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Energy saving in transport of goods – a pilot project in rural natural resource based industries

Final report from the European Commission SAVE -project XVII/4.1031/Z/97-229

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Summary

This report presents the results from a project on energy saving in transport of goods. It has been a pilot project in rural natural resource based industries in three Nordic countries. The main object of the project has been to develop and implement actions, strategies and measures for improved energy efficiency in transport of goods. The project has used 3 cases of natural resource based industries, one from each of the three Nordic countries Norway, Sweden and Finland. The cases are fish export in Norway, wood (paper) export in Finland and agricultural products (mainly grain) in Sweden. Pilot actions have been carried out in one company each in Norway and Finland and in two companies in Sweden.

The project constituted 3 main phases: 1) Basic analytic activities, 2) Pilot actions in the "case"-companies and 3) Actions and measures in regional policies. Phase 1 included an analysis of transport means, transport volumes, load factors and energy use in transport of goods in the 3 Nordic countries. Historical data back to 1970 and prognosis up to year 2020 for the three major modes of goods transport road, rail and sea were analysed. This phase also included a literature survey of energy saving in transport of goods. Phase 2 included pilot actions at three levels; reduction of fuel consumption, increased load factor and transfer of goods from road to rail and sea. In Phase 3 an analysis of measures and actions in regional policies for energy saving in the goods transport in the 3 Nordic countries was carried out.

Other publications from the project

Andersen, O., O. Uusitalo, P. Ahlvik, H. Hjortsberg, K. Groven and E. Brendehaug. *Energy in transport of goods. Nordic Examples.* VF-Rapport 6/99.Vestlandsforsking, Sogndal.

Andersen, O., O. Uusitalo, J. Lehtinen, P. Ahlvik, H. Hjortsberg, K. Groven and E. Brendehaug. *Pilot actions for energy saving in transport of goods. Nordic Examples.* VF-Rapport 2/2001.Vestlandsforsking, Sogndal.

Andersen, O., U. Suutari, H. Hjortsberg, K. Groven and E. Brendehaug. *Measures and actions in regional policies for energy saving.* VF-Rapport 3/2001.Vestlandsforsking, Sogndal.

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Preface

This report presents the results of a pilot action project under the European Commission DG XVII –programme Specific Actions for Vigorous Energy Efficiency (SAVE). The content of the report is the sole responsibility of the publishers, and it does not in any way represent the views of the Commission or its services.

The main object of the project has been to develop and implement actions, strategies and measures for improved energy efficiency in transport of goods.

The report is edited and partly written by researcher Otto Andersen at Western Norway Research Institute, who also has been responsible for co-ordinating the project. The report is based on contributions from several other researchers both at Western Norway Research Institute and the two partners Ecotraffic R&D in Sweden and VTT Building and Transport in Finland. Each contribution is however based on comments and suggestions by all three partners.

Several people within the transport sector have contributed to the content of the report, and we are most thankful for all their help.

Karl Georg Høyer has headed the project.

Sogndal, February, 2001

Karl G. Høyer

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Summary

The project "Energy saving in transport of goods - a pilot project in rural natural resource based industries" was carried out with financing from the SAVE II-program in the European Commission DG XVII.

The main object of the project was to develop and implement actions, strategies and measures for improved energy efficiency in transport of goods.

The project used 3 cases of natural resource based industries, one from each of the three Nordic countries Norway, Sweden and Finland. The cases are fish export in Norway, wood (paper) export in Finland and agricultural products (mainly grain) in Sweden. One company each in Norway and Finland and two companies in Sweden are selected and pilot actions are carries out in each of the companies.

The project constituted 3 main phases: 1) Basic analytic activities, 2) Pilot actions in case-companies and 3) Actions and measures in regional policies.

Phase 1 included an analysis of transport means, transport volumes, load factors and energy use in transport of goods in the 3 Nordic countries. Historical data back to 1970 and prognosis up to year 2020 for the three major modes of goods transport road, rail and sea were analysed. Both the volumes (in tonnekm) and the energy use have increased rapidly for road transport of goods in all the 3 countries. The increase appears to be largest in Norway with a more than doubling of transport volume between 1970 and 1995. The increase in energy use for road travel goods transport is four-fold for the same period. This phase also included a literature survey of energy saving in transport of goods identified potential actions and measures at three levels; reduction of fuel consumption, increased load factor and transfer of goods from road to rail and sea.

Phase 2 included pilot actions at the same three levels. This consisted of analyses and implementation of pilot actions for energy saving in transport of goods connected to the case companies in the tree countries. Case companies in each of the three countries have participated in the project. In Norway the results from the pilot actions indicated that fish transport from western Norway to the continent has an average energy use for down-trip and return trip of about 0,22 kWh per tonnekm. The return trips give lower energy efficiency. This is caused by low load factor. If the load capacity had been fully utilised on return trips, the energy efficiency could be improved to about 0,18 kWh per tonnekm.

Different driving style could have a great influence on fuel use and thereby energy efficiency. Our cases show that non-economic driving could increase fuel consumption with 25 percent. The energy saving potential in today's lorry transport is greatest in mountain and hilly areas.

The actual energy saving effect in the today's lorry transport is 5 % according to the result in the transport company Nistad in western Norway. For the whole fish export transported on lorry this would give an energy saving effect of about 12.000 tonne fuel or about 115 mill kWh.

If all the fish export from Norway to the European continent where transported by train the total reduction in energy use could be about 70.000 ton fuel or nearly 700 mill kWh. This calculation is based on the assumption that our four cases give a representative picture of

transport distance and transport mode in the today fish export. This is not necessarily right, but our calculation gives an estimate of the future energy saving potential.

During the project period transferral from road to rail and ferry were done for two of the four case routes. Rail based transport with dried cod to Italy reach a reduction in energy use at 60 % compared with lorry based transport. The effect comes from the more energy efficiency train transport used on the whole distance from Western Norway to Verona in Italy. The transport is similar in time efficiency (5% difference) to the lorry-based transport in 1999.

The other implemented action frozen fish to Boulogne SM in France, is based on ferry and train transport. Here the reduction in energy use is "only" about 20 percentage, caused by the train from Åndalsnes to Oslo. The energy saving effect is limited due to the long ferry distance Oslo-Rotterdam. Ferry is less energy efficient than lorry transport.

In Finland the energy use in the case company UPM-Kymmene Group and their transport chain, from Voikkaa paper mill to the customer in Cologne, Germany is analysed. The energy use is calculated for transporting 8 800 tonnes paper. The amount of raw materials is estimated from their yearly volumes in proportion to yearly production of paper. The energy use includes loading, unloading and other handling of goods except for the possible handling in Germany, which differs from the handling in Finland. The total energy use of the transport chain amounts to 2 971 MWh, which is 0,34 MWh per paper tonne. From the energy efficiency, kWh/tonne-km, it is evident that the train transport in Germany is more energy efficient than the train transport in Finland. This is probably due to the fact that transport distances in this case are shorter in Finland than selected distance in Germany, and that the share of electric locomotives is larger in Germany than in Finland.

The study of energy use in the Swedish case company ODAL provided an overall idea of the approximate amount of energy used in different parts of the transport chain. The transport chain has been divided into the steps "farmer-to-silo", "silo-to-silo", "to export", and, in the special case, also "from export harbour to import harbour". The figures in different parts of the chain are partly uncertain and can differ up to 20% or more, especially since the transport volumes differ considerably between years and regions in ODAL. However, the data could be used to show, which the areas of main energy use are, and the potential for energy-saving activities. The important factors in energy saving, such as the choice of transport mode and distance between producer and consumer, etc., are also highlighted via the study of energy use and pilot actions.

It can be noted that about 1/3 more energy is used in the "silo-to-silo" step (11,3 GWh/year) compared with the "farmer-to-silo step" (7,41 GWh/year). The distance is also longer in the "silo-to-silo" step. The average energy efficiency in "silo-to-silo" is however larger, about 0,15 kWh/tonnekm, compared to 0,67 kWh/tonnekm for "farmer to silo". The "farmer-to-silo" step includes more use of tractors, which are also assumed to have a lower load factor than lorries. About 65% of the grain in ODAL is exported and the energy use for transport to export harbours in Sweden is about 12,2 GWh/year.

The special case study called "Söderköping" illustrates the great effect of a short transport distance and high-energy efficiency of the transport mode. The special case has more than 50% higher energy use per delivery (about 136 kWh compared to 84) compared to the average for the general farmer-to-silo transport case. The main explanation for this is the more frequent use of tractors as the transport mode and a longer average distance to the silo (about

18,9 km compared to 11,4 km). The average energy efficiency in the special case is about 0,77 kWh/tonnekm.

Phase 3 included an analysis of measures and actions in regional policies for energy saving in the goods transport in the 3 Nordic countries. Actors important for a mode change from today's road based transport, to a transport using more rail and sea have been identified in all three countries. The actors which were considered to be the most important relating to this mode change have each been interviewed at two occasions. Actors were selected both from within the regional and local political/administrative system and from within transport companies.

The results from the interviews indicate first of all that actors operating in the goods transport field are not co-ordinated well enough in their activities. A well functioning system of co-ordinated actors representing different transport modes is essential for improved mode change from road to rail /sea and for increased use of transmodal transport solutions. Lack of co-ordination between the actors appears to be a barrier to this mode change.

The implementation of local and regional transport plans, which could facilitate the desired mode changes, also requires a high degree of co-ordination between the involved actors. This co-ordination appears to be lacking today. National transport planning appear not to have taken into account the energy saving potential from road to rail/sea mode change and increased transmodal transport. The protection of free market principles appear to be a barrier to forming national policies for facilitating these energy saving mode changes.

Environmental labelling of goods transport appears to only have limited effect today, but could be an important factor in the future. It would be an advantage if the eco-label system is internationally harmonised, so that the guidelines are equal for neighbouring countries. A system for Eco-labelling is considered an important measure in general, but the measures to develop and affect that kind of systems are seen as difficult. Eco-labelling of transport is however a way in which the consumers' opinion can affect the choice of the mode of transport.

1. Introduction and background of the project

Transport accounts for a large share of total energy use both in the Nordic countries and in the European Community as a whole. It is the societal sector which has been subject to the largest percentage increase in energy use the last twenty years. While other sectors generally have stabilised or reduced their energy use the later years, it has continued to increase both in transport of passengers and goods. The increase in road transport, in volume of transport work as well as energy use, has been particularly large. Much of this transport has a low load factor and generally has much lower energy efficiency than rail and sea transport. Traditionally sea transport has been of particular importance in the transport of goods to and from the Nordic countries, and has been performed with high load factors and energy efficiency. The last couple of decades this form of transport has however lost much of its former importance. Rail transport has at the same time generally not increased in the volume of transported goods. The result has been a lowering of energy efficiency in total in the transport of goods.

Natural resource based production has always been a major segment of the industrial structures of the Nordic countries. This has also in general been the case in other rural regions within the European Community. transport of goods to and from these industries similarly accounts for large shares of the total transport volumes. This constitutes a background for the project *" Energy saving in transport of goods – a pilot project in rural natural resource based industries"* and the choice of project "cases" for actual implementation of pilot actions. All "cases" are transport in connection to rural natural resource based industries in the 3 Nordic countries Finland, Norway and Sweden.

One objective of this project has been to generate knowledge from the 3 "cases" that can be transferred to other forms of transport of goods both in relation to export and import. This implies that the project has included an *analytical part* on opportunities and potentials for improved energy efficiency in industrial transport of goods in general. The intention has been to establish a basis for continued actions after the project period has ended.

The main objectives of the project has been:

- To develop and implement actions, strategies and measures for improved energy efficiency in transport of goods.
- To gain knowledge of the conditions and effects of such actions, strategies and measures through pilot actions in 3 different rural, natural resource based industries.
- To analyse the conditions for transferring this knowledge to other forms of transport of goods with the intention of establishing a basis for continued actions after the project has ended.

The project has consisted of 3 main phases:

Phase 1. Basic analytic activities
Phase 2. Pilot actions in case-companies (company level). This phase includes an evaluation of the effects of the pilot actions
Phase 3. Actions and measures in regional policies (policy level).

2. Methodology

The methodological approaches used in the three phases of the project is described below:

2.1. Methodology for Phase 1

Phase 1 of the project was divided into four main tasks:

Task 1: Energy-use in transport of goods in the 3 countries
This task constituted of an analysis based on statistical data of energy use in transport of goods in the 3 countries. Historical data, present data and prognoses for the future were included in this analysis. Statistics on energy use in Europe as a whole was included for comparison purposes.

Task 2: Energy saving in transport of goods
This was a literature survey on energy savings in goods transportation. It was based on existing data, both national and international.

Task 3: Identification and decicions on case companies
This task consisted of establishing contact with possible case companies, and finally decide upon which case company to use.

Task 4: Identification of potential pilot actions within the case companies
This task consisted of analysing the possible actions and finally decide upon which pilot actions were the most likely to focus on in each of the case companies. The pilot actions covered 3 different levels:

- *Fuel consumption level.* These were actions that the companies could implement in order to reduce fuel consumption in today's lorry based transport. These actions were at different levels in the companies, specifically at management-, garage- and driver level. A central issue was to obtain knowledge of which strategies the companies could develop in order to secure a process towards continuous increase in the lorry based fuel economy.
- *Load factor level.* These were actions and strategies that the companies could implement in order to increase the load factor in today's lorry based transport. A central issue was how the potential for transport of the return of goods could be utilised in this context
- *Transferral of goods level.* These are actions and strategies that the companies can implement in order to achieve a transferral of goods from lorries to more energy-efficient rail- and ship transport. An important aspect of this issue was the utilisation of the potential for combined transport modes.

2.2. Methodology for Phase 2

Phase 2 of the project constituted of preparing and performing the pilot actions in the case-companies. The data material was obtained from the two main sources 1) Documentation from the case companies and 2) Interviews.

The actions were implemented through internal company processes, which involved *participation* by the project researchers and a *constructive dialogue* between company employees and the researchers. This gave the basis for systematising the experiences and results both through evaluation and participatory observation.

The aim of the project has also been to evaluate the effects of pilot actions as performed during phase 2. This consisted of the following activities:

- An evaluation of the conditions for implementing actions and strategies at the different levels in the 3 companies. This has mainly been based on participatory observations.
- An evaluation of the actual and potential energy saving effects of pilot actions and strategies. This has mainly been based on systematic reporting made by the involved researchers through the whole phase 2. The energy saving effect has been evaluated in relation to the following variables:
  - Fuel consumption in lorries
  - Load factors in lorries
  - Transfer of goods to rail- and ship transport.
- An evaluation of potential energy saving effect of transferring actions and strategies identified through the project to other industrial sectors in order to achieve greater energy efficiency in transport of goods in general.

2.3. Methodology for Phase 3

Phase 3 of the project has constituted of eleven main tasks:

1. Preliminary identification of the actors (All 3 partners). This included an exchange between the partners, of the results obtained.
2. Preparation of guide for first interview round (WNRI)
3. Identification of key informants in each actor (All 3 partners)
4. Send out the questions for the first interview round to the informants (All 3 partners)
5. Carry out first round of interviews by phone and e-mail (All 3 partners)
6. Report on the results from the first interview round (All 3 partners)
7. Preparation of guide for second interview round (WNRI)
8. Send out the questions for the second interview round to the informants (All 3 partners)
9. Carry out second round of interviews (All 3 partners)
10. Summing up the results (All 3 partners)
11. Write final report from Phase 3 (WNRI)

The interview guides used for the first and second interview round are enclosed in this report as Attachment 1 and 2 respectively.

The results from the first interview round formed the basis for the questions which was asked during the second round of interviews.
In order to identify the measures and actions on regional level, the interviews have been supplemented with a study of relevant literature. The choice of literature and informants for interviews were based information from persons in different societal levels (national, regional and local).
In the report the result from the literature research, the choice of the informants and the result from the interviews with the informants is accounted for. The description of the literature in the area can serve as a background and also to some extent clarify the role of different agents in the field of transport mode change. The approach of a thorough literature review was mainly used for the Swedish conditions.

Some of the studied literature is on EC level and on national level (including national strategies and aims etc.). This is relevant since the measures and actions on a regional level often is the result of breaking down national measures, actions and principles.
The structuring of the measures and actions has been guided by the question of what they (the measures and actions) are directed towards, or expressed in another way; where the measures and actions could have an affect. The main structuring thereby is a differentiation between 3 types of measures and actions:

1) General measures and actions for road to rail/sea transfer
2) Specific measures and actions for road to rail transfer
3) Specific measures and actions for road to sea transfer

3. Energy use in transport of goods

3.1. The situation in Europe

Energy use of transport in the EU was about 3208 TWh in 1995. The corresponding figures for 1985 were 2349 TWh. The energy use grew by an average annual rate of 3,2% between 1985 and 1995, but in the period of 1990-95 the growth was at 1,7% per year (EC, 1997a).

Road transport is by far the largest sub-sector, accounting for 83% (2661 TWh) of total energy demand. The energy implications of road transport are increasing further, and the expected growth in transport volumes is likely to more than offset the expected energy efficiency improvements. The forecast is that the technical improvements are more likely directed towards greater consumer comfort levels than lower fuel consumption.

Between 1985 and 1995, the diesel consumption for transport increased by 70%, from 725 to 1229 TWh. Total goods transport work has increased by more than 70% over the past 25 years and the transport of goods by road has more than doubled. The road goods transport proportion has increased at the expense of other transport modes, especially rail. As a consequence, diesel oil in road consumption has continued to increase, passing from 41% in 1990 to 46% in 1995 (EC, 1997a).

GDP growth in Europe is forecasted to rise from 2,4% in 1997 to 3,2% in 2000. Total energy demand is forecasted to grow as well. Transport demand dominates the demand of oil. Its share in 1994 was 45% of the total oil consumption. During the forecasted period it is expected that the transport share of total oil demand will recover to its share of about 42% in 1992 (EC, 1997a).

3.2. Energy use in transport of goods in Norway

The purpose of this chapter is to present data on energy use in Norwegian domestic goods transport for the transport modes road, sea and rail.[1] Figures on both *energy efficiency* (kWh per tonnekm) for different categories of transport means will be given, as well as *total energy use* (TWh) for the three transport modes. In addition figures on utilisation of capacity (load factor) is presented.

3.2.1. Historical and present data

There are no official statistics with authoritative time series on energy use in goods transport in Norway. Hence, several sources and methods is used to reconstruct a picture of the development in this field since 1970. Rideng (1997) presents long time series on transport volume (tonnekm) for different transport modes.

[1] Goods transport volume for air transport is very small compared to other transport modes (0,1 % of total in 1995).

Table 1 Norwegian domestic transport volume 1970 – 1995 (bio. tonnekm)

	Road	Railway	Sea	Total
1970	3,19	1,45	10,25	14,90
1975	4,57	1,51	9,84	15,92
1980	5,25	1,66	9,79	16,72
1985	6,42	1,77	9,30	17,51
1990	8,23	1,63	9,07	18,95
1995	9,65	1,65	6,90	18,22

Source: Rideng (1997).

Table 1 shows domestic goods transport volume performed in Norway in the period 1970 – 1995.

The most important change in this time span is the strong growth of road transport at the expense of sea transport. While transport volume performed by lorries tripled in size between 1970 and 1996, sea transport declined by 33 per cent in the same period. The relative share of total transport volume for these transport modes changed from 69 to 36 per cent for sea transport and from 21 to 55 per cent for road transport. Railway transport remained stable throughout the period, constituting approximately 10 per cent of total domestic goods transport volume.

Transport of oil and gas from the continental shelf to mainland is not included in Table 1. The exploitation of offshore oil and gas resources from late 1970's has put Norway in a unique position among Nordic countries regarding transport patterns. By means of oil tankers and pipelines, crude oil and natural gas is transported from the North Sea to mainland terminals and refineries before final export. If included in domestic transport statistics this transport counts for a substantial part of inland transport volume.[2] Because it has no clear relevance to the goods transport investigated in this report, transport of oil and gas is excluded from the study. This also makes it possible to compare the goods transport in the three countries Norway, Sweden and Finland.

There are no available complete statistics on the transport work in import and export of goods. Rideng (1997) presents figures on transport work performed on Norwegian territory in connection with foreign trade, but it is somewhat unclear what these figures include. According to Rideng, import and export in 1996 produced about 35 billion tonnekm within the Norwegian borders, most of it as sea transport. Rideng does not point out how much of this was related to petroleum industries, but oil and gas export is obviously playing an important role here.

Above, we have seen how goods transport has developed with regard to transport volume. In the following presentation energy efficiency and total energy use for road, sea and rail transport is analysed.

[2] In 1996 transport of oil and gas from the continental shelf to mainland counted for 9,3 bio. tonnekm performed by oil tankers and 9,2 bio. tonnekm by pipelines, thereby constituting a transport volume almost as large as all ordinary domestic goods transport in Norway that year.

A. Road transport

Literature on energy use in road goods transport mainly rely on official transport and energy statistics assembled by Statistics Norway. In addition energy use factors based on measurements (e.g. emission tests like ECE 13-mode) are incorporated in some studies. Some of the literature we refer to have main focus on emissions from transport, but as emissions depend on fuel use, energy figures also can be deduced. The emphasis is on energy efficiency and load factors, while results on total energy use is presented at the end of this subchapter.

In Table 2 energy efficiency for vans, lorries and special vehicles in 1993-95 is presented. Data are based on Holtskog and Rypdal (1997), hereafter also referred to as "the SSB study".[3] Figures are based on a sample survey performed by Statistics Norway (SSB, 1997).

Table 2 Energy efficiency in Norwegian domestic goods transport on road, 1993-95

Vehicle class / load capacity (tonne)	Energy efficiency (kWh/tonnekm)	Load factor[4] (%)
Vans / small combined vehicles (1-1,5 tonne)	**5,64**	**15,4**
Lorries (average)	**0,73**	**41,3**
1,0 - 3,4 tonne	3,95	29,3
3,5 - 4,9 tonne	1,58	37,8
5,0 - 7,9 tonne	1,19	33,4
8,0 - 10,9 tonne	0,88	37,5
11,0 - 12,9 tonne	0,42	40,5
13,0 tonne and above	0,44	45,2
Special vehicles (average)	**0,51**	**43,2**
Tank lorries	0,59	39,5

Source: Holtskog and Rypdal (1997) and Statistics Norway (1997).

Because energy efficiency differs so much between vehicle types and weight classes, average figures for road transport as a whole have limited information value. Energy efficiency increases with vehicle load capacity, as shown in Table 2 (the table however indicates some exceptions from this rule). Load factor shows an even tighter correlation between vehicle load capacity and energy efficient transport. Vans and small combined vehicles may be up to a factor of 13 less energy efficient than heavy duty vehicles. This can partly be explained by the use of lighter vans for combined person/goods transport and "non goods transport" (e.g. use by craftsmen).

In Table 3 figures on energy efficiency in 1996 for different vehicle classes are presented. This table is based on Thune-Larsen et al. (1997), hereafter referred to as "the TØI study".[5]

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[3] SSB is the acronym for Statistisk sentralbyrå (Statistics Norway), the publisher of the report.

[4] Actual transport volume (tonnekm) measured as a percentage of capacity-kilometres performed (capacity-kilometre is defined as vehicle-kilometres run multiplied by the load capacity). Load factor includes empty driving.

[5] TØI is an abbreviation for Transportøkonomisk institutt (Institute of Transport Economics), the publisher of the report. "The TØI study" might be a misleading expression, because the calculation of energy use for different vehicle classes actually was performed by Statistics Norway on order from TØI.

The data have been generated by Statistics Norway, based on a computer model for calculation of emissions (SFT, 1993).

Table 3 Energy efficiency in Norwegian domestic goods transport on road, 1996

Vehicle class	Total weight (tonne)	Average load capacity (tonne)	Energy efficiency (kWh/tonnekm)
Light van	< 2,7	0,26	2,94
Heavy van	2,7-3,5	0,79	1,11
Light goods	3,5-10	2,51	0,86
Medium goods	10-20	4,18	0,78
Heavy goods (DHLH)	>20	15,63	0,22

Source: Thune-Larsen et al. (1997).

According to TØI the heaviest lorries had an energy efficiency factor in 1996 of 0,22 kWh/tonnekm (Table 3), while the energy use of the comparable vehicle class in the SSB study was at 0,44 kWh/tonnekm in 1993-95 (Table 2). Hence heavy goods vehicles are twice as energy demanding according to Holtskog and Rypdal (1997) compared to the estimates of Thune-Larsen et al. (1997). How can this rather dramatic discrepancy be explained?

There are several features of the two studies which contribute to the difference in estimated energy efficiency for heavy lorries:

- Different weight classes: The heaviest weight class in the SSB study is lorries with total weight above 20 tonne, while TØI refers to lorries with load capacity of 13 tonne or more (the latter category might be equal to a minimum total weight of approximately 17 tonne[6]). This implies that the energy efficiency factor for heavy lorries in the SSB study should be somewhat higher, because it includes some medium sized vehicles between 17 and 20 tonne which are excluded the TØI study.
- Different reference year: The SSB study covers the period 1993-95, and the TØI study has 1996 as reference year.
- Different calculation of tonnekm: If we compare the studies with regard to energy use per *vehicle kilometre*, the difference decreases. Measured in this way, energy use for heavy lorries is 39 per cent higher according to SSB compared to TØI, while the difference is 100 per cent when measured in kWh per tonnekm (Table 4).
- Different data sources: The SSB study is based on a top-down method, using information on fuel consumption given by lorry drivers participating in the sample survey SSB (1997). The TØI study uses a bottom-up model, starting with energy use factors based on measurements. This methodical difference is probably one of several explanations why the TØI and SSB studies give very different figures on energy efficiency (Kjetil Flugsrud, pers. comm.).

Table 4 Energy efficiency factors for heavy lorries, comparison between two Norwegian studies

Study	Reference	Total weight	Average load	kWh/	kWh/

[6] For heavy goods vehicles the load capacity represents 2/3 of total weight (Vegdirektoratet, 1997).

	year	(tonne)	capacity (tonne)	tonnekm	vehicle km
Holtskog and Rypdal (1997)	1993-95	> 17	11,0	0,44	4,84
Thune-Larsen et al. (1997)	1996	> 20	15,6	0,22	3,49

The relatively smaller difference between the two studies when energy efficiency is measured in kWh per vehicle kilometre indicates that the way of calculating tonnekm is a major source for the differing results. In the TØI study, tonnekm figures were based on statistics for vehicle kilometre and figures on average load capacity for each weight class (Harald Thune-Larsen, pers. comm.). For the vehicle class DHLH lorries above 20 tonne total weight this average load capacity was set to 15,6 tonne (Table 3). The corresponding figure for the heaviest weight class in the SSB study was 11,0 tonne.

In 1999 the Norwegian Pollution Control Authority published an updated version of the report "Emissions from road transport in Norway" (SFT 1999). The report presents estimates of fuel consumption for different vehicle classes for the period 1973 - 1997, based on a data model made by three authoritative Norwegian institutions in this field.[7] The first issue of the road transport model, which was presented in SFT (1993), served as data source for the TØI study mentioned above (Thune-Larsen et al. 1997). The methodology behind the data model has been improved in the latest issue. Hence energy efficiency estimates in SFT (1999) should be of higher quality than those in the TØI study. In this context it is a problem though, that SFT (1999) links fuel use in road transport to vehicle kilometre only, and not to transport volume measured as tonnekm.

In order to estimate energy efficiency expressed as kWh per tonnekm based on SFT (1999), other sources must be used to find the relation between vehicle kilometre and tonnekm. Survey studies on road goods transport made by Statistics Norway (SSB, 1999 and earlier issues) may be used, still there is an obstacle connected to different weight classes and mismatch regarding reference years between the survey studies and SFT (1999). In Table 5 we have shown that weight classes can be combined for lorries above 7,5 tonne total weight for the year 1988 and later.

Table 5 Matching of weight classes between SFT (1999) and SSB (1999 and earlier issues)

Total weight (tonne) SFT (1999)	Load capacity (tonne) SSB (1999 and earlier)		
1973-97	1973-83	1988	1993-97
< 3,5	1 - 5	1 - 5	1 - 3,5
3,5 - 7,5			3,5 - 5
7,5 - 16	5 - 8	5 - 8	5 - 8
	> 8	8 - 11	8 - 11
> 16		11 - 13	11 - 13
		> 13	> 13

[7] Statistics Norway; The National Institute of Technology (TI) Norway; Norwegian Institute for Air Research.

In Table 6 the development of energy use per tonnekm and average tonnage between 1988 and 1997 is shown for two weight classes of lorries: DHLM (7,5-16 tonne total weight) and DHLH (above 16 tonne total weight).[8]

Table 6 Energy efficiency and average tonnage for lorries above 7,5 tonne total weight, 1988, 1993 and 1997 (kWh/tonnekm; tonne per vehicle).

Year	7,5 - 16 tonne total weight		> 16 tonne total weight	
	kWh per tonnekm	tonne per vehicle	kWh per tonnekm	tonne per vehicle
1988	0,53	4,04	0,31	10,71
1993	0,67	3,22	0,34	9,93
1997	0,66	3,12	0,33	9,62

Source: SFT 1999; SSB 1999, 1997 and 1991.

According to Table 6 energy use per tonnekm increased from 1988 to 1993 for both weight classes (26 and 10 per cent respectively). The next four years energy efficiency showed a minor improvement. The growth in energy use per tonnekm from 1988 to 1993 indicated by Table 6 occurred despite a general development towards more energy efficient vehicles throughout the period. Composition of vehicle fleet and utilisation of capacity will be discussed as possible explanation factors.

In Statistics Norway's survey studies of road goods transport, each vehicle class applied in Table 6 are divided into another two weight classes (Table 5). Numbers of registered vehicles show a clear trend towards heavier lorries within each weight class. In Table 7 this is shown for vehicles above 16 tonne total weight (i.e. above 11 tonne load capacity). A similar trend is found also for medium sized lorries, but not as evident as for the heaviest lorries.[9]

Table 7 Distribution of weight classes among lorries above 11 tonne load capacity, 1992, 1994 and 1997 (per cent)[10]

Year	11 - 13 tonne	> 13 tonne	Total
1992	42	58	100
1994	33	67	100
1997	23	77	100

As average weight within the weight classes rises, two effects should be expected: Both energy use per vehicle kilometre and average tonnage are likely to increase. Table 6 shows that average tonnage (tonne per vehicle) decreased by 10 per cent from 1988 to 1997 for the heaviest lorries, and by 23 per cent for lorries with total weight of 7,5 - 16 tonne. This could be a result of changed goods transport patterns, with stronger emphasis on "just-in-time" deliveries.

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[8] Energy efficiency calculation is based on data of fuel use measured in kg per vehicle kilometre (SFT 1999) and the relationship vehicle kilometre / tonnekm (SSB 1999, 1997 and 1991). "Tonne per vehicle" is the inversion of the latter figure.

[9] The development of lorry size within the weight class DHLM (7,5-16 tonne total weight) is not shown in Table 7. From 1992 to 1997 the heavier lorries (8-11 tonne load capacity) in this weight class increased their share from 44 to 49 per cent of registered vehicles at the expence of the lighter ones (5-8 tonne load capacity).

[10] The data sources have no information on the distribution of these particular weight classes before 1992.

Empty driving has shown a falling trend among the heaviest lorries (above 13 tonne load capacity): In 1993 30% of driven kilometres were without load; in 1997 empty driving was at 28%. Hence reduced utilisation of capacity was not due to more empty driving, but a result of *larger vehicles combined with smaller freights*. This is the most reasonable explanation of the reduced energy efficiency in road goods transport from 1988 to 1997 (Table 6). A likely interpretation of the slight improvement from 1993 to 1997 is the introduction of more energy efficient vehicles, which more than compensated the negative trend in capacity utilisation.

Time series on *total energy use* in road goods transport can be generated by adding energy use figures for different vehicle classes given by SFT (1999). Figure 1 shows the energy use from 1973 to 1997. Energy use has almost tripled during this 24-year period (3,62 TWh in 1973; 10,64 TWh in 1997), with a continuous and rapid growth except the years 1988-90 and 1994. The growth occurred for the heaviest and lightest vehicles: Lorries above 16 tonne total weight increased their share of energy use from 30 per cent in 1973 to a maximum of 61 per cent in 1986. In late 1980's the energy use by heavy goods vehicles decreased, and the level for 1987 was not regained until 1995. Combined with a steady growth in transport by vans, this resulted in a reduced share of total energy use for heavy goods vehicles to a level of approximately 50 per cent from 1993.

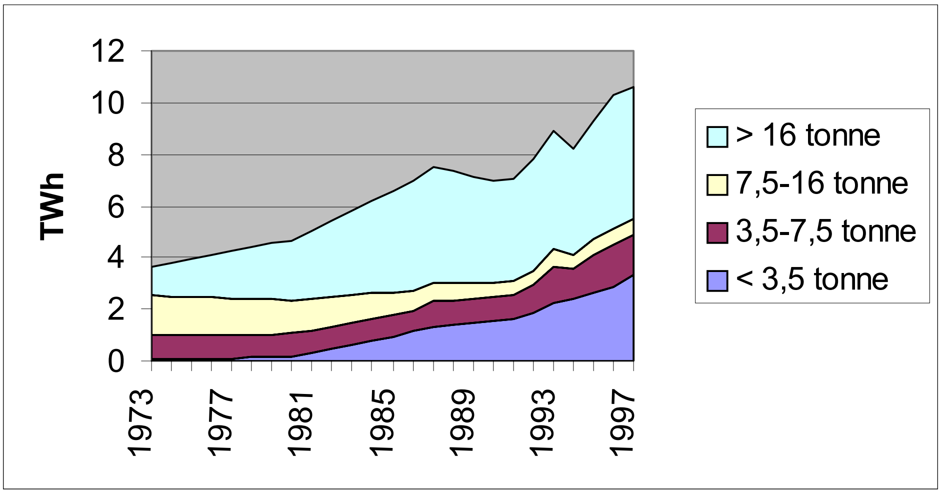


Figure 1 Total energy use by Norwegian diesel driven goods vehicles (above 3,5 tonne total weight) and vans / minibuses (below 3,5 tonne total weight) 1973-1997 (TWh)

In Table 8 the energy use figures from SFT (1999) are compared with two other sources: Bartlett (1993) and Holtskog and Rypdal (1997). The data from Bartlett (1993) represent an attempt made by Statistics Norway at describing the evolution of Norwegian energy use since 1950. In the description of the transport sector, energy and transport statistics are combined, and long time series on energy use measured in GJ per capita is presented. In Table 8 these figures are converted into total energy use in road transport (in TWh) during the period 1970 - 1990. The figures from Bartlett are based upon two earlier works (Schipper et al., 1990; Schipper and Meyers, 1992), and uncertainties exist concerning their empirical relevance for our study.

Holtskog and Rypdal (1997) give information on total energy use for lorries as an average for the period 1993-1995. This figure is remarkably low, only 60 per cent, compared to the 1995 level given in SFT (1999). We have not been able to find the explanation on this discrepancy, but consider SFT (1999) as the best estimate currently available.

Table 8 Estimates of energy use in Norwegian domestic road transport of goods, 1970-1995. TWh.

	SFT (1999)	Bartlett (1993)	Holtskog and Rypdal (1997)[11]
1970	3,17	4,83	
1975	3,92	5,33	
1980	4,68	6,12	
1985	6,56	7,84	
1990	6,99	9,18	
1995	9,29		5,60

B. Railway transport

Statistics Norway has regularly published statistics on the State railway's total use of energy for propulsion and heating of trains[12]. Table 9 shows the use of electricity and fuel for both passenger and goods transport between 1970 and 1995.

Table 9 Use of fuel and electric energy for propulsion and heating of all trains of State Railways in Norway, 1970 - 97

	Diesel oil (1000 tonne)	Electricity (TWh)
1970	23,3	0,29
1975	16,8	0,31
1980	17,3	0,37
1985	16,4	0,39
1990	30,3	0,38
1995	32,2	0,39
1997	23,4	0,50

Source: Transport and communications statistics, Statistics Norway.

In order to differentiate between energy use for goods and passenger traffic, data on the distribution of transport work between the two transport forms is needed. While net tonnekm are used for calculating goods transport's share of total energy use for most means of transport, gross tonnekm are used in the case of railway transport (Holtskog and Rypdal, 1997). For the period 1992 - 1997 State Railways provides statistics on gross tonnekm for both goods and passenger traffic.[13] Goods transport counted for 53 per cent of gross transport

[11] Table 3.37 in Holtskog and Rypdal (1997): Energy use for lorries, average for the years 1993-95. Includes tank lorries and special vehicles.
[12] Lubricating oil, fuel for road motor vehicle service and electricity for secondary consumption are excluded.
[13] The transport work performed by private railways is negligible.

work performed by electrified railways in this time span. Railways driven with diesel oil locomotives constituted a corresponding 60 per cent share of goods traffic. There are no reason to believe that the transport work in goods transport compared with passenger transport was much different during 1970's and 1980's (Egil Strand, State Railways, pers. comm.). Applied on the energy use figures in Table 9, it gives a total energy use as shown in Table 10. From this result and statistics on transport work (*net* tonnekm), development of the energy efficiency factor (kWh/tonnekm) can be derived (see the column on the far right in Table 10)[14].

Table 10 Energy use in Norwegian railway transport of goods, 1970 - 97. (TWh; kWh/tonnekm)

	Diesel oil	Electricity	**Total**	Energy efficiency
	TWh			kWh/tonnekm
1970	0,16	0,16	**0,32**	0,11
1975	0,12	0,16	**0,28**	0,11
1980	0,12	0,20	**0,32**	0,10
1985	0,12	0,21	**0,33**	0,11
1990	0,21	0,20	**0,41**	0,16
1995	0,22	0,21	**0,43**	0,16
1997	0,17	0,24	**0,41**	0,17

The increase in energy use from around 1985 was only to a smaller extent correlated to changes in performed transport work. The yearly average for performed net tonnekm was two per cent higher for the period 1970 - 1984 compared to 1985 - 1997, even though average energy use rose considerably in the last period. Table 10 shows that the energy efficiency factor (based upon net tonnekm) was approximately 0,11 kWh/tonnekm till 1985, but increased to 0,16 kWh/tonnekm in the 1990's. Hence the larger energy use might be a result of reduced efficiency.

According to State Railways the indications on rapid fluctuations in diesel oil consumption most likely are due to unreliable data sources. Registration routines have recently been changed due to the unexplainable fluctuations. Hence there are reasons to be critical to the variations in the last decade's energy use and energy efficiency data for Norwegian rail goods transport.

C. Sea transport

Table 11 shows specific energy use in sea transport of goods in 1993-94, by different classes of vessels (Thune-Larsen et al. 1997).

Table 11 Energy efficiency in Norwegian domestic goods transport at sea, 1970-1997.

[14] For 1995 the share of gross tonnekm performed by goods transport is set to 57 per cent for diesel driven railways and 54 per cent for electrified railways. Corresponding figures for 1997 are 62 and 49 per cent.

	Energy efficiency kWh/tonnekm
Ferries	7,103
Long distance services[15]	1,870
Local services	3,034
Freight vessels 100-500 Gwt	0,420
Freight vessels 500-3000 Gwt	0,338
Freight vessels >3000 Gwt	0,052
All vessels	**0,194**

Source: Thune-Larsen et al. 1997.

These figures are corresponding quite well with energy efficiency data given in Holtskog and Rypdal (1997):

Table 12 Energy efficiency and load factor in Norwegian domestic goods transport at sea, 1993.

	Energy efficiency kWh/tonnekm	Load factor %
Tankers and combined vessels		
101-500 gross tonne	0,49	78
501-3000 gross tonne	0,28	70
> 3000 gross tonne	0,05	75
Dry cargo vessels		
101-500 gross tonne	0,34	75
501-3000 gross tonne	0,28	72
> 3000 gross tonne	0,08	69

Source: Holtskog and Rypdal 1997.

Older statistics on coast transport of goods are divided in two categories: "Scheduled service" and "transport for hire or reward and on own account". Sample surveys on scheduled service were published for the years 1969 and 1979, with no figures on fuel use. Yearly survey studies include operating expenditures for bunkers. For vessels in coastal trade for hire or reward, sample surveys were made every five years since 1965. Only for the year 1980 there is published statistics on fuel use. In 1980 specific energy use in domestic sea transports was 26 litres per 1000 tonnekm. Converted to energy units, the energy efficiency factor was 0,306 kWh/tonnekm. This indicates an improvement in energy efficiency at 37 per cent from 1980 to 1994.

Assumptions has been made on the development of energy efficiency in sea transport, indicating a continuous improvement of about 0,5 per cent per year during the 1970's and 1980's (Peter Ahlvik, personal information). In Table 13, a backwards-linear extrapolation of the energy efficiency factor has been made, with the well-documented 1994 value of 0,194 kWh/tonnekm as a starting point. For the year 1980 this method gives a specific energy use at 0,203 kWh/tonnekm. This implies an improvement at just seven per cent from 1980 to 1994, in sharp contrast to the results based on the statistics from 1980.

[15] Express service Bergen-Kirkenes ("Hurtigruta").

Table 13 Energy use in Norwegian domestic goods transport at sea, 1970-1997.

	Transport work Mio. tonnekm	Energy efficiency kWh/tonnekm	Energy use TWh
1970	10 253	0,219	2,24
1975	9 836	0,213	2,10
1980	9 794	0,208	2,04
1985	9 300	0,203	1,89
1990	9 073	0,198	1,80
1995	6 900	0,194	1,34
1997	7 020	0,194	1,36

Table 13 gives a rough estimate on the development of energy use in coastwise goods transport from 1970 to 1997. We emphasise that these figures are based on an general assumption of the change in energy efficiency in sea transport since 1970, and should therefore be considered as an illustration only.

3.2.2. *Prognoses for the future*

Institute of Transport Economics (TØI) has, on the instructions of the Department of Transport and Communications, has generated prognoses for goods transport 1996 - 2020 (Madslien et al., 1998).[16] The prognosis indicates an increase in transported volume by 37 per cent during the next 25 years, and a growth in performed transport work at 49 per cent. As a consequence, longer transports are expected to increase more than short transports.

Expected growth in transport work in the period 1996-2020 is 54 per cent for sea transport, 78 per cent for railway and 40 per cent for road transport. Total increase will, according to Madslien et al. be distributed in this way: sea 44 per cent; railway 16 per cent; road 40 per cent (Table 14).

Table 14 Yearly and accumulated change in transport work 1996-2020 (per cent)

Transport mode	Yearly growth	Accumulated growth	Share of total growth
Road	+ 1,4 %	+ 40 %	40 %
Railway	+ 2,4 %	+ 78 %	16 %
Sea	+ 1,8 %	+ 54 %	44 %
Total	**+ 1,7 %**	**+ 49 %**	**100 %**

[16] The prognosis of Madslien et al. (1998) is based upon:
A. Macroeconomic terms stated by the Ministry of finance in its long-range programme 1998-2001 (St.meld nr. 4 1996-97), with a yearly growth in GNP at 1.6 per cent in the period 1996-2020, or 46.6 per cent during the whole period. Yearly growth in private consume is calculated to 2.7 per cent, and 1.2 per cent for public spending.
B. Effects of larger investment projects for changes in infrastructure are included. This deals with (mainly road) infrastructure projects which are planned started up by end of year 2001.
C. CO_2-tax as result of international treaty on stabilising emissions of greenhouse gases at 1990 level. All countries are supposed to adopt a general tax at NOK 360 (1997 currency) per ton CO_2 from 2010.

Source: Madslien et al. (1998).

Table 15 shows the expected energy use in Norwegian domestic goods transport, with a growth in transport work as predicted by Institute of Transport Economics.

Table 15 Prognosis for energy use in Norwegian domestic goods transport (TWh)

	Road	Railway	Sea
2000	8,67	0,32	1,44
2005	9,29	0,36	1,57
2010	9,96	0,41	1,72
2015	10,68	0,46	1,88
2020	11,45	0,52	2,05

Source: Madslien et al. (1998).

3.3. Energy use in transport of goods in Finland

This chapter deals with energy use in transport of goods in Finland, starting from the national level and coming down to the sectorial level and further to the level of energy use by a single transport mode and mean when the data is available. The data on energy use as well as transport performance figures in Finland is collected on a yearly basis and in addition to that, individual surveys are made on transport demand and transport forecasts.

Finnish energy use statistics is compiled by Statistics Finland (1996) that, for its part collects the information from about 30 separate sources. Those sources include, among others, Finnish Petroleum Federation, the Finnish Electricity Association, Finnish Maritime Administration and Finnish State Railways. In addition to that, Statistics Finland carries out occasional research on energy use in Finland. The Energy Statistics contains the years from 1970 to 1996. Year 1970 (and 1980 in some extent) is being used as basic year for historical review in this report.

Compiling statistics is neither complete nor 100% accurate. One reason for this is that gaps in statistics exist. The other is that the organisations responsible for collecting statistical data for Statistics Finland use different classifications and methods in data collection. Also, various units and magnitudes are used to indicate the level of energy use. Those units include, among others, terajoules (TJ), ton oil equivalents (toe) and tonnes (t). Different conversion factors have been used in this report in order to express the energy use in kilowatt-hours or, more often, terawatt hours (TWh = 10^9*kWh). The conversion factors used in this report are taken from Statistics Finland (1996), and utilising those factors causes, by definition, small inaccuracies in the energy use values in this report.

VTT Communities and Infrastructure has, together with VTT Energy and other co-operation partners, such as Finnish Petroleum Federation and transport sector public authorities, developed a model to define transport related energy use (Mäkelä, 1997a). The model is called LIPASTO and it defines fuel consumption and emission values for four transport modes, separately and together, from 1980 to 1996 (the latter as basic year) and also makes prognosis for the future, until year 2016. LIPASTO is divided into four sub-models, ILMI for air transport (Mäkelä, 1997b), RAILI for railway transport (Mäkelä, 1997c), MEERI for waterway transport (Mäkelä, 1997d) and LIISA for road transport (Mäkelä, 1996). The LIPASTO model is updated yearly. This project uses LIPASTO96 (version of 1996) with its sub-models as basic model and also utilises LIPASTO97 (version of 1997), mainly as basis for forecasts.

The chapter is based mostly on statistics (total energy use at national level and in transport) and LIPASTO. The latter is merely used to define the energy used by transport modes. In addition to that, literature references are included to illustrate the present situation and to forecast the future in transport related energy use in Finland.

3.3.1. Historical and present data

Energy use at national level

Total energy use in Finland amounted to 1247000 TJ or 350 TWh in 1996. The figures were 1,73 times larger than in 1970, when energy use barely exceeded 720500 TJ or 200 TWh.

Energy end users or use sectors in Finland are classified in four categories (Figure 2):

1) Industry
2) Space heating
3) Transport
4) Other users.

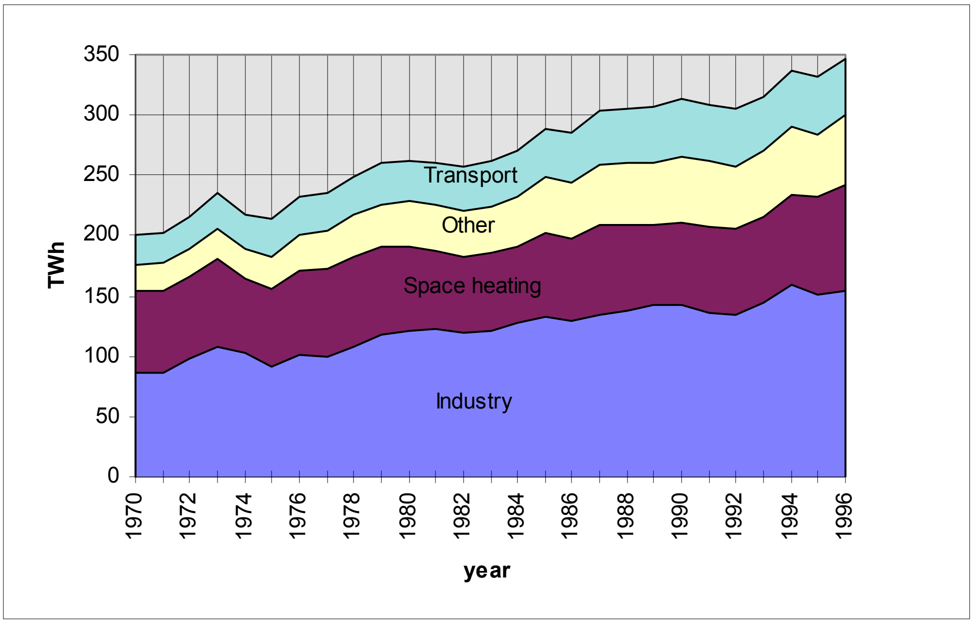


Figure 2 Total energy use by end user sector in Finland from 1970 to 1996, TWh (Statistics Finland, 1996)

End user percentages of total energy use have remained mostly the same during the observation period. Industry has been using 45, space-heating 26, transport 14 and other end users 15 per cent of total energy.

Energy use in transport

From 1970 to 1996, the share of transport of total energy use in Finland was between 12 and 14 %. Quantitatively, however, transport used 1,88 times as much energy as in 1970 (Figure 2).

Division of energy use between *transport modes* from 1970 to 1996 was divided as follows:

1. Road traffic: 92%
2. Railway traffic: 3%
3. Air traffic: 3% and
4. Waterways: 2% of total energy used in transport.

Transport performance in tonne kilometres (hauled gross tonnekm in railway transport) is a critical factor to illustrate the transported volumes by distance. Total transported tonnekm divided between goods transport modes in Finland are given in Table 16. It can be seen that road transport volumes have increased by 76%, railway transport by 40% and domestic waterway transport by 42%. Share of air cargo volumes has been insignificant in the period. Road transport had 66%, rail transport 25% and domestic waterway transport 10% of total transport volumes (tonnekm) in 1996.

