Diagram 1: Calculated environmental impact at 10% on-line shopping for 2 200 households in Hammarby Sjöstad, Stockholm. Case A1: Co-ordination via the logistics centre. Case B1: Timed refrigerator-freezers in stairwells. Case C1: Current system for deliveries of on-line purchases. ("1" indicates a delivery from a traditional grocery store). The calculations include only changed environmental impacts in the link between the grocer and customer.

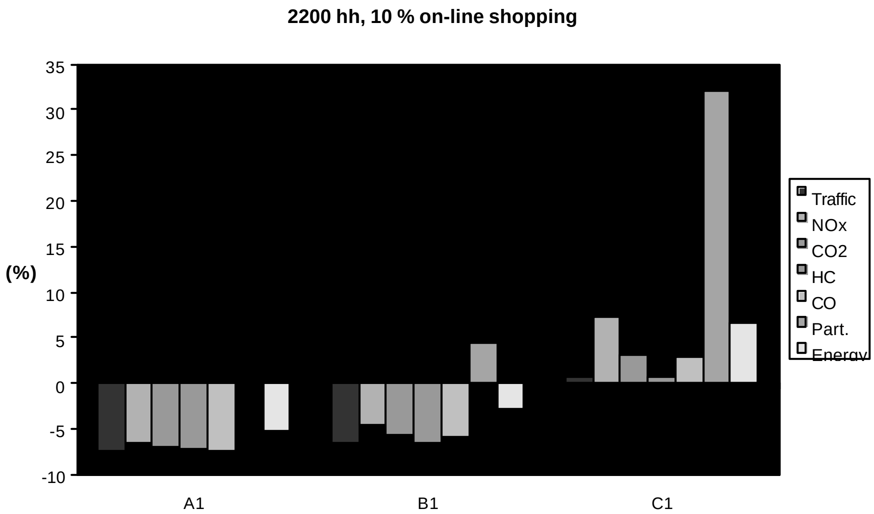


Diagram 2: Calculated environmental impact at 10% on-line shopping for 8 000 households in Hammarby Sjöstad, Stockholm (2012 AD). Case A1: Co-ordination via the logistics centre. Case B1: Timed refrigerator-freezers in stairwells. Case C1: Current system for deliveries of on-line purchases. ("1" indicates a delivery from a traditional grocery store.) The calculations include only changed environmental impacts in the link between the grocer and customer.

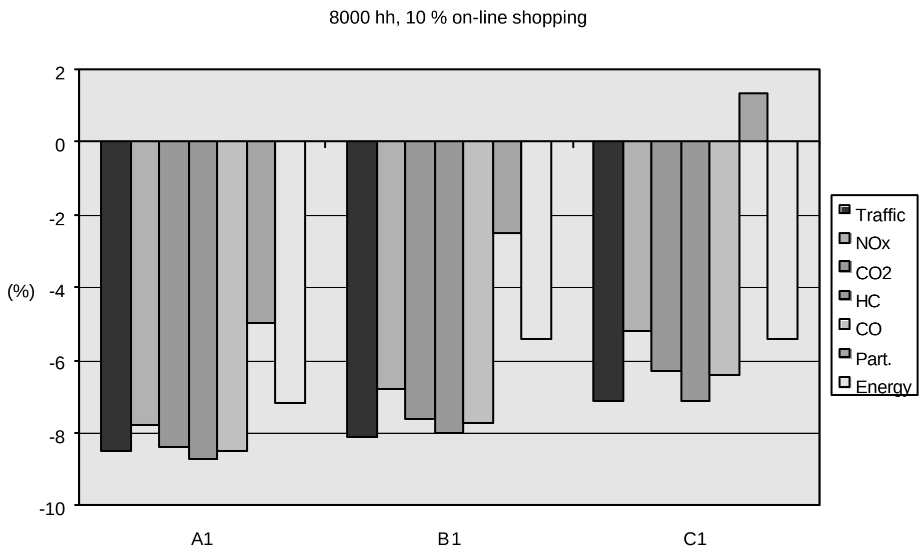
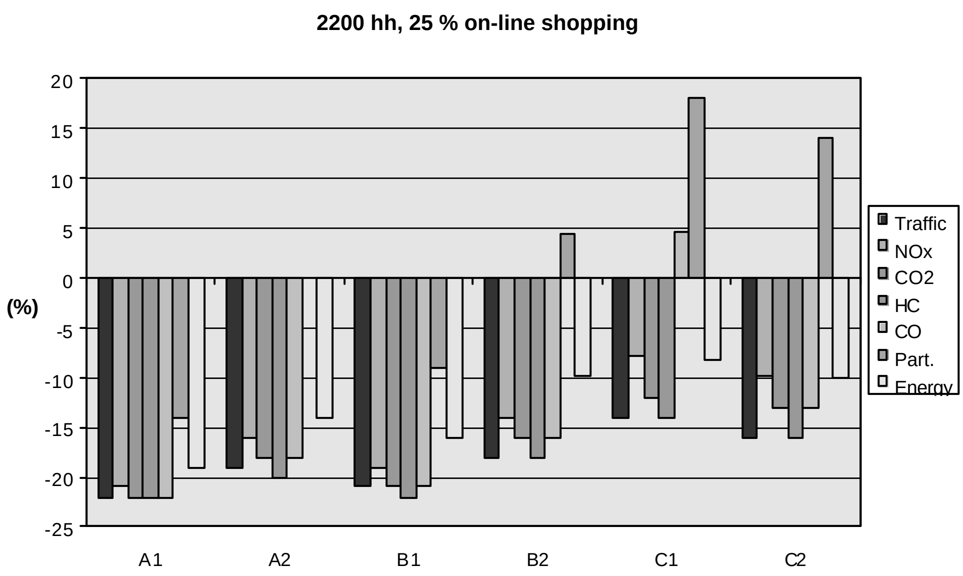