Table 16 Transport modes and their shares of total transport volumes in Finland, bio tonnekm and per cent (Statistics Finland, 1997)

	1970	**1975**	**1980**	**1985**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Road transport*	13,2	15,4	17,9	20,1	25,4	23,8	23,8	24,1	24,8	22,3	23,2
Railway transport	6,3	6,4	8,3	8,1	8,4	7,6	7,8	9,3	9,9	9,3	8,8
Waterway transport**	2,4	2,6	3,4	2,7	3,0	2,7	2,8	3,0	3,3	2,9	3,4
Air transport	0	0	0,002	0,002	0,002	0,002	0,002	0,002	0,003	0,003	0,002
Total	***21,859***	***24,435***	***29,597***	***30,894***	***36,783***	***34,133***	***34,421***	***36,431***	***38,003***	***34,473***	***35,367***
Percentages											
Road transport	60 %	63 %	60 %	65 %	69 %	70 %	69 %	66 %	65 %	65 %	66 %
Railway transport	29 %	26 %	28 %	26 %	23 %	22 %	23 %	26 %	26 %	27 %	25 %
Waterway transport*	11 %	11 %	11 %	9 %	8 %	8 %	8 %	8 %	9 %	8 %	10 %
Air transport	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %

* lorries > 3,5 t
** shipping and floating excluded

A: Road transport

Road transport volume in Finland by lorries amounted to 23,2 billion tonnekm in 1996. That was about 1,76 times as large as in 1970. Between those two years, road transport increased from 60 to 70 per cent by 1991 and came down to 66 per cent of total transported tonnekm in 1996 (Table 16). The overall growth in economy has increased transport demand and especially road transport demand due to punctuality and customer service requirements that can best be reached by road transport. Also the size of vehicle fleet for both goods and passenger transport grows along with GDP. In Finland, the average transport distances are longer than in Europe and the country is sparsely inhabited. The road transport is often the only possible transport mode, as the other transport modes cannot cover the whole country. The average logistics costs in Finland amount to 10,3% (15% in export products), as they generally in Europe are around 5-6 %. Direct transport costs of end products amount to 24 billion FIM every year. These costs are the second highest variable cost item after employment costs (Finnish Ministry of Transport and Communications, 1997b).

Road transport is the largest energy user of all transport modes in Finland. Between 1970 and 1996 its share of total fuel consumption in transport increased from 89 to 93 per cent. In 1996 road transport used total of 39,36 TWh of energy, nearly twice the amount of 1970, 20,55 TWh (Table 17).

Table 17 Fuel and electricity consumption by different transport modes 1970-1996, converted into TWh (Statistics Finland, 1996)

Year	Roads	Railways	Waterways	Air	Total fuel	Electricity	*Total all*
1970	20,55	1,51	0,43	0,58	*23,07*	0,04	***23,11***
1971	21,66	1,31	0,43	0,62	*24,02*	0,04	***24,06***
1972	22,98	1,36	0,44	0,65	*25,43*	0,05	***25,49***
1973	24,89	1,37	0,44	0,77	*27,47*	0,06	***27,53***
1974	24,07	1,35	0,41	0,99	*26,82*	0,07	***26,88***
1975	26,17	1,16	0,41	1,10	*28,84*	0,09	***28,93***
1976	26,10	1,14	0,84	1,02	*29,10*	0,12	***29,22***
1977	26,47	1,07	0,83	0,94	*29,31*	0,14	***29,44***
1978	26,94	0,98	0,81	0,94	*29,67*	0,16	***29,82***
1979	28,96	1,01	1,13	1,04	*32,13*	0,19	***32,32***
1980	28,78	1,04	1,01	1,05	*31,88*	0,22	***32,10***
1981	29,17	1,02	1,02	1,13	*32,34*	0,24	***32,58***
1982	30,09	0,94	1,04	1,08	*33,15*	0,26	***33,40***
1983	31,03	0,92	0,85	1,09	*33,89*	0,28	***34,17***
1984	31,94	0,86	0,94	1,15	*34,89*	0,31	***35,20***
1985	33,42	0,84	1,07	1,08	*36,41*	0,33	***36,74***
1986	35,73	0,76	1,07	1,12	*38,67*	0,31	***38,97***
1987	37,44	0,84	1,13	1,22	*40,62*	0,34	***40,96***
1988	38,76	0,83	1,01	1,40	*42,00*	0,36	***42,35***
1989	41,18	0,80	0,95	1,42	*44,36*	0,37	***44,72***
1990	41,83	0,72	0,84	1,58	*44,97*	0,39	***45,36***
1991	40,64	0,67	0,79	1,60	*43,71*	0,40	***44,10***
1992	40,58	0,67	0,78	1,51	*43,54*	0,41	***43,95***
1993	38,79	0,72	0,84	1,47	*41,81*	0,42	***42,23***
1994	40,15	0,76	1,01	1,49	*43,40*	0,44	***43,84***
1995	39,60	0,69	0,98	1,38	*42,65*	0,47	***43,11***
1996	39,36	0,62	0,97	1,49	*42,43*	0,47	***42,90***
Averages	***32,12***	***0,96***	***0,83***	***1,14***	***35,06***	***0,26***	***35,31***

Vehicles are divided in 5 classes according to their *motive power*: 1) lorries, 2) vans (< 3,5 t in Finnish transport statistics), 3) cars, 4) buses and 5) special automobiles (Statistics Finland, 1997). Cars amount to 87% of total vehicle fleet, whereas share of vans is 9%, share of lorries 2% and share of special automobiles 1%. Buses account for less than 1% of total vehicle fleet in Finland (Table 18).

Table 18 Vehicles by motive power in 1996 (Statistics Finland, 1997)

	Cars	Buses	Vans	Lorries	Special automob.	All
Gasoline	1777462	22	49953	600	2515	1830552
Diesel oil	152109	8172	155175	49902	17005	382363
Electricity	7	0	113	0	0	120
Other	4	4	2	13	1	24
All	1929582	8198	205243	50502	19521	2213059
In per cents	*87 %*	*0 %*	*9 %*	*2 %*	*1 %*	*100 %*

LIISA model for road transport defines the average fuel consumption (excluding special automobiles and e.g. machines in terminals) for different vehicle classes (Tables 14 and 15). Comparing the figures below to the total fuel consumption figures in Energy Statistics reveals small differences. This is because the official statistics is based on oil sales figures and includes all vehicle types, including tractors and motorcycles, special automobiles and machines. The machines needed during transport e.g. in terminals, will be considered later in this chapter under the heading "*Energy use in terminal machines*".

Table 19 Average Finnish fuel consumption by road transport modes 1980 - 1996 (LIISA96)

Road transport mode	Fuel consumption, converted into TWh	Fuel consumption as percentages of total fuel consumption incl. all road transport modes
Lorries	8,18	23%
Vans	3,44	10%
Cars	20,81	60%
Buses	2,59	7%
Total, in average per year	35,02	100%

Finnish National Road Administration (Finnra) collects data on transport volumes on Finnish road network by goods transport (lorries and vans) and passenger transport (cars and buses). This basic division is also used here. The passenger transport in Finland was taken care of by 1,94 million vehicles and goods transport by 256000 vans and lorries. As for energy used in transport, goods transport had one third and passenger transport two thirds of total fuel consumed in road transport from 1980 to 1996 (Table 19).

Nearly 57% of road transport energy use consists of gasoline and 43% of diesel oil (Statistics Finland, 1996). According to LIISA, 55% of consumption consists of gasoline and 45% of diesel oil.

Diesel oil is used as motive power by all vehicle classes (incl. machines) of transport statistics. Of road transport vehicles, practically all lorries in professional transport use diesel oil and so do 85% of the vans (Vehicle Administration Centre www-pages 7.5.1998). In passenger traffic, 99,8% of all buses and about 10% of cars use diesel oil (Statistics Finland, 1997). The average consumption of diesel oil from 1980 to 1996 for the road transport modes as shown in Figure 3 below.

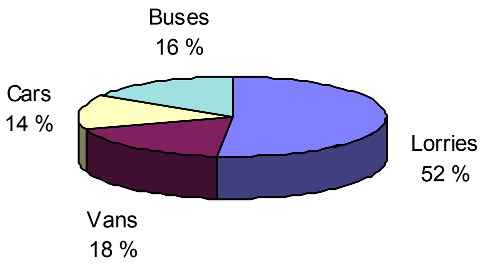


Figure 3 Average Finnish diesel oil consumption by road transport modes from 1980 to 1996 (LIISA96, Statistics Finland, 1996)

The yearly consumption values are given in Table 20.

Table 20 Consumption of diesel oil by different vehicle classes in Finland, 1980-1996, converted into TWh (LIISA, Statistics Finland, 1996)

	Lorries	Vans	Cars	Buses	Total TWh
1980	7,73	2,05	1,59	2,39	13,76
1981	7,62	2,15	1,63	2,37	13,77
1982	7,53	2,27	1,69	2,38	13,87
1983	7,46	2,41	1,78	2,42	14,08
1984	7,49	2,51	1,86	2,45	14,31
1985	7,74	2,63	1,97	2,50	14,84
1986	8,11	2,83	2,13	2,51	15,58
1987	8,20	3,02	2,27	2,61	16,09
1988	8,37	3,13	2,38	2,65	16,54
1989	8,90	3,36	2,53	2,80	17,59
1990	9,11	3,45	2,58	2,77	17,90
1991	8,22	3,40	2,56	2,68	16,86
1992	8,16	3,41	2,56	2,65	16,79
1993	8,10	3,20	2,42	2,56	16,28
1994	8,80	3,34	2,44	2,77	17,34
1995	8,59	3,33	2,41	2,67	17,00
1996	8,96	3,28	2,34	2,75	17,33
Average	*8,18*	*2,93*	*2,19*	*2,58*	*15,88*

Road transport of goods by lorries and vans thus used 70% of the total diesel oil consumed in transport. Lorries' share was in average 52% (8,18 TWh) and vans' share being 18% (2,93 TWh). The average energy use in goods transport in Finland by road amounted to 11,11 TWh (lorries and vans) between 1980 and 1996 (Table 20).

A total of 50502 lorries were registered in Finland by the end of 1996. Of those lorries, 25698 were in professional use. The number of vans was over 200 000 and of them 3181 (1,5%) were in professional use (Finnish Trucking Association www-pages 7.5.1998).

This study concentrates on lorry transport and on professional transport in particular. Lorries and vans are classified in three groups:

1. N1 = vans and lorries, weight under 3,5 tons
2. N2 = lorries, weight between 3,5 and 12 tons
3. N3 = lorries, weight surpasses 12 tons.

Following the classification above by Finnish Trucking Association (hereinafter also referred as SKAL) and the principles for the project, classes N2 and N3, lorries over 3,5 t are considered from this point forward. This is also one of the classification principles in Finnish transport statistics.

Generally, the lorries registered for professional transport are heavier than average and usually carry out transport work with trailers or semi-trailers. From the total lorry transport volumes of 1996, around 90% were from professional transport. The maximum total weight of lorries in Finland has increased 13 times during 70 years, mostly for transport economic reasons. In 1990 the maximum total weight was increased to 56 tonnes for 7-axle combination vehicles (SKAL www-pages 7.5.1998).

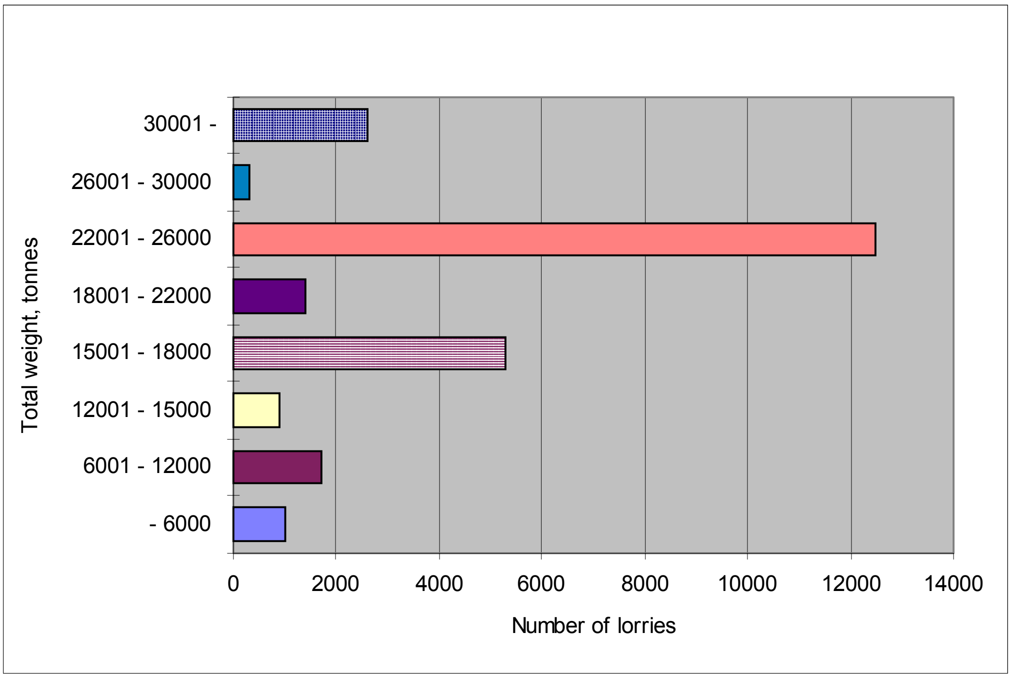


Figure 4 Division of professional lorries by total weight in Finland at the end of 1996 (SKAL www-pages 7.5.1998)

The shares of lorries, semi-trailers/-combinations and trailers with Finnish registration is shown in Table 21. The average age for lorry fleet in Finland was 9,7 years in 1996. In professional transport, however, the average age for lorry fleet was approx. 2 years lower. 45% per cent of lorry fleet is over 10 years of age. In order to prevent the average age of the fleet to rise further are 3500 lorries going to be replaced with new ones every year (SKAL www-pages 7.5.1998).

Table 21 Classification of lorry fleet in Finland from 1975 to 1995 (SKAL www-pages 7.5.1998)

Year	Lorries	Semi-trailers/ -combinations	Trailer combinations	All
1975	38700	3200	9000	50900
1980	37100	3000	12400	52500
1985	34800	2800	14400	52000
1986	34300	2700	14700	51700
1987	33900	2700	15300	51900
1988	33800	2800	16100	52700
1989	34200	2900	16700	53800
1990	34000	3100	17200	54300
1991	32000	3100	16500	51600
1992	29100	3000	15500	47600
1993	27100	3200	14900	45200
1994	27500	3700	15300	46500
1995	29000	4100	15100	48200

Compared with total fuel consumption in road traffic, lorry transport consumed in average 23,4% of all fuel in road transport from 1980 to 1996 (8,18 TWh in Table 20 divided by total average fuel consumption, 35,02 TWh). As already mentioned, special automobiles were not included in LIISA and that may slightly affect the percentages above.

Finnish Trucking Association has defined the average fuel consumption levels for different vehicle types (Table 22). Official statistics on the subject is not available. SKAL does not give consumption values for vehicles of different age but has used the statistical average, 9,7 years, to define the average fuel consumption. The average consumption is approx. 30 l/100 km for a lorry. For a *trailer combination* the average diesel oil consumption in *raw material* transport is estimated to be approx. 50 litres per 100 kilometres and for *finished products* around 45-47 litres per 100 km (Mr. Timo Airila, SKAL, Helsinki, April 1998).

Table 22 Fuel consumption by selected vehicle types, l/100 km (SKAL course material, received from Mr. Timo Airila, Helsinki, April 1998)

Vehicle type	**Fuel consumption l/100 km**
Light van	8….13
Heavy van	12….18
Light lorry (2-axle)	15….25
Medium heavy lorry (2-axle)	22….35
Heavy lorry (3-4 axle)	30….40
Light combination of vehicles (4-axle)	30….40
Medium heavy combination of vehicles (5-6 axle)	35….45
Heavy combination of vehicles (6-7 axle)	40….50
Heavy combination of vehicles (7-8 axle)	45….55

Table 23 was defined in Motiva programme for the transport company ASG. Motiva is a service centre that was established to bring the Finnish government's energy saving programme into practice. The centre informs on possibilities to decrease energy use and for that, helps in development of new methods and techniques if needed. The aim is to improve the energy efficiency in households, transport, services and industry by 10-20%. The centre activities are supervised by the Energy Department of Finnish Ministry of Trade and Industry. Given that the programme objectives are reached the energy costs in Finland should decrease by 10 mio Finnish marks (Ms. Ulla Eskelinen, Motiva, Helsinki, 28.4.1998).

Table 23 Fuel consumption, litres/100 km, as function of total lorry weight and age of lorry fleet (Ms. Ulla Eskelinen, Motiva, Helsinki, 28.4.1998)

	Total weight in tonnes										
Age in years	***10,0***	***14,0***	***18,0***	***25,0***	***38,0***	***42,0***	***44,0***	***48,0***	***52,0***	***56,0***	***60,0***
1	18,3	20,5	22,8	26,7	34,0	36,2	37,4	39,6	41,9	44,1	46,4
2	18,8	21,0	23,3	27,2	34,5	36,8	37,9	40,2	42,4	44,7	46,9
3	19,3	21,6	23,8	27,8	35,1	37,3	38,5	40,7	43,0	45,2	47,5
4	19,9	22,1	24,4	28,3	35,6	37,9	39,0	41,3	43,5	45,8	48,0
5	20,4	22,7	24,9	28,9	36,2	38,4	39,6	41,8	44,1	46,3	48,6
6	21,0	23,2	25,5	29,4	36,7	39,0	40,1	42,4	44,6	46,8	49,1
7	21,5	23,8	26,0	30,0	37,3	39,5	40,6	42,9	45,1	47,4	49,6
8	22,1	24,3	26,6	30,5	37,8	40,1	41,2	43,4	45,7	47,9	50,2
9	22,6	24,9	27,1	31,1	38,4	40,6	41,7	44,0	46,2	48,5	50,7
10	23,2	25,4	27,7	31,6	38,9	41,2	42,3	44,5	46,8	49,0	51,3
11	23,7	26,0	28,2	32,1	39,5	41,7	42,8	45,1	47,3	49,6	51,8
12	24,3	26,5	28,8	32,7	40,0	42,3	43,4	45,6	47,9	50,1	52,4
13	24,8	27,1	29,3	33,2	40,5	42,8	43,9	46,2	48,4	50,7	52,9
14	25,4	27,6	29,8	33,8	41,1	43,3	44,5	46,7	49,0	51,2	53,5
15	25,9	28,1	30,4	34,3	41,6	43,9	45,0	47,3	49,5	51,8	54,0

Among the different goods categories, transport of gravel accounted for 43%, 165641 tonnes of total goods transport (383135 tonnes) by road in 1997. As shown in Table 24, did transport volumes of gravel however only account for 10% (2,434 billion tonnekm) of total, due to short transport distances. Approx. 12% of total goods amount was round wood and because of longer transport distances, wood amounted to 15% of total tonne kilometres (Statistics Finland, 1998).

An example of energy use by goods categories and tonne kilometres is calculated below, based on the available data. First, energy use figures given in
Table 23 for a 10-year old vehicle are weighted by vehicle km data for each fleet weight category in 1997 (taken from Statistics Finland (1998), not included in Table 24). Then the tonne kilometres per product categories are divided by the corresponding vehicle kilometres. Further, the average weighted fuel consumption 46,2 l/100 km (0,462 l/km) is divided by the result in the column tonnekm/vehicle kilometre to define fuel consumption per tonne kilometres and product classes. After that, the results in litres per tonnekm have been converted into kWh per tonnekm (Table 24).

Table 24 Fuel consumption and energy use per goods categories, litres and kWh per tonnekm (Statistics Finland (1998); SKAL; Motiva)

Goods category	mio tonnekm	veh. km mio	tonnekm/veh.km	l/tonnekm	kWh/tonnekm	l/km
Wood, paper, furniture	7713	286,9	26,9	0,017	*0,167*	0,462
Foodstuff, fodder	3919	283,8	13,8	0,033	*0,326*	
Sand, gravel, etc.	2434	108,8	22,4	0,021	*0,201*	
Empty containers, swap bodies etc.	1648	187,9	8,8	0,053	*0,513*	
Construction materials	1394	66,4	21,0	0,022	*0,215*	
Chemicals	1066	39,2	27,2	0,017	*0,166*	
Oil products	1046	47,7	21,9	0,021	*0,205*	
Processed products/metal industry	923	50,5	18,3	0,025	*0,246*	
Agricultural products	892	64,4	13,9	0,033	*0,325*	
Machinery, equipment, vehicles	886	86,8	10,2	0,045	*0,441*	
Solid fuels	568	16,3	34,8	0,013	*0,129*	
Ore, metal scrap	449	18,7	24,0	0,019	*0,187*	
Glass, ceramics, plastics etc.	396	34,3	11,6	0,040	*0,389*	
Fertilisers	346	13,8	25,0	0,018	*0,180*	
Road paving materials	269	12,5	21,5	0,022	*0,210*	
Maintenance	260	95,1	2,7	0,169	*1,646*	
Waste materials	200	26,8	7,5	0,062	*0,602*	
Textiles, clothing	100	19,3	5,2	0,089	*0,869*	
	24509	**1459,3**	**316,5**	**0,040**	**0,390**	
	Total	*Total**	*Average*	*Average*	*Average*	

* Percentage of empty driving: 28,8%, total vehicle kilometres 2049 mio km

The figures calculated based on this data indicate an average energy use of 0,39 kWh per tonne kilometre in road transport in 1997.

Fuel consumption and energy use per 1000 tonne kilometres is lowest for the heaviest bulk goods that have higher load factors (measured in the statistics in volumes, not in weight) and correspondingly highest for lighter goods and e.g. transport of empty containers with lower load factors.

The above definition procedure follows the same pattern as Harri Kallberg used in his report "The Energy efficiency by different modes of transport" from 1982. As load and lorry weights and load factors differ, according to the products and the year the calculations can only be indicative. Comparison between the energy efficiency figures of selected product classes given in Kallberg's report and recent data is made in Table 25. The average energy efficiency for year 1979 cannot be calculated based on the data as energy efficiency every figure are not available for every product class given in 1997 data. Interpolation based on figures in 1980 indicates an average of 0,425 kWh/tonnekm (Figure 5 below).

Table 25 Energy efficiency of selected product classes in goods transport by lorries in Finland, 1979 and 1997 (Kallberg 1982; Statistics Finland, 1998)

Selected goods category	Year 1997 (kWh/tonnekm)	Year 1979 (kWh/tonnekm)
Wood, paper, furniture	*0,167*	*0,295(wood)/0,197(paper)*
Foodstuff, fodder	*0,326*	*0,230 (foodstuff)/0,200 (fodder)*
Sand, gravel, etc.	*0,201*	*0,27 (long dist.)/0,57 (short dist.)*
Oil products	*0,205*	*0,282*
Construction materials	*0,215*	*0,270*

Figure 5 shows the energy efficiency time series for Finnish lorry transport from 1970 to 1997. For year 1997 the calculated energy efficiency (Table 25) is around 0,39 kWh/tonnekm (Figure 5).

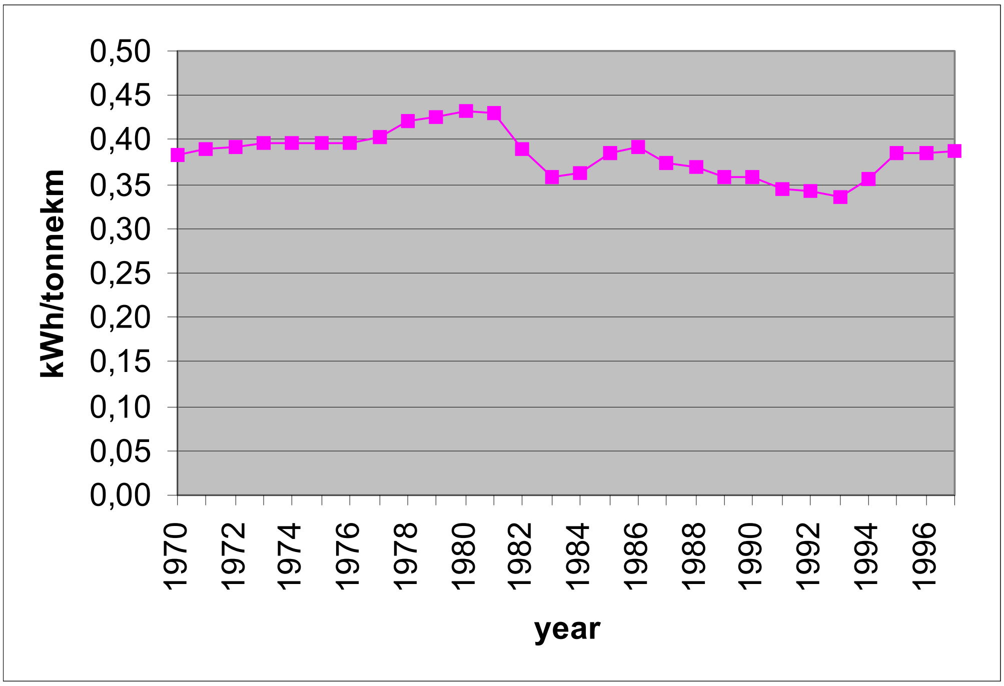


Figure 5 Energy efficiency in Finnish road transport by lorries, 1970-1997. Years 1971-74 and 1976-79 extrapolated (estimated, based on Statistics Finland (1997); LIISA96 and LIISA97)

B: Railway transport

The goods transport volumes on railways in Finland increased from 6,6 to 8,8 bio tonnekm between 1970 and 1996. This includes both purely domestic and international transport (wagons for export transit transport) within Finnish borders. During the period of 1970 to 1996, the share of railways of total transport tonnekm was between 22 and 29 per cent (Statistics Finland, 1997). The share of railways of total energy used in transport has decreased from 1,55 TWh, 6,7% in 1970 to 1,09 TWh, 2,5% in 1996 (Statistics Finland, 1996; RAILI96).

Railways use light fuel oil and electricity as energy source. Before year 1983 also coal was used and before 1981 even firewood. The share of light fuel oil as energy source for railways has decreased from 1,17 TWh in 1970 to 0,616 TWh in 1996 (Statistics Finland, 1996, Pussinen 1997). Meanwhile, the share of electricity has been increasing. The railways in Finland used 0,47 TWh electricity in 1996 (Statistics Finland, 1996). Share of passenger transport was 2/3 and share of goods transport 1/3 of electricity used on railways.

In total, goods transport on railways used 0,655 TWh of energy in 1996 (RAILI96; Statistics Finland, 1996; Pussinen, 1997).

Compared with the total energy use figures, including electricity and fuel, the share of goods transport was about 60 %. Of light fuel oil goods transport used about 81% in 1996, and of electricity, its share was approx. 33% (Table 26). RAILI96 and Statistics Finland, 1996 have compiled the time series for years 1970-1996 for energy use on railways (Figure 6).

Table 26 Energy use on railways in 1996, TWh (calculations based on Statistics Finland, 1996, RAILI 96 and Pussinen 1997)

	Light fuel oil	**Electricity**	**Total energy use**
Passenger transport	0,117	0,315	0,431
Goods transport	*0,500*	*0,155*	*0,655*
	0,616	0,470	1,086

In order to estimate the share of goods transport in energy use, Figure 6 assumes that division of energy use between goods and passenger transport by energy source (fuel or electricity) is similar as in 1996.

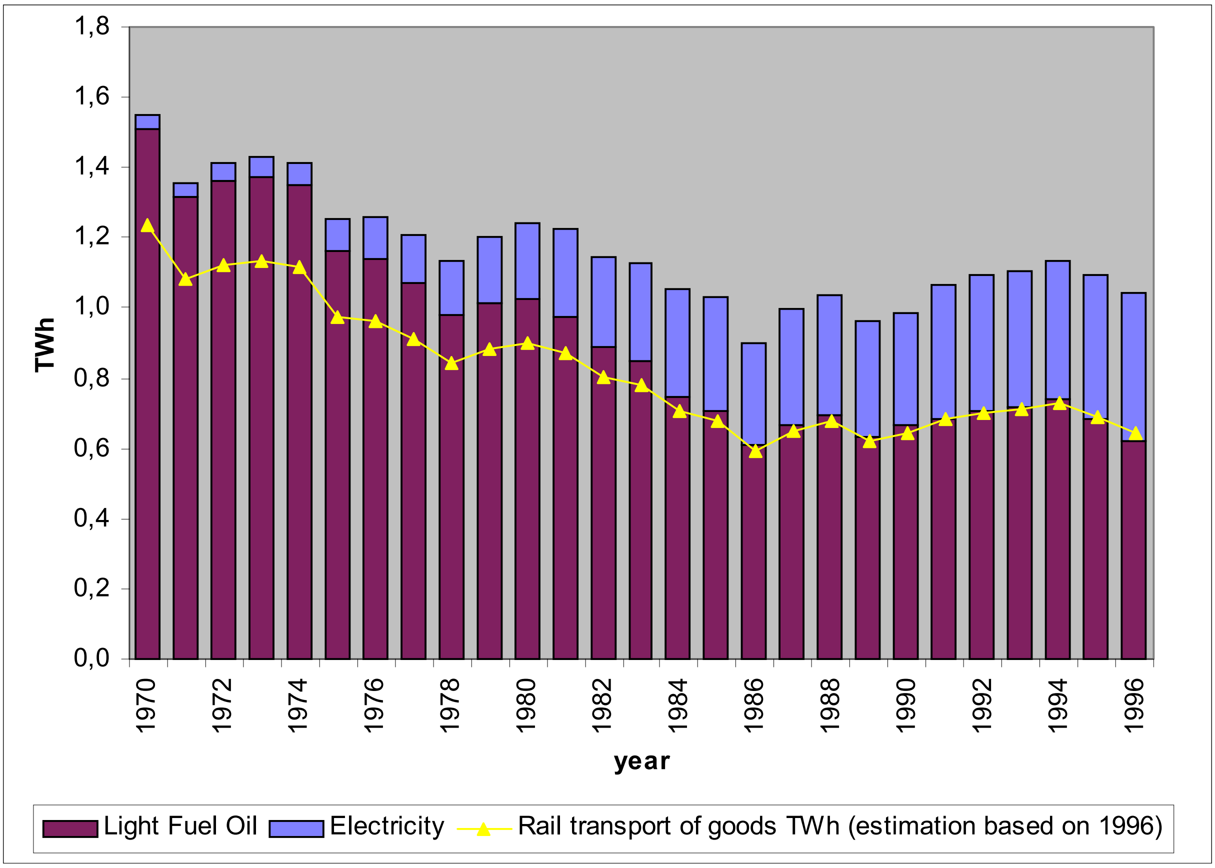


Figure 6 Energy use on Finnish railways 1970-1996, goods transport estimated (RAILI96, Pussinen 1997, Statistics Finland, 1996)

RAILI 96 considers the energy use on railways as a whole, and calculates energy use for the whole transport chain. The energy use values thus include not only the transport work but also the energy used on station yards. Finnish State Railways has measured energy use for selected engine types and specified energy curves for them. Based on those curves, estimations on energy use have been made for certain type of goods or passenger trains (Table 27). The energy use is expressed in litres or kWh per hauled gross tonnekm (Pussinen 1997). Classification of goods trains by weight and their specified energy use values are given in Table 27.

Table 27 Classification of goods trains by weight and energy use curves by class (Pussinen 1997)

Freight train class	Weight (t)	Energy efficiency (kWh or litres per 1000 gross tonnekm)	
		Electricity freight train	*Diesel freight train*
1	<250	17,5	10,2
2	250-499	16,5	8,2
3	500-799	15,5	6,4
4	800-999	14,5	5,2
5	1000-1249	13,5	4,2
6	1250-1499	12,5	3,8
7	1500-1749	11,7	3,0
8	1750-1999	11	2,4
9	2000-2249	10,1	2,2
10	>2250	7,5	2,2

Pussinen (1997) used 0,074 kWh/tonnekm as average energy efficiency for all trains (weighted by transport performances). Diesel trains had energy efficiency of 0,11 kWh/tonnekm and electricity trains energy efficiency of 0,034 kWh/tonnekm in 1996. Calculating the corresponding figures for other years shows that energy efficiency has improved significantly(Table 28, Figure 7).

Table 28 Energy efficiencies for goods transport by rail in Finland, kWh/tonnekm, 1970, 1975, 1980, 1985-1996 (calculated, based on RAILI96 and RAILI97; Statistics Finland (1997); Pussinen 1997)

Year	1970	1975	1980	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
TWh/tonnekm	0,197	0,151	0,108	0,084	0,085	0,088	0,086	0,078	0,077	0,089	0,089	0,077	0,073	0,074	0,074

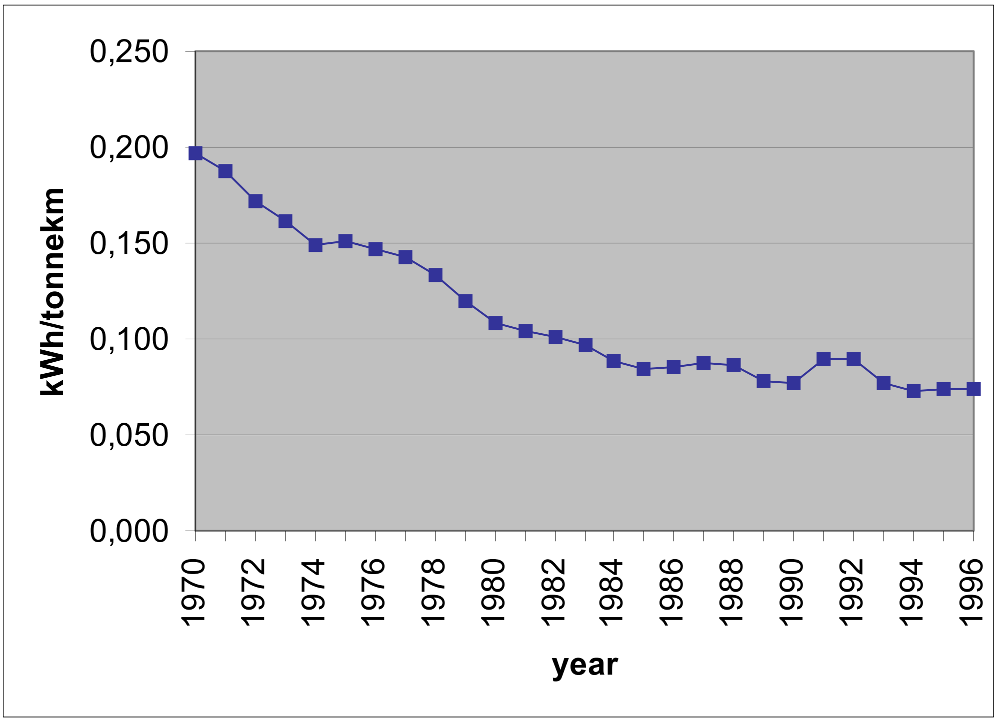


Figure 7 Energy efficiencies for goods transport by rail in Finland, kWh/tonnekm, 1970-1996 (calculated, based on RAILI96 and RAILI97; Statistics Finland (1997); Pussinen, 1997)

Wood products, textiles and clothing and processed products by metal industry are the largest goods categories transported by rail in national transport, as measured in tonne kilometres (Table 29). Wood products had a 36% (2054 tonnekm), textiles and clothing a 22% (1247 tonnekm) and metal products a 15% (854 tonnekm) share of total transport volumes in 1996. In international transport the dominant product classes are oil products, wood products and ore and metal scrap (Statistics Finland, 1997).

There is no detailed statistics on how much energy each transported product category uses. The information would require detailed knowledge on the weight of a train transporting different product classes and no such data is available for every product category. For paper industry transports in a *specified* route, calculations have indicated energy efficiency of 0,08 kWh/tonnekm (Transpress 2/98). However, as no such data is available for any other products, the following comparison uses the energy efficiency 0,074 kWh/tonnekm. According to that logic wood, paper and furniture, textiles and clothing, processed products by metal industry, and chemicals were the main energy users in domestic railway transport in 1996. In international rail transport, oil products, wood, paper and furniture, ore and metal scrap and chemicals used most of the energy (Table 29). The common share of these goods categories amounted to some 84% of total energy use. These figures are, however, highly indicative. Regarding this issue, forest industry related transport is discussed more in detail in Chapter 7.

Table 29 Energy use in rail transport 1996 per goods category (calculations made based on data from Pussinen 1997 and Statistics Finland, 1997)

National/product category	**tonnekm mio**	**TWh**		**International/product categ.**	**tonnekm mio**	**TWh**
Wood, paper, furniture	2054	0,152		Oil products	743	0,055
Textiles, clothing	1247	0,092		Wood, paper, furniture	465	0,034
Processed products/metal ind.	854	0,063		Ore, metal scrap	460	0,034
Chemicals	365	0,027		Chemicals	437	0,032
Machinery, equipment, vehicles	293	0,022		Processed products/metal ind.	294	0,022
Sand, gravel, etc.	264	0,020		Fertilisers	234	0,017
Ore, metal scrap	241	0,018		Miscellaneous	233	0,017
Oil products	177	0,013		Textiles, clothing	99	0,007
Fertilisers	56	0,004		Foodstuff, fodder	40	0,003
Miscellaneous	42	0,003		Solid fuels	28	0,002
Foodstuff, fodder	41	0,003		Machinery, equipment, vehicles	26	0,002
Construction materials	33	0,002		Sand, gravel, etc.	24	0,002
Solid fuels	30	0,002		Construction materials	18	0,001
Glass, ceramics, plastics etc.	2	0,000		Glass, ceramics, plastics etc.	4	0,000
Agricultural products	0	0,000		Agricultural products	2	0,000
Total	**5699**	**0,422**		**Total**	**3107**	**0,230**

Estimated energy efficiency: 0,074 kWh/tonnekm

C: Waterway transport

Finnish statistics on domestic waterway transport includes shipping and floating. Floating tonnekm decreased considerably from 1970 to 1996 and floating figures are excluded from the domestic waterway transport figures and left out of consideration in this study.

Transport volumes on domestic sea transport by vessels have increased from 2,4 bio tonnekm in 1970 to 3,4 bio tonnekm in 1996. Share of domestic waterway transport by vessels was between 8 and 11 %in the period (Statistics Finland, 1997).

In 1996, 31500 visits to Finnish harbour were documented. 11% of those were domestic transport and 89% foreign traffic. goods vessels performed 64% of all visits, and domestic goods vessels about 16% (Shipping Statistics, 1996).

Energy Statistics figures on waterway transport energy use include fuels that are sold in Finland for vessels that have domestic destinations. Those vessels may be either domestic or foreign (Mr. Kari Grönfors, Statistics Finland, June 1998). According to the sales amount, domestic waterway transport in Finland used 0,43 TWh or 1,9% of total energy in Finnish transport in 1970. By 1996, their share had increased to 0,97 TWh or 2,3%. Energy sources for vessels are heavy and light fuel oil. According to Statistics Finland, 1996, consumption of light fuel oil increased until year 1979 after which it decreased by over a half by 1996. Consumption of heavy fuel oil has correspondingly increased. The average yearly energy use from 1970 to 1996 was 0,83 TWh of which 0,24 TWh generated from heavy fuel oil and 0,59 TWh light fuel oil (Statistics Finland, 1996).

Following the same logic as in domestic waterway transport, statistical data on energy use in foreign transport includes the sale of fuel for those vessels that have foreign destinations and does not differentiate whether the vessel in question is domestic or foreign. The statistics classifies these vessels as bunkers. The sales figures were not included in Table 12 and Figure 3 but are given in Figure 8 below. Bunkers used 375 toes or 4,4 TWh of energy in 1996. That was five times more than in 1970 but only a half of energy use in peak year 1984.

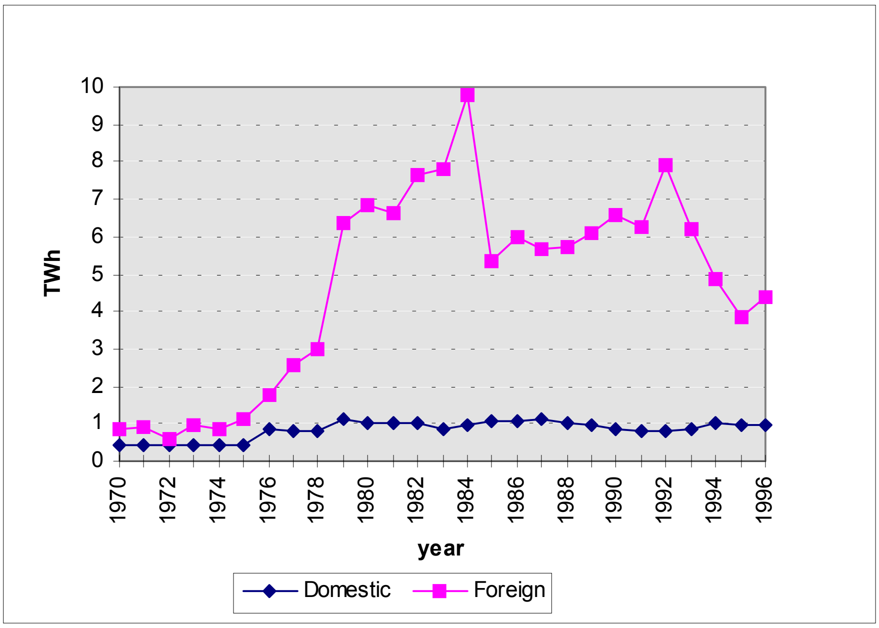


Figure 8 Energy use in domestic waterway transport and foreign transport (bunkers) in Finland, 1970-1996, TWh (Statistics Finland, 1996)

The foreign vessels are not properly documented in the statistics and the problem is that the statistics does not clearly divide whether the fuel has been consumed within Finnish waterways or abroad. MEERI model calculates the energy use for domestic and foreign vessels, for domestic and foreign transport within Finnish waterways and by the type and size of vessel (in gross register tonnes). For this reason, the MEERI figures are higher than those in Energy Statistics that rely on fuel sales figures. The calculations are based on transport volumes (tonnekm), transport data on port visits and distance matrix. Vessel types used in MEERI are railway ferry, ro-ro vessel, container ship, bulk vessel, other dry bulk vessel, tanker and other (MEERI96 and MEERI97).

For comparison with the official statistics, MEERI figures indicate that the total energy use in Finnish waterway transport in 1996 was 9,7 TWh (about 5,5 TWh in Energy Statistics). goods and passenger vessels together used 8,6 TWh and the rest was used by small boats and icebreakers. A more detailed calculation shows that in 1997 the total energy use within Finnish borders by domestic and foreign goods vessels amounted to 0,4463 TWh (4,1% of total energy use defined) (MEERI97).

Alexandersson et al. (1993) have specified consumption values for diesel motors by their time of construction. For a modern 2-synchronous motor the specific value is 160 g/kWh and for a 4-synchronous motor 170-180 g/kWh. Older motors consume about 200 to 220 g/kWh. VTT's MEERI model uses the value 200 g/kWh for all types of vessels in all kinds of loads.

Lehtinen (1998) specifies the energy efficiency in waterborne transport to be about 0,06 kWh per tonne kilometre but does not specify the type of vessel. The calculations based on MEERI96 and 97 and Energy Statistics indicate that within Finnish waterways the energy efficiency was about 0,151 kWh/tonnekm in 1997. The time series 1980-1997 for energy efficiencies in Finnish domestic waterway transport is given in Figure 9. Goods transport time series have been calculated based on MEERI97 assuming that also in previous years, some

4,1% of total energy in the model was used by domestic and foreign goods vessels within Finnish waterways (MEERI97).

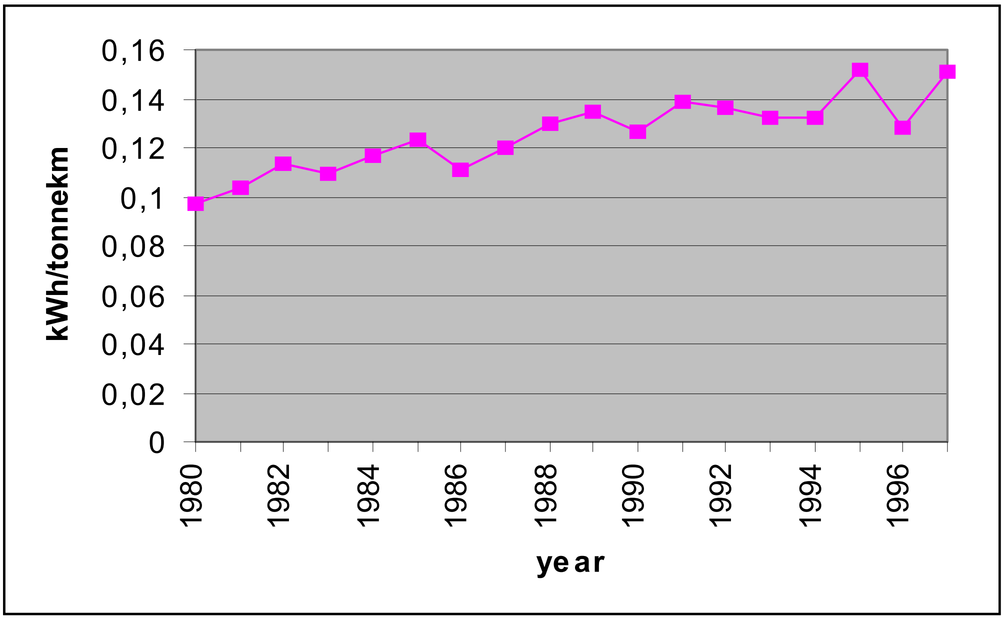


Figure 9 Energy efficiency in Finnish domestic goods transport by water, 1980-1997 (estimated, based on MEERI97)

Energy use will be considered further in Chapter 7 for forest industry transport. Vessels and engine types will be taken into discussion at that point, too.

D: Air transport

Air transport was responsible for 2,5% of total energy used in transport. By 1996 its share had increased to 3,5%. The volume of goods transported by air of total transport volumes (tonnekm) is 0,002% and its significance to forestry is unimportant.

E: Terminal machines

Energy use of machines in terminals and other nodes in transport chain is dealt with separately. This is because the diesel consumption of terminal equipment is a crucial issue when dealing with forest industry products. Official statistics is not compiled, but a list of terminal machines and their average fuel consumption is available (Steveco, Finland). Two reports on energy use in machines are used in this project. One is a Finnish study by Arto Puranen (1992) and the other is a EU study by Z. Samaras and K-H. Zierock (1994). The latter estimates the off-road emissions and energy use in European Union, split into subcategories of power source (diesel, gasoline 2 stroke, gasoline 4 stroke and LPG) and use (agriculture, forestry, industry, household, railways and inland waterways). The results indicate that of the total energy use 505 TWh in 1992, 47% was used by industry, 37% by agriculture, 10% by railways machines, 3% by inland waterways, 2,5% by forestry and 0,5% by households. The machines for material handling consumed nearly 7% of total diesel oil in off-road vehicles, and in gasoline consumption the share was some 45 % (Samaras and Zierock, 1994).

Puranen (1992) has defined energy use in g/kWh for different types of machines including also those used for material handling. The figures are based on situation in 1990.

Table 30 Energy use by selected terminal machines, g/kWh (Puranen, 1992)

	Machines using diesel					***Machines using gasoline***
	Cranes	Forklift > 12 t	Forklift < 12 t	Other truck	Industry tractor	Forklift
g/kWh	240	240	250	250	250	350

A review on energy use by terminal machines can be made based on figures given in Table 30 above and handled tonnes. The review on energy use by terminal machines is given more closely in Chapter 7.

3.3.2. Prognoses for the future

Energy Strategy drafted by Finnish Government assumes that during the next 30 years, Finnish economy grows at a yearly rate of 2,5%. That would double the total production by 2025. The growth is assumed to be most effective in the branches where the operations are less energy efficient, such as service industries. Assuming that increase in total production becomes reality, energy prices increase moderately along with import prices, energy use is neither limited nor guided at national level, and energy technology is developed steadily, the total energy use by 2025 is expected to be 1,4 times the level of 1995 (Energy Strategy 1996, Ministry of Trade and Industry www-pages, 1.6.1998). The Strategy states that if the scenario becomes reality the energy intensity (unit of energy needed for a unit of GDP) would og down. This means that the growth in total energy and electricity use would remain lower than the GDP growth. This is, however, forecast to be mainly the case in the industry sector and the change would be rather slow. The industry sector is more energy intensive than service sector (including transport), meaning that in industry sector, less units of energy are needed to produce one unit of GDP (see e.g. EC, 1997a).

The economic growth is one of the strongest factors influencing the energy use (see e.g. Bosseboeuf et. al, 1997), so when the GDP grows, the energy use grows as well. Traditionally, the influence has been particularly strong in goods transport sector. The historically strong correlation between trends of GDP growth and goods transport growth cannot continue if society shall develop in the direction of sustainable development. (Schleicher, Tappeser - Hey and Steen, 1997) The problem can be contained by two basic approaches: 1) Technological improvements or 2) Slowing down transport growth. Transport growth is mainly determined by transport volume, transport distance and transport efficiency and four key factors are identified for developing strategies to separate GDP and goods transport growth in the future.

Firstly, the economy should be dematerialised which means a reduction in material resources needed per unit of GDP. This is also called decreasing the material intensity of the economy. A lower material intensity leads mainly to lower transport volumes but may also have a negative influence on transport efficiency. Secondly, the spatial range of material flows (e.g.

the distances between production and warehousing and lower split in transport network) should be reduced so the transport volume and transport distances would come down. Transport flow efficiency should also improve through potential bundling of products. The third strategy includes the improvements in handling requirements of goods including aspects of safety, packaging, consignment size, speed and punctuality. The last of the decoupling strategies is the organisation of transport, incl. logistical service level and business trends of logistical service providers (Schleicher, Tappeser - Hey and Steen, 1997). The development trend in Europe is towards larger and fewer transport service providers (Kähäri, 1993, OECD, 1992).