Diagram 2 shows the preliminary estimates for 10% on-line shopping of daily household goods for 8 000 households, that is everyone in Hammarby Sjöstad when totally occupied in 2012. As in Diagram 1, the calculations include only reduced environmental impacts in the link between the grocer and customer. Even with 8 000 households, Case A, the logistics centre, gives the best results with respect to environmental impacts. However, the differences among the various scenarios are not as pronounced. It is worth pointing out that even Case C shows reduced CO_2 emissions as well as reduced energy consumption.

6.2.3 Scenarios 3 and 4: Possible long-term changes, 25% and 50% on-line shopping

In order to see what the environmental impact of an even greater change in shopping habits for daily household goods would be, we reran the calculations at 25% and 50% on-line shopping for both 2 200 and 8 000 households in Hammarby Sjöstad. Diagrams 3 and 4 review the scenarios of 25% on-line shopping for 2 200 and 8 000 households, respectively, and diagram 5 shows the results for 50% on-line shopping for 8 000 households (preliminary results).

Diagram 3: Calculated environmental impact at 25 % on-line shopping for 2 200 households in Hammarby Sjöstad, Stockholm. Case A: Co-ordination via the logistics centre. Case B: Timed refrigerator-freezers in stairwells. Case C: Current system for deliveries of on-line purchases. (The number "1" indicates a delivery from a traditional grocery store, "2" indicates delivery from an e-business warehouse centre.) The calculations include only changed environmental impacts in the link between the grocer and customer.



For 25% on-line shopping, all simulations preliminary produce positive results, for all or a majority of the simulated parameters, in all cases examined. At 25% on-line shopping it is also relevant to consider the potential effects of a restructured retail system from traditional groceries to e-business warehouses. In common with the 10% on-line shopping case, the best results include co-ordination via a logistics centre. According to the calculations energy consumption reduces by 21% and CO_2 emissions by 24%. However, the preliminary results of the differences between the various cases at 25% on-line shopping is considerably less that with 10% on-line shopping.

At 50% on-line shopping, the calculations (preliminary) continue to show the same results, Case A is the best solution from an environmental perspective. Here the reduced energy consumption for transport preliminary comes to 46% and the estimated reduction of CO_2 emissions comes to

Diagram 4: Calculated environmental impact at 25 % on-line shopping for 8 000 households in Hammarby Sjöstad, Stockholm (2012 AD), preliminary results. Case A: Co-ordination via the logistics centre. Case B: Timed refrigerator-freezers in stairwells. Case C: Current system for deliveries of on-line purchases. (The number “1” indicates a delivery from a traditional grocery store, “2” indicates delivery from an e-business warehouse centre.) The calculations include only changed environmental impacts in the link between the grocer and customer.

8000 hh, 25 % on-line shopping

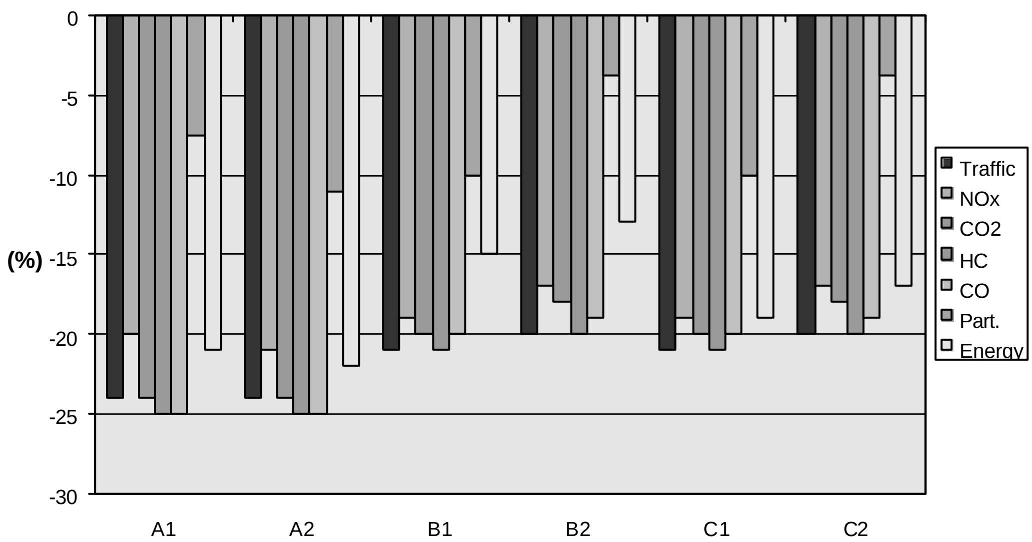
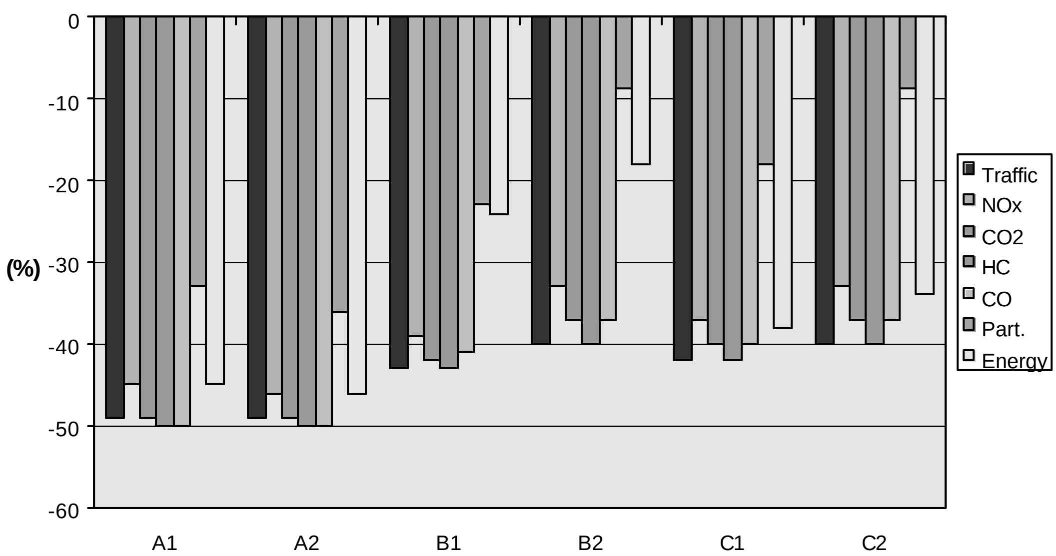


Diagram 5: Calculated environmental impact at 50 % on-line shopping for 8 000 households in Hammarby Sjöstad, Stockholm (2012 AD), preliminary results. Case A: Co-ordination via the logistics centre. Case B: Timed refrigerator-freezers in stairwells. Case C: Current system for deliveries of on-line purchases. (The number “1” indicates a delivery from a traditional grocery store, “2” indicates delivery from an e-business warehouse centre.) The calculations include only changed environmental impacts in the link between the grocer and customer.