The Energy Strategy states that energy efficiency should be intensified further and the Finnish energy saving programme tightened in a way that the growth of primary energy use stops within 10-15 years. Decreasing use of fossil fuels and reducing CO2 emissions according to international conventions are included in the strategy.

Transport volumes

Finnish Ministry of Transport and Communication suggests that total goods transport volumes (tonnekm) in Finland increases by 50-60% by 2020. The growth should be very intensive by 2010 and slow down after that. The Ministry estimates that total transport volumes should amount to 58 bio tonnekm in 2020 (Finnish Ministry of Transport and Communications, 1998a).

Road transport will remain the most important transport mode in Finland also in the future. Road transport volumes as well as motor vehicle fleet in Finland is estimated to grow further by the year 2020. The lorry fleet is expected to be 66000 in 2020 compared with 50500 in 1996, and as in 1996 the vehicle kilometrage of lorries amounted to 2730 million, it is assumed to grow to 4400 million vehicle kilometres by 2020. Road transport tonne kilometres would amount to 40 billion in 2020. Forecast on growth rate of light lorry transport is estimated to be 70% from 1995 to 2020 (Finnish National Road Administration, 1996), SKAL www-pages 7.5.1998, Finnra’s transport and vehicle fleet forecast 1995-2020 on Finnra www-pages 14.8.1998; Finnish Ministry of Transport and Communications, 1998).

Iikkanen (1997) has made a forecast on goods transport by rail from 1997 to 2020. Since 1960’s the growth of rail transport has been slower than growth rate of total production and growth in total transport demand. The volume of rail transport depends heavily on forest, heavy metal and chemical industry production developments. It is expected that rail transport will maintain its role in basic transport of products and raw materials of those industries. The expected intensive growth in forest and heavy metal industries until 2001 will increase the volumes transported by rail. In forest industry, this is mainly due to increase in raw material transport from Russia. After year 2001, the GDP growth is assumed to come down to 1-2% yearly level and to be based mainly on growth in light industry products that do not generate rail transport demand. By 2010, the goods transport by rail (domestic and transit) is expected to increase to 50,4 million tonnes, and to slowly come down to 48,5 million tonnes by 2020. The corresponding figure in 1996 was 37,7 million tonnes, of which 21,6 tonnes national and 16,1 tonnes international transport (Iikkanen, 1997; Statistics Finland, 1997).

Future rail transport tonne kilometres can be roughly calculated by using the average length of transportations of the last five years (1993-1997), 240 km, as multiplier. The goods transport volumes by rail would amount to 12,1 bio in 2010 and 11,6 bio in 2010 (Statistics Finland, 1997; Iikkanen, 1997).

Waterway transport will remain the main transport mode in export and import of bulk, and railways is expected to be the main transport mode for domestic bulk transport. Finland can be described as an island as for the transport from Finland to central Europe. The domestic waterway transport volumes are highly dependent on transport of round wood by vessels and logging. High-speed vessels can give opportunities to better the competitiveness of Finnish export industries (Finnish Ministry of Transport and Communications, 1997a and 1998). The forecast by Finnish Maritime Administration states that the harbour visits by goods vessels grow by 130% by 2016.

Transporting of goods by air is a growing area but does not have significance in transport of mass products. The air transport volumes, although growing, remain quite small compared with other transport modes.

Energy use forecast for 1997-2020

Total energy use in Finnish transport including all transport modes is expected to increase from 42,9 TWh in 1996 to 50,17 TWh by 2016 (LIPASTO96). This includes both goods and passenger transport. Energy use for years 2017-2020 has been interpolated based on the year 2016.

Road transport will remain the largest energy user. The share of road transport of total energy use in 2016 is expected to be some 87% of the total energy used in goods transport. Road transport energy use in 2016, 43,9 TWh, should surpass the total energy used by all transport modes in 1996, 42,9 TWh. These forecasts include both goods and passenger transport.

The figures for goods transport alone are not available in official statistics. Only a rough estimation can be made. For road and rail transport, the energy use forecasts are taken directly from LIPASTO96 based on the same logic as earlier in this report (diesel oil consumption by lorries > 3,5 t, goods trains energy use percentage of total used in railway transport etc.). Energy use in domestic waterway transport of goods can be roughly estimated based on MEERI percentage of energy used by domestic and foreign goods vessels within Finnish waterways in 1997 (MEERI97).

Forecast on energy use separately for goods and passenger transport by air is not available. Given that the division of transport volumes between goods and passenger transport remains stable, it can be argued that the energy use in goods transport is about 21,4% of total fuel used by air transport. Table 31 shows the future estimate for energy use in goods transport from 1997 to 2020. Years 2018-2020 have been interpolated to follow the trend.

Table 31 Forecast on energy use in transport of goods in Finland, 1997-2020 (estimation based on LIPASTO96 and 97, years 2017-2020 interpolated to follow the trend)

	Road	Rail	Waterway	Air	Total
1997	10,05	0,68	0,40	0,58	11,71
1998	10,33	0,66	0,40	0,59	11,99
1999	10,52	0,66	0,41	0,61	12,19
2000	10,70	0,66	0,41	0,62	12,39
2001	10,87	0,66	0,42	0,63	12,58
2002	10,98	0,66	0,43	0,64	12,72
2003	11,16	0,68	0,44	0,65	12,93
2004	11,33	0,68	0,44	0,67	13,12
2005	11,53	0,68	0,45	0,68	13,34
2006	11,78	0,69	0,46	0,70	13,62
2007	11,97	0,69	0,46	0,71	13,83
2008	12,22	0,69	0,46	0,73	14,09
2009	12,40	0,69	0,46	0,74	14,29
2010	12,55	0,69	0,46	0,76	14,45
2011	12,63	0,69	0,46	0,77	14,55
2012	12,77	0,69	0,46	0,78	14,70
2013	12,90	0,69	0,46	0,80	14,84
2014	12,96	0,69	0,46	0,81	14,93
2015	13,08	0,69	0,46	0,83	15,07
2016	13,20	0,69	0,46	0,84	15,19
2017*	13,32	0,69	0,46	0,85	15,32
2018*	13,44	0,69	0,46	0,86	15,45
2019*	13,56	0,69	0,46	0,87	15,58
2020*	13,7	0,69	0,46	0,88	15,73

Estimation for all transport modes made this way show results that from 1997 to 2020, the energy use in goods transport would increase from 11,7 TWh to 15,7 TWh.

The energy efficiencies for road, rail and waterborne transport in Finland in 5-years intervals from 1970 to 2020 are summarised in Table 32 on the next page.

Table 32 Energy efficiency kWh/tonnekm in goods transport by road, rail and waterways in Finland, 1970-2020 (Statistics Finland, 1996, LIPASTO96 and 97, Statistics Finland (1997) for Finland 1997, Pussinen 1997)

	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Road	0,383	0,392	0,432	0,385	0,359	0,385	0,405	0,395	0,382	0,364	0,343
Rail	0,197	0,151	0,108	0,084	0,077	0,074	0,060	0,060	0,057	0,059	0,060
Waterway	0,058	0,073	0,097	0,123	0,127	0,152	0,129	0,119	0,104	0,092	0,081

3.4. Energy-use in transport of goods in Sweden

In this chapter the energy use in Sweden is described. In the first section, the historical and present data has been compiled and in the second section the forecasts are presented.

3.4.1. Historical and present data

In this section the historical and present data are summarised. First, the total energy use in Sweden is summarised and secondly the energy use in the transport sector and in the transport of goods is analysed.

The existing statistical data in Sweden concerning most of these issues is not readily available and the quality of the data is not always satisfactory. Therefore, much of the data have been compiled from many different sources by Ecotraffic. Since this information in the primary stage often has been compiled with different objectives, the direct comparison between different sets of data is not always straightforward. Different boundaries and assumptions have been made in each case. Therefore, the comparisons are not optimal.

Some of the most important sources of information used in this study originate from the following organisations:

- Swedish Institute for Transport and Communication Analysis (SIKA)
- Statistics Sweden (SCB)
- The Swedish Network for Transport and the Environment (NTM)
- The Swedish National Energy Administration (STEM)
- The Swedish Civil Aviation Administration (CAA)
- The Swedish National Road Administration (SNRA)
- Swedish State Railways (SJ)
- Association of Swedish Automobile Manufacturers and Wholesalers (BIL)
- The Swedish Road Haulage Association (ÅF)

Energy use on a national level

Energy use in all sectors
Energy statistics in Sweden is compiled by The Swedish National Energy Administration (STEM[17]) every year.

[17] STEM is Sweden's national authority on issues regarding the supply and use of energy

In general terms, the relative proportions in energy use for most of the sectors have remained more or less stable between 1970 and 1996. The energy use accounted for by internal transport has risen from 15% to 22%. A considerable increase in conversion and distribution losses is due to the introduction of nuclear power plants since the 1970's as a complement to hydropower electricity. Today about 50% of the electricity in Sweden is generated by nuclear power and the rest by hydropower.

Energy use in the transport sector

The energy use regarding the internal transports in Sweden consists of goods and passenger transport. The energy use in this sector, divided into different transport modes, is shown in Figure 10.

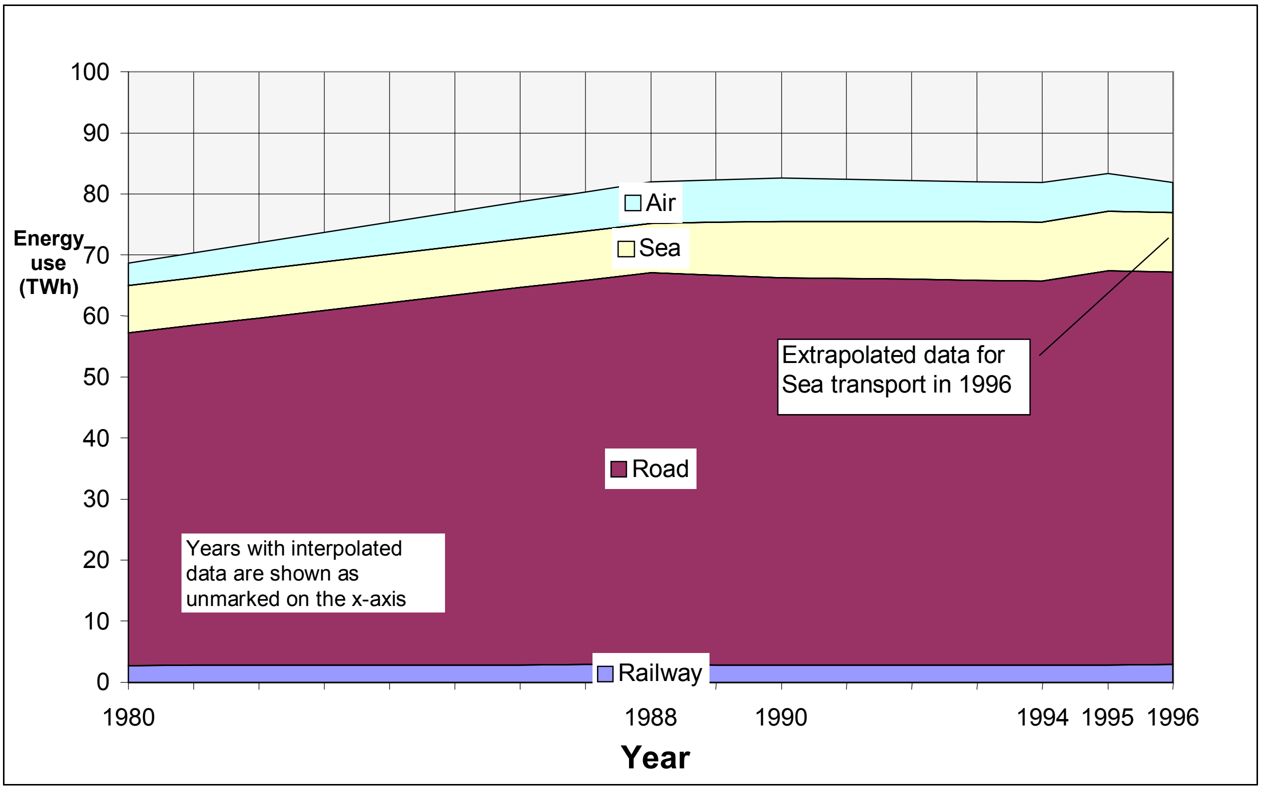


Figure 10 Energy use in Sweden TWh/year, transport of both passenger and goods (national averages based on Trafikverkens miljörapport, 1997)

As seen in Figure 10, the energy use is dominated by road transport. Rail transport has the smallest share but both air and sea transport is small in comparison to the road transport.

Some growth can be seen for the road transport from 1980 to 1988 but during the 1990's, the increase has been insignificant. The primary reason is most likely the economic recession in Sweden during this period. An increase in the economy will most likely also increase the transport volume (tonnekm). As a consequence of Sweden joining the European Union, the transport volume (tonnekm) presumably will increase further. It is also assumed that road transport will get the greatest share of this increase.

Energy use of petroleum products
In Sweden, as mentioned earlier, the total energy use is mostly based on hydropower and nuclear power. In the transport sector and associated businesses, petroleum products are more dominating. The energy use based on petroleum product consumption statistics is shown in Figure 11.

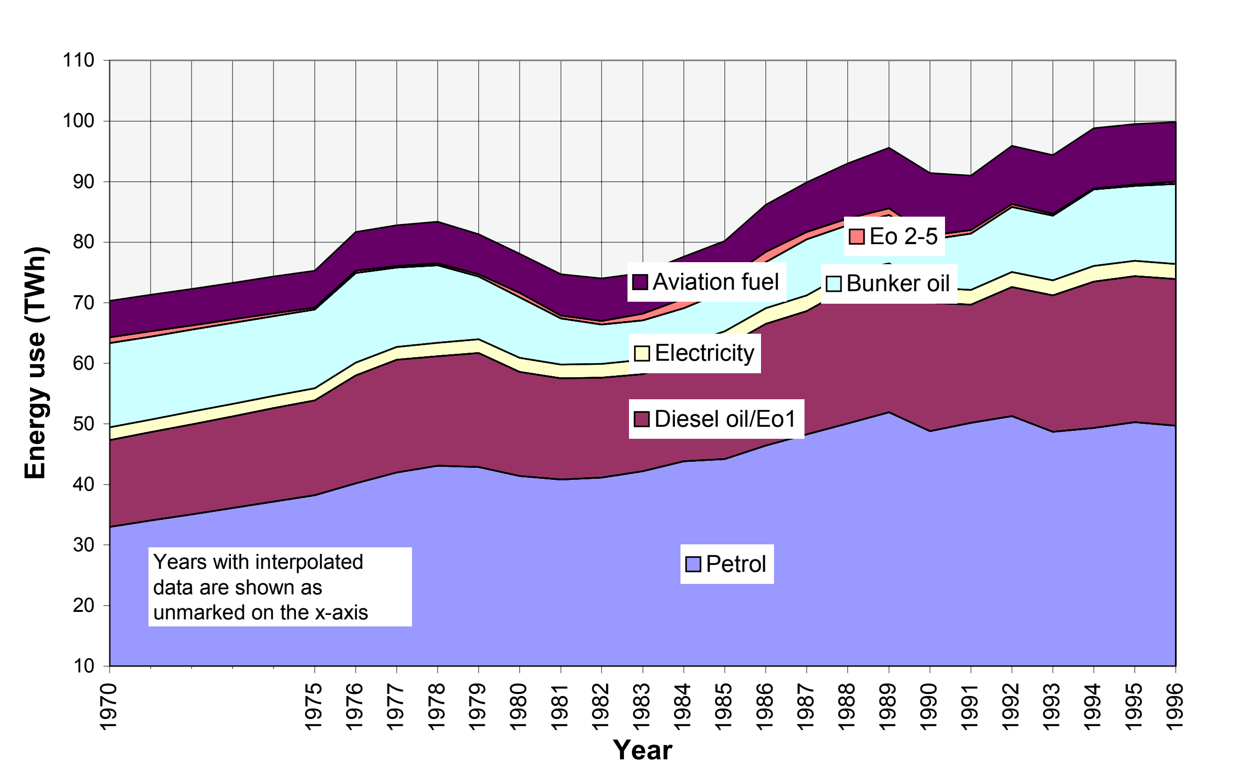


Figure 11 Energy use (national averages) in the transport sector and associated businesses divided on different fuels (STEM, 1998)

It is clear that the petrol and diesel oil (incl. light oil mainly for heating purposes, fuel oil 1) consumption has increased during the period shown in Figure 11.

The petrol use has levelled off during the 1990's. The fuel consumption of new passenger cars decreased in the period between 1975 and 1985. After that the fuel consumption of new cars has remained more or less stable. Since the car fleet is very old in Sweden (one of the oldest fleets in Europe), changes in the fuel consumption of the fleet are delayed many years in comparison to the consumption of new vehicles.

The diesel oil consumption has increased somewhat during the period shown. Heavy goods vehicles in Sweden consume most of the diesel fuel. For example, the sale of diesel fuelled passenger cars have until recently been as low as 2%. About one third of the diesel fuel is consumed by off-road vehicles, construction machinery etc. The fuel consumption of new commercial vehicles has decreased steadily during the period. One major problem with the statistics of diesel oil and fuel oil no 1, is that it is not separated between different uses. There have been some estimates but the reliability of these estimates is not clear. The reason for the increase in diesel fuel consumption during the period is mostly due to an increase in the road transport volume (tonnekm).

Apart from the criteria cited above, the economic development (especially the recessions) has had a considerable impact on the consumption of both petrol and diesel fuel.

Energy use in transport and transport volume

In this section, the energy use and the transport volume (tonnekm) in the total transport sector is discussed first. Secondly, the energy use and transport volume (tonnekm) is described in more detail for the different transport modes respectively.

Statistics about the amount of energy used for the transport of goods only (not including passenger transport) in Sweden is not complete. The statistics for the total energy use in the transport sector and the transport volume (tonnekm) is better, but still not on a reliable level.

The total transport volume (tonnekm) has increased during the period 1975-1995. Road transport has increased by almost 50% from 20 to 29 billion tonne kilometres. Railway transport has increased from about 9 to about 10 billion tonne kilometres (slightly more than 10%) from 1975 to 1995. Transport of goods by air has decreased from 6 million tonne kilometres in 1975 to 3 million tonne kilometres in 1995 (–50%) and represents only a marginal part of domestic transport. Sea transport has also decreased from 9,1 to 8,3 billion tonne kilometres during the same period (about –9%).

The increase in transport volume (tonnekm) for international and domestic transport of goods for road transport has been about 50% for road transport between 1980 and 1997. During the same period, rail transport has increased by 20%, air transport by about 45% and sea transport by about 18%. In contrast to domestic transport, the international transport volume (tonnekm) is increasing for all transport modes during the period.

A: Road transport

A major part of the nationally transported goods (in terms if tonnage) is transported by lorries. The advantages by using lorries are, for example, speed and flexibility. Lorries are both used in short transports like collection of goods and delivery to customers and in transports over long distances.

Road transport of goods is growing fast, both for domestic and international transport. The energy use (fuel consumption) for road transport is seen in Figure 12. The data in Figure 12 originate from the yearly environmental reports of the Swedish National Transport Administrations and from Johansson (personal communication).

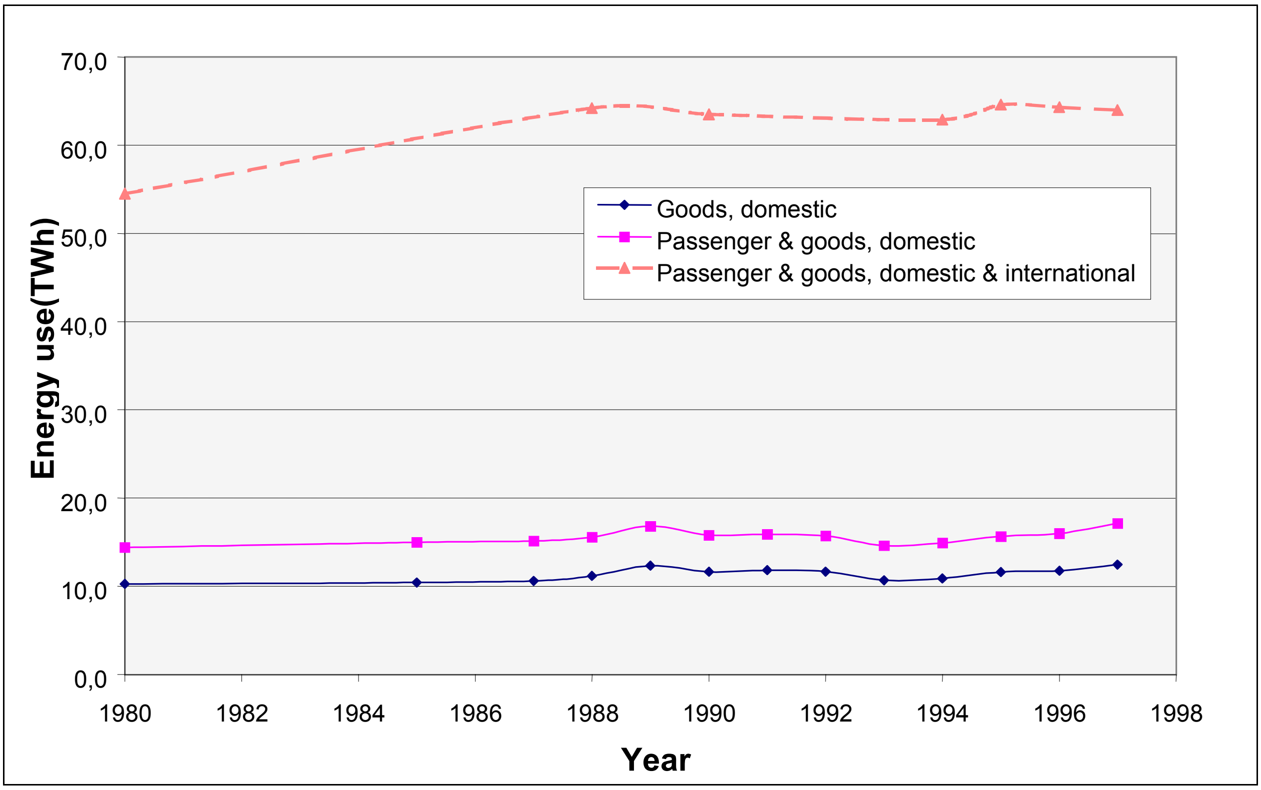


Figure 12 Energy use, for goods only, domestic destined; goods and passenger domestic destined & finally for goods and passenger domestic and international destined (TWh) (based on case routes)

As can be seen in Figure 12, the fuel consumption is increasing. Since 1980, all road transport (domestic, international etc.) has increased by about 20%. The increase has varied during the years and in the total road transport (goods and passenger domestic and international destined) the increase has not been as clear during the last 5 years as for the transport of only domestic goods. In road transport of goods, the fuel mostly used is diesel oil.

The energy use from diesel consumption in domestic transports of goods and passengers is shown in Table 33, for different vehicle types and for use in rural and in densely populated areas.

In Table 33, it can be noted that the energy use has not increased during the period for all vehicle types (not for passenger cars and lorries 3,5-16 tonnes), but the total energy use has increased by about 10 %. The energy use decreased for many vehicle types around 1993, but increased later.

Table 33 Fuel consumption in different vehicle classes and in rural areas and in populated areas (TWh), domestic transports of goods and passengers (based case routes from Johansson, The Swedish National Road Administration, 1998)

Vehicle type	1980	- 85	- 87	- 88	- 89	- 90	- 91	- 92	- 93	- 94	- 95	- 96	Aver.
Passenger car	2,18	2,35	2,24	2,08	1,65	1,75	1,62	1,59	1,46	1,50	1,51	1,68	*1,80*
Light-duty lorry	0,34	0,62	0,66	0,68	0,55	0,70	0,71	0,70	0,69	0,70	0,76	0,84	*0,66*
Bus	1,96	2,19	2,27	2,30	2,82	2,39	2,41	2,45	2,47	2,51	2,54	2,52	*2,40*
Lorry 3,5-16t	1,06	0,88	0,83	0,85	0,87	0,83	0,84	0,82	0,75	0,76	0,81	0,81	*0,84*
Lorry 16t-	8,85	8,93	9,13	9,65	10,9	10,1	10,3	10,1	9,24	9,42	10,0	10,1	*9,74*
Moped	0	0	0	0	0	0	0	0	0	0	0	0	*0*
Motorcycle	0	0	0	0	0	0	0	0	0	0	0	0	*0*
Rural areas	11,2	11,4	11,5	12,0	13,0	12,2	12,4	12,2	11,2	11,4	12,1	12,3	*11,9*
Populated areas	3,22	3,60	3,63	3,62	3,82	3,57	3,55	3,54	3,43	3,50	3,59	3,72	*3,57*
Total TWh	**14,4**	**15,0**	**15,1**	**15,6**	**16,8**	**15,8**	**15,9**	**15,7**	**14,6**	**14,9**	**15,7**	**16,0**	***15,5***

The average total energy use during the period is about 15,5 TWh per year. About 75% of the energy is used in transports in rural areas. Note that this is the energy use and the allocation of *diesel fuel* on different vehicles. Different categories of vehicles often use different kinds of fuels.

In Table 34 below, the vehicle fleet of 1996 is divided into different vehicle types and the specific fuels used and the numbers of vehicles (and in per cent) that used different kinds of fuels, in 1996, is illustrated.

Table 34 Vehicle by fuel category according to different vehicle classes in 1996 (National averages by Association of Swedish Automobile Manufacturers and Wholesalers, 1997)

Fuel category	Cars	Buses	Lorries	Tractors	*All*
Gasoline/Petrol	3 549 146	940	198 929	23 640	**3 772 655**
Diesel oil	105 117	13 378	112 587	291 803	**522 885**
Kerosene	0	0	0	8 634	**8 634**
Other fuels	657	435	235	314	**1 641**
All	**3 654 920**	**14 753**	**311 751**	**324 391**	**4 305 815**
In per cent	*84,9%*	*0,3%*	*7,2%*	*7,5%*	*100%*

In Table 34, it can be noted that petrol and diesel oil are the most frequently used fuels by all vehicle classes. Petrol is the most common fuel in cars and kerosene is mainly used in some of the older tractors.

Heavy-duty vehicle fleet in Sweden
The number of heavy-duty vehicles in Sweden can be classified depending on their total weight (kg). Statistics of this vehicle fleet is reported yearly by the Association of Swedish Automobile Manufacturers and Wholesalers (BIL). In Figure 13, the number of heavy-duty vehicles divided into different weight classes is shown for the years 1993, 1996 and 1997.

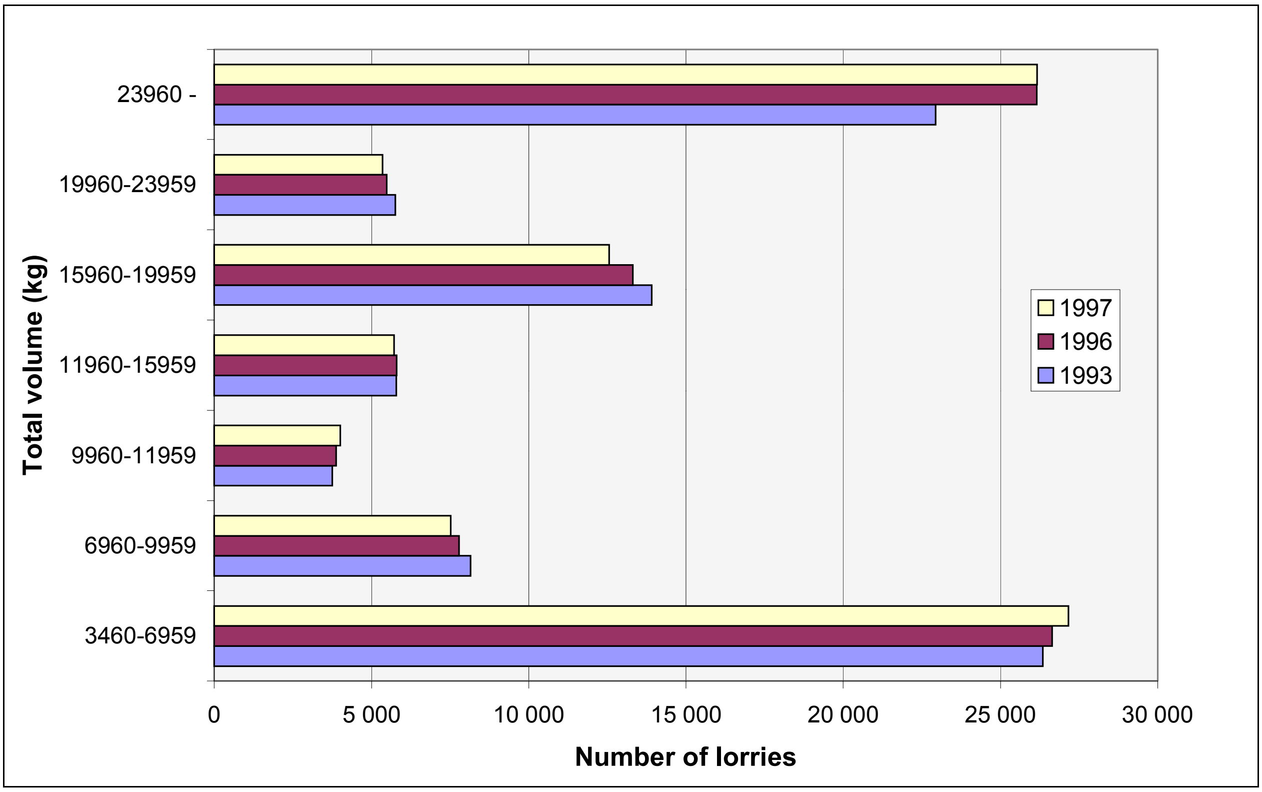


Figure 13 The number of lorries in different weight classes regarding the years 1993, 1996 and 1997 (National averages from Association of Swedish Automobile Manufacturers and Wholesalers, 1997).

In Figure 13 it can be noted that the majority of the vehicles are in the heaviest (23 960 kg -) and the lightest classes (3 460-6 959 kg). The total number of vehicles in all classes increased marginally between 1993 and 1997 (2 %) but decreased between 1996-1997 (–0,5%).

The vehicles can also be classified depending on maximum load (kg). This type of classification is shown in Table 35 and also with division into different types of vehicles as well. Table 35 shows the heavy goods vehicles divided into different types.

Table 35 Trucks, divided on chassis type and size 1997 (National averages from Association of Swedish Automobile Manufacturers and Wholesalers, 1997)

Maximum load (kg)	Vans	Lorries with body	Timber lorries	Tank lorries	Tractor + Semi-trailer	Fire engine	Other spec.veh.	Total
-999	65 848	80 380	1	0	16	338	10 260	**156 843**
1000-1999	38 067	50 879	1	10	29	347	1 640	**90 973**
2000-2999	2 917	2 054	1	6	2	162	658	**5 800**
3000-3999	1 826	1 439	0	4	2	78	537	**3 886**
4000-4999	1 777	1 522	1	9	3	142	457	**3 911**
5000-5999	1 135	1 237	0	23	5	149	653	**3 202**
6000-6999	1 053	768	1	62	7	526	830	**3 247**
7000-7999	1 297	1 543	2	119	21	401	765	**4 148**
8000-8999	1 648	2 053	0	148	43	216	532	**4 640**
9000-9999	923	1 236	0	130	187	134	453	**3 063**
10000 -	6 356	10 218	1 477	2 109	4 642	217	6 818	**31 837**
Total	**122 847**	**153 329**	**1 484**	**2 620**	**4 957**	**2 710**	**23 603**	**311 550**

In Table 35, it can be noted that in the categories: Lorries with bodies, Vans and other special cars, lower maximum load is more frequent than in the other categories.

The average age of the lorry fleet in Sweden is 10 years (1988). About 11 % of the Swedish heavy goods vehicles are from the model year 1988. About 54 % of the fleet of heavy goods vehicles are 10 years or older.

Energy use in heavy goods transport
It is very difficult to find reliable data for fuel consumption and energy use (i.e. energy efficiency) in real transport for different kind of vehicles. The source of the facts and figures used here is NTM (the Swedish Network for transport and the environment, 1998-09-28). This organisation has compiled data from its members and has presented some preliminary data from this work. A selection of the data is shown in Table 36.

Table 36 Energy use in heavy goods transport of some selected vehicle types (based on case routes)

Type of lorry & use	Type of engine	Payload/ total weight	Load factor weight-%	KWh (fuel) /tonnekm	L/100 km
Light-duty lorry distribution traffic	Before 1990, Euro 1 & 2	8,5/14	50	0,63	25-30
Light-duty lorry distribution traffic	Euro 0	8,5/14	70	0,45	25-30
Middle heavy lorry, regional traffic	Before 1990, Euro 0, 1, 2	14/24	50	0,49	30-40
Heavy lorry with trailer, long-distance	Before 1990, Euro 0, 1, 2	26/40	70	0,19	32-38
Heavy lorry with trailer, long-distance	Before 1990, Euro 0, 1, 2,	40/60	70	0,17	43-55

In each vehicle category data is shown, which correspond to different categories of vehicle age. The age categories correspond to the introduction of emission regulations namely: before 1990, 1990 – 1992 (Euro 0), 1993 – 1995 (Euro I), 1996 and later (Euro II). One should be aware of the fact that some vehicle manufacturers offered vehicles that fulfilled the legal requirements for exhaust emissions 2 – 3 years before the regulations were applied. The weight of the load is specified as "freight hauling weight". This implies that goods below a certain density (about 250-300 kg/m^3) is recalculated to the weight that the same volume would have if it weighed 275 kg/m^3.

In Table 36, it can be noted how the energy efficiency and fuel consumption varies for different types of vehicles, how the load factor varies etc.

In Table 36, we can see that the fuel consumption of the vehicle (in l/100 km) generally is increasing by increasing vehicle total weight. If the comparison is made per tonne kilometre transported goods; the heavier vehicles are more energy efficient, as expected.

The development of transport volume (tonnekm) of goods transported by road since 1975 is shown in Figure 14. The data in Figure 14 originate from Thörn at SIKA (personal communication).

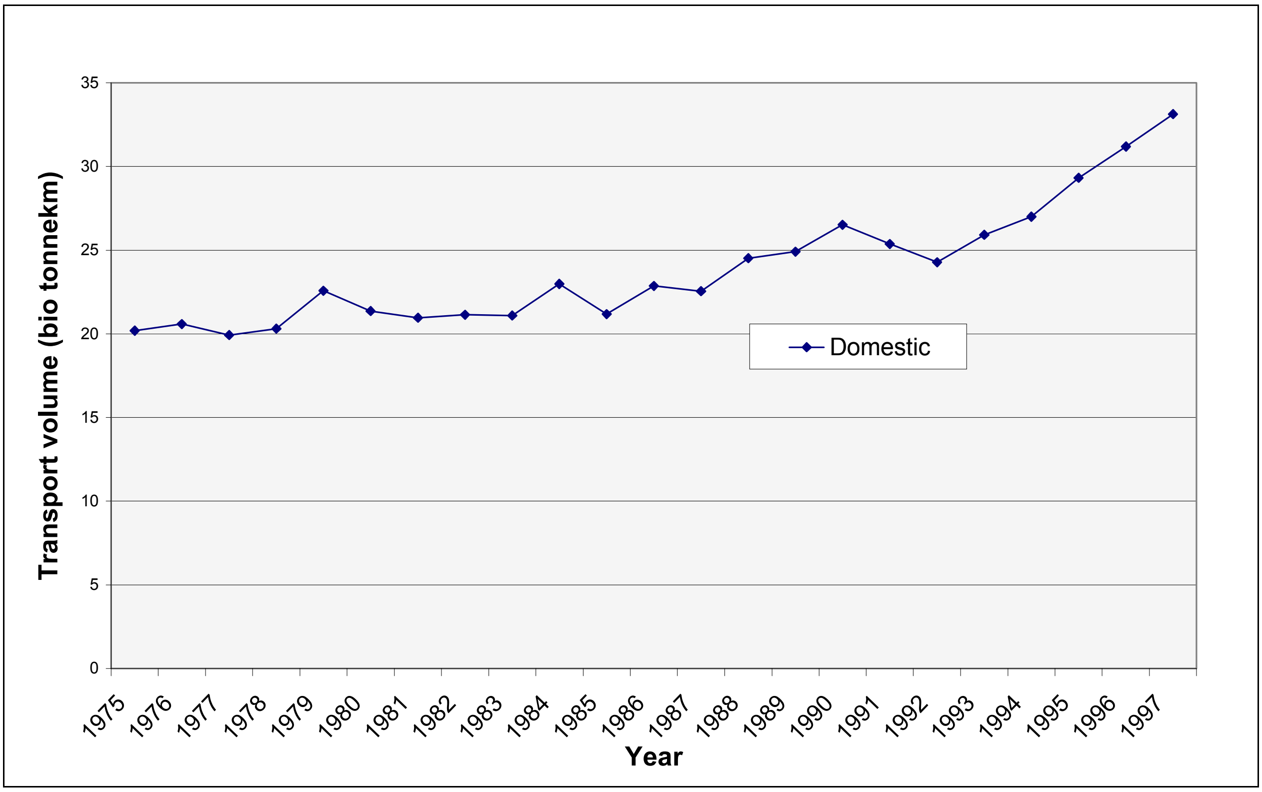


Figure 14 Transport volume by road transport (bio tonnekm) for domestic destined goods (national averages)

In Figure 14 it can be noted that transport volume (tonnekm) has increased considerably during the period 1975 to 1997, about 65 %. The increase has been quite regular. The dip in 1993 was due to the economic recession in Sweden at that time.

Most of the transport in various goods categories is carried out in relatively short distances by truck. Considerable amounts of timber, provisions and building materials (soil, gravel etc) are transported by trucks. Of all the transported goods in Sweden, only slightly more than 9 % is transported longer than 300 km.

B:Railway transport

In Sweden, goods transports by rail are mostly associated with ore, steel and timber transports. The advantages of railroad transport historically have been most obvious in transports over long distances with heavy load, even though new solutions are emerging as for example combined transports.

The majority of the goods transports by rail are handled by SJ (Swedish State Railways). There are also some joint transports between SJ and one or several private rail companies. The business with combi-trains within SJ was in 1992 to some extent transferred into a separate company called Rail Combi AB.

Freight trains can be divided into different categories, namely: goods train (traditional), goods train (system), combi-train and diesel fuelled train. A goods train (traditional) is a traditional goods train, comprising wagons of different models and contents, which are used between different destinations.

Freight train (system) is only used between two destinations and is not switched over to other destinations or shunted. System trains usually carry no goods on the way back from a delivery. Combi-train includes the load carrier in the payload (2 – 8 tonnes extra). Combined transports can be used for such businesses that conduct rail transports using their own containers and trailers in combination with other transport means like ferries and lorries.

Diesel engines are mainly used for shunting and transporting goods. Diesel trains are operated on both electrified and non-electrified tracks. This can be of an advantage, since this sometimes can give better utilisation of the train and can be more practical and economical. A number of different diesel engines are used in these trains. However, trains using the T44 locomotive (2-stroke diesel engine), carry out the vast majority of goods transport.

The electrically propelled trains account for about 95% of the total transport volume (tonnekm) on trains in Sweden. The energy use in rail transport (passenger & goods and domestic & international) is shown in Figure 15 below. The data in this Figure originate from SIKA 1995 and Sjöberg at SJ (personal communication).

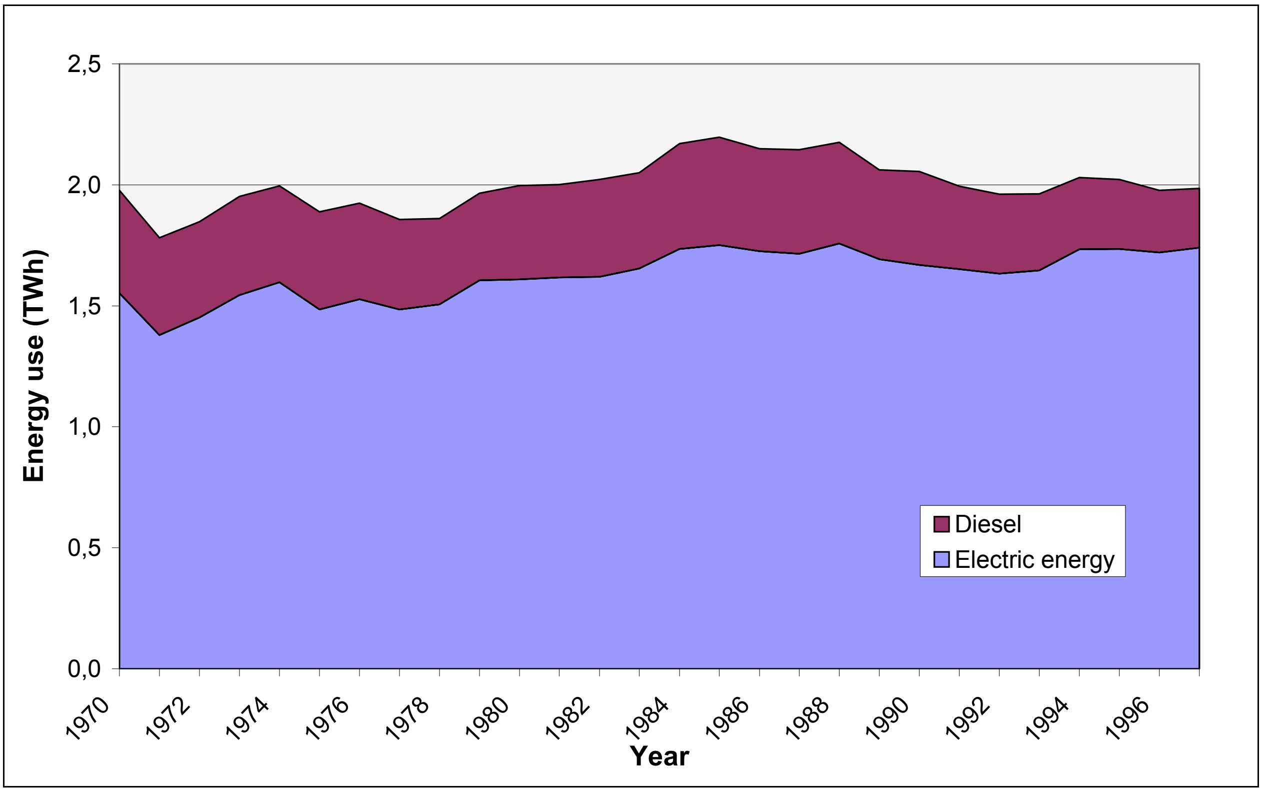


Figure 15 Energy use in train transport for passenger & goods (TWh), for domestic and international destined goods (based on case routes)

The facts and figures in Figure 15 shows that the energy use was about the same in 1970 and in 1997 (1,98 TWh), but we can see that while the use of electric energy has increased, the diesel fuel use has decreased. Statistics of the energy use in domestic destined transports of goods is not available. However estimation has been made. According to the Swedish State Railways, about 40% of their electricity and 75% of the diesel fuel was used for domestic goods transport in 1997. If these relationships are assumed to be relevant for the whole time period, the energy use can be calculated. The results are shown in Figure 16.

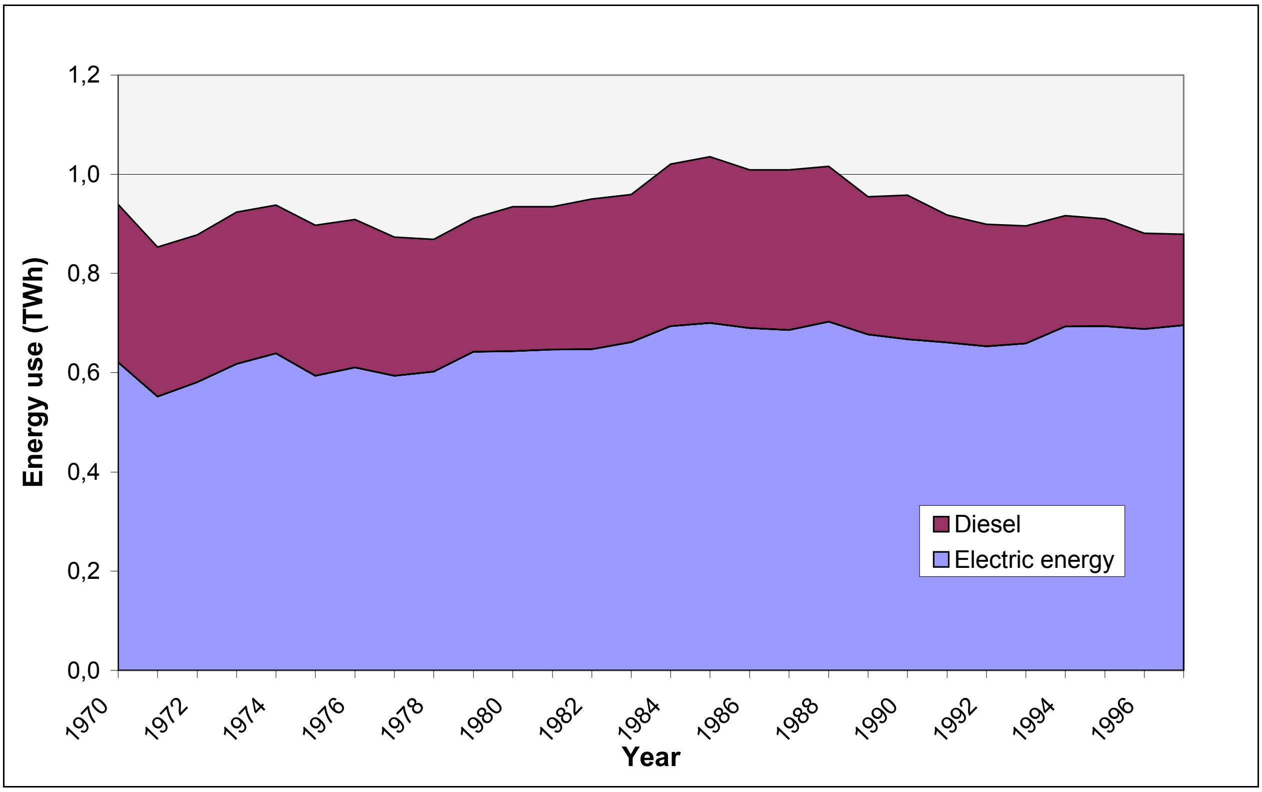


Figure 16 Energy use (TWh) in train transport, for domestic destined goods (based on case routes)

As can be seen in Figure 16, the diesel use has decreased by about 42% between 1970 and 1997, while the use of electricity in goods transport has increased by about 12%. The total energy use has decreased by about 6% during the same period.

Energy efficiency in transport of goods by trains (kWh(LCI)/tonnekm and kWh(fuels)/tonnekm[18]), divided in different categories (average), is shown in Table 37.

[18] Since it sometimes in railway statistics (in tonnekm) is included the weight of the trains, it should be noted that the figures in the table exclude the weight of the train. This is an advantage when a comparison with other transport modes is carried out.

Table 37 Energy efficiency in rail transport by selected categories, average (based on case routes form NTM, 1998-09-28).

Type of train	Load factor[19]	KWh (fuel)/ tonnekm
Freight train (traditional)	69%	0,042
Freight train (system)	56%	0,050
Combi-train	66%[20]	0,043
Diesel train	55%	0,064[21]

The values in Table 37 are based on the mix of sources of electric energy bought by SJ and the Swedish National Railroad Administration (Banverket). Most of this energy is hydroelectric power (49%) and the second major share is nuclear power (45%). Energy losses from power plant to the track electricity grid (about 4%) have been included in these values.

The most frequently used engine, the RC-engine, has been used in calculating data for the electric trains. For diesel trains the calculations have been based on a T44-engine (2-stroke diesel engine).

The reason why goods train (system) is using more energy than the traditional goods train is probably because it often has no goods on the way back from a delivery. A possible cause why the combi-train is using more than a traditional goods train is that it has a higher air resistance due to different types of wagons. The difference between the electrically propelled train and the diesel-fuelled train is surprisingly small considering the difference in efficiency between an electric motor and a diesel engine. The reasons behind the differences in energy efficiency between the electric trains are not entirely clear.

The transport volume (tonnekm) of goods transported by rail is shown in Figure 17 (Sjöberg, SJ personal communication).

[19] The load factors are not collected from the same source as the energy efficiency but an estimation.
[20] The value is a weighted mean value for all electricity trains. No specific load factor value is available for combi-trains. A problem when comparing combi-trains is that the load carrier is sometimes included in the payload which affects the load factor.
[21] This value is somewhat low compared with the energy use for the electric train and in other investigations, the level has been up to five times higher. The correct value is probably somewhere in between.