8000 hh, 50 % on-line shopping

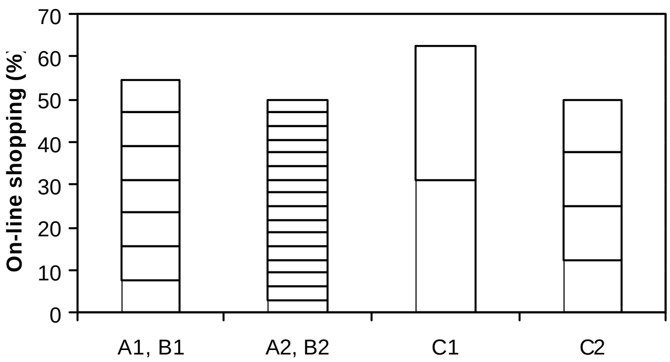


49%. As seen in diagram 5 the largest difference between the three cases shows in particulate matter.

6.3 Sensitivity analysis of the transport load capacity ratio

No linear relationship was seen in the calculation of the environmental impact caused by the delivery of daily household goods, instead the relationship is represented by a step function caused by space capacity restrictions in the selected vehicles. The step function becomes clearer as the service area considered gets smaller. Figure 2 shows the break points for on-line shopping as the percent of the total daily household goods shopping for Hammarby Sjöstad in relation to the use of fully loaded lorries.

Figure 2: Breakpoints (%) of on-line shopping of the total purchase of daily household goods in order to deliver fully loaded lorries for the six cases studied in Hammarby Sjöstad, Stockholm.



To obtain full loads, the optimal breakpoints are obtained using logistics centres with e-business warehouses (Case A2) and refrigerator-freezers in stairwells with e-business warehouses (Case B2), for which full loads are reached at 3.1% on-line shopping. In the case of on-line shopping without co-ordination, 31% on-line shopping is needed in order to deliver using fully loaded vehicles (See Fig. 3).

7 CONCLUSIONS

This project comprises logistical solutions for construction work, existing companies and (new) residents to the new Hammarby Sjöstad city district. This presentation has focused on residential logistics, with an in-depth description of the simulations of possible strategies for reducing environmental impact obtainable by restructuring the delivery of daily household goods. The calculations have focused on transport between retailers of daily household goods and the customer, but considerable environmental gains can also be obtained if correct measures are taken to make transport more efficient between the producer and retailer.

The LIP Council of the City of Stockholm is conducting a logistics project with the aim of testing whether a logistics centre for the residents (as constituting Case A in the estimates) as a good solution.

In the short to middle term, environmental impact as a result of transport of daily household goods can be substantially reduced. Even at a level of on-line shopping of 10% of all daily household goods, energy consumption and CO_2 emissions can be reduced by 5-7% and 7-8%, respectively. However, the risk of environmental impact as a result of transport of daily household goods can increase instead if relevant measures and controls are not established.

In the long run, with a dramatic increase of the proportion of daily household goods purchased via the net (here estimated at 25% and 50%), the case with the logistics centre (case A) continues to produce the environmentally best effects. However, the two other cases calculated also decreased environmental effects. Should such a high proportion of on-line shopping of daily household goods become reality, we can predict a large restructuring of the branch, which too will have a far-reaching impact on the logistics of daily household goods shopping and thereby its environmental impact.

8 REFERENCES AND ENDNOTES

1. *IT, mat &miljö, en konsekvensanalys av elektronisk handel med dagligvaror.* Swedish Environmental Protection Agency, R5038, Orremo, F. et al, Stockholm, Sweden, 1999. (Approximate English title "IT, Food & Environment"). In Swedish, English summary.
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3. *LOU, Lagen om Offentlig Upphandling*, the National Swedish Procurement Law.
4. Op cit ref 1.
5. Elcidis (Electric Vehicle City Distribution Systems) is a Thermie project.
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8. Op cit ref 1.
9. Personal communication with representatives from major Swedish daily household goods retailers and wholesalers (KF, Axfood, D-gruppen, ICA).
10. Op cit ref 1 (SNV 5038, *ICA-handlarna*, "The ICA-shopper").