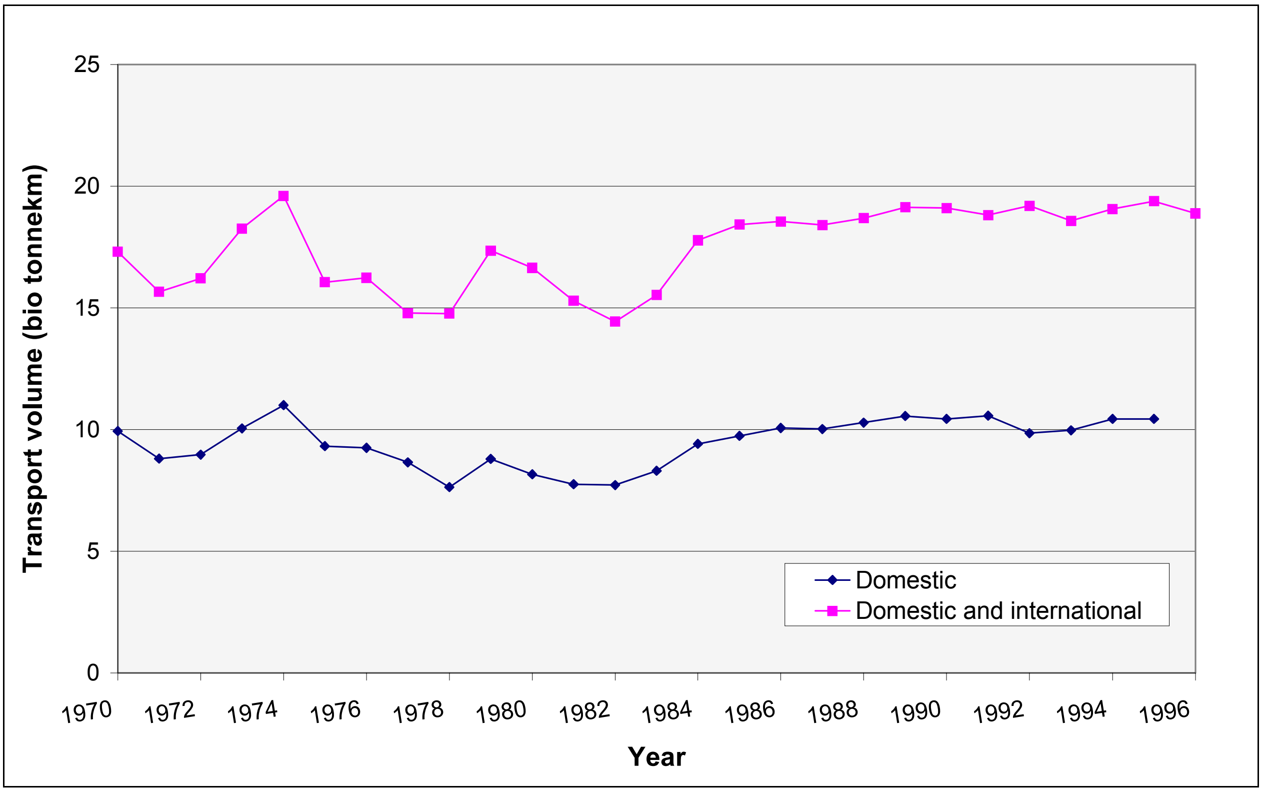


Figure 17 Transport volume of goods transported by rail (bio tonnekm), regarding domestic and domestic & international destined goods (based on case routes)

In Figure 17, it can be noted that transport volume (tonnekm) was slightly higher in 1996 than in 1970, although there was a somewhat higher transport volume in 1974. There was also a period in the 1980's with considerably lower transport volume (tonnekm).

C: Sea transport

Shipping and sea transport is mostly used between continents and when the speed is of minor importance. For example, trailers can be loaded on ferries for international transports. The energy use in sea transport generally is very low. This is especially true when large quantities of goods are transported at a low speed. Usually this transport mode has the lowest energy use of all transport modes, although the energy use varies with type of ship (which will be discussed later in this section).

About 95% of the Swedish international trade is handled by sea transport. However, ships registered in foreign countries carry out most of the international trade.

In Figure 18, the energy use by domestic sea transport divided into fuel categories is shown. Data for this Figure has been provided by Uhlin at SCB (personal communication).

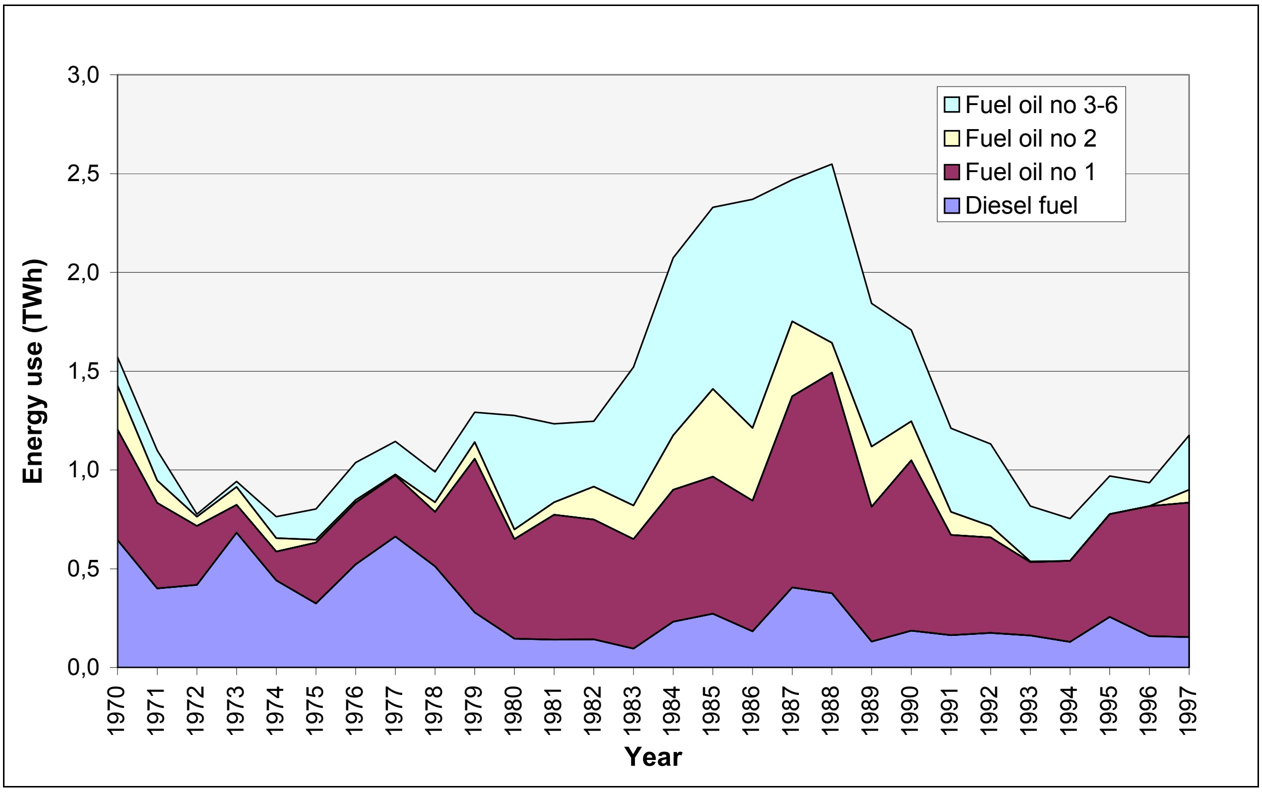


Figure 18 Energy use of different fuel categories in domestic sea transport, passenger & goods (TWh) (national averages)

In Figure 18*,* it can be noted that the use of fuel oil no 1 and no 3 – 6 have increased while diesel oil and fuel oil no 2 have decreased during this period. The total energy use has decreased during the period, although there was a peak in energy use around 1988.

In Figure 19 below, the energy use by international sea transport divided into fuel categories is shown. Data for this Figure has been provided by Uhlin at SCB (personal communication).

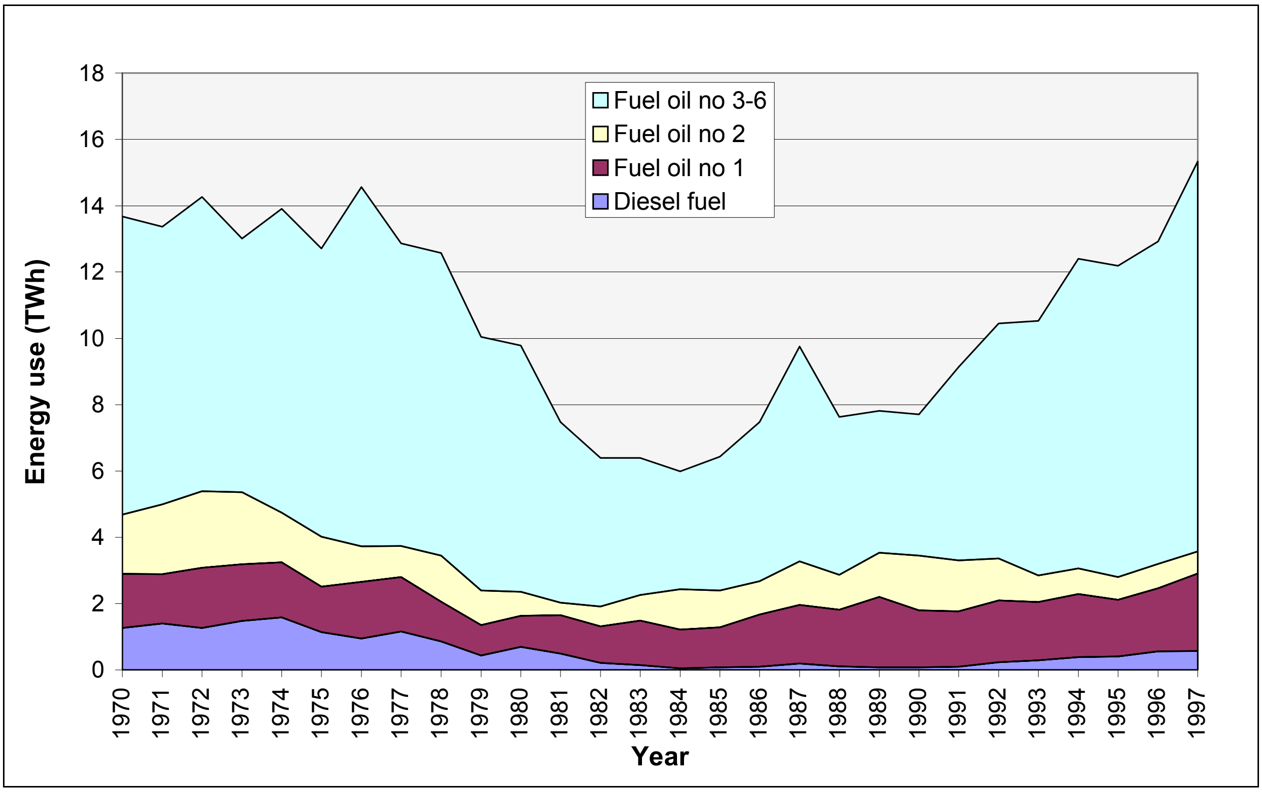


Figure 19 Energy use of different fuel categories in international sea transport, passenger & goods (TWh) (national averages)

In Figure 18 and in Figure 19, we can see that fuel oil 1 and 3-6 have grown while diesel fuel and fuel oil 2 have decreased during the period. We can also see, when domestic and international transport is compared, that in international transport the most used fuel is no. 3-6. In domestic transport, fuel oil is the most used type of fuel.

In Figure 20 the energy use in both international and domestic sea transport is shown. Data for this Figure has been provided by Uhlin at SCB (personal communication).

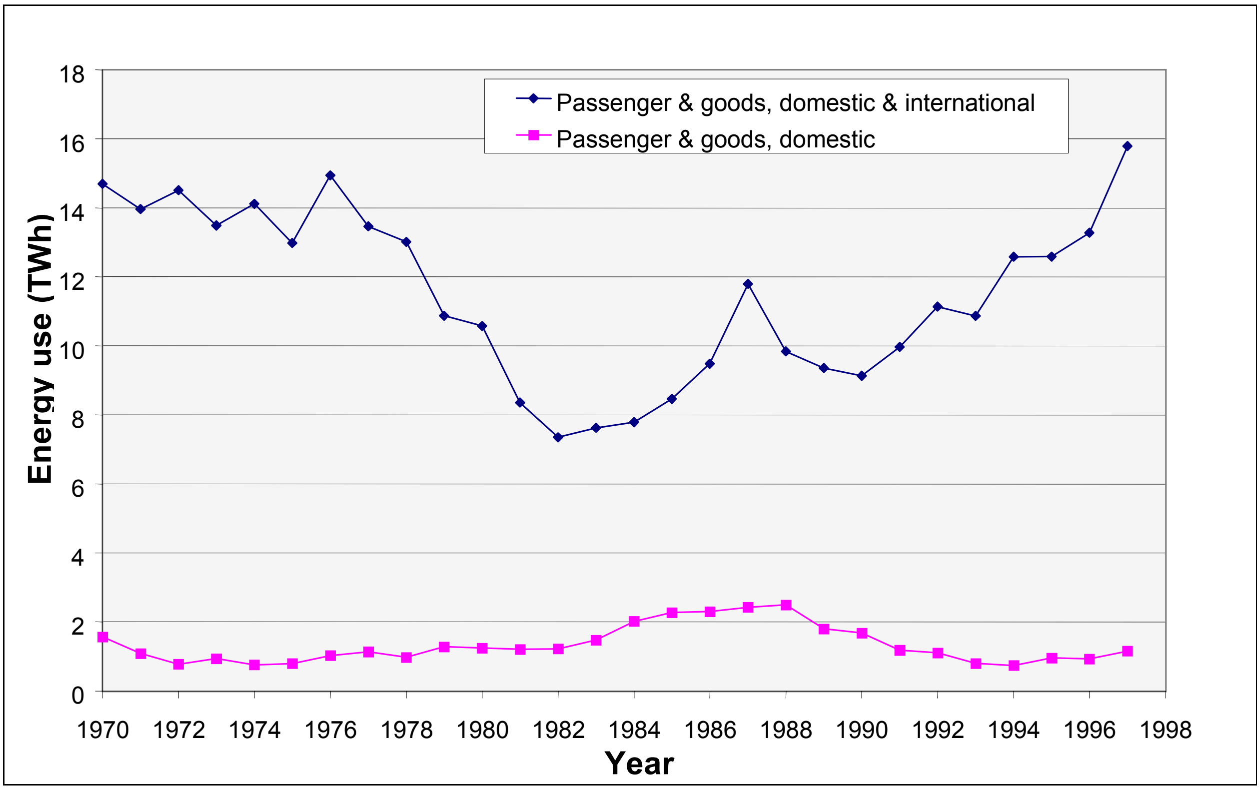


Figure 20 Energy use in sea transport, passenger & goods domestic and international; domestic national averages (TWh) in Sweden for 1970-1997

Figure 20 shows that the total energy use in transport of passengers and goods domestically and internationally has increased by about 7 % in the time period. The domestic only transport of passengers and goods has decreased by about 25 %. In both cases, large variations can be seen, especially for the international transport, which decreased considerably in the 1980´s. Data on the share of the total energy use that represent goods transport is not available today.

Sea transport is a little different from the other transport modes, since every ship is specially built for the transport it is supposed to carry out. This makes it difficult to measure the energy use in sea transport. Despite the difficulties the energy efficiency in sea transport for a few different categories of ships is shown in Table 38.

Table 38 Energy efficiency in sea transport in different categories, average (based on case routes from NTM 1998-09-28)

Means of transport	Load factor[22]	KWh (fuel)/ tonnekm
Freight ship (large, >8' dwt[23])	60%	0,056
Freight ship (middle, 8'-2' dwt)	60%	0,078
Freight ship (small, <2' dwt)	60%	0,11
Ro-Ro (2'-30' dwt)	80%	0,090
Ferries (size of Finland-Sweden ferries)	60%	0,11

In Table 38, it can be noted that large goods ships have the highest energy efficiency while small goods ships and ferries have the lowest energy efficiency. Generally, the energy efficiency is higher for a tanker than for a bulk ship. Again, a bulk ship has higher energy efficiency than a Ro-Ro ship.

The reasons for the differences are mainly the design of the ship, how the ship is used and the speed of the ship. The energy use of ships is proportional to the speed 2 squared. This means that as the speed is doubled, the energy use will increase by a factor of four.

Transport volume (tonnekm) in sea transport of goods is shown in Figure 21 below. Data for this Figure has been provided by Thörn at SIKA (personal communication).

[22] In the load factor, (which indicates how much of the load capacity that is used) the load carrier is also included, for example a container.
[23] “Dwt” stands for dead weight tons and is a measure of load capacity, although it includes bunker, some equipment, water etc. and can’t therefore reach more than about 80-90% of max load capacity.

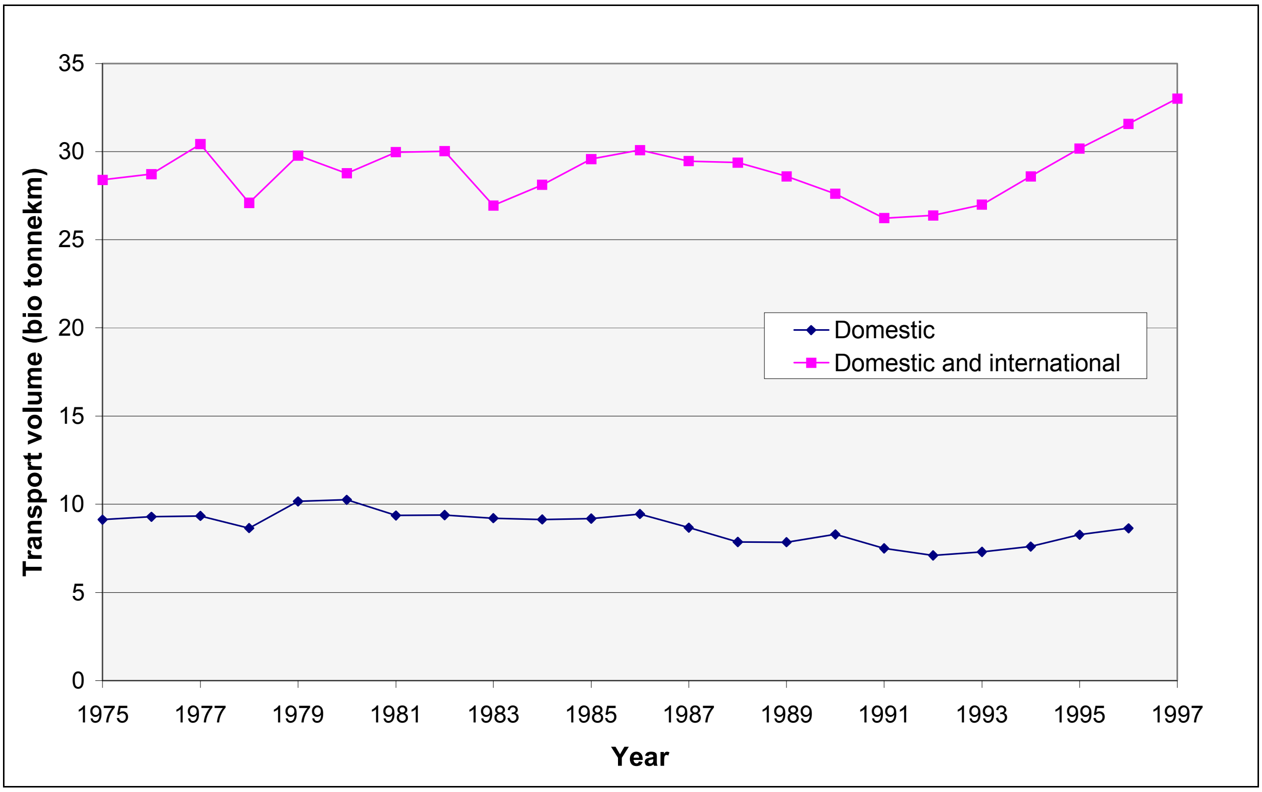


Figure 21 Transport volume (tonnekm) by sea transport of goods, domestic and international; domestic (bio tonnekm) in Sweden for 1975-1996 (based on national averages)

In Figure 21*,* it can be noted that the domestic transport volume (tonnekm) has decreased by about 5%. Domestic and international transport volume (tonnekm) has increased by about 16%. The large goods categories are oil, bulk goods, cement, sand, ore, gravel and provisions (grain etc.).

Grain is a product that is both imported and exported. The volumes vary over time. In 1995, Sweden exported about 0,5 million tonnes of grain, which was about double the amount imported. Most of the grain was loaded in the harbours of Norrköping, Varberg and Falkenberg.

D: Air transport

Air transport is mostly used for fragile goods, for goods with high refinement value and for transports over long distances. Transports are often co-ordinated with other forwarding agents so that the degree of utilisation is increased. Still the energy use in air transports is generally considered very high. However, the energy use has decreased somewhat for new aircraft.

In Figure 22*,* the energy use in air transport of goods is shown. Data for this Figure originates from CAA and NTM. It should be noted that only 3/7 of the international transport of goods is accounted for in the statistics (CAA).

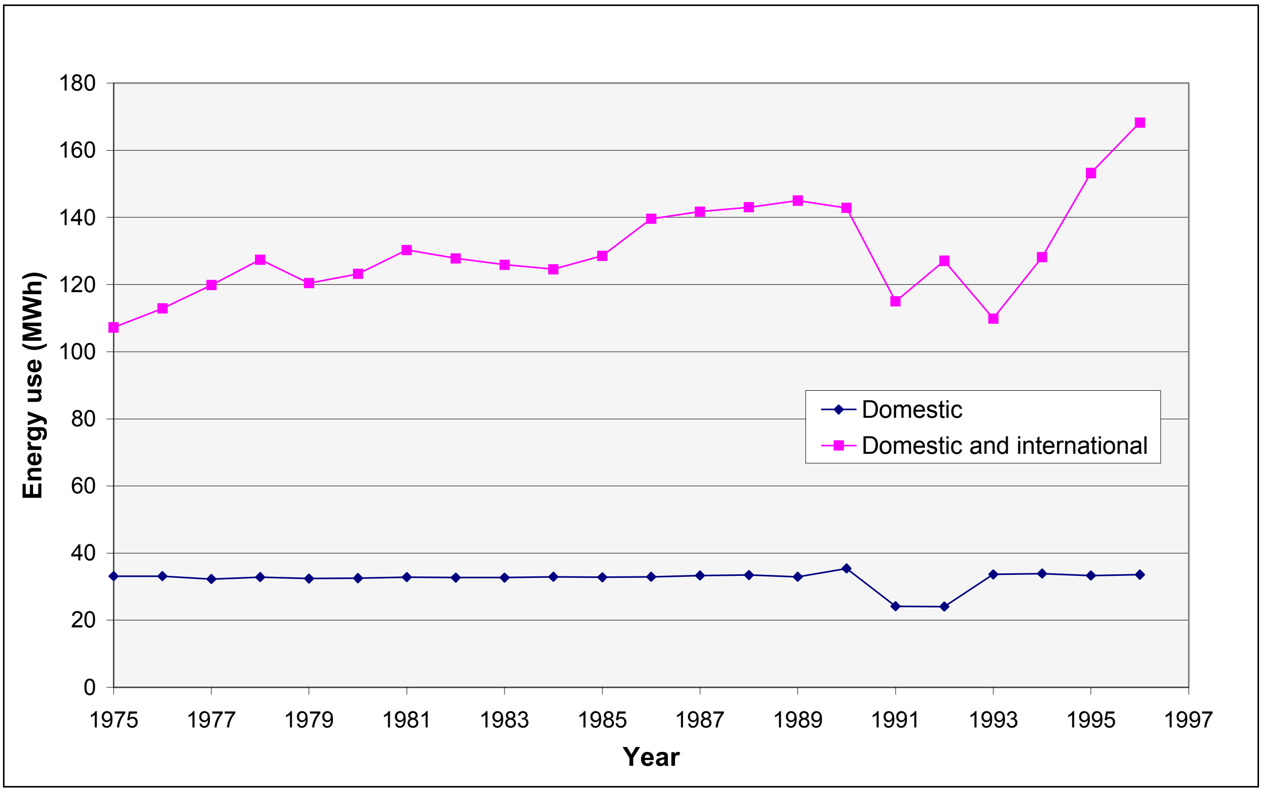


Figure 22 Energy use, goods, MWh, domestic and international; domestic (based on case routes)

The domestic energy use has been basically unchanged during the period but when the international transports are included, the fuel consumption has increased by almost 60%.

When goods are transported long distances, jet aircraft are normally used, whereas on shorter distances turbo propeller-driven aircraft are often used. As an example of a jet plane a MD82 with the engine JT8T-217 has been chosen. This aircraft is relatively energy efficient in its category. A Saab 340A using the engine CT7-5A2 represents a turbo propeller-driven aircraft used on shorter distances. The energy efficiency in air transport by these aircraft is shown in Table 39.

Table 39 Energy efficiency in air transport in different categories, average (based on case routes from NTM 1998-09-28)

Means of transport	Load factor	KWh (fuel)/ tonnekm
Jet plane (600 km)	65%	6,0
Jet plane (300 km)	65%	7,9
Turbo Propeller-driven aircraft (400 km)	65%	1,1
Turbo Propeller-driven aircraft (200 km)	65%	1,4

In Table 39 we can see that the jet plane, which travels 300 km (in average), is the least energy-efficient aircraft. The "Turbo Propeller-driven aircraft (400 km)" is, on the other hand, the most energy efficient aircraft.

To calculate the energy efficiency factors, the flight path for different parts of the way have been simulated considering goods weight and flying distance as well. The weight at the takeoff is most important for the energy efficiency, as is the flying distance.

In Figure 22, the transport volume (tonnekm) of air transport of goods is shown. Data for this Figure originates from CAA. Again, it should be noted that only 3/7 of the international transport of goods is accounted for in the statistics (CAA).

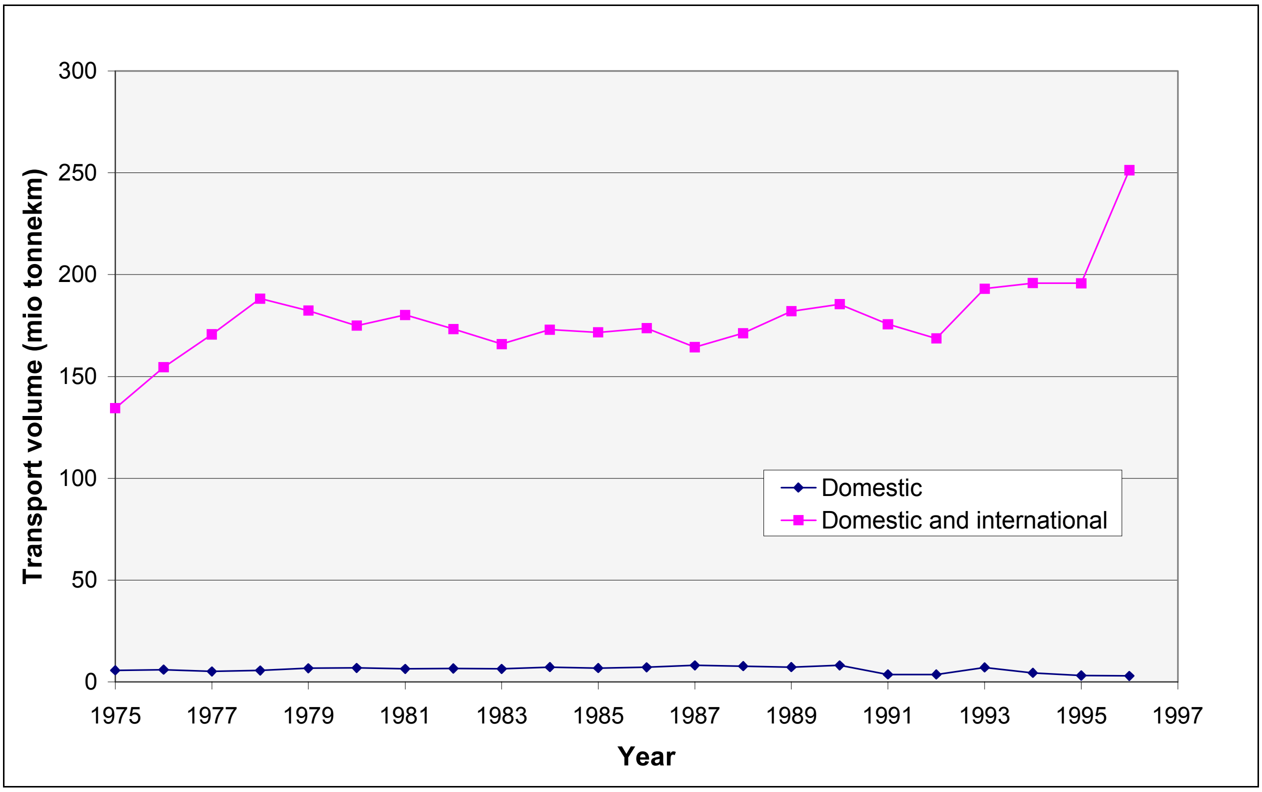


Figure 23 Transport volumes, Air, goods, million tonne kilometres, domestic and international; domestic (national averages)

During the period domestic transport volume (tonnekm) has decreased by almost 50 %. Domestic and international transport together has on the other hand increased by about 85 %. About 80% of the domestic goods in 1998 were represented by mail. International air transport is mostly fragile goods and goods with high refinement value

3.4.2. Prognoses for the future

In this section, the prognoses for the future are summarised. First, the total energy use forecast in Sweden is elucidated. Second, the available energy use forecast in the transport sector and in the transport of goods is reported.

The statistic information available in Sweden concerning most of these issues is not complete. SIKA, SCB and STEM have made some forecasts of the transport activity and energy use. Some of this data is shown in the Figures below.

Energy use forecast on a national level

Energy use forecast in all sectors
Energy statistics in Sweden is compiled by STEM. The total energy use was 484 TWh in 1996. STEM has, based on available statistics, estimated the total energy use in 1997 to 475 TWh. During the period 1996 – 1999 the energy usage is expected to rise by 3 TWh (0,6%).

In the transport sector, the energy use is expected to rise by 3 TWh from 87 (1996) to 90 (1999) TWh. The domestic energy use in the transport sector is dominated by the use of oil products such as petrol, diesel oil and aviation fuel.

The prognoses for the energy use in the transport sector are based on statistics of delivered amount of fuels and is also, apart from the available statistics, based on preliminary estimates from the National Institute for Economic Research (in Sweden) of Consumer Price Index (CPI), the private consumption and the development of the industrial production. Energy use prognoses are also based on price prognoses for petrol.

The amount of diesel oil used is largely depending on the development of the trade and industry since this fuel is mostly used in the transport of goods. The use of diesel fuel is estimated to increase by 3,8% in 1997, 3,3% in 1998 and 3,1% in 1999.

Aviation fuel used domestically was slightly more than 1.0 million m^3 in 1996. The use of aviation fuel is expected to rise by 0,3% in 1997, 2,2% in 1998 and 1,4% in 1999.

Domestic use of light and heavy fuel oils (mainly in domestic shipping) has decreased by 50% during the first part of the 1990's. The use of high sulphur oil is expected to remain more or less stable in 1997. In 1998 and in 1999 it is expected to decrease by 6% and 9% respectively. Low sulphur oil is expected to decrease by 1,4% in 1997, 6,7% in 1998 and 6,3% in 1999.

The use of bunker oil for international shipping is expected to rise in 1997, decrease in 1998 and remain unchanged in 1999.

Energy use forecast in the transport sector
SIKA (Swedish Institute for Transport and Communications Analysis) has also carried out a study to make forecasts of the energy use in the transport sector. The national transport administrations for each transport mode have delivered some of the data used by SIKA.

The total transport of both goods and passenger transport in the past and a prognosis to 2020 is shown in Figure 24.

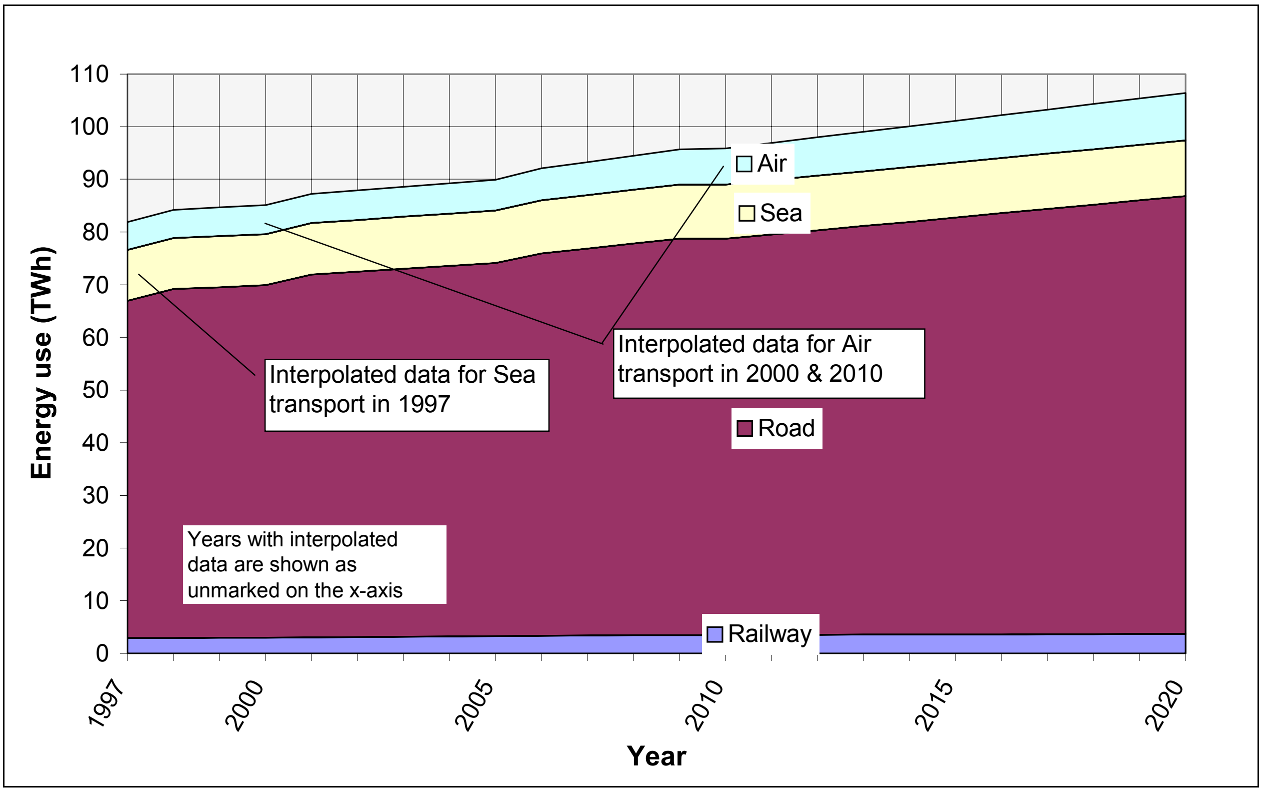


Figure 24 Forecast of energy use in Sweden (TWh/year), all transport (passenger and goods), 1997-2020, domestic and international destined goods (national averages)

Only data for 1997, 2000, 2005, 2010, 2015 and 2020 are available in the forecast in Figure 24. Please note that data for sea transport in 1997 and for air transport in 2000 and 2010 are also missing. Interpolations have been used in these cases.

Energy use in the transport sector is estimated to increase by 30% from about 82 TWh in 1997 to 106 TWh (+24 TWh) in 2020. The forecasted increase in road transport is also 30%, and this increase of 19 TWh is the main part of the increase in total energy use in transportation. The increase in the energy use in road transport is common in most studies of this kind. Rail transport will increase by 0.8 TWh in this forecast (+28%) in contrast to many other international studies where it usually decreases or remains constant. The increase in sea transport is relatively moderate at 0.9 TWh (+9%). The relative increase in air transport is 70% in relative terms but only 3 TWh in absolute terms.

Figure 25 shows the development in energy use for the different transport modes as a percentage of the total transport.

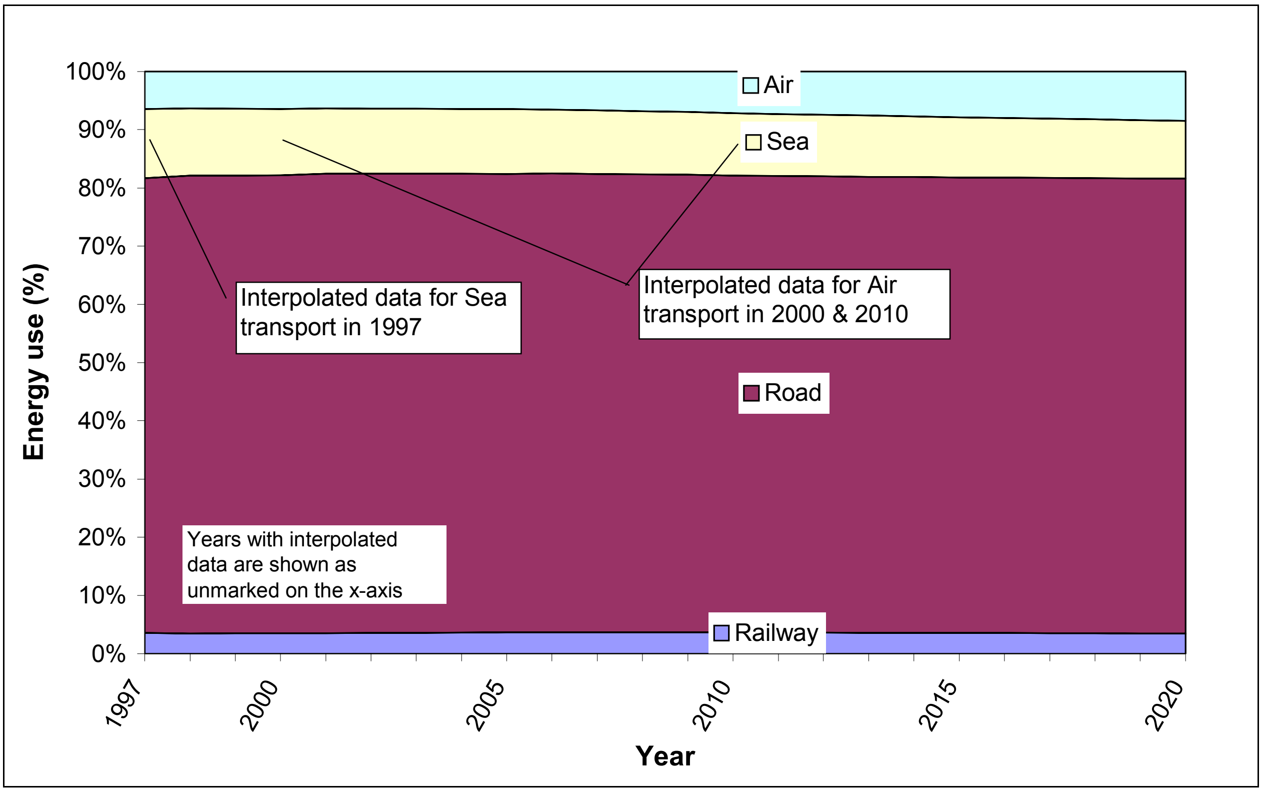


Figure 25 Forecast of energy use in Sweden (%), all transport (passenger and goods), 1997-2020, domestic and international destined goods (national averages)

The share of rail and road transport will remain almost constant during the period at 78% and 3.5 % of the total energy use respectively. Sea transport will decrease its share from 11.8% to 10 % and air transport will increase its share from 6.5% to 8.5%.

Transport volume (tonnekm) forecast in the transport of goods

In this section, prognoses for the future will be described regarding transport volume (tonnekm) in the transport of goods. In Figure 26 below, a prognosis for the transport volume (bio tonnekm) for domestic destined goods is illustrated. The data for this prognosis have been compiled mainly by The Swedish National Road Administration (SNRA) and Banverket. The data for rail is an estimation by Ecotraffic based on data for domestic and international transport, which was not separated in the original data. Domestic data are assumed to represent about 54% of the total amount of transported goods, since this has been the average relation between 1970 and 1995.

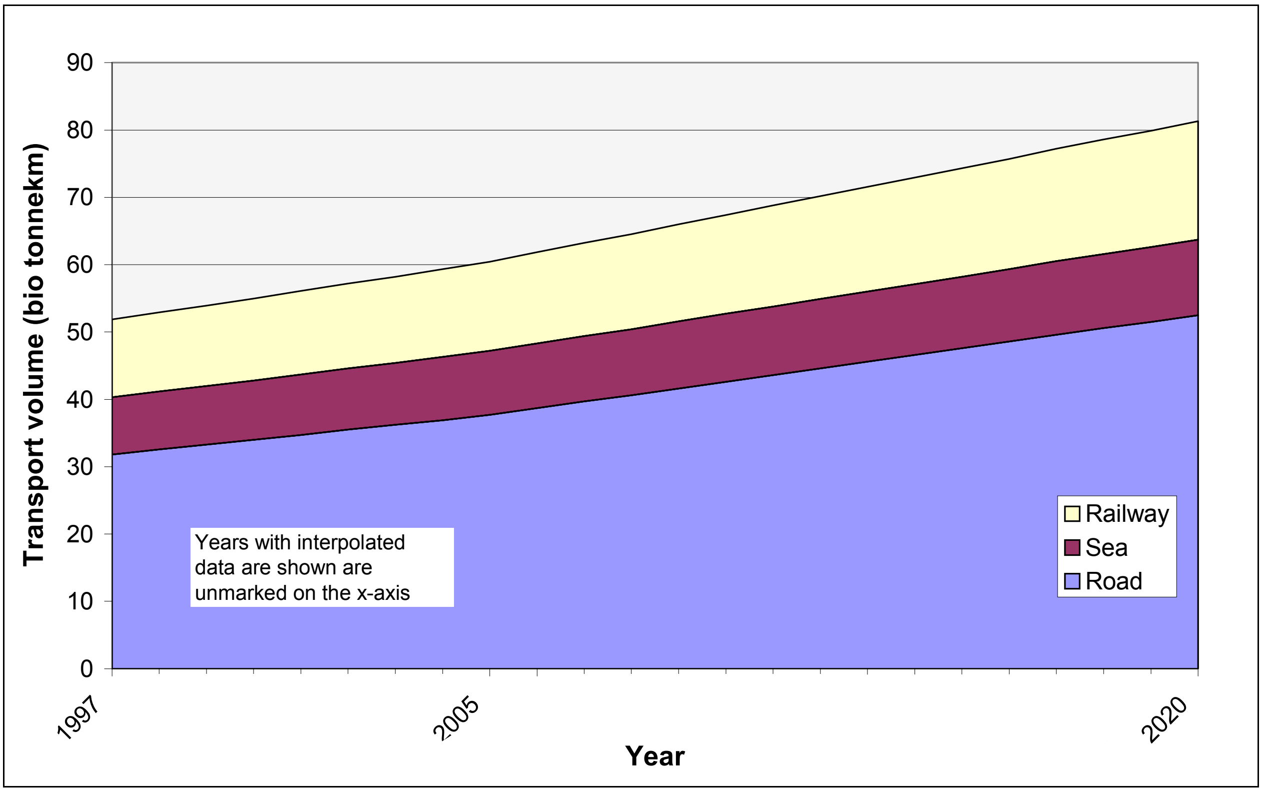


Figure 26 Prognosis for the transport volume (bio tonnekm), for domestic destined goods, regarding 1997-2020 (based on case routes)

In Figure 26, it can be noted that the transport volume (tonnekm) for road will increase by about 65%, for sea about 32% and rail with about 52%. The reliability of these data is, however, uncertain since so much of the data have been interpolated and estimated.

A prognosis for the transport volume development in the transport of goods (bio tonnekm), for domestic and international destined goods has also been made. These data have been compiled by SIKA using input from the national transport administrations. In Figure 27, the development of the transport volume (tonnekm) for different transport modes and means is shown.

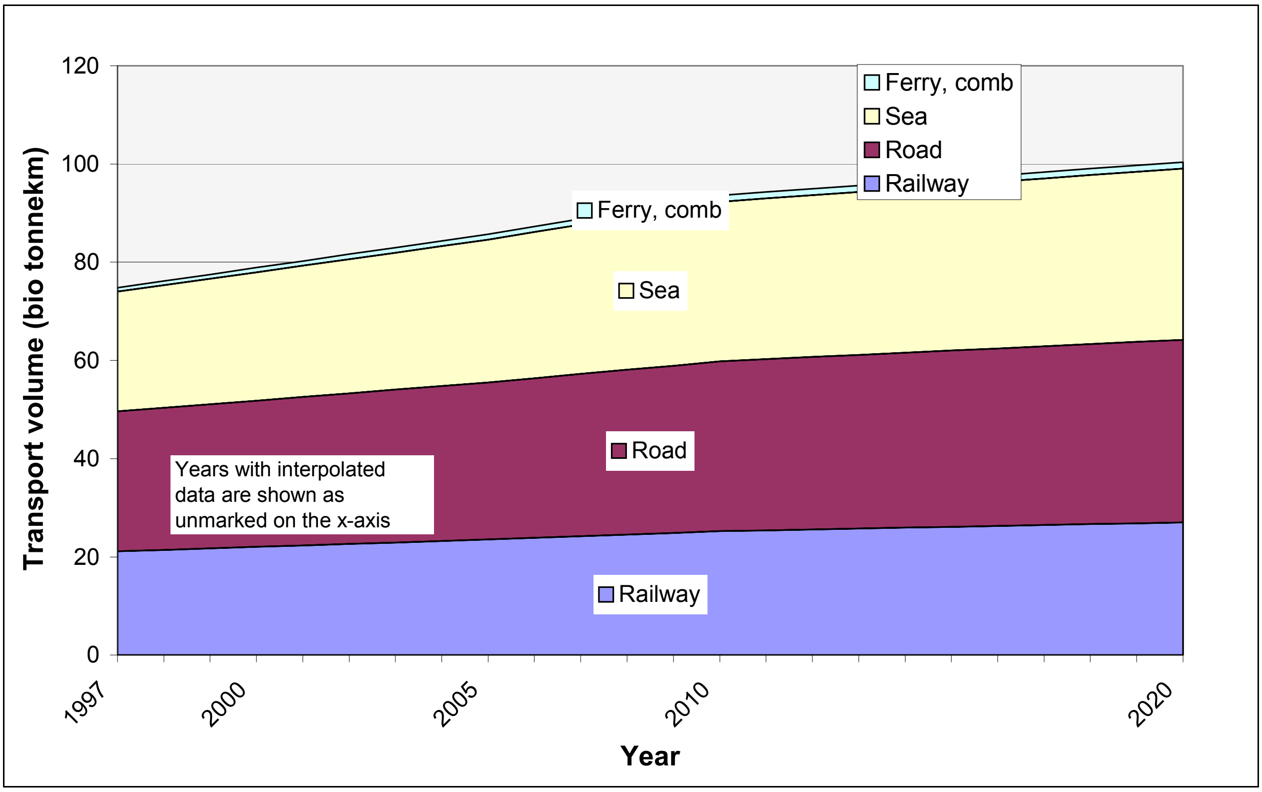


Figure 27 Forecast of the transport volume development in the transport of goods (bio tonnekm), 1997-2020, domestic and international destined goods (national averages)

The prognosis describing the total transport of goods for 2010 and 2020 have been calculated by using a method that considers the future development of different regions and industries. In 1997 and 2010, the prognosis has been carried out by using the so-called STAN-system (a commercial program for network analysis).

These prognosis have also included the following assumptions:

- The Sound Bridge (from Sweden to Denmark) is included in the transport networks for 1997, 2010 and 2020.
- No increase in the fuel-efficiency is assumed.
- Constant fuel prices
- Fees for rail tracks in Germany are adjusted to present level.

As we can see in Figure 27, the total transport volume (tonnekm) is expected to grow in Sweden by about 30%. Combined ferry transport and sea are the fastest growing (in relative terms) transport modes and means with an increase by about 63% and 43% respectively. Rail transport is increasing by about 28% and road transport is increasing by 23% in relative terms.

Figure 28 shows the development in transport volume (tonnekm) for different transport modes and means as a percentage of the total transport.

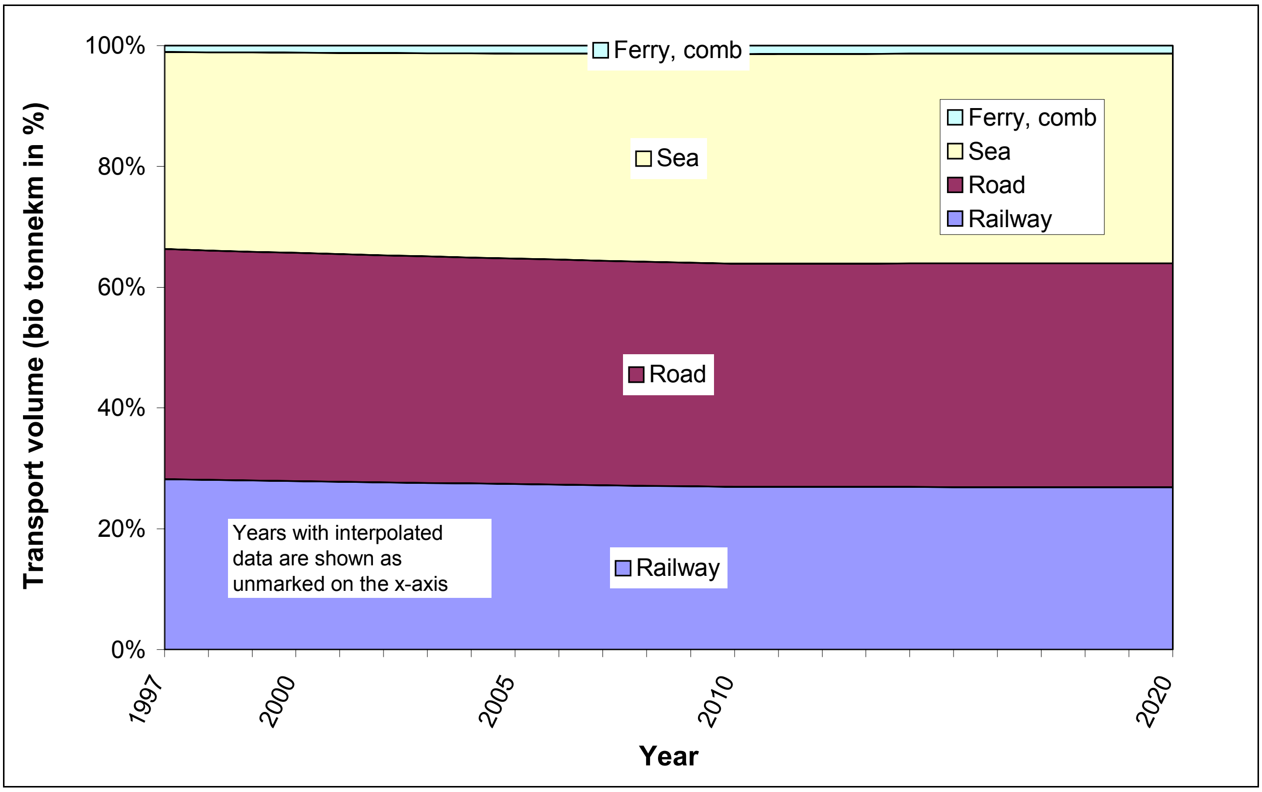


Figure 28 Forecast of the transport volume (tonnekm) development in the transport of goods, modal distribution (%), 1997-2020, domestic and international destined goods (national averages)

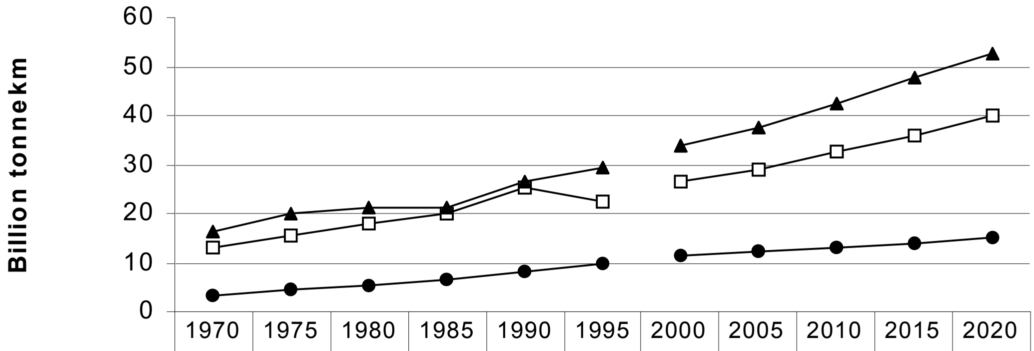
The road and railway transports share of the total transport volume (tonnekm) is expected to decrease marginally from 38% to 37% and 28 to 27 respectively. Sea transport will increase from 33% to 35%, while the ferry and combined transport share will remain more or less on the same level for the whole period. These trends are in contrast to many international studies that foresee continuously increasing share for road transport.

The international road transport volume (tonnekm) might be underestimated. Studies of international road transport volume (tonnekm) can be difficult and are seldom carried out in Sweden today (only with spot tests) according to Thörn at SIKA (personal communication).

4. Comparison of volume and energy use in goods transport in the 3 Nordic countries

4.1. Transport volume

A comparison of the energy use in major forms of transport for the 3 Nordic countries has been carried out by using the data presented in the three previous chapters. First, the transport volume (billion tonnekm) for each of the three main modes of transport (road, water and rail) is compared. The historical data and the prognoses are combined to obtain a time span of 1970 to 2020. Only data for every 5-year within this time span are included. The data on road transport volume is shown in Figure 29.



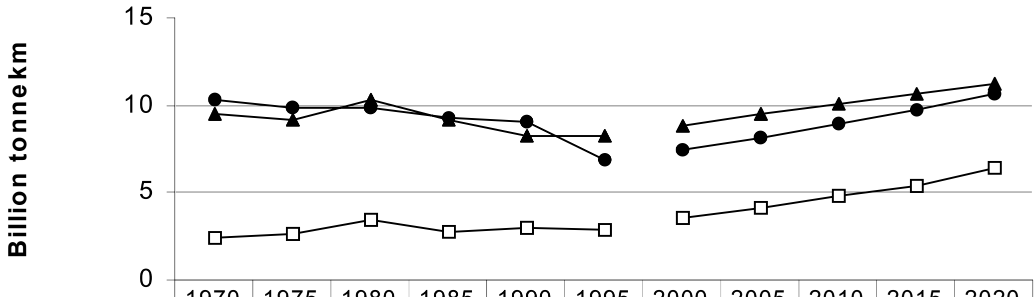
	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Nor	3,2	4,6	5,3	6,4	8,2	9,7	11,3	12,1	12,9	13,9	14,9
Fin	13,2	15,4	17,9	20,1	25,4	22,3	26,4	29,1	32,7	36,0	40,0
Swe	16,2	20,2	21,4	21,2	26,5	29,3	34,0	37,7	42,6	47,6	52,5

Figure 29 Transport volumes of goods on road in three Nordic countries for 1970-2020 (billion tonnekm)

As can be seen from Figure 29, there has been a continuous[24] growth in transport of goods on road in all the three Nordic countries between 1975 and to 1995. The road-based goods transport volume in Sweden and Finland has been approx. 2-3 times larger than in Norway the whole period since 1970. The prognoses for all three countries are for a continued growth at about the same pace for Norway, and a slightly more rapid pace for Sweden and Finland.

[24] The gap in the lines between 1995 and 2000 in this and the following graphs in this chapter is due to the fact that the historical data is for the years up to 1995. The prognosis data starts at year 2000.

The data on volumes of goods transported on sea is shown in Figure 30.

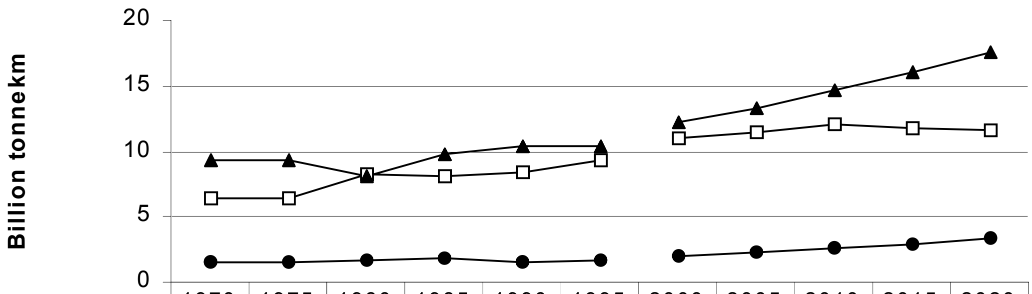


	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Nor	10,3	9,8	9,8	9,3	9,1	6,9	7,4	8,1	8,9	9,7	10,6
Fin	2,4	2,6	3,4	2,7	3,0	2,9	3,5	4,1	4,8	5,4	6,4
Swe	9,5	9,1	10,3	9,2	8,3	8,3	8,8	9,5	10,1	10,6	11,2

Figure 30 Volumes of goods in sea transport in three Nordic countries for 1970-2020 (billion tonnekm)

As can be seen from Figure 30, the share of transport on water has decreased in Norway and Sweden. Finland has not experienced the same decrease. The prognosis for Norway, however, shows a strong increase to reach the same level before 2020, as was the case in the 1970s. The prognosis for Finland is also for a strong increase in this transport mode. The amount of waterbased transport of goods in Finland in 1995 is between half and one third of the size of the corresponding transport volume in Norway and Sweden respectively.

The data for transport volumes on rail is presented in Figure 31.



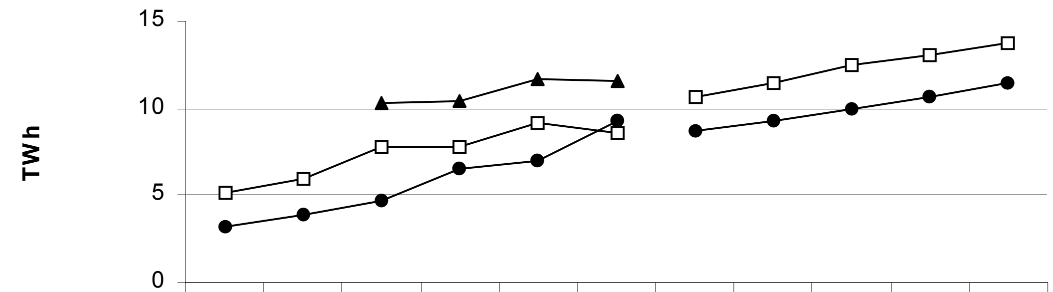
	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Nor	1,5	1,5	1,7	1,8	1,6	1,7	2,0	2,3	2,6	2,9	3,3
Fin	6,4	6,4	8,3	8,1	8,4	9,3	11,0	11,5	12,1	11,7	11,6
Swe	9,3	9,3	8,2	9,7	10,4	10,4	12,2	13,3	14,7	16,1	17,6

Figure 31 Volumes of goods in railtransport in three Nordic countries for 1970-2020 (billion tonnekm)

As can bee seen from Figure 31, the transport volumes of goods by rail in Sweden and Finland are each 3-5 times larger then in Norway. There has been a slight overall increase in the transport volumes in Sweden and Finland, while this is not the case for Norway, where the volume of rail transport has been stable. The prognosis in Norway and Sweden is however for a continuous increase up to year 2020. The prognosis in Finland is for a slight increase to year 2010 and then a slight decrease to year 2020.

4.2. Energy use

Energy use data in major forms of transport of goods in the three countries are shown in the next three figures. In Figure 32, we show the energy use in road transport of goods.

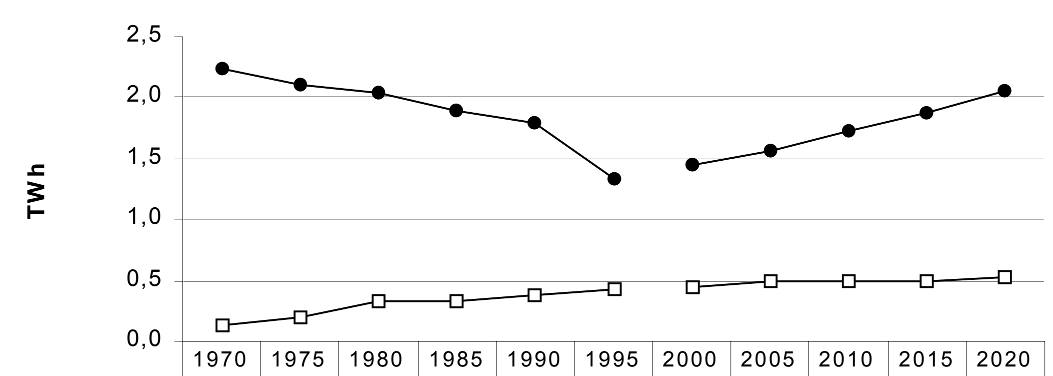


	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Nor	3,2	3,9	4,7	6,6	7,0	9,3	8,7	9,3	10,0	10,7	11,5
Fin	5,1	6,0	7,7	7,7	9,1	8,6	10,7	11,5	12,5	13,1	13,7
Swe			10,3	10,4	11,7	11,6					

Figure 32 Energy use for transport of goods on road in three Nordic countries for 1970-2020 (TWh)

As can be seen from Figure 32, the energy use for road transport of goods overall has increased steadily in Norway and Finland between 1970 and into the 1990s. Corresponding Swedish data between 1980 and 1995 also indicate a growth, although not as rapid as in Norway. The prognosis for Norway and Finland shows a continuing growth rate at about the same level as the growth up to the 1990s. Corresponding Swedish prognosis data is not available.

In Figure 33, we show the energy use of goods transported on water.

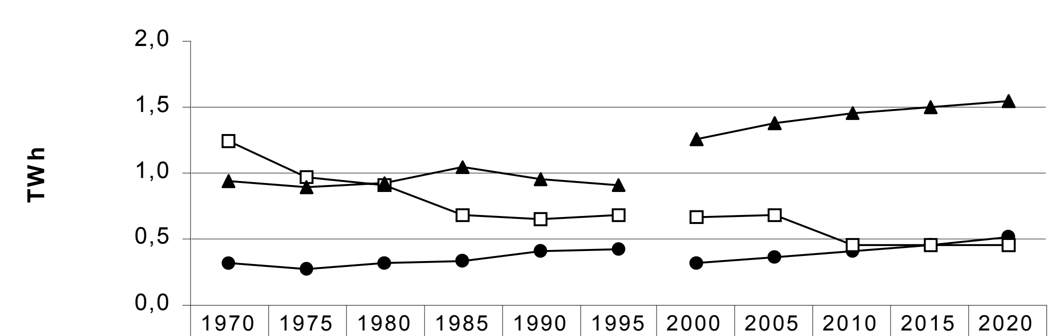


	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Nor	2,2	2,1	2,0	1,9	1,8	1,3	1,4	1,6	1,7	1,9	2,1
Fin	0,1	0,2	0,3	0,3	0,4	0,4	0,5	0,5	0,5	0,5	0,5

Figure 33 Energy use in water-transport of goods in two Nordic countries for 1970-2020 (TWh)

As can be seen in Figure 33, the energy use in water transport of goods has been declining in Norway the last decades. The prognosis for Norway towards year 2020 is however for an increase to reach the same level in 2020 as was the case in 1980. Data from Finland indicate a very different situation with a steady increase since 1970. The prognosis for Finland calls for just a very slight increase. Corresponding Swedish data is not available.

In Figure 34, we present the energy use for rail-transport of goods.



	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Nor	0,3	0,3	0,3	0,3	0,4	0,4	0,3	0,4	0,4	0,5	0,5
Fin	1,2	1,0	0,9	0,7	0,6	0,7	0,7	0,7	0,5	0,5	0,5
Swe	0,9	0,9	0,9	1,0	1,0	0,9	1,3	1,4	1,5	1,5	1,5

Figure 34 Energy use for rail-transport of goods in three Nordic countries for 1970-2020 (TWh)

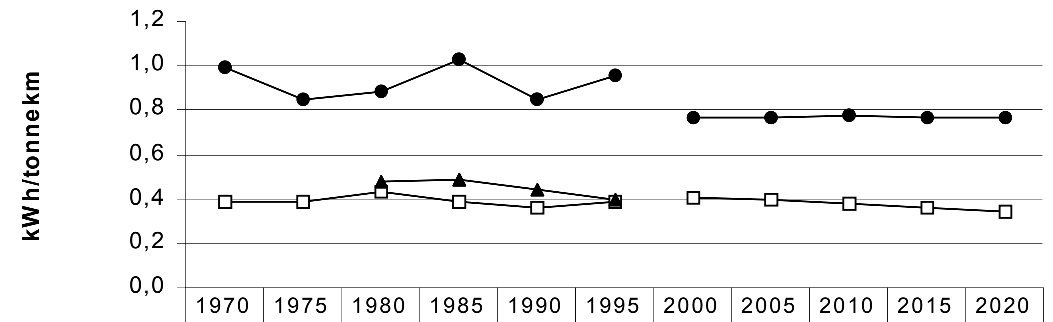
As seen in Figure 34, the energy use in rail transport of goods in Norway has increased slightly between 1970 and 1995. The prognosis is however for a continued increase up to year 2020 except that the prognosis data start with lower energy use than the data for 1990 and

1995. The Finnish situation is quite different with a strong decrease in energy use in rail goods transport the last decades and prognosis for a further decrease. The energy use in rail-transport of goods in Sweden show a stable or slightly increase between 1970 and 1985 and then a decrease between 1985 and 1995. The prognosis is for a strong growth in Sweden up to year 2020.

4.3. Energy efficiency

The energy efficiency (kWh/tonnekm) of the three main modes of transport in the three countries is calculated by dividing the energy use data (TWh) by the transport work data (billion tonnekm). In some cases, also weighted values based on the statistics are used, e.g. in definition of road transport energy efficiencies in Finland. For each of the three main mode of transport, average energy efficiency is then obtained. The results can be seen in Figure 35, Figure 36 and Figure 37. In these presentations, high energy efficiency gives low numbers for energy use (kWh) per tonnekm. We also present the energy efficiencies for the various forms of goods transport in each main mode. These are shown in Table 40, Table 42 and Table 42.

In Figure 35, we present the average energy efficiency of road transport of goods.



	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Nor	1,0	0,9	0,9	1,0	0,9	1,0	0,8	0,8	0,8	0,8	0,8
Fin	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,3
Swe			0,5	0,5	0,4	0,4					

Figure 35 Energy efficiency in road transport of goods in three Nordic countries for 1970-2020 (kWh/tonnekm)

As shown in Figure 35, the road transport of goods is more energy efficient in Finland and Sweden compared to Norway. This difference is so large that there are reasons making some reservations regarding the comparability of these data. Parts of this difference can however be explained by the more rugged topography in Norway, and the fact that a larger percent of the goods transported in Sweden and Finland is performed by large lorries compared to the situation in Norway. A proportionally larger number of small lorries with low load factor (of the type shown in Table 40) are used in Norway. Part of this difference is also illustrated in Table 40 by the separation of the large lorries in Sweden into several classes with high load factors.

Table 40 Energy efficiencies of the various forms of road goods transport in the three Nordic countries

Transport mean and load capacity	**Norway**		**Finland**		**Sweden**[25]	
	Energy efficiency[26] (kWh/tonne-km)	Load factor (%)	Energy efficiency (kWh/tonne-km)	Load factor (%)	Energy efficiency (kWh/tonne-km)	Load factor[27] (%)
Vans:						
1-1,5 tonnes	5,64	15,4				
Lorries:						
1,0-3,4 tonnes	3,95	29,3	4,28[28]			
3,5-4,9 tonnes	1,58	37,8				
5,0-7,9 tonnes	1,19	33,4				
8,0-10,9 tonnes	0,88	37,5	*3,5-10 t:* 3,17[29]			
11,0-12,9 tonnes	0,42	40,5	*10-14 t*: 1,05[30]			
>13,0 tonnes	0,44	45,2	*>14 t:* 0,38			
Average >3,5 tonnes			0,39[31]	0,72[32]		
14[33]					0,63	50
14[34]					0,45	70
24[35]					0,49	50
40[36]					0,19	70
60[37]					0,17	70
Average all lorries[38]	0,73	41,3				

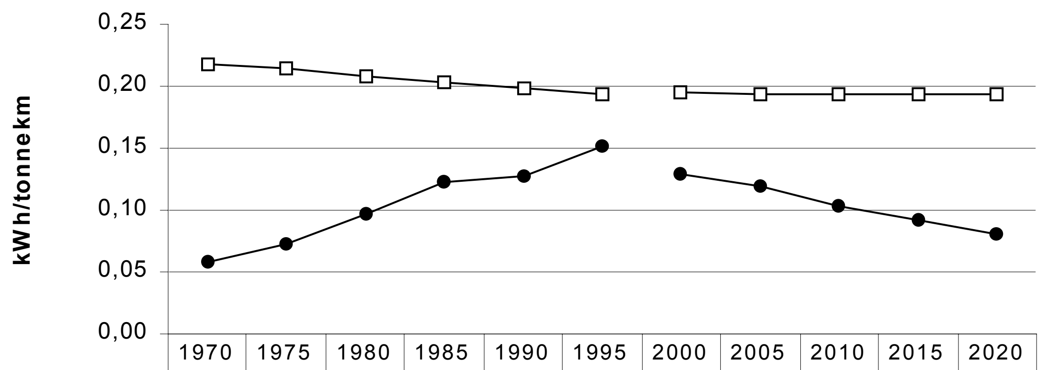
In Table 40 the data shown for each vehicle category corresponds to different categories of vehicle age. The age categories correspond to the introduction of emission regulations namely: before 1990, 1990 – 1992 (Euro 0), 1993 – 1995 (Euro I), 1996 and later (Euro II). One should be aware of the fact that some vehicle manufacturers offered vehicles that

[25] The data on load factors and energy efficiency are based on case studies (not on national averages) mainly collected from: http://www.ntm.a.se/ "NTM - Nätverket för Transporter och Miljön", and from Swedish State Railways, (1998).
[26] The energy efficiency for road-transport in Norway is based on average national data for the years 1993-1995.
[27] Weight-%.
[28] Includes Finnish vans and lorries < 3,5 t. The statistics does not divide vans under 3,5 t into weight classes.
[29] Weighted value, calculated from 1997 statistics. Classification of lorries into different weight classes differs from the one in the Table.
[30] Weighted value, calculated from 1997 statistics. Classification of lorries into different weight classes differs from the one in the Table.
[31] Weighted value. 1997 statistics.
[32] Load factor (in volume utilisation) measured from total transport volumes (all trips).
[33] Light-duty lorry distribution traffic, With engine type before 1990, Euro 1 & 2.
[34] Light-duty lorry distribution traffic, With engine type Euro 0 and CRT.
[35] Middle heavy lorry, regional Traffic, With engine type, Before 1990, Euro 0, 1, 2.
[36] Heavy lorry with trailer, long-distance, With engine type, Before 1990, Euro 0, 1, 2.
[37] Heavy lorry with trailer, long-distance, With engine type, Before 1990, Euro 0, 1, 2 .
[38] Weighted value.

fulfilled the legal requirements for exhaust emissions 2 – 3 years before the regulations were applied. The weight of the load is specified as "freight hauling weight". This implies that goods below a certain density (about 250-300 kg/m^3) are recalculated to the weight that the same volume would have if it weighed 275 kg/m^3.

It is assumed that the large differences between the energy efficiencies of road transport in Norway on the one hand and Sweden and Finland on the other shown in Figure 35 can be explained by a relatively larger portion of transport using a lower load factor (as shown for the lorry categories in Table 40) in Norway.

The energy efficiency of water-transport of goods is shown in Figure 36.



	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Fin	0,06	0,07	0,10	0,12	0,13	0,15	0,13	0,12	0,10	0,09	0,08
Nor	0,22	0,21	0,21	0,20	0,20	0,19	0,19	0,19	0,19	0,19	0,19

Figure 36 Energy efficiency of water transport of goods in two Nordic countries for 1970-2020 (kWh/tonnekm)

As seen in Figure 36, the water-transport of goods in Finland experienced a strong loss in energy efficiency between 1970 and the 1990s. In Norway, the energy efficiency has slowly improved over the same period. The data indicate that the energy efficiency in Norway however is not as good as in Finland. These differences are large, and we have to be careful drawing conclusions from these numbers due to the lack of confidence in the comparability of the data. The differences in energy efficiency is however likely to be due to structural differences in the coast-transport with the use of transport means with different energy efficiencies (as shown in Table 41) and inland water-transport in the two countries. Swedish comparative data are not available.

Table 41 Energy efficiencies of the various forms of water goods transport in the three Nordic countries

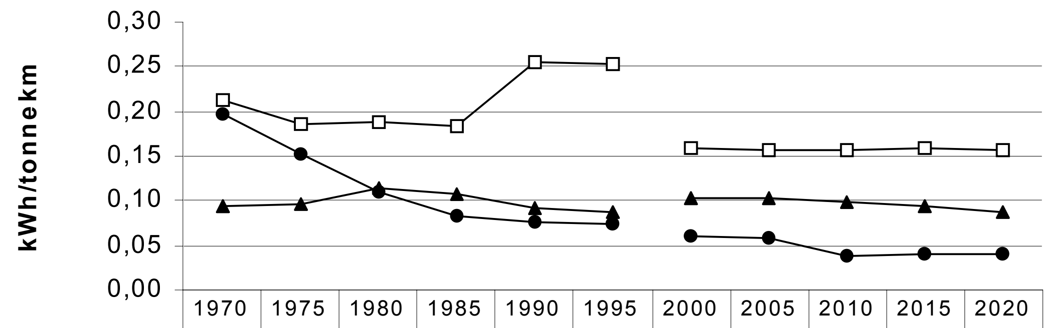
Transport mean and gross tonnage (GWT)	**Norway**		**Finland**[39]		**Sweden**	
	Energy efficiency[40] (kWh/tonne-km)	Load factor (%)	Energy efficiency (kWh/tonne-km)	Load factor (%)	Energy efficiency (kWh/tonne-km)	Load factor (%)
Ferries:						
Long dist. Services[41]	1,87				0,11	60%
Local services	3,03					
Average all ferries	7,10					
Freight vessels:						
100-500 GWT	0,42					
500-3.000 GWT	0,34				0,11	60%
<3.000 GWT					0,11	60%
>3.000 GWT	0,05					
3.000-12.000 GWT					0,08	60%
>12.000 GWT					0,06	60%
Average all vessels	0,19		0,151			
Ro-Ro vessel:						
3.000-45.000 GWT					0,09	80%
Average all vessels						

[39] The average for goods transport energy use within Finnish borders. Includes both domestic and foreign vessels. Total tonnekm in 1997 divided by MEERI 97 figure for waterborne goods transport in Finland.

[40] The energy efficiency for road-transport in Norway is based on average national data for the years 1993-1995. The data for sea-transport is based on average national data (except for long distance ferry services) for 1993-1994.

[41] The ferry category " Long dist. Services" is the express service Bergen-Kirkenes ("hurtigruta") in Norway and also the corresponds to the Finland-Sweden ferries.

The energy efficiency of rail-based transport of goods is presented in Figure 37.



	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
Fin	0,20	0,15	0,11	0,08	0,08	0,07	0,06	0,06	0,04	0,04	0,04
Nor	0,21	0,19	0,19	0,18	0,26	0,25	0,16	0,16	0,16	0,16	0,16
Swe	0,09	0,10	0,11	0,11	0,09	0,09	0,10	0,10	0,10	0,09	0,09

Figure 37 Energy-efficiency of rail-based transport of goods in two Nordic countries for 1970-2020 (kWh/tonnekm)

As seen in Figure 37, rail-based transport of goods in Norway did slowly become more energy-efficient between 1970 and 1985. Between 1985 and 1990 the data indicate an increase in the energy use per tonnekm. The variations can however be a result of unreliable data sources for this period. The prognoses call for better and stable energy efficiency from 2000. The data for Finland indicate a steady decrease in energy use per tonnekm between 1970 and 1985. From 1985 the improvement in energy efficiency has only been marginal. The prognosis for Finland is for a further improvement in the energy efficiency. Swedish data indicate a worsening of energy efficiency between 1970 and 1980, and then a continuous improvement up to year 1995. The prognoses indicate a slight increase in energy efficiency towards year 2020.

The data indicate that the energy-use per ton-kilometres in rail transport in Norway is higher than in Finland and Sweden. But, again we have to make some reservations regarding the comparability of these data. The difference in the energy efficiency of rail transport is evident from Table 42 where the various forms of rail goods transport are presented. The differences can be explained by the fact that long and energy efficient trains carrying bulk goods are more frequently used in Sweden and Finland than in Norway. This can explain a significant part of the difference. And again, there is a topographical factor that will play a role.

Table 42 Energy efficiencies of the various forms of rail[42] goods transport in the three Nordic countries

Transport form and load capacity	**Norway[43]**		**Finland[44]**		**Sweden**	
	Energy efficiency (kWh/tonne-km)	Load factor (%)	Energy efficiency (kWh/tonne-km)	Load factor (%)	Energy efficiency (kWh/tonne-km)	Load factor[45] (%)
Diesel	0,27		0,11		0,064[46]	55[47]
Electricity	0,14		0,034		0,042[48]	66
Average all trains	0,17	75[49]	0,074[50]	56[51]	0,043	65

The load factor for the trains is calculated as the percentage of loaded wagons of all the wagons transported (for all three countries).

As seen in Table 42 the energy use per tonnekm of goods transport by train is 2-4 times higher in Norway than in Sweden and Finland. This is the case both for diesel and electric trains.

[42] Since railway statistics (in tonnekm) sometimes includes the weight of the trains, it should be noted that the figures exclude the weight of the train (net tonnekm). This is an advantage when a comparison with other transport modes is carried out.
[43] The data for rail-transport is for 1997.
[44] The load factor figure for Finnish rail transport are from Finnish State Railways (1997).
[45] Weight-%.
[46] This figure is a bit low compared with the electricity figure and in investigations the level has been up to five times higher. The correct value is probably somewhere in between.
[47] The load factor is not collected from the same source as the energy efficiency but is an estimation.
[48] Net tonnekm.
[49] Percentage of loaded wagons of all wagons transported.
[50] Finnish averages for rail transport in 1996.

5. Energy saving in transport of goods – a literature review

A literature study of energy saving in transport of goods has been carried out in the project. Western Norway Research Institute has had the responsibility for carrying out this task, but it is also based on ideas from the two other partners, VTT and Ecotraffic.

This task of the project is based on existing data on energy savings in transport of goods. Both national and international data sources and literature are utilised.

The main objectives of this task are to identify the potential *actions* and *measures* that can be applied to achieve energy saving in the transport of goods. The potential *gains* to be expected from these actions and measures are also discussed.

5.1. Strategies for energy saving in transport of goods

In this project, the three main strategies for achieving energy saving are: 1) reduced fuel consumption in today's goods transport, 2) increased load factor in today's goods transport and 3) transfer of goods to more energy efficient rail- and ship transport.

5.1.1. Reduced fuel consumption in today's goods transport

The focus in our project is on reduced fuel consumption in *road transport* of goods. The reason for this is that the potential gains from increased energy efficiency in this transport mode are likely to be larger than the corresponding gains for rail and waterway transport. However, the introduction of the new high-speed ships for goods transport might represent a worsening of the energy efficiency of the sea transport mode. We have included a discussion of this issue at the end of this section.

Road Vehicles

Tests performed in the US of the most energy-efficient new lorries under optimal driving conditions for high efficiency have achieved fuel economies 50 to 70% above the current fleet average efficiency (USC/OTA, 1994). Although real-world operating conditions, including average rather than optimal driving skills, would yield reductions in these efficiency advantages, the test results suggest that there is a considerable energy saving potential from using or upgrading to commercially available and new technologies.

Driver skills

There is a large potential in energy saving from improving the driver skills and the information and instructions the drivers receive. It is estimated that the driver can affect the fuel consumption by 25%[52]. Several factors influence the fuel consumption of trucks. These factors include (Scania, undated):

[52] Information provided by Norsk Scania AS, Oslo

- Driving style
- Planning the route
- Average vehicle speed
- Rolling resistance
- Air resistance from exterior equipment
- Electricity usage
- Cleanliness of the vehicle

The *driving style* can be divided into a transport *component* and a *technical component.*

The transport component of the driving style includes such actions as releasing the gas pedal before a hilltop, to let the kinetic energy “push” the vehicle over the top. Another action is to utilise the downhill momentum of the vehicle to let the lorry roll a way up the next uphill. The transport component of the driving style also includes the fuel efficient driving in relation to transport lights, such as rolling slowly towards the light to let the vehicle remain in movement when the light turns to green.

The technical component of the driving style contains such elements as being aware of the rpm of the engine. Driving the engine in the most fuel-efficient rpm-range, which is the “green” area on the rpm counter, is also important. A shift has occurred in the most fuel-efficient rpm-range in that newer vehicles have a “green” area for lower rpm than on older vehicles. Observing the rpm before and during up-hills can be important for the fuel consumption. Sufficient speed before the hill gives the engine the possibility to move the vehicle up the beginning of the hill without depressing the gas pedal further. With the reductions in rpm on a hill, the use of whole gearshifts is recommended. The intermediate or “split” gears should be used only for fine adjustments in the speed. A “split” constitutes a change in rpm of approx. 300 rpm, and frequent use of these shifts will increase fuel consumption.

The increased rpm from downshifting gears can be utilised to maintain the speed up the hill. Releasing the pressure on the gas pedal rather than increasing the speed of the vehicle could contribute to this.

Planning the route should take into consideration topography to avoid hills and excess turns whenever possible. This can have strong influence on the fuel consumption. transport jams are usually concentrated to certain time periods of the day, and driving during these hours will imply much “stop and go”, and unnecessary idling which gives increased fuel consumption. An example from Scania (ibid.) of how the fuel consumption increases with number of stops is presented in Table 43.

Table 43 Fuel consumption and average speed on a 100 km trip with two different numbers of stops and 80 km/h maximum driving speed

Number of stops	Average speed (km/h)	Fuel consumption (litre)
0	74	42
10	68	49

As shown in Table 43 the fuel saving from reducing the number of stops from 10 to zero on a distance of 100 km is 7 litres of diesel.

The energy saving from reducing the *average vehicle speed* is shown in the example in Table 44.

Table 44 Average fuel consumption on a trip between Oslo and Trondheim at three different maximum and average speeds

Maximum speed (km/h)	Average speed (km/h)	Fuel consumption (litre/100 km)
70	67	Reference (R)
80	74	R+4
90	79	R+4+6

As seen in Table 44 the fuel saving potential from reducing the maximum speed from 90 km/h to 70 km/h is 10 litre /100 km, with a reduction of average speed on only 12 km/h.

The *rolling resistance* of a lorry can be influenced by the pattern of the tires and the air pressure in them. The fuel saving from increasing the tire air pressure 1 bar (kp/cm^3) up to optimum pressure on all tires on the vehicle is 1-2 litres/100 km (ibid).

Adding exterior equipment that increases the air resistance will increase fuel consumption. Such items include:

- Roof signs
- Roof grids
- Michelin man
- Extra lights

Vertical roof sign increases the air resistance substantially, while correctly mounted roof spoilers can reduce the air resistance and thereby the fuel consumption correspondingly.

Energy saving in the form of reduced fuel consumption is possible by lowering the *electricity usage* on the vehicles. On a certain test truck,[53] the dynamo requires energy from 980 litres of diesel per year to produce electricity for the lights. Avoiding using unnecessary light equipment is therefore an action the driver can take to save energy. The brake system can also have an effect on the fuel consumption. For example, the "Telma" electromagnetic brake is more electricity requiring than the integrated "retarder" on Scania vehicles (ibid.), and will thereby require more fuel.

The *cleanliness of the vehicle* can have an effect on the fuel consumption. Snow, ice, mud and dirt can build up on the frame and increase the weight of the vehicle with several hundreds of kilos if cleaning is neglected (ibid.).

[53] The data is from a Scania R 113 HL 6x2 380 46A with the following specifications: Driver hut: CR 19 Topline/Streamline, Motor: DSC 1122 m/EDC (380 Hk), Gearbox: GRS 900 R, Differential: R780, Transmission ratio 3,4:1 (106 km/h at 1.900 rpm), Annual dist. driven: 150 000 km, Weight of vehicle: 40 tonne, Diesel consumption: 40 litre/100 km

Improved logistics

Logistics decisions may help to prevent the increased fuel consumption in different ways:

- Design, planning and management of outbound logistics network
- Inventory decisions
- Transport mode and carrier selection
- Changes in material handling operation and warehousing

These different ways to prevent an increase in fuel consumption are described in more detail below.

Design, planning and management of outbound logistics network

A single transport company selects its logistics network option(s) depending on its goals and resources. The options include e.g. direct shipping or hub-and-spoke, central warehouse or distributed network, intermodal or single mode transport, and third-party services or private fleet. Energy-saving practice favours fewer shipments, less handling, shorter movements, more direct routes and better goods and warehouse space utilisation (Wu - Dunn, 1994). The network level is a strategic issue and requires top-level decisions making. The personnel most knowledgeable of energy-saving issues in logistics are likely to be in position of middle and upper management (Murphy - Poist - Braunschweig, 1995).

Inventory decisions

Inventory decisions in outbound logistics include stock levels and stock points, centralised vs. decentralised distribution centres, different service policies for different customers and items, back order management and replenishment policies. Basically, environmentally responsible logistics would use slower but more environmentally responsible carriers and use advanced information systems, such as bar-coding (see also Table A-2 in the Appendix) to manage logistics better (Wu - Dunn, 1994).

Transport mode and carrier selection

Transport mode selection has profound impact on the energy use. Rail and waterway transport use less energy or use energy more efficiently than other modes like road haulage and air cargo. A typical transport mode decision determines what transport option to use and affects transport congestion and energy use both directly and indirectly (Rao - Grenoble - Young, 1991).

Slater (1990) classifies the factors affecting the choice of transport modes into four groups:

- *Customer characteristics*: geographical location, delivery points, time restrictions, size of order, product knowledge, mechanical handling equipment used, service level requirement, type of sale (e.g. FOB) and aftersales service requirements
- *Product characteristics*: weight, size and shape, fragile nature, obsolescence and deterioration, danger and value
- *Environmental characteristics*: other road users (effects), infrastructure, technology (vehicle and equipment), climate, legal consideration and road patterns

- *Company characteristics*: service level policy, sales territories, warehouse locations, manufacturing locations, financial policies and performance of competition.

This project concentrates merely on product and environmental characteristics. Product characteristics are discussed in connection with case companies. Vehicle technologies include discussion on alternative fuels and potential to increase energy efficiency through better planning.

Along with increased consumer demand for more environmental friendly products and processes, some industries are paying more attention to purchasing transports in companies that take environmentally responsible practices in transport (Wu - Dunn, 1994). Some 30% of the respondents in the research by Murphy, Poist and Braunschweig thought that outside third parties should be involved in strategies to manage environmental issues in logistics.

Changes in material handling operation and warehousing

Material handling refers to possibilities to use bulk transport instead of individual packaging. The method uses fewer resources and less energy per transported tonne. The possibilities to shift into bulk transport are, however, limited and strongly connected with product characteristics (e.g. dangerous goods).

Warehouses generate much of the packaging waste in the supply and distribution chains. Standardised reusable containers help to reduce operational costs and packaging wastes. Good warehouse layout also cut storage and retrieval movements and thus save energy used by terminal machines. They also save on operational costs.

Finnish examples of a routing simulation programme and vehicle workstation are Genimap and Aplicom. Genimap routing programme includes Finnish road network and helps in route planning and optimisation to minimise costs and decrease environmental effects. Aplicom vehicle workstation is Aplicom that was developed to help transport service providers in using their vehicle fleet efficiently e.g. in selecting the most appropriate transport mean for different types of goods. Increasing the efficient use of vehicle fleet at one part delimits the growth of road transport and environmental effects (Karttakeskus Ltd, 1998; Aplicom, 1998).

The special case of high-speed goods ships

The use of high-speed ships for transport of goods is very problematic from the point of energy saving. MARINTEK in Trondheim has estimated the increase in energy use for these ships compared with the alternative modes of transport on three different routes. The routes were transport of fish from Ålesund and Oslo to Paris, Antwerp and Frankfurt respectively. Today most of this transport is done with lorries combined with ferries from Oslo to either Kiel or Frederikshavn. Using a high-speed ship at a speed of 25 knots from Ålesund/Oslo to Zebrugge combined with road transport (Ålesund – Oslo and Zebrugge - Paris/Antwerp/Frankfurt), the energy use for this transport routes increases in the range of 250% - 650% per weight unit goods (Mørkve, 1993). At a speed of 35 knots the increase is in the range of 550% - 1200%. A switch to high-speed ships for transport of goods is therefore clearly not compatible with energy saving.

5.1.2. Increased load factors in lorries

The term “load factor” refers to the percentage of goods carrying capacity in use during transport. The factor varies between product types and transport modes. Also customer specific requirements have an impact on the load factor.

Modal split of goods transported in one load and product mix is crucial when the objective is to increase the load factor. Some consignments such as dangerous goods and bulk need to be transported separately. Consolidation is thus possible only for certain types of smaller consignments and products. The increasing unitisation has made it at least in theory possible to consolidate different kinds of products.

Freight consolidation improves vehicle efficiency and is environmentally responsible. Full vehicle loads (FTL) also save money as more units of goods share the same transport overhead. The goods consolidation and break bulk operations are performed by special types of warehouses, so the potential of utilising transport capacity more efficiently increases (Wu & Dunn, 1994). Using hub-and spoke networks, main ports, intermodal transport and other possibilities to increase consolidation by using standard load units could result in large energy savings (OECD, 1992).

Load factor could also be increased by broader use of return transport or backhaul management. The number of trips can be reduced by balancing backhaul movements (Wu – Dunn, 1994). The EU commission also states that the transport activity in economic development can be avoided or minimised by reducing unnecessary transports like empty trucks. Improved transport management and logistics (routing) are seen as tools for this. The problems to achieve efficient backhauling are often that the return goods is not available along the route and the goods space cannot be used for different kinds of goods. The average use of capacity in Finland, for example, varies between 23 and 98 %, depending on the type of transported goods.

Increasing the load factor can facilitate an increase in transport of goods without the corresponding increase in energy use. Increased load factor in lorry transport would necessitate better co-ordination within the goods transport area as a whole, thus impacting both transport purchasers and hauliers. According to the Danish ministry of environment and energy, one way to achieve increased load factor is through the establishing of goods terminals in all large cities and towns (Energistyrelsen, 1995). This would render the co-ordination possible thus ensuring better utilisation of vehicle capacity for both transports between the different terminals and within the individual urban areas.

5.1.3. Transfer of goods from road to rail- and sea transport

According to a Finnish study, one kilometre transport of 40 tonnes would cause the following energy consumption figures (Transpress 2/98):

- 0,69 kWh for an electricity goods train
- 2,27 kWh for a diesel goods train and
- 4,98 kWh for a lorry transport.

Transfer of goods to rail and ship transport would, according to this, thus decrease the energy use. Decreasing the road transport volumes is one the main objectives of EU transport policy.

Congestion and environmental effects of road transport are the main reasons for that. The working paper by European Commission (July 1998) on environmental problems connected with lorry transport suggests the following points, among others, to attack the problem:

- Increase the use of combined transport by relating the transport charges more closely to actual road use as well as greater flexibility on weights. In practise this means reduction of vehicle taxes and road user charges and increasing maximum weight of vehicle combination from 40 to 44 tonnes. The current legislation does not take into account that combined transport loads may be heavier. Also, the combined transport should be exempted from weekend, night and holiday transport restrictions.
- Burdens caused by road vehicles are minimised. Improved technical standards are tools for this.
- Environmentally friendly modes of transport (rail, inland waterways and short sea shipping) are made commercially more attractive. This may be done by making them more competitive (improvements to infrastructure, logistics, door-to-door service and reliability), providing a level of playing field (e.g. improved enforcement of the rules on driving time) and by improving combined and intermodal transport especially by making them more attractive over short distances.

The European Commission states in its COM(97) 243 document "Intermodality and intermodal goods transport in the European Union" that

> "An efficient transport system is a prerequisite for the European Union's competitiveness. With the projected growth of international trade, the possible extension of the Union to the Central Europe and enhanced co-operation with the Mediterranean countries, the role of transport will become more important. " Furthermore, the report states "in order to achieve socio-economic and environmental sustainability, the efficient and balanced use of existing capacities throughout the European transport system becomes a key challenge.
>
> Intermodality is a quality indicator of the level of integration between the different transport modes: more intermodality means more integration and complementarity between modes, which provides scope for more efficient use of the transport system. The integration between modes needs to take place at the levels of infrastructure and other hardware (e.g. loading units, vehicles, communications), operations and services, as well as regulatory conditions."

The development of intermodal transport in the overall context of the Common Transport Policy will take place via four key strategies (EC):

1. A European strategy on infrastructure: trans-European transport networks and nodes
2. The single transport market: harmonisation of regulation and competition rules
3. Identification and elimination of obstacles to intermodality and the associated friction costs and
4. Implementing the Information Society in the transport sector.

The Commission further identifies the following key actions towards intermodality:

1. Integrated infrastructure and transport means
    - Intensify intermodal design of TEN

• Enhance design and functions of intermodal transfer points • Harmonise standards for transport means
2. Interoperable and interconnected operations • Integration of goods freeways in an intermodal context • Development of common charging and pricing principles • Harmonise competition rules and state aid regimes on an intermodal basis
3. More independent services and regulations • Harmonisation and standardisation of procedures and EDI • Intermodal liability • Research and demonstration • Benchmarking • Intermodal statistics

A proposal for a Council Directive (Consolidated text 4 (26/6/98)) states that trains must play a key role if the objective toward sustainable mobility is to be realised. An action should be taken in order to prevent the further decline of rail transport market share. The goods transport market share of train in Europe was 18,8% in 1990 and had decreased to 14,4% in 1995.

The Commission's Railway White Paper set out a strategy for enabling progress to revitalise Community railway which will in turn progress towards its high level goals. The White Paper aimed at building on the existing Community legal framework and proposed further measures to develop the market. Two of the identified measures were the need for further action in the areas of railway infrastructure capacity allocation and railway infrastructure charges.

The Article 10 in the council directive 91/440/EEC provides that international groupings of railway undertakings are permitted access for combined transport services in international transport. The pre-existing situation then changed in two ways. First, the access rights initiated a separation of railway infrastructure management from the operation of trains. Second, they made it possible that multiple users could use an individual railway infrastructure. A legislative framework was required to ascertain the governance of access conditions. In 1995, the Council adopted a the Directives 95/18/EC on licensing of railway undertakings and 95/19/EC on the allocation of railway capacity and the charging of infrastructure fees for services described in the Article 10 of directive 91/440/EEC above.

The energy saving potential of shifting goods from lorry to rail is made uncertain by the nature of most goods energy data; they measure total energy use by mode, but the mix of products carried by different modes is quite different. For example, in 1990, the average energy efficiency for inter-city goods movement by lorry in the US was 0,52 kWh/tonnekm, whereas the average efficiency for inter-city goods movement by train was 0,06 kWh/tonnekm, or a ratio of 8:1 (USC/OTA, 1994). However, an examination of the energy consumption by both lorries and trains for moving identical cargo over the same route, for a few specific cargoes and routes, suggests that lorries use 1,3 to 5,1 times as much energy as do trains to move the same cargo over the same route. This study found that trains generally use 0,02 to 0,05 kWh/tonnekm to move mixed goods over long distances, whereas lorries use about 0,12 to 0,15 kWh/tonnekm for the same service. According to the Campaign for New transport Priorities in Washington DC, trains are three times more energy efficient than lorries (Totten and Settina, 1993). Many other estimates have been made of modal energy efficiency. These include some that try to include not only the propulsion energy (i.e. the energy required to move goods from one point to another), but also the energy associated with vehicle manufacturing, road and rail construction, maintenance, and access (getting goods to and from the terminal). A comprehensive but dated review of these LCA-estimates found that they vary widely (suggesting that such numbers be used carefully), and estimated that including all of these factors, would yield a 1,7:1 truck-to-train energy ratio. These estimates suggest that for long-distance movement of some commodities, the energy savings from shifting goods from lorries to trains could be significant, but much less than would seem to be the case from a simple examination of average energy efficiencies.

An important consideration for the realisation of long-term energy efficiency from transfer of goods is that new goods terminals are located along train lines and close to harbours to the greatest possible extent (Energistyrelsen, 1995).

6. The Norwegian case

6.1. The case company Waagan Transport

The following presentation is based on information from the manager of Waagan Transport (WT), Per Waagan. The company was founded in 1969, and has been a stock holding company since 1976. The head office is in Vegsund (since 1988), 15 km from Ålesund, Møre og Romsdal county. In 1998 WT has budgeted for NOK 140 mill. sales in Norway and NOK 50 mill. in Denmark. The lorries driving for the company have three types of ownership: 1)leased from Volvo, 2)owned by WT and 3)contracted trucks. The use of the two last categories is decreasing.

The company was originally based on transport of furniture. Today, WT also distributes general goods (routes in Møre og Romsdal). For the wholesale dealer BAMA, the company also distributes fruit and vegetables. Since 1985, WT has been transporting fish, of which most shipments have been Norwegian salmon to Europe.

6.1.1. Domestic offices and offices abroad

Branch offices are located in Ørsta (since 1989) and Molde (since 1994), both in Møre og Romsdal county. WT has a fine-meshed distribution system for general cargo between Møre og Romsdal and other parts of Norway, and in particular within Møre og Romsdal county.

The export department of WT has a goods network all over Europe. A subsidiary company in Denmark, earlier EB Transport in Skagen, has a cold storage for sorting and forwarding deliveries of Norwegian salmon (since 1994). Moreover WT has a goods terminal in Padborg, at the border between Denmark and Germany.

6.2. Methodology for the pilot actions in the Norwegian case

In order to implement actions and strategies, and also to be able to evaluate the energy saving effects, a few transport routes were selected in the case company. The routes were chosen based on the following principles:

- the study needs stability over time for measurement of the energy use, implement actions and to evaluate the effects on the same routes. Unstable routes are not suitable.
- the transport routes had to comprise a substantial quantum fish during the year
- it is desirable to cover different fish products and routes with different destination structure

Four routes are selected. The energy use in kwh/tonnekm was measured before actions were implemented. The effects of the pilot actions should be seen by comparing with the situation in the basis year (before actions).

The method used is based on the classic experiment; measuring the effect by manipulating one variable when other variables are constant. The main problem is to keep the other variables constant. In transport companies many factors are changing at the same time.

One problem has been to select stable routes. Two of the first four selected routes are discontinued due to changes in customers, both for the transport company and the export company. The case company explains the increasing unstable situation in the transport sector the latest year by the change from stable contracts between export and transport company to a spot market situation.

In order to obtain comparable data for measurement of reduction in *fuel consumption* in today's lorry based transport, we have made a test arrangement taking into account variable factors. The comparison had to be done with:

- The same lorry and with the same total weight. (Lorries with the same technical standard could differ).
- The same drivers.
- Taking into account the season, weather and other driving conditions (such as transport jams and accidents). The measurements were carried out in autumn 1999 and autumn 2000.
- Lorries had completed their "running-in" period (after 30.000 km).

To measure the effect of transferral of goods from road to rail we have compared the distances where transport mode has changed during the project period. The test design for this effect differs from the test used in assessing of effects from driving style. Here, the energy use in tonnekm by the lorry transport by all drivers is averaged. This is compared with the energy use in tonnekm for the same distance by rail.

6.2.1. Data collection

The energy consumption in today's lorry transport of fish from Western Norway to the continent has been measured. Two types of data were collected from the case company:

1) Energy use on four different transport routes (described in more detail below).
2) Average energy use in various transport routes.

In the project, four routes were selected, in co-operation with the case company . The criteria for selecting the special routes have been described earlier. The routes are (Kleppe, 1999):

A) Fresh and frozen herring from western Norway to Poznan in Poland. The route is lorry transport from Ålesund to Trelleborg (in Sweden), ferry to Rostock, and lorry transport on the last distance by Frankfurt to Poznan.

B) Dried cod from western Norway to Torino in Italy. The route today is lorry transport from Ålesund to Gothenburg, ferry from Gothenburg to Kiel, lorry transport from Kiel to Manching, rail transport (lorry on rail) from Manching to Brenner, and lorry transport on the last distance to Torino.

C) Fresh coalfish filet from western Norway to Bremerhaven. The route is lorry transport from Ålesund to Moss (southeastern Norway), ferry from Moss to Hirtshals (Denmark), and lorry transport from Hirtshals to Bremerhaven.

D) Fresh (and frozen) white fish from western Norway to Boulogne-sur-Mer in France. The route is lorry transport from Ålesund to Oslo, ferry to Kiel, and lorry transport on the last distance.

The energy consumption is measured with a Volvo Road Relay system mounted in the trucks. This is an electronic log which measure parameters such as distance, time, fuel consumption, speed, idle- and economy driving. The drivers had the responsibility for operating the data-system themselves after instructions were given by the company management. In addition to the electronic data from the Road Relay system, the drivers completed a written log for each trip with information regarding:

- Cargo weight
- Driving route
- Weather
- Fuel tanking
- Traffic situation (jams etc.)

The manual log gave important information for interpretation of the data from the Road Relay system. For instance, the fuel consumption could be controlled with the log. In most cases, the differences between the Road Relay system and the manual log was within ± 1-3 percent.

6.3. Energy efficiency

In the two tables below we have summerized the energy use from the measurements. The first table gives data from the four routes, and the other table gives data from general measurements.

Table 45 Energy use in lorry fish transport from Western Norway to the continent. Average data for four routes, data collected 1999-2000

Case/route	Payload trip[54] average tonne	kWh/tonnekm average	km empty, average	km per trip, average	Number of trips
A	18	0,22		3700	3
B	22	0,16		4600	1
C	16	0,22	83	2500	5
D	17	0,20	104	3650	3

The table shows the average energy use on down trip and return trip. The higher energy efficiency in case B could be explained by the higher load factor. Note that the data in case B is only based on one trip.

[54] "Down trip" is used to express the trip from loading place in Western Norway to the destination on the continent. "Return trip" is used for the trip back again. "Trip" is used to express the sum of down trip and return trip.

Our second data-set based on measurement on variable (the differences are not described) routes from Western Norway to the continent shows the same picture of energy efficiency: 0,20-0,22 kWh per tonnekm. The table below shows the data from two measurements with different drivers, one from winter 1999/2000 and one from summer 1999. In the last row these two measures are included in addition to seven other measurements. Payload data is not available for this data set.

Table 46 Average energy use in lorry fish transport from Western Norway to the continent. Non specified routes. Payload: 17 tonnes (assumed)

Km	Number of measurements	Period	kwh/tonnekm	Driver number[55]
59000	1	Winter -99/00	0,22	1
55000	1	Summer –99	0,21	2
190000	9	1999-2000	0,20-0,22	1,2,3,4

In our four cases the load factor is lower on return trip than down trip in most cases. The energy efficiency is therefore better on the down trip than on return trip. The figure below illustrates this.

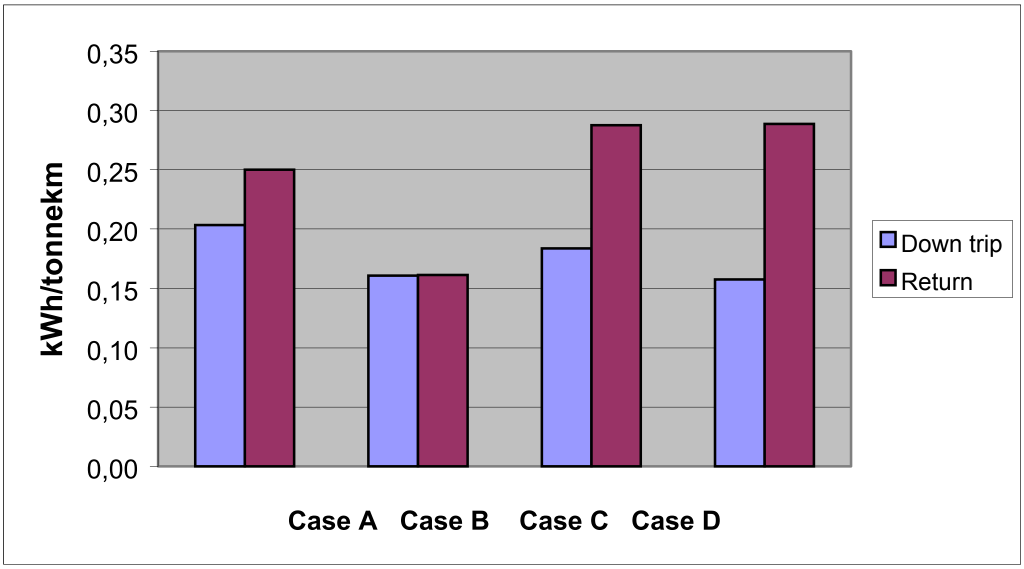


Figure 38 Energy use per tonnekm on down trip and return trip. Four different routes. Data collected 1999-2000

In case B the load factor is 100 percent on return trip. The difference in energy efficiency on down trips between case C and D is hard to explain. The topography is a possible explanation. Driving distance on the continent in Route C is relatively shorter than in route B and D. The higher energy use per tonnekm in route A could partly be explained by the driving style on

[55] A specific number is designated for each driver (to be able to analyse the effect of driver style)

one down trip. In the manual log for this particular route, the driver has entered: “hard driving”.

Energy use by the ferries is a substantial part of the total energy use. In case B and case D the ferries count for near the halves of the total energy use due to the long ferry distances in these cases. The figure below shows this.

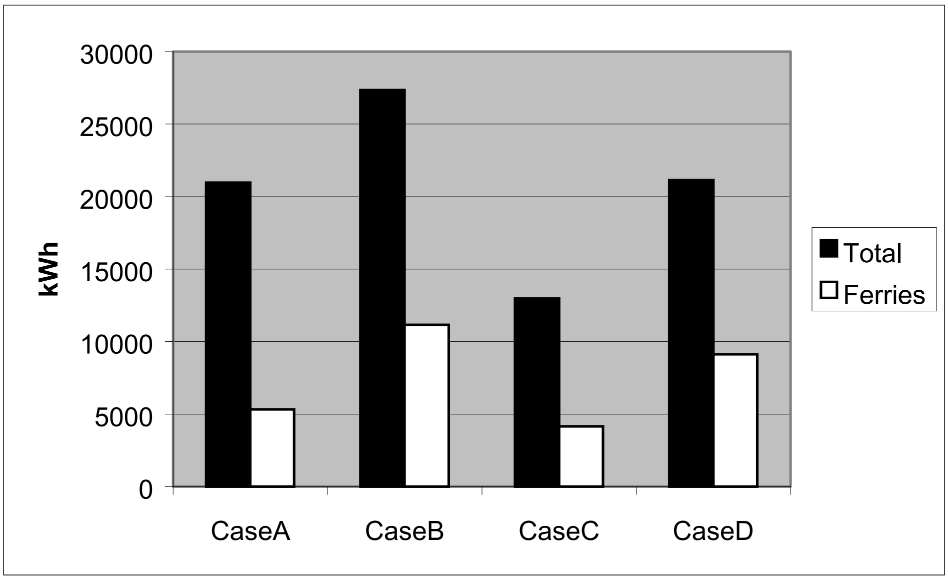
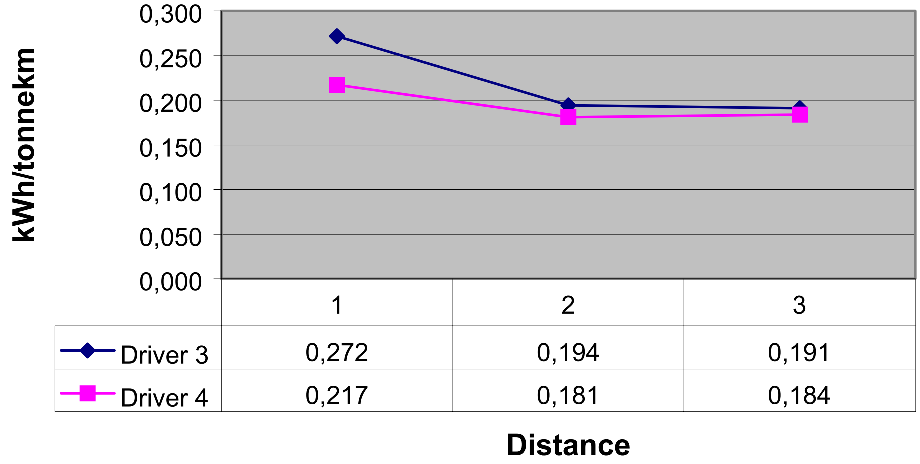


Figure 39 Energy use by the four cases of transport of fish round trips between Norway and the European continent. Total and distances with transport of lorries on ferries

6.4. Effect of driving style, load factor and topography

We have compared different drivers on the same distance with the same load factor trying to assess the effect of different driving style. The most striking effect is shown in figure below. Each distance is marked with a point.



	1	2	3
Driver 3	0,272	0,194	0,191
Driver 4	0,217	0,181	0,184

Figure 40 Effect of driving style on energy efficiency. Same distance and weight, different driver and truck

Driver 3 had 25 percent higher energy use per tonnekm than driver 4 on the first distance, Ålesund-Otta, on the route carrying herring to Poznan. On this distance driver 3 has explained the result with "hard driving". From Otta to Oslo this difference is reduced to 4 percent. According to the log this difference could be explained by rain and transport jam for driver 3, when driver 4 had good weather and not transport problems. The result on the last distance, Trelleborg too Poznan, with nearly the same energy use could support this explanation.

As we have shown before the energy efficiency is usually lower on return trips. This is caused by lower load factor. Also on down trips we find this effect, although the variation in weight is smaller. The figure below shows the energy use per tonnekm for two down-trips by the same driver and truck.

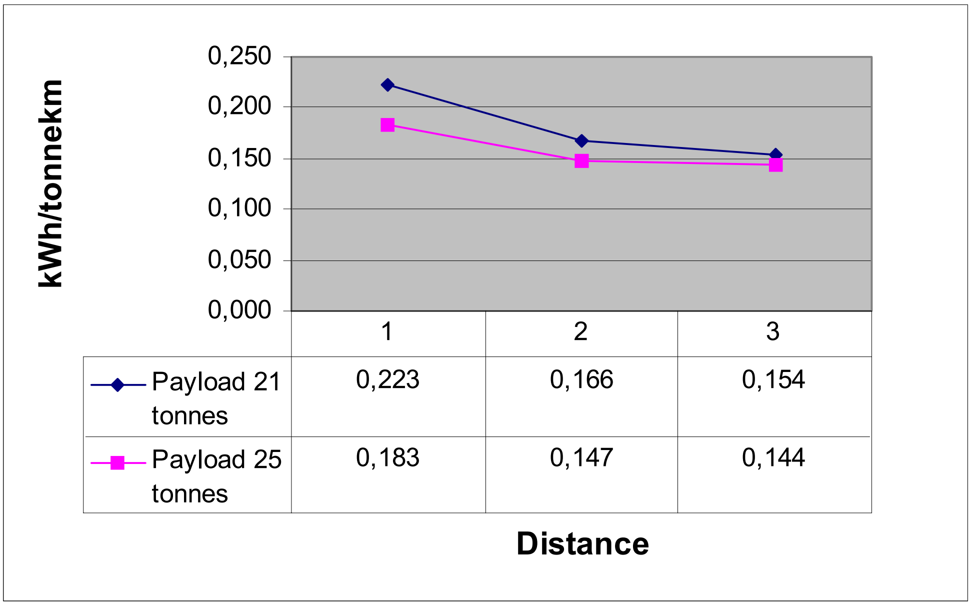


Figure 41 Effect of difference in load factor on energy efficiency. Same driver and lorry on the two down trips

The down trip with payload 25 tonnes had good driving weather while the other (21 tonnes payload) had partly rain on distance one and two. Difference in weight has given bigger effect in Western Norway with hilly topography compared with driving on the continent.

Our data indicates lower energy efficiency on the eastern parts of the continent compared with driving in western parts, but the data-set is to small to make this conclusion. The figure below shows this together with results from down trips to Boulogne-sur-Mer (BSM) and Torino. There the same effect from different driving style, as explained earlier, can be observed.

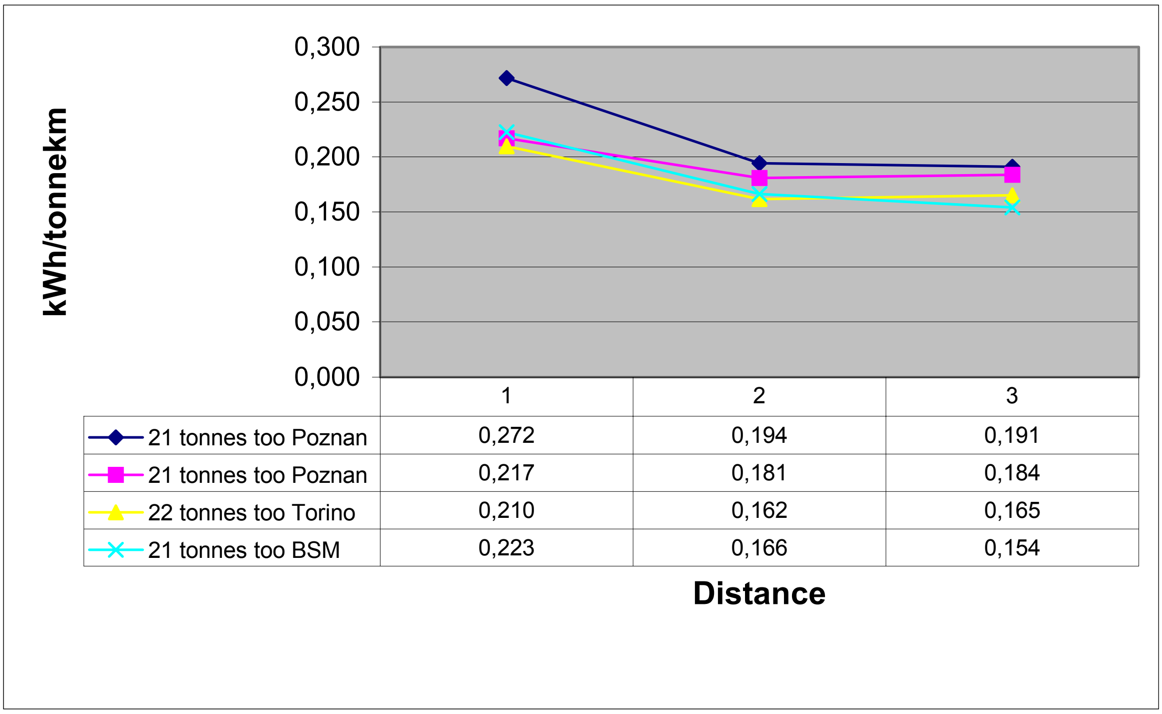


Figure 42 Energy efficiency by different routes and drivers. Distance 1 and 2 is the same. Distance 3 is different routes on the continent

Summing up our findings:

- The figures of energy efficiency in fish transport from western Norway to the continent shows an average energy use for down- and return trip of about 0,22 kWh per tonnekm.
- The return trips give lower energy efficiency. This is caused by low load factor. If the load capacity had been fully utilised on return trips, the energy efficiency could be improved to about 0,18 kWh per tonnekm.
- Also with relatively good payload utilisation there is a potential for energy efficiency improvements by increasing load factor.
- Different driving style could have a large influence on fuel use and thereby energy efficiency. Our cases show that non-economic driving could increase fuel consumption with 25 percent.
- The energy saving potential in today's lorry transport is largest in mountain and hilly areas.

6.5. Description of actions and the necessary conditions for their implementation

The selected actions and the necessary conditions for their implementation is described in this section.

6.5.1. Actions to reduce fuel consumption

The presentation of the actions is structured as: 1) Driver information and motivation and 2) Already implemented actions.

Driver information and motivation

The company have also earlier focused and informed the drivers of the importance of driving style to reduce fuel consumption. In the beginning of the 1990's the company was encouraging the drivers to drive economically, and extensive idle running was banned. Approx. in 1994, at the time the computer information system was installed in the trucks, drivers at Waagan Transport were competing in reducing the fuel consumption. According to manager Per Waagan, there is a difference between older and younger drivers when it comes to awareness of fuel costs: For instance, younger lorry drivers are prone to neglect the importance of avoiding idle running when the car is standing still.

Expansion of the company during the last years has made it more difficult to control driving pattern at the individual level. In connection with renewing the lorry fleet in 1996, Volvo requested a driving course for all drivers in the company. About 80 percent of the drivers completed the energy-economy course (Waagan, P., 1998-2000).

The company was willing to continue this work. The plan was first to establish a driving course for some of the drivers to measure the effects on fuel consumption. Subsequently, a new driving course for all the drivers in the company would be held. The course was to focus on energy efficient driving with these subjects:

- Develop the driving style
- Reduce driving resistance
- Avoid idle driving.
- Route planning
- Choose the most energy efficient maximum and average speed.

The course was to be carried out in a co-operation with VOLVO. VOLVO was willing to take the responsibility for teaching the drivers in the spring of year 2000 (Nordvik, 1999-2000). For different reasons, described later, the course has not been carried through. To compensate this we have made efforts to use experiences from another transport company working with energy saving issues. This succeeds and we present the actions in the company below.

Actions already implemented in the case company

The management at WT emphasises the importance of providing the best engine technology available. The company renews the lorry fleet every second year, and selects the most energy saving engine, trailer type and cooling system. The lorries are being replaced with new ones after having driven 150.000-170.000 km. Other actions already implemented in the company are (Waagan, P., 1998-2000):

- Extra equipment on the lorries to reduce air resistance (e.g. signs on roof).

- Ordinary service including shift of air filter and diesel filter is done regularly by the garage of WT.

- Lorry cleaning (ice, snow and dirt) to avoid increased weight is done as often as possible by the garage employers. The frequency of the cleaning varies somewhat, from cleaning after every trip to cleaning every second week.

Nistad transport company
This presentation is based on information from Arne Nistad, manager of Nistad Transport company. The company is located in western Norway and also carries foodstuff for the industry, but not fish. The company has 19 lorries used for long distance transport and shorter distribution- and supply transport.

In April year 2000 the company started a developing process with the aim to reduce energy consumption in lorry transport with 5 % during one year. The information and motivation work include actions as:

- energy saving course for all drivers
- examinations
- motivation and competence developing processes in groups of drivers

The work is mandatory for all drivers. An important element is to organise the drivers in three groups according to their living area. Fuel reduction aims are set for the group and not individually. This gives a constructive competition between the groups to reduce fuel consumption, and focus on teamwork.

The company have reached their goal regarding energy saving. Measurement during the first year indicate an average fuel reduction of about 5 %. Energy saving effect differs from driver to driver, the largest measured effect is 20 %. Significant reductions have been measured both for long distance transport and for shorter distribution and supply transport.

In addition to lower fuel cost the energy saving work has had positive economical effects, by reducing maintenance on the lorries and reduced wheel wear and tear. Nistad Transport company has plans for further work in these issues in the years to come.

6.5.2. Actions to increase load factor

Actions to increase load factor have been on the agenda in discussions with WT, and it was concluded to investigate the possibilities of co-operation with other transport companies to utilise load capacity on return trips in a better way. However, only limited improvement possibilities in this area has been revealed.

6.5.3. *Actions at the transfer of goods level*

The most current strategy at this level has been a transfer of goods from road to rail. This has been implemented during the project period and has given the project a unique position to measure the energy saving effects by this transferral. Another action has been to streamline the custom routines and the taxes on the ship from Norway to the continent, making this form of transport more attractive to use.

From road to rail

The presentation is based on information from Per Waagan (Waagan Transport) and Knut Brunstad and Kjell Owrehagen from Norwegian Railways (NSB). Before the project-period WT had been in contact with NSB trying to establish a transfer of goods from road to rail at the route between Åndalsnes and Oslo. The SAVE-project gave an opportunity to bring this issue up again and in a broader context. Western Norway Research Institute therefore suggested for Waagan Transport to raise the question again concerning the possibility of transporting semitrailers on rail from Åndalsnes to Oslo.

This effort was successful, and during the winter 1999/2000 concrete negotiations between WT and NSB gave results. On february 14th 2000 a contract for transport of trailers on rail from Åndalsnes to Oslo, a distance of about 450 km, was signed. According to the agreement, WT will use NSB as transporter for all cargo between Møre og Romsdal county to Oslo or through Oslo. In August 2000 the first of these transports was taking place.

This intermodal transport is based on “huckepack” technology, giving opportunities to combine the transport means road, rail and sea. The first distance from the west coast of Norway, mainly the western part of Møre og Romsdal county, is made by lorry to Åndalsnes. The distance from WT terminal (close to Ålesund) to Åndalsnes is 110 km. In Åndalsnes the semitrailers are being placed on rail carriages to Oslo. The train has two departures a day from Åndalsnes to Oslo (06.30 and 21.00) and two return departures from Oslo. The trip lasts nine hours in each direction. The maximum payload on train for one trip at the Rauma railway to Oslo is about 550 tonnes. The limitation is the steep Rauma railway up the valley Romsdal. Each train carries 8-10 semitrailers in addition to ordinary containers.

About 50 percent of WT total transport volume in direction Eastern Norway, included exports, is by the year 2000/2001 carried by train to Oslo. In autumn 2000 the fish transport from Oslo to the European continent went both on rail and road. Transport of dried cod from Western Norway to Italy by train started in the middle of November year 2000. From Oslo this transport takes 48 hours to Verona in Italy, from where the fish is transported by lorries to the customers.

Frozen herring and mackerel to Boulogne-sur-Mer is transported by rail from Western Norway to Oslo and by boat from Oslo to Rotterdam, from where the lorries bring the fish to the customers in BSM. In France, efforts are being made to make it possible to use the huckepack-system on rail. In this way WT has developed an intermodal transport chain based on truck, train and ferry from the western coast of Norway to the continent.

Barriers with the customs check

WT has re-negotiated with Colorline the customs control at the ships trying to streamline the routines for paying the customs duties and taxes. The customs control on some of the routes has constituted a barrier to the use of ship transport. WT has succeed in their efforts to solve this problem, and the procedures connected to the customs control has been improved. Thereby this barrier has been removed (Waagan, K., 2000).

6.5.4. Necessary conditions for implementing actions

Necessary conditions for implementing actions are described according to this structure:

- Generally necessary conditions
- Conditions to reduce fuel consumption in today lorry's transport
- Conditions to the transferral between transport modes

Generally necessary conditions

In the 1980's Waagan Transport tried to develop energy efficiency as a part of an environmental friendly image used in marketing. Their experience at that time was that no possibilities to increase the transport payment existed. Their customers did not want to pay more for an environmentally friendly transport service (Waagan, P., 1998-2000).

To reduce the energy use, more than to a level required by public laws and regulations, a commercial company such as WT needs an economical motivation. Such motivation could be from an increase in income or reduction in costs. Reduction in energy use could also be a strategy for developing the company to keep their position in the market without particular possibilities to increase income or to reduce costs.

Necessary conditions to turn energy efficiency into a business strategy are therefore actions which bring the company in position to:

- reduce costs, or
- increase income, or
- get other competitive advantages (e.g. positive image)

Conditions to reduce fuel consumption

One important experience in this project, according to conditions for implementation of actions in the case companies, could be stated in this question: Are the actions, and the implementation processes, suitable or compatible with the main processes going on in the company? If not, it would be very difficult to implement new actions and strategies.

Another important experience is that combining implementation of actions with measurements is difficult in the transport sector. This is a sector where rapid changes occur, and the time available for implementation of such development processes is limited. The plan was to implement a driving course to develop energy efficient driving, and the effects of the course was to be measured. This objective required measurements made before and after the driving course. The measurements before implementing the action was time- and resource consuming for the case company in 1999. Being ready to start the driving course in the spring of 2000, practical problems arose: It was difficult to gather the drivers at one place at the same time for a course without reducing the custom service, and it would be expensive to teach them one by one. In the meantime two of the drivers got sick for a long time, and two others changed to newer lorries. The concept of measuring the effect of the training course, was therefore not carried through.

For the reasons indicated above, the implementation process took much time, and the project in a period overlapped with other main processes in the company: developing transferral of goods from road to rail. This process changed the conditions for implementation of a driving course essentially. The distance with properly the greatest energy saving potential, the hilly and steep Norway, was reduced substantially. In addition, the company changed their organisation by to a large extent hiring transport services from other companies.

A third factor which influenced the conditions for reducing the energy use is, according to the case company, a new phenomenon the last years: All types of fish transports are in a hurry and has to be delivered exactly on time. The customers of the fish-exporter are emphasising short delivery times. These are not the best conditions for choosing the most energy efficient driving style. It also sometimes could make it difficult to choose the most energy-friendly transport route. Late deliveries from the exporter to the transport company, also made this situation worse.

To sum up the project experiences, important conditions for reduction of fuel consumption in today's lorry transport include:

- actions and strategies has to be suitable with other main processes going on in the company
- the hard competition in the transport sector makes it difficult to spend much time on developing processes
- it is difficult to combine actions implementation processes and measurements of the effects from the same actions
- the increasing demand for deliveries on time makes it difficult to use the most energy efficient driving style.

Conditions for the transferral from road to rail

Both WT and NSB have made preparations to initiate fish transport on rail. Here we focus on conditions necessary to realise the introduction of intermodal transport between road and rail on the line Åndalsnes - Oslo.

Waagan Transport (WT)
This presentation is based on information from Per Waagan. WT's motivation for transferral of goods from road to rail is reduction in costs. Driver wages represent 40 percent of total costs in the company, and it is impossible to compete with other companies on the continent with "eastern European (low) wages". Transferral of goods to rail is one solution for reducing costs for wages. Another motivation is to develop a more flexible transport system with road, rail and sea. Rail transport makes it also possible to improve the public acceptance. Positive environmental image might bring new customers to the company.

Investment in 49 new trailers with the huckepack system is the most important action made by WT to realise the transferral to rail transport. This kind of trailers are adaptable for different transport modes. WT has also changed their driver organisation. In both ends of the rail transport segment they are hiring services from other transport companies.

WT has started to transport furniture and some fish products to obtain experiences with this new intermodal transport chain. In autumn 2000 fresh salmon was difficult to include in this system due to non-optimised logistic chain. When the punctuality is improved WT is going to include fresh fish in these intermodal transport chain.

This transferral of goods from road to rail has given a substantial reduction in the volume of goods transported by WT on road. In the coming years, with also fresh fish being transported on rail, this mode change will have been carried even farther. The important factor for these operations is a streamlining of the logistic chain to improve the stability of the deliveries.

Norwegian railways (NSB)

Here we present preparations done both by NSB Cargo and The Norwegian National Rail Administration. The presentation is based on information from Knut Brunstad and Kjell Owrehagen in NSB Cargo.

The transport of semitrailers on train demands larger space than traditional goods trains. This implies that some tunnels need to be enlarged to facilitate this type of combined transport. In August 2000 Raumabanen (Dombås – Åndalsnes) was ready for such transport after preparation work of The Norwegian National Rail Administration. The administration is responsible of the rail infrastructure. NSB has made efforts to obtain this line to be adapted for semitrailers.

NSB Cargo has procured wagons for semi-trailer transport. They also got new lorries especially adapted for handling semitrailers to be able to carry such goods.

The first one third of the rail distance from Åndalsnes to Oslo is not electrified. Hence NSB use diesel train at this distance. At Otta they change to electricity train on the way to Oslo, and opposite on return. This is done of environmental considerations and increase costs in NSB. The change to electricity train at Otta gives lower utilisation of the trains than using the diesel train the whole distance to Oslo.

In summer year 2000 NSB Cargo changed the timetable on the ComiXpress on Rauma Railway in order to favour WT fish transport. This could be difficult in the future because of a potential conflict between Cargo trains and public trains. The plan is to develop the public services with faster trains, but this will increase the need for double tracks for trains in same direction. The policy in NSB is to give the public trains priority before Cargo trains.

In year 2000 WT was the only transport company using the Åndalsnes-Oslo line for fish transport. When the intermodal transport co-operation between WT and NSB Cargo was published in august 2000, NSB got many inquiries from other transport companies. In 2001 therefore two new large transport companies are going to transfer goods from road to rail using this line. Our case company has apparently started a process among the transport companies resulting a substantial reduction in energy use in transport of goods. In NSB Cargo this process is termed “the Waagan effect”.

6.6. Routes for fish on rail from Norway to the continent

Norwegian Railways has in co-operation with different companies in Swedish Railways (SJ) established transport possibilities for fish on rail with connection to rail transport-systems at the continent. This gives the unique opportunity to transport fish from e.g. Narvik in nothern Norway all the way to Verona in Italy, a distance of about 2700 km.

The transport product is called "CombiXpress" and comprises the possibility to bring semintrailers, ordinary containers and Swap bodies with the same train. The costumes can order reservation or buy transport services daily. For fish transport, semitrailers on train has had a large increase last year (2000). In Norway these lines are adapted for intermodal transport (www.nsb.no):

- Oslo- Åndalsnes
- Oslo-Trondheim
- Oslo-Narvik
- Oslo-Kristiansand-Stavanger

Further plans included the opening of parts of Nordlandsbanen (Trondeim-Bodø) before the end of 2002 for this type of transport. More long-term plans exist for Oslo-Bergen, but this requires much work due to the many tunnels on this route. Below we give a short presentation of the rail transport routes from Scandinavia to the continent. So far, by year 2001, the main fish transport route with rail from Norway to the continent occur with Artic Rail Express (ARE) and Padborg-Oslo Rail Express. Some fish cargo is also transported by Scandinavian Rail Express to Italy (Owrehagen, 2001).

6.6.1. ARE: Artic Rail Express

This rail serves fish transport from northern Norway (Finnmark, Troms and northern part of Nordland county). The trip takes 36 hours with departure from Narvik (Norway) or Gällivare (Sweden) through Sweden to Hälsingborg and across Denmark to Padborg (Figure 43). The connection to Padborg was established in year 2000 with direct connection to Malmö and Padborg without any reloading. See the map.

In January year 2001 there were six departures from Narvik to Oslo, and one to Padborg each day. NSB is making efforts to increase the volume to Padborg. The volume of fish carried by ARE was about 2700 containers, or about 30.000 tonnes in 1999 and 2000 each year. The halves with fresh fish and the other halves with frozen fish (Bertnes, 2001).

The utilisation is 60 percentage on the trip from Narvik to the continent, and 100 on the return trip. Total cargo weight on one train is 700 tonnes, and a normally fish transport contains about 300 tonnes fish.

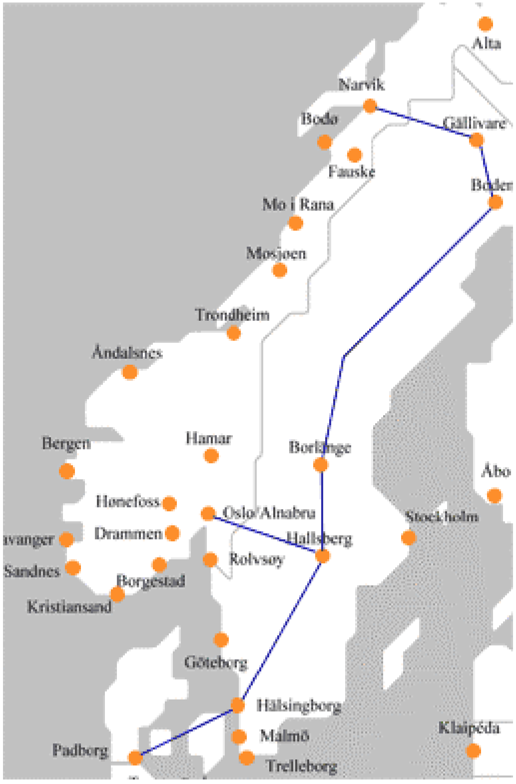


Figure 43 Artic Rail Express from Narvik/Gällivare to Padborg

Source: www.nsb.no

6.6.2. Scandinavian Rail Express

The Scandinavian Rail Express has connected the "CombiXpress" in Scandinavia to different combitrains-systems on the continent since 1997 (Figure 44). There are five weekly departures from Oslo to Travemünde, Duisburg, Köln, Mannheim and Basel. Train-time from Oslo to Basel is 36 hours. There is also connection to Verona and Milano in Italy. This transport route is now often used for dried fish from Norway to Italy. See the map to the right.

In 1999 timetable was changed to get better connections with the ferry from Trelleborg to the continent, and the transport volume increased (Owrehagen, 2001). Scandinavian Rail Express is established in co-operation between NSB Cargo and Rail Combi AB in Sweden.

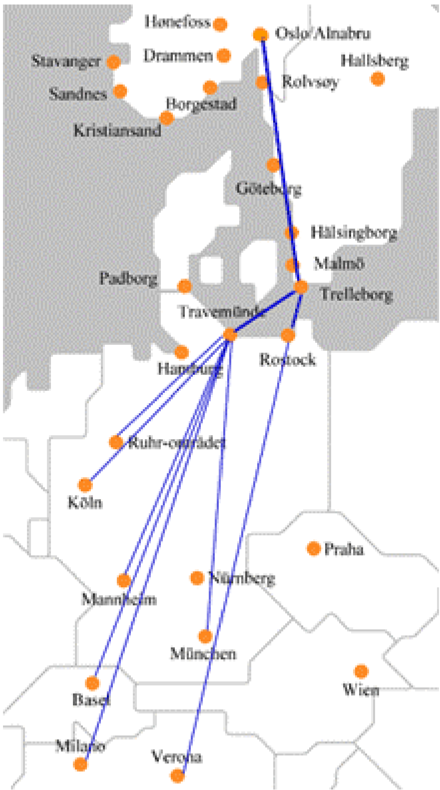


Figure 44 Scandinavian Rail Express (SRE), Oslo-Trelleborg-continent

Source: www.nsb.no

6.6.3. Padborg - Oslo Rail Express

After the opening of the Öresund brigde a new combi-express train between Oslo and Padborg was started (Figure 45). This connection is adapted especially for fish transports to the continent. Departure from Oslo every friday to serve the fish market on the continent over the weekend.

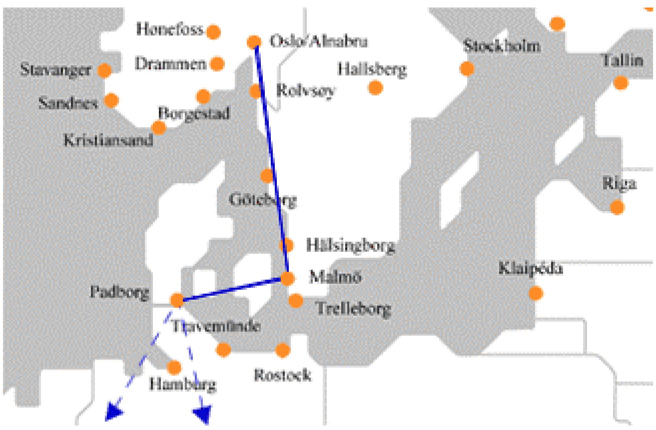


Figure 45 Padborg – Oslo Rail Express.

Source: www.nsb.no

6.7. Energy saving effects

In this chapter we present the energy saving effect of the pilot actions and possible actions. The focus is on energy saving effects in the lorry transport, and the effect of transfer of transport mode from lorry to rail and sea. The effects are shown both for our four cases and for the fish export as a whole.

6.7.1. Energy saving effects of actions in today's lorry transport

Here we present the actual energy saving effects in the lorry transport of fish exported from Norway. The calculations are based on the four cases. We assume these four cases to be representative for Norwegian fish export. This is of course not correct, but good enough to illustrate the energy saving effects.

The actual energy saving effect in the today's lorry transport is 5 % according to the result in the transport company Nistad in western Norway. For the whole fish export transported on lorry this would give an energy saving effect of about 12.000 tonne fuel or about 115 mill kWh. The table below shows this effect.

Table 47 Energy saving effects in the today's lorry transport of fish from Norway to the European continent. Round trips (Norway – European continent – Norway)

Ton export year 2000	3.222.557
Kwh/ton exported[1]	317
5 % reduction, kWh	114.864.998
5 % reduction, ton fuel	11.769

[1]Average of the four cases.

6.7.2. Energy saving effects of transfer to rail and boat

In this chapter we present the potential energy saving effects of a transfer of fish transport from road to rail and sea. The calculations are based on the four cases of fish transport from Western Norway to the European continent (described in chapter 2). The today lorry transport is the basic alternative.

The fuel consumption, distances, duration and average loads for the cases are shown in Table 48. Data for this transport is based on the measurements made during the project.

Table 48 Average fuel consumption, distances, time usage and loads for the four cases of fish transport. Round trips (from Norway to the European continent and back to Norway). 1999-2000

Case	Lorry fuel con-sumption[56] (litre)	Road distance (km)	Ferry duration[57] (hrs)	Rail distance (km)	Total duration (hrs)	Payload (tonnes)
A	1537	3161	16	-	96	18
B	1659	4622	28	436	158	22
C	904	2515	14	-	98	16
D	1232	3644	44 (14)	-	134	17

For all cases and alternatives the distance from the west coast of Norway near Ålesund to Åndalsnes (about 110 km) is done by lorry. During the project period transfer of transport mode is implemented for case B and Case D. Dried cod (case B) is transported by train on the main distance from Åndalsnes to Verona (Italy). Lorry is used the last distance to Torino. This route is named B_R. In Case D lorry transport is replaced with rail and cargo ferry. Frozen herring and mackerel is transported with rail from Åndalsnes to Oslo, with boat from Oslo to Rotterdam, and lorry the last distance to Boulogne SM. This route is named D_{FR}. These two intermodal transport routes were established during autumn year 2000, and have replaced lorry based transport.

The other alternatives is described as follows:
* *Case A* (fresh herring to Poland) with train to Poznan. This assumes railway bridge across the Fehmarn Belt (Rødby-Puttgarden). This route is named A_R.
* The sea alternative in *Case B* (dried cod to Italy) is boat from Ålesund harbour to Genova, and lorry the last distance to Foligno. This route is named B_B.
* *Case C* (fresh saith filet to Germany) with the two alternatives rail (C_R) or sea (C_B). The rail alternative includes rail from Åndalsnes to Bremerhaven. The sea alternative assumes boat the whole distance from Ålesund harbour to Bremerhaven.
* The boat alternative in *Case D* (fresh and frozen white fish to France) is by boat the whole distance from Ålesund harbour to Boulogne-Sur-Mer. This route is named D_B.

The same average payloads as for the actual transports by lorry are used for the calculation of the energy and time usage in the alternative routes. The energy factors shown in Table 49 are applied.

[56] The numbers are averages for each of the cases. Case A and D are each based on three round trips, B on one and C on five.
[57] The number in parenthesis is the route with ferry between Moss and Fredrikshavn.

Table 49 Factors applied in the energy use calculations for rail and ferry

Transport mean	**Energy use (kWh/tonnekm)**
Ferry[58] (at 80% load factor)	0,35
Lorry[59] (at 60% load factor)	0,26
Train[60], electric (at 70% load factor)	0,06
Boat[61] (at 70% load factor)	0,08

The result of the energy use calculations for all alternatives are shown in Table 50.

Table 50 Energy usage in the cases of fish transport. Round trips (from Norway to the European continent and back to Norway). Actions implemented during the project are hatched

Case	Lorry distance	Rail distance	Sea distance	Total duration[62] (hrs)	Energy use (kWh)
A_R	226	3574	0	108	4918
B_R	826	4674	0	166	10894
B_B	814	0	10686	438	23463
C_R	226	3074	0	90	3891
C_B	0	0	2700	116	3456
D_B	0	0	3300	139	4488
D_{FR}	826	900	2056	128	16802

A comparison between the actual cases with lorry transport in 1999 and the alternatives: rail transport, boat transport and ferry and rail based transport is shown in Table 51 and Table 52.

[58] The energy use factor is calculated from data given from DFDS Tor Line. They have a cargo route from Oslo to Rotterdam.
[59] Lorries are used for distances at 300 km and shorter. This explains the higher energy use factor than on long distance lorries.
[60] Trains are assumed to be powered by electricity only. The trains for goods transport are assumed to have maximum speed of 120 km/hr and with carriages for transport of containers/semitrailers on 2 floors. Already at the end of the 1990’s did Swedish and Finnish rail transport average 0,03-0,04 kWh/tonnekm (load factor 60-70). A higher energy use factor than this is used to compensate for the weight of containers/semitrailers and the need for cooling of the fish during the transport.
[61] This is energy use for traditional long distance cargo ship using less energy than the ferries.
[62] An average speed of 80 km/hr is assumed for trains. In addition 6 hours waiting time at each of the loading/recoupling locations. The average speed of boats is assumed to be 14 knot. In addition is a loading and unloading time of 4 hours at each port. This is low due to the improved efficiency of the port operations. The average speed for lorries (including rest hours) is assumed to be 60 km/hour. This might appear to be low, but as pointed out earlier, the lorries are assumed to be mainly used for shorter distances in distribution- and supply transports.

Table 51 The energy use (Kwh) for the cases of fish transport. Round trips. Percentage change compared with lorry transport in parenthesis. Actions implemented during the project are hatched

Main transport mode/case	**A**	**B**	**C**	**D**
Lorry based transport (1999)	20959	27341	12975	21145
Rail based transport	4918 (-77 %)	10894 (-60 %)	3891 (-70%)	
Boat based transport		23463 (-14%)	3456 (-73%)	4488 (-79%)
Ferry and rail transport				16802 (-21%)

Table 52 Time use for the cases of fish transport. Round trips. Actions implemented during the project are hatched

Main transport mode/case	**A**	**B**	**C**	**D**
Lorry based transport (1999)	96	158	98	134
Rail based transport	108 (+13 %)	166 (+5 %)	90 (-8 %)	
Boat based transport		438 (+177 %)	116 (+18%)	139 (+ 4 %)
Ferry and rail transport				128 (- 4 %)

Rail based transport with dried cod to Italy (B_R) is *implemented* during the project in our case company. The reduction in energy use is large, with 60 % lower energy use than lorry based transport. The effect comes from the more energy efficiency train transport used on the whole distance from Western Norway to Verona in Italy. The transport is similar in time efficiency (5% difference) to the lorry based transport in 1999.

The other *implemented action* D_{FR}, frozen fish to Boulogne SM in France, is based on ferry and train transport. Here the reduction in energy use is “only” about 20 percentage, caused by the train from Åndalsnes to Oslo. The enery saving effect is limited due to the long ferry distance Oslo-Rotterdam. Ferry is less energy efficient than lorry transport.

The other potential transferable alternatives give lager reduction in energy use. From the tables above it is clear that the train transport of fresh herring to Poland (Case A_R) is close to be as time efficient as the lorry based transport. The increase in time use is 13%, or 12 hours. The reduction in energy use is however immense, with 77% lower energy use than lorry based transport. This effect is found by the more energy efficient train, but also by non ferry use. This calculation assumes bridge across the Fehmarn Belt (Rödby- Puttgarden).

One of the three boat alternatives, dried cod to Italy, gives only little reduction in energy use because of the long boat distance into the Mediterranean. The transport by boat (B_B) is more time consuming, but since the product is dried cod, this is of less importance due to the long durability of the fish product. The important question is not the time efficiency in itself, but rather if the delivery reach the destination at the time agreed upon. Even if the sea transport, as is also the case for the ferry transport, is affected by increased storm activity from climate changes, it is due to its “loose couplings” and “simple interactions” able to deliver at the time agreed upon, though not as fast as the rail transport.

The sea transport, by ship (not ferry), is more energy efficient than the lorry based transport. In alternative C_B and D_B the boat made a large reduction in energy use at about 70-80 percentage compered with lorry transport. It is important to state that these calculations are based on the assumption of using large boats today used overseas between Europe and America and Europe and Asia.

The transport of fresh seight filet to Germany by rail (C_R) is similar to the lorry transport (8 % difference). The energy saving is in addition large with a reduction in energy use of 70%. The transport by sea to Bremerhaven (C_B) takes 18 % more time than the lorry based transport. Even though the time of transport (58 hours one way) is not so large that this represents a problem, will the reduced time efficiency lower the likelihood of the sea transport as the preferred choice. The energy saving of the sea transport compared to the lorry based transport for this case is quite large, with a reduction in energy use of 73%.

The transport of fresh whitefish by boat to France (D_B) is almost as time efficient as the lorry transport, taking 9 hours longer. This can be explained by the long ferry distance that was used in the lorry based transport. The reduction in energy use by the sea transport in this case is large, with 79% lower energy use than lorry based transport.

6.7.3. Potential effect for all fish transport

If all the fish export from Norway to the European continent where transported by train the total reduction in energy use could be about 70.000 ton fuel or nearly 700 mill Kwh. This calculation is based on the assumption that our four cases give a representative picture of transport distance and transport mode in the today fish export. This is not necessarily right, but our calculation gives an estimate of the future energy saving potential.

7. The Finnish case

7.1. The Finnish case company

7.1.1. Production and financial background

The UPM-Kymmene Group is, measured by turnover, the biggest forest industry enterprise in Europe and among the biggest in the world. In 1997, the company's turnover amounted to FIM 46 billion. The share of overseas operations in company's turnover was 84%. Europe is the company's main market; 68% of turnover came from EU countries (excl. Finland) in 1997. The rest was divided between other European countries (8%), North America (7%), Finland (6%) and the rest of the world (11%). The production capacity of the company was almost 7,2 million tonnes in 1997 (UPM-Kymmene www-pages, 10.9.1998). Table 43shows UPM-Kymmene's classification in the global market measured by production capacity.

Table 43 UPM-Kymmene's classification by capacity of production (UPM-Kymmene www-pages, 10.9.1998)

Forest industry product	Classification in Europe	Classification in the world
Paper and paper board	1.	2.
Coated printing paper	1.	1.
Newsprint	1.	2.
Fine paper	3.	7.
Supercalendered* (SC) paper	1.	1.
Sawn wood products	2.	Not among 10 biggest

* supercalendering = treatment of paper on an off-machine supercalender to improve smoothness and gloss; uncoated magazine paper

UPM-Kymmene has 14 mills in Finland, of which 10 paper and board mills and 4 pulp mills. Most of the mills are located somewhat scattered in the southern parts of Finland, exceptions further in the north are Pietarsaari mill on the West Coast and Kajaani mill inland (UPM-Kymmene Annual Report 1997).

UPM-Kymmene production is divided in the following divisions (UPM-Kymmene Annual Report 1997):

- Resources division: chemical pulp and procures wood and energy
- Timber division: sawmilling and joinery products
- Schauman Wood: plywood for construction material to many industries
- Newsprint division: high-quality newsprint to publishers and printers
- Fine Paper Division: paper for office and printing use
- Magazine division: paper for magazines, advertising materials and sales catalogues etc.
- UPM-Kymmene Pack: packaging materials for consumer goods and industrial products

- Special Product Companies: self-adhesive label stocks, stationery products and air-laid papers

Magazine Paper is the largest division measured by turnover (26%). After that come Fine paper division (15,5%), Newsprint (12,5%) and Packaging materials (nearly 11%). Sawmilling, special products and chemical pulp all have a share of 9-10%. Plywood is the smallest single division with 7,5%. 27% of total turnover comes from other products (UPM-Kymmene Annual Report 1997).

The company employed nearly 34000 people in 1997, of which over 23000 in Finland (UPM-Kymmene Annual Report 1997).

Transport volumes and flows

Forest industry has the largest contribution to haulage in Finland measured in tonne kilometres. In 1996 the industry's total *domestic haulage* was 14 billion tonnekm, about 38% of total domestic tonnekm (36,5 billion) (including all transport modes). Forest industry contributed about one third of the total road tonne kilometres. In tonnes domestic haulage totalled 84 million tonnes in 1995. Almost 60 million tonnes were transported by road, of which 3/4 was roundwood haulage (Forestforum Finland www-pages 6.7.1998).

Rail transport of forest industry was 22 million tonnes, of which over 50% was roundwood. Rail transport accounted for over 50% the total haulage measured in quantity and tonnekm (Forestforum Finland www-pages 6.7.1998).

Waterway transport, about 2 million tonnes, consisted mainly of round-wood log floating and transport downstream in inland waterways. Forest industry's products were the largest group in haulage after surface deposits like gravel and soil (250 million tonnes). In forest industry statistics 1997 it can be seen that the long distance transport of round wood from 1986 to 1997 has shifted towards increase in railway transport from 10 to 15 per cent. Road transport has retained somewhat at the same percentage level (75-79%) and waterway transport has decreased from 15 to 5 per cent (Forestforum Finland www-pages 6.7.1998; SKAL www-pages 7.5.1998; Statistics Finland, 1997).

65% of the forest industry's domestic haulage consisted of round-wood transports from the forest to places where it would be used. The share of product haulage from mills to harbours (export) or for domestic consumption was one quarter and the rest consisted of raw material haulage to the mills (Forestforum Finland www-pages 6.7.1998).

Transport volumes in *import and export transport* of forest industry amounted to nearly 30 million tonnes in 1995, of which 17 million tonnes for export and 12 million tonnes for import. This was about 35% of total import and export transport volumes. In export haulage, forest industry amounted for almost 60% and in import haulage (mainly round-wood), well over one fifth (Forestforum Finland www-pages 6.7.1998).

UPM-Kymmene's 14 mills have different kinds of transport solutions and mode combinations. There are no typical chains so selecting the case company's transport chain for the project is thus closely linked to the *transport system* selection. UPM-Kymmene's representative makes the selection of the case transport chain from Finland to the destination abroad. The selected chain will be one within various solutions of company's paper export chains.

Environmental issues

Finnish forest industry has invested a total of some 326 million FIM in environmental protection in Finland, with the pulp and paper industry accounting for 97%. In peak years 1989-92 and 1995-96 about 700-800 million FIM were invested in environmental protection. The years of peak investments in environmental protection seem to be over along with slowing investment rate in the forest sector in general. The manufacturing capacity was updated after recession. At present, the focus of environmental investments has shifted from necessary treatment technologies to further development of more environment-friendly manufacturing processes (Finnish Forest Industries Federation, 1997a).

In 1997, fuel consumption by the forest industry totalled nearly 70 TWh, which was 65% of the total industry as a whole. Wood accounts for almost 70% (49 TWh) of total fuel consumption by the forest industry. Another domestic fuel used is peat. The use of both coal and heavy fuel oil has steadily declined as biofuels and natural gas have taken their place (Ibid.)

A report from 1982 calculated the transport energy consumption for mechanical wood processing industry 1980-1982. The estimates were based on year 1979 so the figures are allusive. The amount of energy consumed in transport of mechanical wood processing industry by road was 795000 GJ or 0,22 TWh. The transported weights of forest industry's products are usually heavier than average. Rail transport energy consumption in UPM-Kymmene's paper and kaolin transport between the company's mills in Jämsä in the Central Finland and Rauma on the West Coast has been measured. The average consumption was 0,08 kWh/ton-kilometre. For normal electricity goods train the energy use is 0,69 kWh and for a diesel train 2,27 kWh for a transport of 40 tonnes (Transpress 2/98).

7.2. The pilot actions in Finland

The Finnish part of the project deals with forest and especially the paper industry. The Finnish case company is UPM-Kymmene. A description of the case company can be found in the Phase 1 report from the project (Andersen & al., 1999). Within the case company one export transport chain is selected and thoroughly examined. This transport chain covers transports of raw materials to Voikkaa mill and the transport of paper to the customer in Germany and the associated energy use. In addition, the energy use of handling is included in the calculations.

7.2.1. System boundaries for the Finnish study

The energy use in the case transport chain, which includes the following phases, is studied:

- Transport of raw materials: logs, kaolin and chemical pulp
- Paper handling at the mill
- Transport to the export port (Kotka) and handling at the port

- Sea transport

The manufacturing process of the paper and transports inside the mill are not included in the study. In addition, the energy production phases are excluded. Consequently, the energy use in the transport chain can be different when the whole life cycle is taken into consideration.

The present energy use is calculated with a calculation model, which is presented in Chapter 7.9. Pilot actions and their evaluation are also carried out with the model. The basic data for the calculation model is collected from UPM-Kymmene and various previous studies on energy use in transport. Firstly, the report describes the phases of the case transport chain. Then the calculation model and the evaluation of the pilot actions, and the results from them are described. Finally, the report is concluded with summary, main findings and some discussion.

The transport volumes of the case export chain in 1998 are shown in Table 53. The distance in the transport of logs is an example of a typical transport distance.

Table 53 Transport volumes in the case transport chain.

Distance[63]	**Transported goods**	**Km**	**Tonnes**	**Transport volume, 1000 tonne-km**
Forest - Voikkaa mill (example, direct lorry)	Log	100	407 077	40 708
Forest - Voikkaa (example, train)	Log	140	171 231	23 972
Voikkaa-Kotka/Hamina, lorry	Paper	65	189 500	6 545
Voikkaa-Kotka/Hamina, train	Paper	65	178 750	11 618
LPR[64]-Voikkaa	Chemical pulp	100	114 000	10 260
Kotka-Voikkaa	Kaolin	65	134 500	8 743
Kotka-LPR	Transfer	120	0	0
Kotka/Hamina-Lübeck, boat	Paper	1 285	33 000	42 405
Lübeck-Cologne, train/lorry	Paper	490	8 800	4 324
Total			1 236 858	148 575

Voikkaa is located in Southern Finland, and the transport distance to the port is quite short. Logs are transported to the mill from the surrounding area, kaolin is mainly transported from the port of Kotka and chemical pulp from Lappeenranta. An other UPM-Kymmene paper mill, Kymi Paper in Kuusankoski, is located almost next to Voikkaa mill. Due to the geography of Finland, sea transport is usually required for exports. The paper of the Voikkaa mill is mainly exported via ports of Kotka and Hamina. A few paper lots can be exported via other ports, too.

[63] Floating is not included
[64] LPR = Lappeenranta, See **Feil! Fant ikke referansekilden.**

7.3. Energy use calculations

In reality, in energy use there is a difference depending on whether a lorry is driven with a full load or empty. However, usually the fuel consumption is indicated as consumption, litres per 100 km, in which case the consumption is usually the average between the consumptions of an empty and a full lorry.

One calculation of the difference of the consumption of an empty and full lorry (VTT Communities and Infrastructure 2000) is with the full trailer combination lorry (of 60 tonnes lorry), where the difference between the empty and full consumption is about 17 litres. In other words, if the full lorry consumes 50 litres / 100 km with a full load, its consumption when empty is 33 litres / 100 km, which is 66% of the fuel consumption with full payload. According to the calculations of Metsäteho, the full trailer combination lorry (60 tonnes) transporting raw wood consumes 42 litres per 100 km when empty and 62 litres per100 km loaded with 42 tonnes (Oijala, 1995).

However, it is problematic to define the energy use of the return transport and the difference in the fuel consumption when there is a return load, of which the load factor is, e.g. 60 %. Even if the proportion of fuel consumption and weight of transported goods are almost linear, the problem is to define the actual load, which can vary a lot. In this case study the lorries are assumed to be either empty or full. The lorry is considered as full when the load factor is approximately 95%, i.e. the load of 38 tonnes when the capacity is 40 tonnes.

In the calculation model of the case, the kilometres that the lorry has driven empty and loaded have been counted, and the fuel consumption and energy use have been calculated according to them. Likewise the kilometres of a full train have been counted in the rail transport section. In addition, the energy use of transporting empty wagons is also estimated. One problem in the road transport of the case is the profitability of the so-called triangle: the distance in which it is more economically and environmentally reasonable to drive a triangle (A - B - C-A, See alternative 1 in Figure 46) in order to get a return load, compared with driving directly back with an empty lorry. “The empty side of the triangle", (the transfer distance) is allocated to the loads in relation to the transported kilometres in this case.

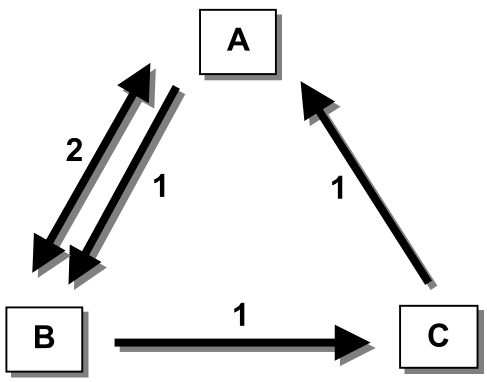


Figure 46 A triangle describing the alternative points to take the return loads.

In addition to the properties of a lorry, other things that affect fuel consumption are, among others:

- The terrain, in other words how hilly and winding the road is
- Surface material of the road

- The number of stops, for example at transport lights and crossroads

When calculating the energy use of transport by lorry, the effect of idle running (in the factory, in the harbour) and stops, on total energy use, has to be taken into consideration. Furthermore, in a northern climate the seasons also affect fuel consumption.

In Finland's project case, a calculation model for energy use in the transport chain was constructed. This model was used when the energy use of the chain was calculated and the pilot actions were examined. In the calculation model the return loads and empty driving were taken into consideration by separately calculating the kilometres, which the lorry drove with a load and without a load. For these kilometres then, different figures of fuel consumption were used. The total fuel consumption can be divided according to the transported tonnes and tonne-kilometres. In the model, the possibly lower fuel consumption of less than maximum loads was not taken into consideration even though the consumption can be considered to be nearly linear with respect to the weight of the load (VTT Communities and Infrastructure 2000). In most cases, the used fuel consumption was selected corresponding to the average load of the lorry.

In the calculations of this case the distance which the lorry drives without a load is multiplied with a factor 1.2 in order to cover all driving e.g. from garage to the mill. This factor is initially used by Metsäteho only for the transport of timber (Oijala 1995), but due to the fact that the distances of other raw materials to and paper transport from Voikkaa mill are relatively short, this factor is also applied in other transports.

In sea transport, the load factor was taken into consideration only when the energy use was allocated to the transported tonnes, because the weight of the load has really no significance on the fuel consumption of the ship. If a ship is carrying no cargo, it has to take on a certain tonnage of water in order to preserve its stability. In the allocating of the energy use average, load factors were used for the load and possible return load.

In order to equalise the use of different sources of energy the net heat contents and conversion factors (Statistics Finland, 1998) have been used. By using these factors the diesel oil consumption of lorries and work machines, the light fuel oil consumption of diesel trains, and the heavy fuel oil consumption of ships are all converted to kilowatt-hours.

The accounting principles are clarified in more detail in Chapter 7.9.

7.4. Forest industry transport in Finland

Measured by kilometrage (trip x number of trips), the forest industry is Finland's greatest provider of transport. In 1997 the domestic transport volume for the forest industry was estimated at 15 billion tonne-kilometres, i.e. approximately one third of the country's total transport volume. The combined amount of tonnage carried in 1997 came to almost 100 million tonnes. Among the goods groups, only gravel and other surface deposits were transported to a greater extent than this (approx. 200 million tonnes).

Approx. 60 % of domestic transport volume comprised the transport of wood raw materials from the forests - in the case of imported timber from the country's borders - to the place where they would be used, including the haulage of by-products (chips, sawdust, etc) from the wood products industry. Most of the other domestic haulage from the forest industry consisted of product transport from production plants to harbours or domestic consumers, and the remainder of the transport of other raw materials (pigments, chemicals, energy raw materials) to the mills (Forest industries, 2000).

The greatest share of domestic waterborne transport is made up of coastal fuel transport and short distance material transport. The forest industry's share of water transport in 1997 came to around one fifth of the total transport and 10 % of the kilometrage. Domestic water transport in the forest industry consists primarily of timber floating and inland water transport. In addition, some 5 % of the forest industry's product export is loaded on to vessels in the harbours of the Lake Saimaa[65] region.

The forest industry's share of transport abroad from Finland in 1997 was an estimated 33 %, the share in sea export almost 60 %, and of all export approximately 20 %. The amount of exports from the forest industry was approximately 17 million tonnes and the imports approximately 12 million tonnes. Two-thirds of export comprised chemical forest industry products, and the rest wood industry products. Imports consisted primarily of raw timber (Forest industries, 2000).

7.4.1. Terminology

There are numerous different terms for lorries with and without trailers, semi trailers etc. Terminology used in Finnish case study is presented below.

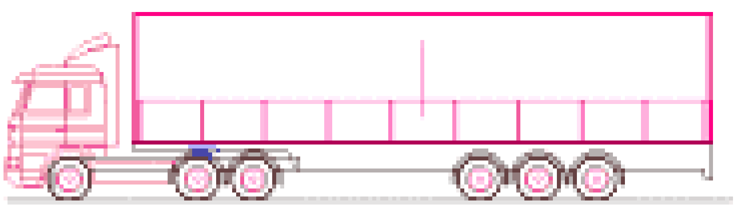


Figure 47 A semi trailer. (Picture: SKAL www-pages 2000)

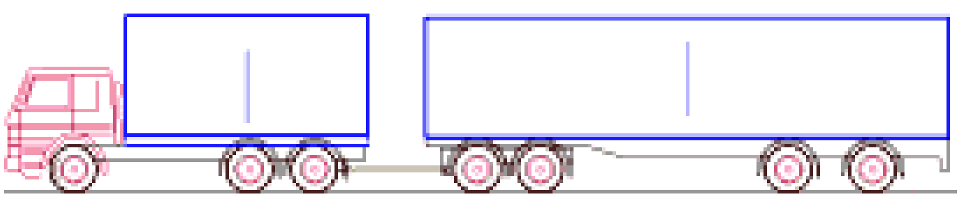


Figure 48 An articulated vehicle. (Picture: SKAL www-pages 2000)

[65] The Saimaa drainage region covers most of the southern part of eastern Finland, a region about the size of Belgium.

The terms are used only when the difference between a semi trailer and an articulated vehicle is required to make evident. Otherwise the word "lorry" is used to describe both of them. The articulated vehicle is also known for example as “road train” or “full trailer combination tuck” among other possible terms. The maximum total weight for the articulated vehicle amounts to 60 tonnes in Finland. In the study 40 tonnes is used as the maximum total weight for the semi trailer.

7.4.2. Timber as raw material for paper

Transporting timber in Finland

Transport by the forest industry by road in 1997 amounted to almost 80 million tonnes, of which two-thirds consisted of timber haulage. The forest industry's share of the goods kilometrage by road came to around a third. By rail, transport by the forest industry accounted for over a half of the total haulage from the standpoint of both tonnage and kilometrage. The total amount of product and raw material transport by the forest industry came to almost 25 million tonnes in 1997, with raw timber, including imported timber, accounting for over a half (Forest industries, 2000).

The average transport distance of timber was 137 km in Finland in 1998. The average transport distance of direct lorry transport was 100 km, the average railway transport distance including the preceding lorry transport was 288 km and the average waterborne transport distance was 284 km. From all timber, 80 % was transported by lorry, 16 % by train and 4 % by floating or by boat (Säteri & al., 1999).

Timber procurement at Voikkaa mill

The mill makes an order for timber in cycles of 3-4 months. The timber procurement is centralized within UPM-Kymmene and is taken care by UPM-Kymmene Forest Department.

The budgeted transport of logs at Voikkaa mill was 672 000 m^3 in 1999, of which

- 475 000 m^3 (71 %) by lorry,
- 140 000 m^3 (21 %) by train and
- 57 000 m^3 (8 %) by floating.

From the surroundings of Voikkaa mill (Kouvola, Kuusankoski and Valkeala area) the logs are mainly transported by lorry, from the area of Pieksämäki and Mikkeli the logs are transported by train and from Kangasniemi, for example, by floating (see Figure 49). The goal is that the logs should be at the mill three weeks at the latest after felling.

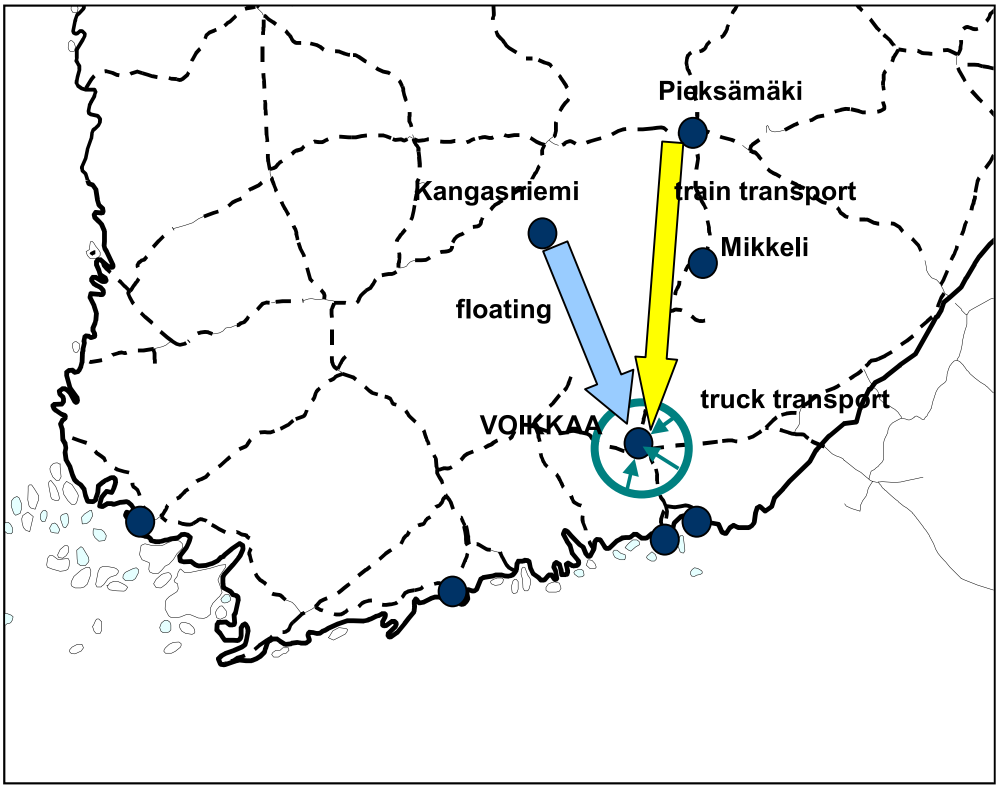


Figure 49 The main timber procurement areas and the modes of transport, Voikkaa mill 1998

The transported log volumes and transport modes in 1998 to Voikkaa mill are presented in Table 54 below.

Table 54 Volumes of logs and the modes of transport to the Voikkaa mill in 1998.

TRANSPORT MODE	LOG VOLUME, M^3 *	LOG VOLUME, TONNES	NUMBER OF LOADS	VOLUME/LOAD
Lorry	504 000	407 077	9 622 loads	n 52 m^3/load
Train	212 000	171 231	4 530 wagons	n.46.8 m^3 / wagon
Floating	72 000	58 154		
Total	788 000	636 462		

* All cubic metres are in cubic metre solid measures

At the mill the timber is discharged by log stackers from the lorry or rail wagon to the wood-room. From the wood-room the logs are taken to the sawing place where the logs are sawn into short pieces of approximately 1-1.5 metres. Owing to the structure of the trailers and wagons planned for transporting the logs, there are no return loads from the mill.

Fuel consumption of the wood-handling machines is represented in Table 55 below. The fuel consumption converted to kilowatt-hours amounted 1.46 kWh per handled timber tonne in 1998. There is no significant difference in handling and the energy use whether the rail wagons or lorries are unloaded. The floated timber is not included in these fuel consumption figures.

Table 55.Wood-handling machines at Voikkaa mill and their fuel consumption in 1998.

MACHINES: VALMET KTD 1510 AND SISU RTD 1523	
Fuel consumption, litres	89 236
Working hours, h	5 842
Fuel consumption, l/h	15.3
Fuel consumption, l/timber tonne	0.15
Fuel consumption, kWh/timber tonne	1.46

Floated timber tonnes not included in handling

Transport of timber by lorry

According to the Finnish forestry research centre, Metsäteho, the average lorry-load in the transport of logs is 52 cubic metres, which is approximately 42 tonnes (Oijala, 1995). Logs are mostly transported by 60-tonne-lorries. In the timber lorries there is also a grapple for loading and discharging the logs. The grapple weighs approximately 3 tonnes. According to Metsäteho, the fuel consumption of a 60-tonne timber lorry is 62 l/100 km with a maximum load and 42 litres per 100 km when driving empty. Loading and discharging the logs consumes 7 litres of fuel per load total, including both loading and discharging (Oijala, 1995).

Transport of timber by train

Mainly domestic timber is transported by rail to Voikkaa. There are no return loads for rail wagons but the empty wagons are transferred back to railway yards or train loading places. At the railway loading place the logs are loaded and the full train is transported to the railway yard of Kuusankoski (the city close to Voikkaa). There the train is usually divided into two shorter trains because the whole timber train, which quite often consists of approximately 20 wagons, cannot be handled in one go at the Voikkaa mill. The logs are measured in Kuusankoski.

Figure 50 The reloading of logs from the lorry to the railway wagon (Foto: UPM-Kymmene 2000).

In the rail transport of logs the goal is that at least ten wagons can be loaded without stopping (without transporting the wagons). Furthermore, the main principle is to get the whole/full train ready for transport as early as possible. UPM-Kymmene Forest Department notifies Finnish Railways (VR) of the number of required wagons. The rail transport of timber is scheduled a month ahead. The schedule, however, usually changes by approximately 30 %. Controlling the rail transport of timber requires much resources since there are over 100 railway loading places, in which the logs are loaded into rail wagons and transported to Voikkaa mill. UPM-Kymmene does not have its own wagons and locomotives but uses Finnish Railways as a subcontractor.

In the following table there is an example of one rail transport timetable to the mill of Voikkaa. The timber trains usually have a load of 1 000 - 1 200 m^3.

7.4.3. Kaolin as raw material for paper

Kaolin[66] is imported from England to the Port of Kotka (Mussalo). The transport company monitors the amount of kaolin at the mill and transports the kaolin automatically when needed. At the port, the kaolin is loaded by bucket charger into a lorry (usually in this case a full trailer combination lorry of 60 tonnes). At the mill, the kaolin is dumped into a silo. The kaolin is not only stored at the mill but also at the port. Currently kaolin is transported from Kotka to Voikkaa by road only.

[66]Kaolin (china clay) = mineral used in papermaking as both a filler and a coating pigment

Table 56 Transported kaolin to the Voikkaa Mill in 1998

	TRANSPORTED KAOLIN IN 1998, TONNES
As coating pigment	104 500
As filler pigment	30 000
Total	134 500

Combining the kaolin and paper transports is one measure to increase utilization of return loads since their material flows are mainly opposite. Kaolin is transported mainly by lorries of 60 tonnes from Kotka to Voikkaa and paper in the opposite direction. Combining these transports has been tried at Voikkaa, but it has been stopped because of some problems that occurred. One problem has been the cleaning of the lorry after the transport of kaolin. Since the kaolin is powdery material the lorry must be cleaned very carefully before transporting paper. Cleaning takes a relatively long time compared to the time that the actual transport takes, since the distance between the mill and the port only is 65 kilometres. However, special lorries that have a double floor can solve this problem; one can be used while transporting kaolin, and another is put down for the transport of paper.

7.4.4. Chemical pulp as raw material for paper

Chemical pulp[67] is transported by road from another UPM-Kymmene mill in Lappeenranta to Voikkaa. In addition to kaolin, also the transport of chemical pulp can be combined with the transport of paper. In this case, paper is transported by lorry from Voikkaa to the port of Kotka, from where the lorry is driven approximately 120 km to Lappeenranta in order to transport chemical pulp from Lappeenranta to Voikkaa. The distance between the pulp mill in Lappeenranta and Voikkaa mill is approximately 100 km (see Figure 51).

The volume of chemical pulp transported to Voikkaa mill in 1998 amounted to 114 000 tonnes. The only currently used mode of transport is road transport. The average load is approximately 40 tonnes by a full trailer combination lorry of 60 tonnes.

[67] Chemical pulp = pulp in which wood fibres have been separated by chemical means

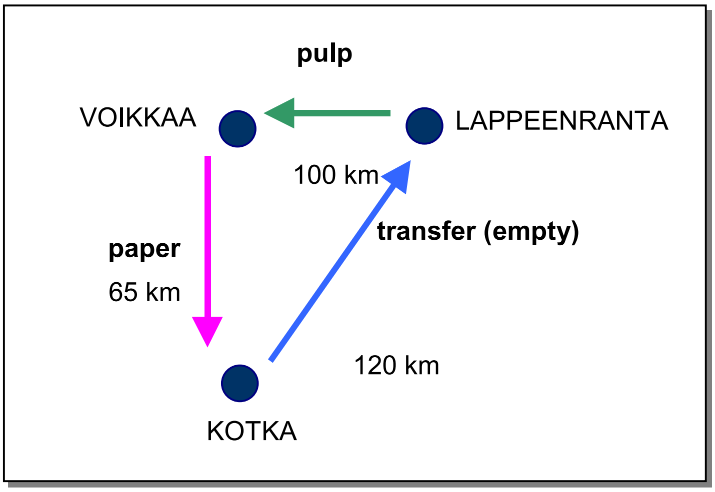


Figure 51 Transport of paper and chemical pulp form a triangle.

In addition to chemical pulp and kaolin, the papermaking process requires many other materials as well. It is possible to take other raw materials into account as well in the calculation model of this project. Miscellaneous raw materials can be interesting when new potential for return loads is studied. However, the definition and energy use of miscellaneous raw materials are not covered in this case study.

7.4.5. Handling of paper and loading at the mill

Paper is loaded by forklift into rail wagons, lorries and containers. The lorries are loaded in three shifts. The trains spend approximately 12 hours at the mill, and they can be loaded directly after the paper rolls come out of the papermaking process. There are two warehouses at the Voikkaa mill. The forklifts in the warehouses are Toyota liquid gas forklifts in one and Toyota diesel forklifts in another warehouse. The fuel consumption and operating hours as well as the paper tonnes handled in the warehouses are presented in Table 57 below.

Table 57 Paper handling in two warehouses of Voikkaa mill in 1998 (Suutari 1999)

	FORKLIFTS	PAPER VOLUMES IN 1998, TONNES	FUEL CONSUMPTION	OPERATING HOURS PER YEAR
PK 11-18	3.5-tonne diesel	322 057	31 166 litres (Neste tempera green)	9 426
PK 16-17	3.0-tonne liquid gas	157 597	25 454 kg (liquid gas)	5 213
Total		479 654		14 639

The energy use in paper handling at the mill is shown in Table 58. The table includes both warehouses. When the energy use in kilowatt-hours per tonne is examined, it can be seen that the liquid gas forklifts use twice as much as the energy used by diesel forklifts. This difference can be caused by many factors. For example, the liquid gas forklifts used at Voikkaa are older than the diesel forklifts.

Table 58 Handling of paper at Voikkaa mill in 1998.

	ENERGY USE PER HOUR		ENERGY USE PER HANDLED TONNE	
	L or kg/h	KWh/h	L or kg/tonne	KWh/tonne
PK11-18 (diesel)	3.3 l	32.2	0.097 l	0.94
PK16-17 (liquid gas)	4.9 kg	62.8	0.162 kg	2.08

The total energy use from paper handling at the mill is calculated in Table 59 below. Furthermore, the weighed average kWh per handled paper tonne is presented in the table.

Table 59 Total energy use and energy use per tonne in handling of paper in 1998 at Voikkaa mill.

	KWH	KWH/TONNE
Pk11-18	303 593	0.9
Pk16-17	327 364	2.1
Total	630 957	1.3 (average)

7.5. Transport of paper from the mill to the Port of Kotka

The transport modes from the mill to the port are road and rail. The share of transport by road was approximately 55 % in 1998 at Voikkaa mill, and the rest was transported by rail. The planning and scheduling of the lorry transports is outsourced to a forwarding company, Combitrans, and Finnish Railways (VR) handles the rail transport.

7.5.1. Transport of paper by road

Transport Service Company

The transport service company Combitrans organises and plans the lorry transport of all the raw materials and paper (except timber). Combitrans also handles orders of wagons. Combitrans monitors the production of paper and gets information on the paper lots in order to plan and schedule transport. Bookings for shipping companies are taken care of by UPM-Kymmene Seaways. If a certain paper lot is manufactured early enough it is transported by train to the port. When the closing time for the ships approaches and the paper transport by train takes too long the paper must be transported by lorry.

It is not common that Combitrans monitors the processes closely. The transport is organized quite independently of Voikkaa mill. For example, at UPM-Kymmene's mill in Lappeenranta, Combitrans' duty is just to carry out the transport. Contracts, for example, with Finnish Railways are UPM-Kymmene's but Combitrans controls and schedules transport by train as well.

In the road transport sector, Combitrans is in continuous contact with the trucking companies and it provides the information on transport demand in the area. Combitrans has two kinds of contracts with the subtracting trucking companies; some trucking companies work permanently for Combitrans and others are employed when increased capacity is needed.

Transport of paper in containers

Containers have been used in the transport of paper at Voikkaa mill since 1997. The containers are loaded at the mill, and the lorry driver waits until the container is loaded (approx. 30 minutes). All containers are transported to the port by lorry so that two 20´ containers are transported at the same time by one full trailer combination lorry, and one 40´ container by one semi-trailer combination lorry. The number of containers transported from Voikkaa in 1998 and 1999 and their average loads are shown in Table 60.

Table 60 Containers at Voikkaa in 1998 and 1999. (Mölsä 2000)

	1998	1999
Tonnes transported in containers	74 000	48 000
Number of 40' containers	1 694	1 431
Number of 20' containers	2 218	1 074
40' average load, tonnes	21.3	21.1
20' average load, tonnes	17.1	16.4

Due to the differences between containers, the maximum load capacity of them may vary. In this study the used maximum load capacities are 18 tonnes for a 20' container and 24 tonnes for a 40' container. When examining the load factor of containers, it is to be noted that the weights of a container, a load and a lorry altogether must not exceed the allowed maximum weight. Consequently, the load factors of the containers cannot be increased significantly.

There are usually 10-12 handlings in the export chain of the paper from Voikkaa to Europe (the paper is usually taken straight to a printing house).

7.5.2. Fuel consumption

The values for fuel consumption presented in Table 61 have been used in this case and for the calculation model when calculating the transport of paper, kaolin and the chemical pulp.

Table 61 Fuel consumption (full and empty) and maximum loads of a trailer combination lorry, semi trailer, 20' container and 40' container. (VTT Communities and Infrastructure 2000)

	MAXIMUM LOAD	FUEL CONSUMPTION	
	Tonnes	Load factor 100%	Load factor 0%
		L/100 km	L/100 km
Articulated vehicle	40	48	32
Semi trailer	25	40	29
20' container	18	24	16
40' container	24	40	29

The fuel consumptions of the lorry used in this study are from another project of VTT Communities and infrastructure, where the emissions and energy use of different modes of transport per tonne-km were calculated. The results of the project can be found in WWW-pages of the LIPASTO model (http://www.vtt.fi/yki/lipasto/). In this case study the fuel consumption of the lorries before 1991 is used, because the real ages of all lorries transporting raw materials and products of Voikkaa mill are difficult to establish. The use of average fuel consumption values would have been even better, but the difference is not significant.

7.5.3. Rail transport of paper

Rail transport of paper in general

Wagons used at Voikkaa in rail transport are of the following type:

- 2-axis G-wagons (mostly used at Voikkaa)
  Capacity approx. 25 tonnes per wagon
- 4-axis SIM-wagons
  Capacity approx. 60 tonnes per wagon (higher rolls can be loaded into the SIM wagon than into the G wagon)

Separate trains run to both Kotka and Hamina. In general in the rail transport of paper at Voikkaa mill, the returning wagons are empty, and it can be assumed that the same wagons which have come full to the port return empty back to the mill (in practice they are not precisely the same wagons). In the rail transport of paper, the train goes from Kuusankoski to the railway yard of Hovinsaari where it is divided in parts; the front part continues to Kantasatama and the rear to Hietanen. The wagons are sorted according to the unloading points. VR Cargo gets a ready load in Kuusankoski from which it leaves only goods of Kuusankoski (small lots are not collected from other mills in the neighbourhood of Kuusankoski). From smaller mills, the paper load has to be collected but not in Kuusankoski, since the volumes of Voikkaa and Kymi Paper (paper mill next to Voikkaa) are adequate. The volumes are steady, and at the moment two trains per day run. If the volumes decrease, the second train is cancelled. On the other hand, if the volumes grow, however, then the capacity will be enough for some time still.

Shunting

In the factory of Kuusankoski (UPM-Kymmene Kymi Paper) there are two diesel locomotives used for shunting. The engines operate in two shifts (16 hrs/day/engine) and Voikkaa uses 45% of the engine capacity.

Table 62 Energy use in shunting at Kuusankoski and Voikkaa (Pik, 2000).

	ENERGY USE PER OPERATING HOUR	ENERGY USE PER TONNE (AVERAGE)
Fuel consumption (litres)	27	0.35
Energy use (kWh)	269	3.5

In the study, shunting has been calculated for the port and the mill separately. The shunting at the mill has been allocated to both timber and paper transport. Other shunting (the shunting of VR in general) has been taken into consideration due to the earlier studies (e.g. Pussinen, 1997), and added in the energy use of trains in the calculation model with the help of certain coefficients.

Energy use in rail transport

According to Pussinen (1997), the energy consumption of the goods train is 0.034 kWh/tonnekm by electric train and 0.11 kWh/tonnekm by diesel train. According to VR's Environmental report, the energy efficiency of the goods transport of the Finnish State Railways (VR Group) in 1998 was 0.25 MJ/tonnekm (0.069 kWh/tonnekm) and in 1999 0.24 MJ/tonnekm (0.067 kWh/tonnekm), including both electric and diesel trains (VR 2000). The energy use considering all the transports decreased due to the increase in use of electric trains, to the taking into use of new Sr2 electric locomotives, and to the rationalization of operations. When examining the energy consumption of the train in the case, the following issues have been clarified:

- Transported trip (km)
- Share of the electric train and of the diesel train of the transported trip (in the factory of Voikkaa generally 76% and 24%)
- The information of the G-wagon is used as the measures of the wagon that transport the paper
- Proportion of rail transport in transport of paper (45% of the paper tonnes, the rest is transported by lorry)

7.6. Handling of goods at the port and sea transport

7.6.1. Port operations

The port of Kotka consists of many separate ports: Kantasatama, Hietanen and Mussalo.The lorry transport in the harbour can be described as follows:

- The lorry comes to the gate and Steveco (a port operator) feeds the information about the lorry of UPM beforehand to the system (at least a shipment lot).
- At the gate the driver goes to the gate office where it is informed that the lorry is coming; => the foreman will reserve suitable equipment.
- When the paper is not in containers, the lorry drives to the unloading to the Lorry Centre where the load is unloaded by forklift lorry to the chassis (cargo is unitised for the sea transport).
    - The paper is unloaded mainly directly to the chassis but if it does not go directly onto them, then the rolls are stacked on the floor.
    - The chassis is transferred to the shelter for chassis where it waits for the transfer to the ship.
    - The chassis is pushed to the ship.

It takes approximately 20-40 minutes for the lorry in the port (it takes longer to unload paper rolls onto a chassis than stack them on the floor). Mainly a ro-ro load is transported to Lübeck. The basis for optimisation of operations and infrastructure at the port is the effectiveness of the handling. Efficient operation in the port saves energy as well. The factors of efficiency that the harbour operator can influence are among others:

- Efficient machine use
- Low warehouse piles
- Short drives

From the point of view of the harbour handling, there is no difference in whether a lorry or a railway wagon is unloaded. The trains come to the port from the railway yard of Hovinsaari.

Sorted trains are driven to the railway yard of Hovinsaari from which they are led, e.g. to Hietanen (the warehouse-specific sorting is performed already in Hovinsaari). In Hietanen the forklift lorry of 3-4 tonnes discharges the paper roll or a pallet at a time onto the chassis. If the paper is going to be in storage, then a small forklift lorry can handle a pile for a bigger forklift lorry (about a 12–tonne forklift), which takes it to the warehouse. Most of the outgoing paper to Lübeck is unloaded directly to a chassis; the small forklift lorry reloads the paper directly from the railway wagon to the chassis. When the load has been made, the chassis is transferred to the chassis shelter (likewise in lorry load handling). The goal is that the wagons are unloaded in about two hours.

The problem with containers is the fact that some equipment for the handling of containers is always needed. If the equipment is already located in the lorry, it will use the some of the load capacity of the transported goods.

The kaolin is stocked in a bulk warehouse and discharged by a bucket loader to the funnel from where the conveyor belt transports it to the warehouse. The ship that transports kaolin is usually full, and the kaolin is loaded in Rotterdam into the ships, which export paper from Finland. The ship that has transported kaolin must be cleaned after the transport.

7.6.2. Port operator's goals:

1. Transport efficiency and handling efficiency
2. Saving of energy
3. Reducing emissions
4. Reducing the amount of waste and recycling of the waste
5. Environmentally safe production

Steveco has obtained new straddle carriers for the container handling. At night and at weekends the containers are arranged (housekeeping), in which case the direct energy consumption in the harbour can increase, but the waiting times of the lorries and ships are shortened. The part optimisation of the transport chain is not reasonable but attention must be paid to the wholeness. The growth of the energy consumption in one phase of the transport chain may save energy elsewhere in the chain. The main problem in clarifying the environmental effects of the harbour handling and of energy consumption is in the data acquisition. The present information processing systems do not produce data for monitoring environmental effects.

Other problems in clarifying the environmental effects of handling are, among others:

- The handling does not generate "the consignment note" in which case it is not possible to obtain the lot-specific information.
- Activity-based costing is not used
- The machine-specific grouping (pulling equipment, container handling, forklift lorries, cranes) has not succeeded; nowadays the energy consumption and the emissions are calculated due to ways of loading (the containers, bulk, storlo[68])

[68] Storlo = a term including sto-ro, ro-ro, and lo-lo. The energy use of storlo is the average of sto-ro, ro-ro and lo-lo loading.

The environmental costs in the harbour constitute about 1 % of the turnover (in the factories 2-4 %). The port operator can count the conveyor systems as environmental investments.

7.6.3. Energy use at the port

The harbour operators' environmental competitiveness was monitored in the project of the Finnish Ministry of Transport and Communications "Environmental competitiveness of port operators - definition and tool" (Ministry of Transport and Communications Finland, 1999). The purpose of the project was to define and develop a practical method to monitor the environmental competitiveness of logistics service companies. The indicators have to be generally approved and they should function as part of environmental management in service companies, but also give customers real comparable indicators of logistics. The environmental competitiveness of port operators was defined with a balanced scorecard that included five elements. One of these elements was operational efficiency and environmental impacts, in which comparable indicators from real company data was calculated. Six Finnish stevedoring companies participated in the project.

The port operation has been grouped into a storlo, container and bulk operation. In general, the cranes of the port belong to the Port Administration. The energy consumption has been collected in the following table according to different ways of loading. The numbers are the averages of the harbour operators who have participated in the study on environmental competitiveness. For the unloading of kaolin in the port, the energy consumption of the bulk handling has been used. The handling of the paper has been calculated from the energy consumption of storlo loading except for the handling of containers, which has own energy consumption figures.

Table 63 Energy efficiency in handling of goods in the port. Averages of six port operators grouped by different loading ways [kWh / tonne handled goods](Ministry of Transport and Communications Finland, 1999).

	ENERGY EFFICIENCY (KWH/TONNE)
Storlo	3.9
Containers	6.8
Bulk	0.9
Whole port, average	3.7

By comparing the numbers, it can be seen that the loading of containers requires most energy whereas the bulk consumes one seventh. Among others, the container crane and the energy used by the transfer of empty containers affect the energy consumption of the harbour handling of containers.

In this study, the value of 0.38 litres (diesel) per tonne has been used for storlo, for the containers 0.52 litres per tonne, and for bulk 0.05 litres per tonne. These numbers for containers do not yet include the electricity consumption of the container crane.

The harbour of Kotka handled 134 000 TEU[69] containers (including empty ones), 79 000 pieces, in 1999. Ten to eleven per cent of the containers (about 7 900 pieces) were loaded ro-ro and the rest (71 100 containers) was loaded onto the ship with the container cranes. The weight of the containers altogether in 1999 was 1 050 000 tonnes (including the load, the weight of the container and the empty containers). The container cranes used nearly 1 000 000 kWh in 1999.
The energy use required by container handling amounted to 0.52 litres per tonne (5 kWh per tonne) in the port of Kotka. When the energy use of container crane 0.9 kWh /tonne is added, the sum of the energy use of container handling is approximately 6 kWh / tonne altogether.
To sum up the energy use at the port, the results of the case study calculation are represented below:

- Paper, lorry or train transport: 3.6 kWh/tonne
- Paper, 40' container: 6.18 kWh/tonne
- Paper, 20' container: 6.12 kWh/tonne
- Kaolin: 0.5 kWh/tonne.

The energy that is needed for the handling of the paper in the harbour is assumed to be the same as the energy use in storlo loading generally. The precise energy use of paper cannot be obtained since the handling phases - unloading the vehicle, storage, loading the chassis, transport to the ship, and stevedoring - are not calculated separately in the energy calculations of the harbour. Therefore, information systems provide no lot-specific data. The problem is the fact that it is not known precisely, how much a lot is handled; one lot can be handled by as many as eight different machines. The effect of the driving behaviour by diesel forklift lorries on the energy consumption is also a point that could be taken into consideration.

7.6.4. Sea transport

UPM-Kymmene Seaways manages the planning of the sea transports of the whole company, operation and the goods contracts (a trend is to focus more and more on the regular liner traffic). The objective is that storage would not be required at the mill. The distance from Kotka to Lübeck is 1 236 km. The energy consumption of ships is allocated to load usually according to lane metres. The generally used relation of tonnes and lane metres is 3.05 tonnes / lane metre. For the paper this relation is a bit different (Tapaninen, Karsio 2000).

The energy use in the sea transport of paper from Kotka to Lübeck with the ro-ro vessel amounts to 0.12 kWh/tonne-km (Tapaninen, Karsio 2000). In the paper ships the load factor is usually good; about 85-90 % on average. If, however, the yearly ship-specific emissions and energy consumption are calculated, the load factor is usually lower since the same ship can transport many sorts of goods on many different routes. Usually consumer goods, etc. are transported from Central Europe to Finland as return loads. The load factor (=utilization rate) of the return transports will remain in 50 % on average if it is measured in tonnes. However, the load factor of the return transports is about 70 % when it is measured due to load metres.

The most significant factors when calculating the energy use of transport of paper by sea are:

- load factor (utilization rate)
- speed of the ship

[69] TEU = twenty-foot equivalent unit, the space occupied by a standard twenty foot container.

- return transport

In particular, with regard to the storlo and ro-ro ships, the speed is the most significant factor that affects the energy consumption of ships. Whether the ship runs empty, full or half full, has actually no effect on the energy consumption (only 1-2 %).

In this case study the fuel and energy consumption of the ship is calculated from the engine output (not including auxiliary engines). For example, when the engine output is 13 200 kW (e.g. Oihonna, a typical paper transporting ship of Finncarriers) the used value in calculations is 85% of that, i.e. 11 220 kW, since the maximum power is usually not used (Finnlines, 2000). In addition, the maximum load capacity of the ship is calculated from DWT. It is assumed that approximately 10 to 15 per cent of the DWT is needed for other goods than actual transported load (e.g. luggage, crew, etc.). Furthermore, it must be taken into consideration that the load factor usually is not 100%, but for sea transport of paper it amounts to 90% in average (measured according to tonnes). The load factor for return loads from Central Europe to Finland (consumer goods etc.) is approximately 70% in average, when it is considered according to volumes. According to tonnes it remains lower, approx. 50%.

7.7. Transport from the Port of Lübeck to the customer

7.7.1. General

The transport from the port of Lübeck to the customer is not considered from a particular customer's point of view, but two areas in Germany (Hamburg and Cologne) have been selected. The transport to the customer is not included in the calculation model, and therefore no accurate energy consumption figures are available. However, the energy use in transporting paper in Germany can be estimated to be quite similar to Finland taking account of some minor differences. First of all, the lorries are smaller in Central Europe than in Finland. Secondly, the weather conditions are different; the cold energy consuming winter doesn't exist in Central Europe. On the other hand, there is more congestion in Germany than in Finland.

Distance from Lübeck to Cologne:

- by train 492 km
- by lorry 488 km

Containers or boats are not used for on-carriage transport from Lübeck to particular customers. The on-carriage transport - for example- to the final destination Hamburg is carried out - in each and every case - by lorry. Due to the fact of the short distance (Lübeck - Hamburg = approx. 70 km) these transports are treated as so-called "short distance traffic". Deliveries to the final destination Cologne are primarily performed by lorry, but also some by train (Schacht, 2000).

The shares of lorry and rail transport for UPM-Kymmene products in Germany are as follows: Lorry transport constitutes between 70 and 75 % , the rest of the volume is transported by rail. In the train transport, 90 % is by electric locomotives, while 10 % by diesel train.

7.7.2. *The energy use of paper transport to the customer*

The calculation model does not cover the transport in Germany in this case in all details. The estimate of the energy use of paper transport from the port of Lübeck to the customer in Germany, however, can be calculated from the fuel consumptions in Finland. Since the allowed maximum weight for lorries is smaller in Germany than in Finland, the fuel consumption of a semi trailer is used (see Table 61). The energy use to the customer is calculated in the summary. It is essential to take into account that the energy use depends on the fact whether the lorry returns back with a full load or without a load. It can be discussed whether the factor used to describe the amount of other driving (refuelling, lunch breaks etc.), 1.2., is too large in this case, since the transport distance is long compared to transport distances in Voikkaa. However, this factor has been used in calculating the transport to the customer as well.

In the calculations, the average distance 490 kilometres from Lübeck to Cologne is used for both modes of transport. The energy use of the shunting work in Germany is assumed to be the same per paper tonne than in Finland, i.e. 3.5 kWh/tonne in average. The shunting is assumed to be performed twice, as in Finland too, so the total energy use of shunting amounts to 7 kWh/tonne.

The unloading of paper at the customer is assumed to use energy as much as the loading of paper at Voikkaa, 1.3 kWh / tonne. This may vary depending on the forklifts used in unloading, but however, the differences are considered to be not significant.

7.8. Pilot actions within the Finnish case company

Initial pilot actions were described in the report from Phase 1 (Andersen et al.1999). Together with the case company UPM-Kymmene the list of pilot actions was modified. Owing to the complexity of the transport chain UPM-Kymmene is not able to directly affect all operation in the chain. Therefore, the list on actions applicable to UPM-Kymmene can do is presented below:

Transport from mill:

- Transport planning
- selection of transport mode
- selection of subcontractors
- monitoring the prime route implementation
- demand/supply mechanism
- payload and return loads

The Ports:

- Transport planning
- Objectives for port operators (it is possible to affect operations only indirectly)

Sea transport:

- Transport planning

Distribution to customer:

- Selection of transport mode
- Selection of transport operators
- Monitoring the prime route implementation
- Payload and return loads

Transport planning of the whole transport chain:

- Strategic structural planning
- Route planning
- Storo/Ro-ro, containers and rail ship: long-term planning
- Reduction of direct transport
- Long-term co-operation with subcontractors (preferred partners)

When the most important actions are summarized the list could look like this:

- Mode choice between mill and port; train, lorry, container, direct train, direct lorry, floating, canal
- Containerisation in the mill or port (intermodal)
- Selecting criteria for subcontractors
- Prime route follow-up (monitoring and measuring)
- Further potential for utilizing of return loads
- Routing for the whole chain

From these pilot actions the effects of mode change and further utilizing of return loads on the energy use are calculated with the help of the constructed model. The model is presented in Chapter 7.9. In addition, the effect of lower fuel consumption level is considered in the next chapter. The fuel consumption could be reduced for example by driver education.

The initial pilot actions consisted of four levels: management, driver and service levels, and level of logistics improvement. These levels haven't been used in Phase 2 anymore since the transport chain is composed of many different companies, and thus of many various management, driver and service levels. Consequently, the level, in which the case transport chain is considered, is actually the level of logistics improvement.

7.9. Calculation model

7.9.1. Introduction

This part of the SAVE research project concentrates on a case study of the energy use of a Finnish paper company that transports raw materials to the factory and sells paper to clients. The purpose of the study is to compare the energy use of different modes of transports in the transport chain from the raw material to the end product. Special attention is paid to determine the possibilities of combining loads on vehicles for incoming and outgoing traffic, and a comparison is made between rail and road transport. Another purpose of the study was to determine the energy use of sea transport between Kotka in Finland and Lübeck in Germany.

The raw materials are:

- Wood / logs
- Kaolin
- Chemical pulp
- Miscellaneous raw materials

The logs mainly come from Finnish forests at an average distance of 80 kilometres from the mill, with the distance very seldom more than 300 kilometres. The majority (64 % of the tonnage) of the logs are transported by special lorries that can each carry 40 tonnes, and about 27 % of the raw material is transported by rail. Only about 9 % of the logs are transported by ship, but owing to the speciality of sea freight, this study does not include the ship transports of raw materials.

The kaolin comes to the mill from the UK via Kotka harbour, where it is stored in warehouses in large lots. This is a bulk cargo that is transported by articulated vehicles capable of carrying powder. The vehicles are equipped with a crane that can unload the cargo by lifting the trailer to allow the kaolin to flow directly into the silo.

Chemical pulp comes from Finnish factories by articulated vehicle. In this study, the kaolin comes from one factory located about 105 kilometres away from the mill.

Miscellaneous raw materials, such as lye, are transported by lorry, but these raw materials make up only a small part of the total volume. They mainly come from Finnish factories, or from the ports, and estimated to be 80 kilometres from the mill.

The paper factory also needs energy to produce paper. The transports of “bark residue” total about 250 000 tonnes per year. However, the transports of energy materials are not included in this study.

The paper is transported by different means of transport mainly via two harbours, Kotka and Hamina, to global clients. Kotka and Hamina are located close together, at a distance of only 20 kilometres apart. Articulated vehicles, containers and rail mainly transport the paper. The cargo coming by rail and articulated vehicles is reloaded in the port warehouse on chassis and then pulled onto the ship. The containers go directly onto the ship. Two twenty-foot containers are hauled together by one articulated vehicle.

The cargo vessels calling at Kotka and Lübeck in Germany have three types of rotations:

- a to-and-from route between Kotka and Lübeck
- a triangular route between Kotka – Lübeck – Helsinki – Kotka
- a specific route

In the first and second case, the vessel calls at Kotka on a weekly basis. In the last type, the vessel makes one whole trip every two weeks.

The following figure illustrates the three types of ship rotations serving clients in the Kotka area.

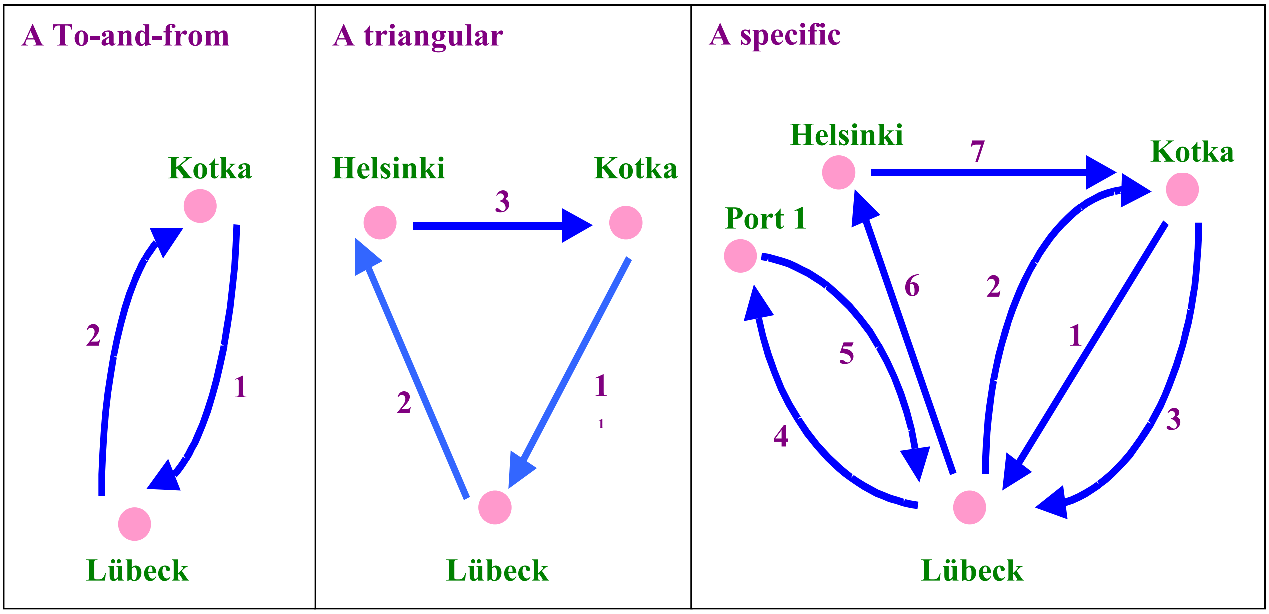


Figure 52 The rotation of cargo vessels between Kotka and Lübeck

7.9.2. Transport of logs to the mill

Transport by lorry

The transport is by lorries specialised in log transports. These units can each carry 40 tonnes of cargo. The lorries are equipped with a crane and thus no other work force is required. It is estimated that the return trip as empty is 1.2 times more than the actual transport distance. About 64 % of the logs are transported by lorry.

In the model there are three elements:

- Handling of logs
- Transport of full loads to the factory
- Returning the empty unit back to the loading place

Transport by rail

Rail transport comprises two phases. In the first phase, the logs are transported with lorries (above) to the nearest railway station. Once there, mainly the driver reloads the logs onto the railway wagons. The logs are pulled to a bigger station, where a whole train of 20 – 40 wagons is coupled and pulled to the station near the factory. A separate engine is needed to move the wagons between the factory area and the nearest station.

The model has the following elements:

- Handling of logs
- Trucking of full loads to the nearest railway station
- Returning the empty unit back to the loading place

- Railway transport of the full wagons to the railway station near the mill
- Returning the empty wagons back to the loading place
- Additional movements of the wagons
- Additional energy use that rail transports require
- Unloading of the logs at the mill

- Additionally, a comparison between electrical engines and diesel engines has been made in this model

The comparison between these two means of transport is done according to the weight of the lots and the distance from the mill. The basic starting point is a typical forest located 100 kilometres away from the mill by road, 20 kilometres away from the nearest railway station, therefore 120 kilometres away from the mill.

The diagram below shows that, when the shipment is less than 300 tonnes, the energy use with lorries is lower than with a train. As the volumes exceed 300 tonnes, the train is more economical.

Figure 53Transport of logs; comparing lorry and train.

7.9.3. Transport of other raw materials to the factory

Kaolin

Kaolin is transported from the port of Kotka to the Voikkaa mill. As Kotka is one important paper export port of the Voikkaa mill, there is potential for combining kaolin and paper on the same lorry. This has not happened so far, because of the following reasons (among others):

- these products require different types of equipment
- the benefit is limited, as the loss of time has proved to be greater than the benefit of combining the loads.

Being aware that some other factories have utilized kaolin reloads, we have included the possibility of using kaolin return loads for paper. As the kaolin volume (134 000 tonnes / year) exceeds the paper volume via Kotka by lorry, we assume that every paper load gets a return load, if required.

- The model has the following elements:
- Loading at the port
- Trucking of full loads to the mill
- Unloading of kaolin at the mill
  - Returning the empty unit back to the loading place
  - Or trucking the empty unit from the paper port to kaolin port

Chemical pulp

Chemical pulp is mainly transported by lorries to the Voikkaa from the UPM-Kymmene mill in Lappeenranta. The total volume per year is 114 000 tonnes, which is more than the paper transports to Kotka. The distance from Lappeenranta to Voikkaa is approximately 105 kilometres, and the distance to Kotka port is 120 kilometres (from Lappeenranta). Technically it is possible to combine paper loads and chemical pulp. As the distance between Kotka and Lappeenranta is 120 kilometres, it seems evident that it is more economical to combine the return load with kaolin than with chemical pulp. The model takes into consideration both possibilities as well as today's practice of returning the empty unit to the loading place.

The model has the following elements:
- Loading at the shipper's factory
- Trucking of full loads to the mill
- Unloading of chemical pulp at the mill
  - Returning the empty unit back to the loading place
  - Or trucking the empty unit from paper port to the loading place

Miscellaneous raw materials

Miscellaneous raw materials are transported from different loading places to the mill. In the case study, the volume is relatively small – estimated at 10 000 tonnes.

7.9.4. Conclusion for energy savings by combining the trucking of return loads of raw materials and loads of paper

The Table 64 below presents the energy use (kWh) for "a normal day". The first column shows the name of the product, the second shows the volume in tonnes. The column "Present" shows the present energy use for a limited exploitation of return loads. In the fourth column, the transport of kaolin has been combined with the transport of paper (exploitation of return loads). In the fifth column, the transport of chemical pulp and the transport of paper have been combined. In the last column, both kaolin and chemical pulp have been combined with paper trucking.

From the table it can be seen that by combining kaolin and paper loads the energy savings is almost 18%, the highest percentage. The percentage for combining chemical pulp and paper gives only about 4 % energy savings. It is interesting to notice that it is more energy-efficient to drive the triangle with 120 kilometres "empty side", and 105 kilometres with a load of chemical pulp instead of driving only 65 kilometres empty from mill to the port. The reason for this is the fact that the "empty kilometres" (= no load) can be minimized with the help of a triangle. Thus one lorry must drive empty 120 kilometres. If both hauls are kept independent, the first lorry drives 65 kilometres empty and the second one drives 105 kilometres.

Table 64 Energy use in different transport possibilities.

Exploitation of return loads		Present method	Concentration to:		
			Kaolin	Chemical pulp	Combination of both
	Tons	kWh	kWh	kWh	kWh
Kaolin	367	5553	4249	5553	4661
Chemical pulp	312	7674	7674	7375	7439
Misc.	27	558	558	558	558
Paper	100	5127	3054	4676	3389
TOTAL, kWh		18913	15535	18162	16047
Savings, %			17,86	3,97	15,15

It can be seen from the chart above, that the model divides the energy saving for both incoming and outgoing (paper) cargo. This is covered in more detail in the next section.

7.9.5. Paper haulage from the mill to the port

The mill ships yearly about 184 000 tonnes of paper via Kotka port, which is about 40 % of the total production. About 55 % of the Kotka volume (100 700 tonnes) is transported by lorry (trailer combinations, semi trailers and containers). Trains transport about 45 %. The distance to the port is 65 kilometres. Normally the units arrive back to the factory empty.

Trucking of paper to the port

The model estimates four potential return loads for paper shipments:

- Loading of kaolin
- Loading of chemical pulp
- Loading of miscellaneous cargo
- Loading of different clients' cargo

The last of the above return loads is excluded from our study, because it is not relevant at a paper factory, but a normal procedure for a logistics / forwarding company.

The model estimates the savings on a yearly basis. This means that on a daily basis the maximal benefit is reached with a volume of 100 700 tonnes / 365 days, which is approximately 275 tonnes per day. As the loading of potential return goods (kaolin, chemical pulp and miscellaneous cargo) is more, about 700 tonnes per day, the shipments are always in imbalance, unless the shipments via Hamina and by rail are included in the total volumes.

The model has the following elements:

- Loading of paper at the paper mill
- Trucking of full loads to the port of Kotka
    - Returning the empty unit back to the loading place
    - Or returning the empty unit to the loading places of
        - Kaolin
        - Chemical pulp
        - Miscellaneous raw materials
        - The loading of the above products, haul to the factory and unloading
- The unloading of the paper at the port is considered separately in the section "Port"

Train transport of paper to the port

Approximately 45 % (86 500 tonnes per year) of paper is transported by train to Kotka port. The cargo is unloaded at the port and loaded on a chassis and then pulled onto the ship. The train operation is multistage. A separate engine at the factory area handles the operations. The engine moves the loaded wagons to the nearest railway station. From there the wagons are pulled to the port operation area. New engines pull the wagons to the right sites at the port, and finally, after unloading pull them back to the port operation area.

The advantage of using rail is that with large volumes the energy consumption is advantageous compared to lorry transports. The disadvantage is that rail transport is not very flexible, especially with urgent shipments. This leads to an additional need to store the paper both at the factory and at the port. In practice, trains transport regular lots, which can be shipped in good time before the vessel departs. Lorries transport the urgent shipments.

The model has the following elements:

- Loading of paper at the paper mill
- Operations of the mill's engine in the mill area
- Moving the full wagons to the port operation area at Kotka
- Moving the full wagons to the sites at Kotka port and moving the empty wagons back to port operation area.
- Returning the empty unit back to the loading place
- The unloading of the paper at the port is considered separately in the section "Harbour"

7.9.6. A comparison between a lorry and a train in paper transports to the port

A comparison has been made for three possible versions:

- The present situation
- Concentrating all the shipments on lorries
- Concentrating all the shipments on trains in the present situation

The factors that influence the versions:

1) Transport volume of kaolin (tonnes)

2) Transport volume of chemical pulp (tonnes)
3) Transport volume of miscellaneous raw materials (tonnes)
4) Transport volume of paper (tonnes)
5) Exploitation of return loads for lorries
6) Minimising the fuel consumption

The present situation is the procedure that the paper mill is mainly using and this is described in the preceding sections. Concentrating all the shipments on lorries means that lorries (articulated vehicles, trailers, and containers) haul all the shipments of paper. Concentrating all the shipments by train means that trains transport all the shipments.

The factors 1 (kaolin), 2 (chemical pulp) and 3 (misc. raw materials) correspond with the factory's yearly production on a daily basis. Therefore, they are constants. The paper volumes and the exploitation of return loads vary in the model (variables). The possibility for significant fuel consumption (>5 %) is estimated.

The charts below illustrate the maximal energy savings.

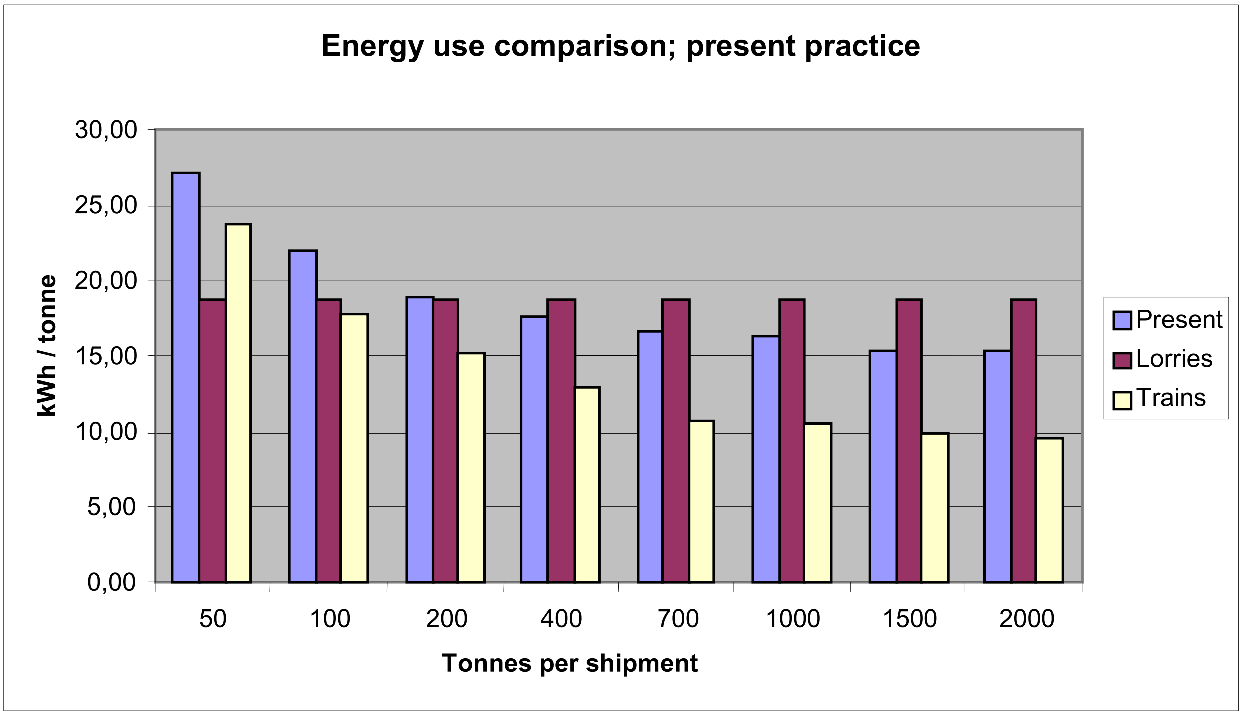


Figure 54 Energy use in the present situation

The bar chart shows the energy use for three alternatives. The first bar in the chart ("Present") describes the energy use in a situation where both trains and lorries are used according to today's established practice. Return loads are not utilised and the fuel consumption is normal. The table shows that the energy use per tonne decreases as the weight of the shipment grows. When the weight of a shipment is 50 tonnes, the energy use in the present situation is approximately 27 kWh per tonne. Consequently, as the shipment is 2 000 tonnes, the energy use in the present situation is approximately 16 kWh per tonne.

The second bar in the chart describes the energy use for the alternative where all the shipments are concentrated on road haulage, but return loads are not utilised, and the fuel consumption is normal. The energy use per tonne does not change as the volume grows, because the synergy effect is limited. When the shipment size is less than 200 tonnes, the energy consumption favours road haulage.

The third bar in the chart describes the energy use for a situation where all the shipments are concentrated on trains. This alternative is more economical than the present situation. As the shipment is 2 000 tonnes, the energy use in the present situation is 9.5 kWh per tonne. This alternative becomes more economical than road haulage as the weight of a shipment exceeds 100 tonnes.

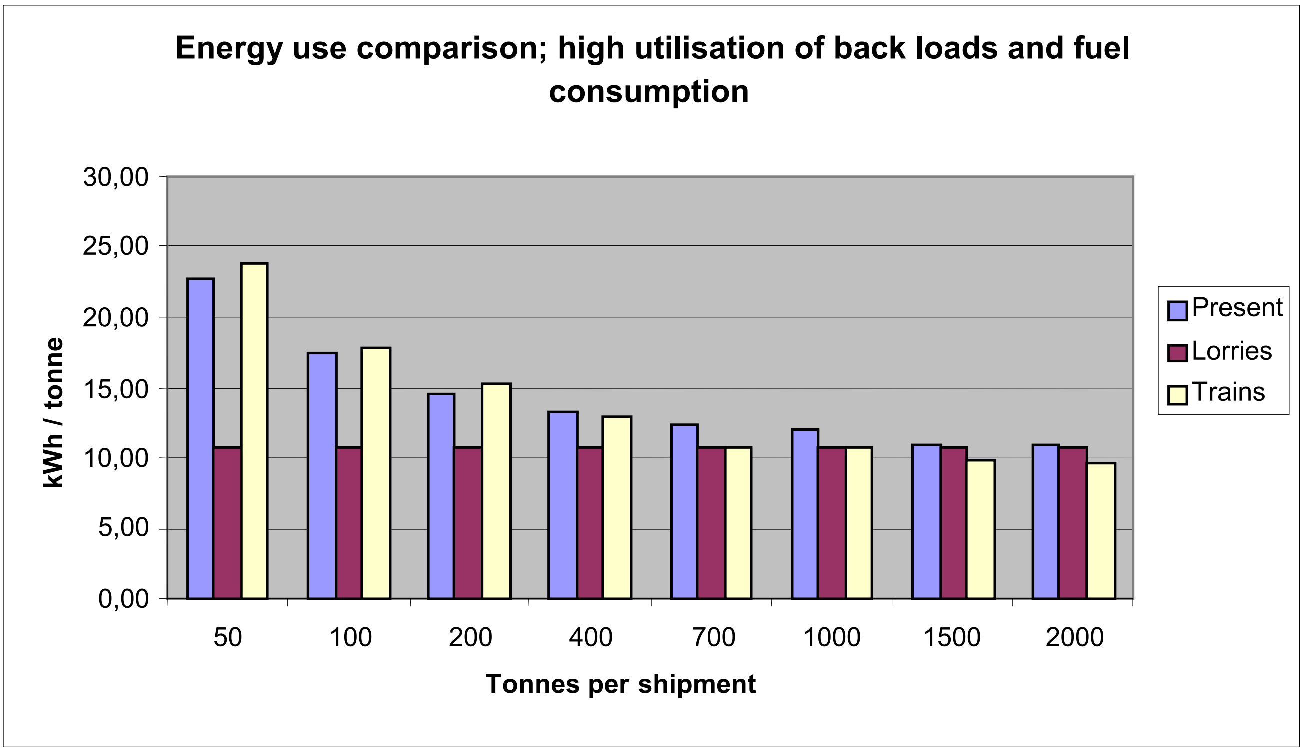


Figure 55 High utilisation of return loads and of fuel consumption

This bar chart shows the energy use for the same three alternatives as in the previous section. The first bar in the chart ("Present") describes the energy use in the situation where both trains and lorries are used according to today's established practice, but return loads are utilised and the fuel consumption decreases 5 %. When the weight of a shipment is 50 tonnes, the energy use in the present situation is approximately 23 kWh per tonne. Consequently, as the shipment is 2 000 tonnes, the energy use in the present situation is approximately 11 kWh per tonne.

The second bar in the chart describes the energy use for an alternative where all the shipments are concentrated on road haulage, return loads are utilised and fuel consumption decreases 5 %. The effect of utilising return loads strongly supports this alternative and makes road haulage favourable in most classifications. The consumption is 10.7 kWh per tonne. Additionally, as mentioned in Section 7.9.4, our model takes account the energy saving also for the raw materials and divides the savings between both cargo. Therefore, on a company level, the saving is bigger than in this bar chart. The total saving is analysed in "The energy use in a transport chain".

The third bar in the chart describes the energy use for an alternative where all the shipments are concentrated on trains. This alternative is the same as in Figure 54, because the back haulage in this study is only defined as road haulage. However, we conclude that – presuming the cargo allows return haulage for trains – this alternative would become more attractive. Our estimation, based on the results of energy savings for road haulage, is that the energy saving could be 20–30 %. Additionally, this estimate does not consider the significance of engine type (electrical or diesel). This question is analysed in section 8.6 "The energy use in a transport chain".

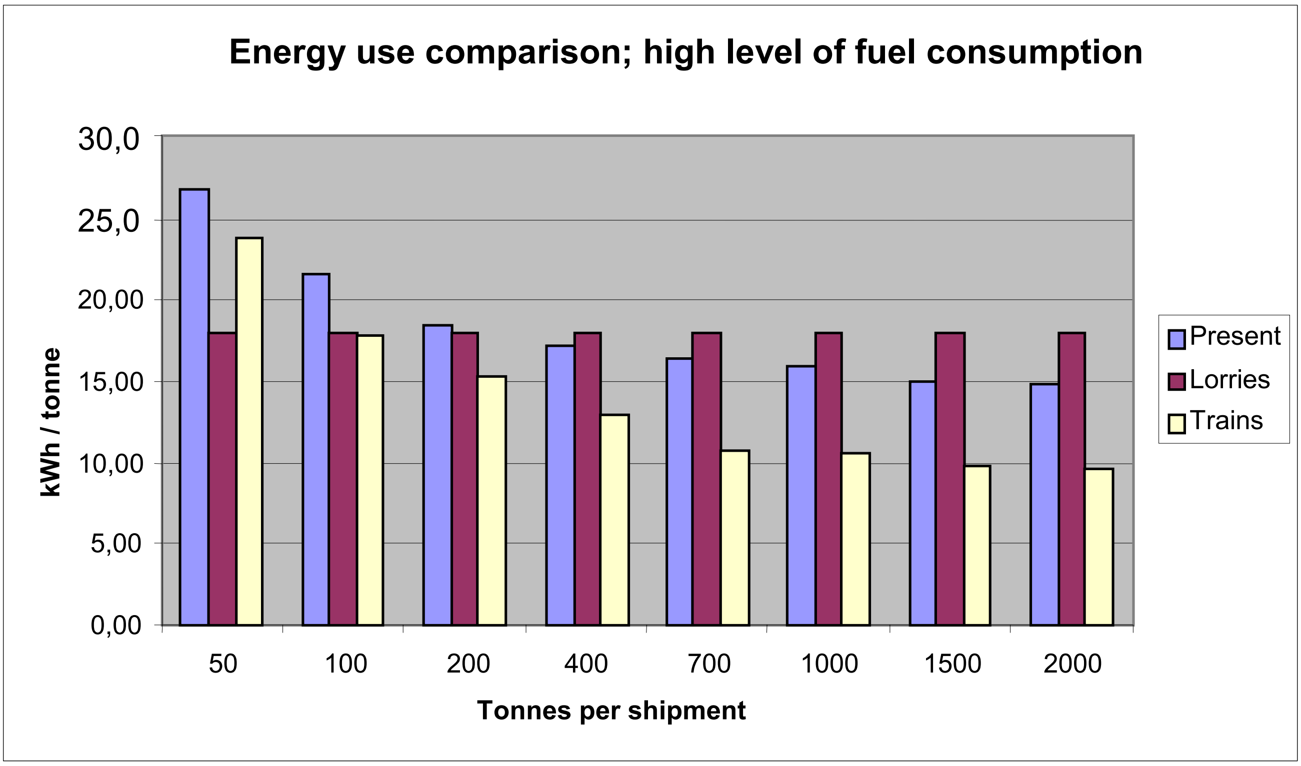


Figure 56 Minimised fuel consumption

This bar chart illustrates the effect of economical road haulage in energy use. During our study, we received slightly different values for the fuel consumption. Some drivers have acquired modern lorries and accessories to reduce fuel consumption. This model corresponds to Figure 54, page 138. The difference is that here a 5 % saving in fuel consumption is considered.

From the table it can be seen that the energy use for lorries is 17.9 kWh per tonne. Compared to the corresponding value of Figure 54 (18.8 kWh per tonne), the energy savings is approximately 5 %.

7.10. Port operations and sea transport

7.10.1. Port operations

The paper that is transported by trains is reloaded at the port. One part of the paper is kept in the port storage until it is shipped and another part is loaded on a chassis on arrival and then pulled via a specific shed onto the ship.

The paper which arrives by lorry is handled according to the means of transport. The paper that arrives by articulated vehicles and trailers is reloaded in the same way as train transports. The paper that is loaded into containers (20′ and 40′) is put onto the ship in the same containers without reloading.

The port operators do not yet collect exact data on their energy use for different operations. Consequently, the numeric values are mean values of the total general energy use of the port. A comparison between different ports has not been made, because of the previous reason and because Finnish ports in those areas (Helsinki, Kotka and Hamina) concentrate on different types of services, and thus they are partly not comparable with each other.

The model has the following elements:

- The handling of loose cargo
- The handling of containers in the port area
- The container lift into the ship
- The handling of bulk cargo

7.10.2. Sea transport

The cargo vessels calling at Kotka and further at Lübeck, Germany, have three types of rotations:

- to-and-from route between Kotka and Lübeck
- triangular route Kotka – Lübeck – Helsinki – Kotka
- a specific route

In the first and second case, the vessel calls at Kotka on a weekly basis. In the last type, the vessel makes one whole trip every fortnight. The different rotations depend on the market situation. The shipping companies try to optimise the productivity of their fleet by changing the ships and rotations according to the market requirements. However, they maintain their good service by granting exact loading times for the cargo vessels. It is typical that the same vessel arrives at the specific port on the same day, weekly or every second week.

The energy consumption does not much depend on the weight of the cargo. Only about 2 % of the energy use depends on the weight. The weight of the ship exceeds many times the weight of the cargo, and the safety of the ship requires that, if there is no cargo, water being pumped into the ballast tanks.

According to a shipping company, the speed of a ship is the best indicator of its energy use. The optimum speed of Finnish liner vessels is approximately 17 knots. At higher speed the fuel consumption increases rapidly.

The energy use can be estimated quite reliably by dividing the total energy use of a ship by the total cargo the ship transports during its round trip (kWh per tonne kilometre,) and then weighting the value according to the kilometres that the specific shipment requires.

It therefore follows that the energy consumption depends on the capacity usage of the ship. Since this is not dependent on the shipper, and as the exact energy use of one client is partly speculative, we do not estimate the most attractive possibilities. We compare ´"the most wasteful" rotation with "the most effective" rotation.

The model has the following elements:

- The rotation of the ship on a weekly or fortnightly basis
- The distances between the ports
- The maximal power of the ship (kW)
- The used power (kW)
- The maximal cargo capacity
- The normal loading measure to different destinations
- The speed in knots

7.10.3. Conclusion of energy use for harbour operations and sea transport

The following table gives the energy use in the harbour and for sea transport, both kWh per tonne and kWh per tonne-kilometre. Because of the mean values of the energy use at the port and during the sea transport, the model gives constant figures in all weight categories.

Table 65 Energy use for the handling in the harbour and for sea transport, kWh/tonne and kWh/tonne-kilometre.

	kWh / tonne	kWh / tonne-kilometre
Harbour	4,30	4,300
Least effective	160,36	0,125
Normal	153,72	0,120
Most effective	149,21	0,116

The harbour energy use is 4.3 kWh per tonne. This is a slightly higher value than the stevedore company reports. The reason for the difference is that the company only counts the energy use that they are responsible for. The container lifts into the ships are included in these calculations. In the model it is estimated that the distance from the port gate to the pier is one kilometre.

The least effective ship uses 0.125 kWh per tonne-kilometre. This is 7.8 % more than the use of the most effective one. In total consumption the difference is considerable. An energy consumption of the least effective shipment of 400 tonnes of paper from Kotka to Lübeck is

64 250 kWh. The distance is 1 285 kilometres. The difference between the most effective (59 624 kWh) and the least effective shipment is 4 626 kWh.

7.11. The energy use in a transport chain

7.11.1. Restrictions of the model

The model is a holistic one that is defined in parts on the previous pages. There are some restrictions. First, the products selected are raw materials and paper. Much cargo arriving at the mill does not belong to these groups. An example is the transport of the fuel and the energy that the factory needs to run the paper machine (e.g. wood chips used to produce energy). Secondly, the kaolin is produced in the UK. The transport from the UK to Finland is not included. Thirdly, Kotka is one port that the mill uses. By connecting other harbours, especially Hamina port, the efficiency might change. Fourthly, this model does not consider capacity restrictions, which might influence the decisions made today. Lastly, the companies make many of their financial decisions according to money savings. Even though there are common features between energy savings and money savings, there are also differences: a lorry that does not move does not consume energy.

The total consumption with the present mode is 114 452 kWh.

The ship transports clearly differ from the other parts. On the one hand, in the chain their energy use is approximately 70 % of the total, but on the other hand the efficiency is remarkable. The energy use per tonne-kilometre is 0.12, which is about 50 % lower than the use of other means of transport.

The use of electric locomotives instead of diesel decreases the energy use for trains. The estimation is restricted to the transports of logs only, but by comparing the values of train in the present situation (10 686 kWh) and electric locomotive (7 535 kWh), we can see that the saving is approximately 30 %. Compared to the diesel locomotive, the difference is about 45 %.

The following figure illustrates the energy savings potential. The lowest energy use is category 8 with a use of 102 000 kWh. Compared to the present use of 114 000 kWh, the potential savings of energy is about 10.5 %.

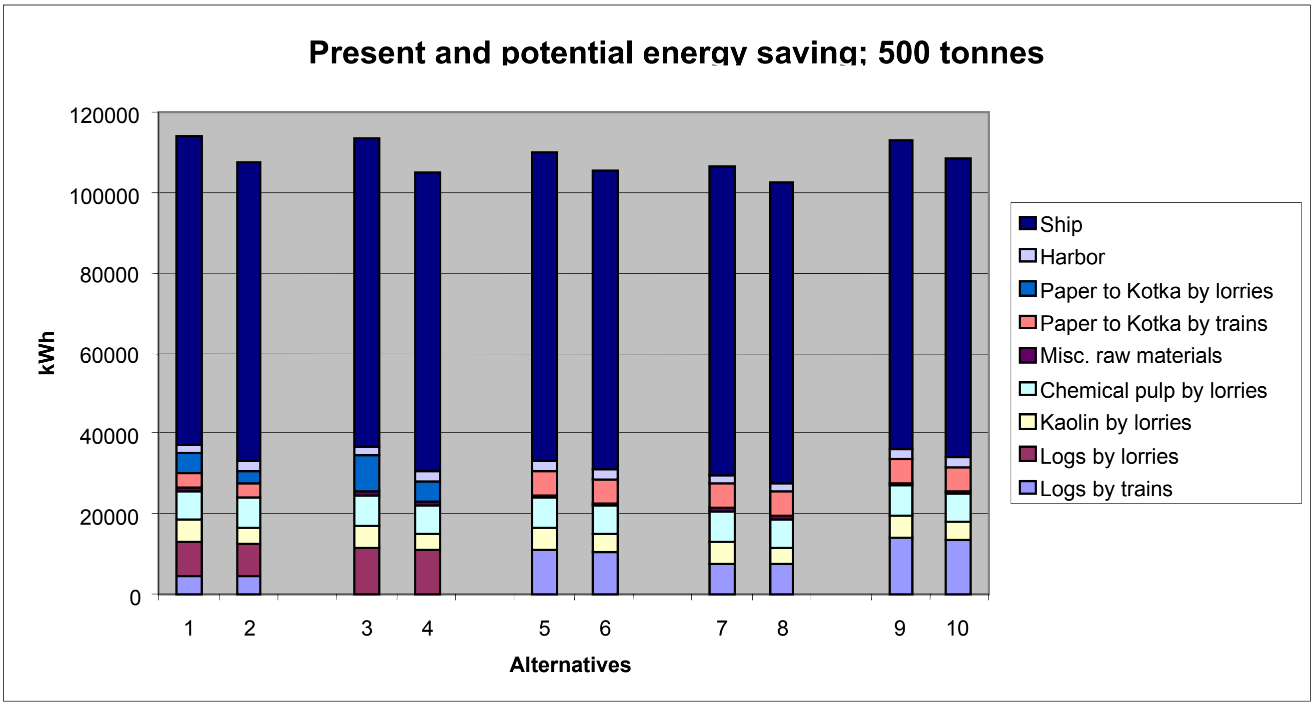


Figure 57 Present and potential energy saving; paper 500 tonnes, logs 400 tonnes

The categories in
Figure 57 are:

1. The present mode
2. The present mode including exploitation of return haulage, fuel consumption and minimised ship rotations
3. The present mode where all the possible transports are concentrated on roads
4. The mode where all the possible transports are concentrated on roads, including exploitation of return haulage, fuel consumption and minimised ship rotations
5. The present mode where all the possible transports are concentrated on rail
6. The mode where all the possible transports are concentrated on rail, including exploitation of return haulage, fuel consumption and minimised ship rotations
7. The present mode where all the possible transports are concentrated on rail with electric engines on the main route
8. The mode where all the possible transports are concentrated on rail with electric engines on the main route and including the exploitation of return haulage, fuel consumption and minimised ship rotations
9. The present mode where all the possible transports are concentrated on rail with diesel engines on the main route
10. The mode where all the possible transports are concentrated on rail with diesel engines on the main route and including exploitation of return haulage, fuel consumption and minimised ship rotations

The energy use fluctuates in the range of 100 000 to 120 000 kWh. The great significance of ship transports is clearly seen from the table. It easily dominates in importance over the other parts. The present mode has the highest energy use, but the differences are quite small. In all of the cases it seems evident that, by concentrating the haulage to either train or lorries, by utilising return loads and by some exploitation of shipments, the mill can save energy.

The figure below represents a shipment of 50 tonnes. The energy use fluctuates between 30 000 and 37 000 kWh. Small shipments favour road transports. As the volumes of kaolin, chemical pulp and miscellaneous raw materials remain at the same level in all classes, their weight in the table is large compared to the previous table. The value of category 4 is 31 000 kWh, while the present use is 36 000 kWh. The difference of 14 % is a potential saving.

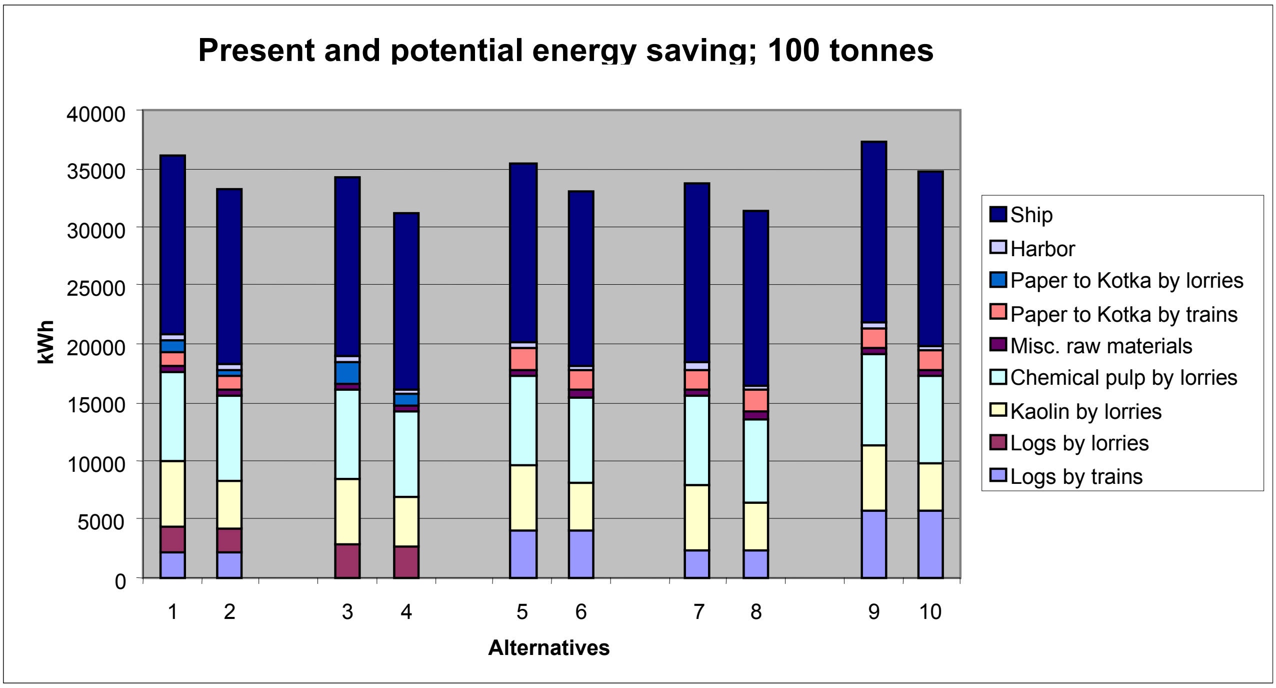


Figure 58 Present and potential energy saving; paper 100 tonnes, logs 100 tonnes

The Figure 59 illustrates a paper shipment of 1 000 tonnes. large volumes favour rail transport. The lowest energy use (category 8) is 192 000 kWh, while the present use is 217 000 kWh (category 1). The difference is 25 000 kWh (exactly 24 829), which is more than 11 %.

The energy use of category 3 is higher than that of the present situation. This means that concentration on road haulage does not seem to produce energy savings, unless the return loads are on hand.

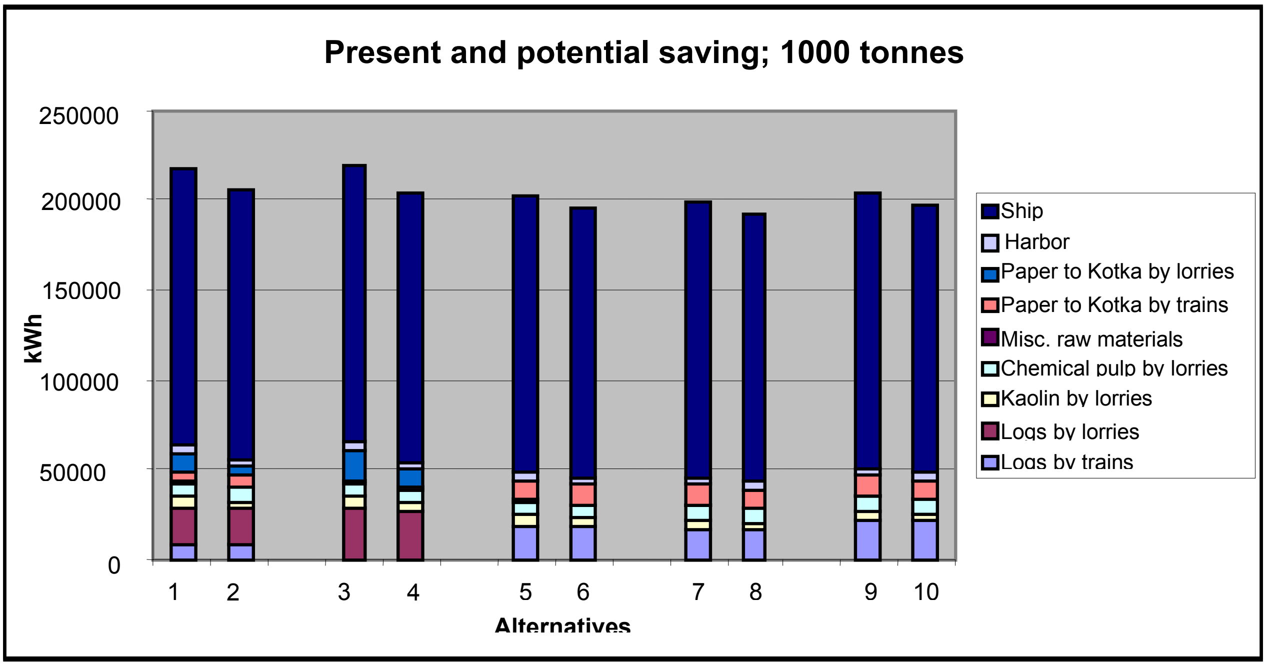


Figure 59 Present and potential energy saving; paper 1000 tonnes, logs 1000 tonnes

7.12. Conclusion – Further studies

Measuring the energy use in a transport chain requires the consideration of hundreds of large as well as small variables. Transport never takes place in static circumstances. Companies have to base their decisions on long-lasting structural solutions. Often the right option is not the maximum but the optimum.

In our study we found that there are possibilities to save energy in the transport chain. Low energy use favours concentrating on large lots. We found some opposing questions:

- Two harbours in the close proximity
- Lorries and trains providing the same kind of a service
- Some products that might be suitable to transport with return loads

Cargo vessels are economical when comparing energy use per tonne kilometre. Their share of the total energy use in the chain is about 70 %. Their energy use largely depends on the speed and implicitly on the loading volumes. We found some energy fluctuation between the vessels.

During our discussions we learned that by training the drivers some savings could be achieved. The fuel consumption varied some 5 % between the drivers. Some drivers did not know how much their consumption was. Some advanced drivers and logistic companies study very carefully the consumption and are keen to investigate into new accessories.

Careful planning is important for haulage. In particular, when there are many loading places for incoming and outgoing cargo, the possibility to combine the hauls requires the ability to control the transport chain.

Our model is structured for one case study with one kind of a transport chain. We are confident that the model could be a useful tool for any kind of authority as well as company that is interested in developing energy-saving logistical chains. To this end, more development of the model is required.

7.13. Summary and conclusions of the pilot actions in Finland

In the table below the energy use in the case transport chain, from Voikkaa paper mill, Finland to the customer in Cologne, Germany is summarized. The energy use is calculated for transporting 8 800 tonnes paper. The amount of raw materials is estimated from their yearly volumes in proportion to yearly production of paper. The energy use includes loading, unloading and other handling of goods except for the possible handling in Germany, which differs from the handling in Finland. The total energy use of the transport chain amounts to 2 971 MWh, which is 0,34 MWh per paper tonne. From the energy efficiency, kWh/tonne-km, it can be seen that the train transport in Germany seems to be more energy efficient than the train transport in Finland. This is, however, firstly due to the fact that transport distances in this case are shorter in Finland than selected distance in Germany, and secondly, the share of electric locomotives is bigger in Germany than in Finland.

Table 66 The energy use of the transport chain of 8 800 tonnes paper from Voikkaa to Cologne, including transport and handling of both raw materials and paper.

	TONNES	KM	TONNE-KM	KWH/TONNE	KWH/TONNE KM	ENERGY USE, MWH
Logs by trains[70]	3 139	140	439 478	19	0.14	60
Logs by lorries	7 463	100	746 284	29	0.29	217
Kaolin by lorries	2 466	65	160 279	15	0.23	37
Chemical pulp by lorries	2 090	105	219 450	25	0.23	51
Paper to Kotka by trains	3 960	65	257 400	13	0.19	50
Paper to Kotka by lorries	4 840	65	314 600	18	0.27	85
Port of Kotka	8 800		0	4		38
Ship	8 800	1 236	10 876 800	154	0.12	1 353
Port of Lübeck	8 800		0	4		38
Paper to Cologne, train[71]	2 200	490	1 078 000	34	0.07	75
Paper to Cologne, lorry[72]	6 600	490	3 234 000	149	0.30	985
Total	***59 158***	***2 756***	***17 326 291***			***2 989***

[70] Including the lorry transport from forest to the railway station

[71] It is assumed, that energy use in the shunting in the case in Germany equals the energy use in shunting in Finland in the case (kWh/tonne)

[72] The lorry is assumed to return as empty. If the load factor in return would be appr. 100% the energy efficiency would be appr. 0.16 kWh/tkm.

In the Table 67 below there are collected energy efficiencies in road transport in Finland in this case when no return loads are utilized but the lorries are returning as empty.

Table 67 Energy efficiency in road transport of paper in the Finnish part of the case, return without loads, and no handling included.

	ENERGY EFFICIENCY (KWH/TONNE-KM)
Articulated vehicle	0.22
Semi trailer	0.30
20' container	0.25
40' container	0.34

According to calculations, the most important energy saving actions is:

8. further utilization of return loads
9. the use of electric locomotives instead of diesel ones in rail transport
10. transport of large volumes in long distances by rail

Utilization of return loads is an important energy saving action. When looking for further potential for them, all material flows coming to the mill must be taken into account. Owing to nature of timber transport, it is almost impossible to imagine any return loads for them, but other raw materials and materials that are used for example for production of energy at the mill, can be potential return loads.

Electric train is more environmentally friendly and less energy demanding, at least when the use of transport mean is examined. However, the use of diesel locomotives cannot always be avoided. Rail transport is essentially more energy saving than road transport when the volumes are large and the transport distance is long. Advantages of rail transport are smaller when small lots are transported short distances. Nevertheless, the paper mill of Voikkaa produces paper in such amounts in one day in average that it can economically be transported by train. In Voikkaa's case, there are two ports in almost the same distance from the mill. At the moment, separate trains are going to each port. There could be a possibility to combine trains when the volumes are not energy-economically sufficient.

Due to the geographical location of Finland, the share of sea transport is already large in export chain. Thus, the waterborne transport cannot be increased more since the use of inland waterways is limited during winter. Consequently, a more likely mode change is from road transport to rail transport. However, the transport by lorry cannot always be seen as a most energy-consuming alternative. In train transport the energy use of handlings (e.g. shunting) is often considerable.

The effect of the speed of the ship on the energy use is the most significant factor when the sea transport is in question. Owing to the large share of the sea transport in the chain, the small reductions in fuel consumption can generate remarkable savings when considering the whole chain.

The export chain of the paper is a complex transport chain where responsibility is shared for many partners. The optimisation of selected phases of the chain must be done with care;

increase in energy use in one phase can decrease it in another and vice versa. In addition to energy use, other effects of energy saving actions on transport chain must be taken into account. Costs of different transport chains can't be excluded when the chains are compared to each other. Investments needed for changes have to be taken into consideration, too.

In addition, the communication has an important role in efficient transport chain. The great amount of partners and subcontractors create high requirements for data, information and knowledge transfer in the chain. However, the various information systems cause problems and difficulties that have to be solved.

This calculation model is constructed based on the specific case transport chain, and the results have been calculated based on the assumptions that are characteristic to that transport chain. However, the source data and basic energy use figures can be generalized to some extent, or at least they can be used as tentative energy use values in other types of calculations. It must be still recognized that the differences in shares of various transport modes, different handling techniques, transport distances, load factor, among many other things, affect the energy use in transport chain. Thus, the calculations based on the same data can give quite diverse results depending on which assumptions have been made.

The calculation of the energy use of a particular transport chain is as reliable as the source data is. Therefore, the continuous developing of data on fuel consumption and energy use of different transport modes, as well as the handling of goods, is vital for this kind of calculations and analyses of the logistics chain.

8. The Swedish case

To study different methods of increasing the energy efficiency in the transport of grain, two case companies have been selected. One is an agriculture trade and industry company, ODAL (ODAL) and the other is a transport- and logistic company, ASG. Both ODAL and ASG are among the leading companies in their branches and are dealing with the types of transports that are the objectives of this project.

First, the companies are described in general terms, and energy savings in this kind of transports through different potential pilot actions are then described.

8.1. Description of the case companies

8.1.1. ODAL

ODAL is a trade and industry company which is owned by 25 600 farmers in the middle region of Sweden. ODAL has 2000 employees and a turnover of 7 billion SEK.

Their business concept is to develop and offer optimal (economical and quality) solutions for environmentally adapted primary production, mainly regarding cultivation and fodder. ODAL takes care of, refines and sells the farmers harvest of grain and oil plants and also sell necessaries for cultivation and animal production. ODAL is also in business with agriculture and forest machinery etc. The organisation is divided into ten market areas, which run the business in form of subsidiary companies. ODAL has also about 80 outlets where they sell products for agriculture, forest industry, gardens and cattle.

One third of the grain is sold to mills, fodder factories and other customers in Sweden. Two thirds is exported mainly through ODAL’s plants in Uddevalla, Stockholm and Norrköping/Djurön.

ODAL’s grain is used for flour, biscuits and bakery products, cereals, pasta, fodder, seeds for sowing, malt, ethanol etc. A major part of the sales on the export market goes to EU (wheat), USA (oats) and the Middle East (wheat/barley).

Every year ODAL:

- produces and sells about 70 000 tonnes of seed for sowing.
- sells about 380 000 tonnes of fertiliser and manure.
- produces and sells about 680 000 tonnes of fodder.
- takes care of, dries, stores and sells about 1,7 million tonnes of grain.

ODAL is also engaged in research and development in these areas. ODAL’s market share on the world market is about 0,5 % a normal year.

Prognosis for the future for ODAL

In ODAL (and in Sweden generally), the animal production sector grows and more of the grain is used as fodder. It is also likely that the animal production in Europe will be transferred further up north due to environmental aspects. As a consequence, the export of grain may decrease slightly in the future. ODAL's forecasted sales are about 2,2 billion SEK (equivalent to about 1,8 million tonnes) in 1998 and about 1,6 billion SEK (equivalent to about 1,4 million tonnes) in 1999.

8.1.2. ASG

ASG is one of several companies that are involved in the transport of many types of goods, of which agriculture products is one. ASG is one of the largest transport- and logistic companies in the Nordic countries and has been heavily involved in energy saving activities in the transport sector.

ASG is divided into 4 market areas: Logistics (total customer solutions); road transport (domestic and international road transports); air & sea (air and sea transports); and finally Specialist Companies (niche business).

The number employees in ASG are about 5700 and the turnover is about 13 billion SEK. ASG AB is of the parent company with head office in Stockholm. The central units, which include business development, communication, IT, manager recruitment, accounting, environmental affairs and financing are located in Stockholm.

ASG is involved in business activities and have subsidiary companies in several countries as; Norway, Finland, Denmark, United Kingdom, USA, Hong Kong, Germany, Ukraine, Luxembourg, Russia and the Baltic countries. The mission (business concept) of ASG is to develop, market and produce efficient transport and logistics services.

Market shares has not been measured by ASG in per cent due to incomplete statistics but ASG can generally be seen as one of the 5 largest companies in the Nordic countries regarding land-based traffic, air & sea traffic. In ITL, ASG is the largest actor in the Nordic countries and in Europe, ASG is the tenth largest transport and logistics company.

The environmental work is conducted in accordance with ASG's environmental management system, which serves as guidance for the subsidiaries future certification according to ISO 14001. The parent company, ASG AB is, since the beginning of 1998, certified according to this standard (ISO 14001).

8.2. System boundaries and approach for the Swedish pilot actions

An analysis of the energy use in the case company ODAL is outlined in the first parts of this section. In a special case study, the energy use in a route to Spain will be illustrated. The pilot actions will illustrate the potential to save energy due to different activities. The energy use regarding the transport of grain in general will also be discussed.

The methodology varies in the different parts of the report. Generally, it can be noted that the energy in transport of grain does not include transport at the farms or energy use at loading and unloading between the transport modes. Neither is loss of grain due to wear and spill when reloading included in the calculations. The load factors are average values based on weight per cent. The more specific methodology will be described in the different sections. Please also note that the numbers in the report (in tables and figures) have been rounded off and might not always show the correct sum when added.

8.3. Energy efficiency factors

To calculate the energy use in agriculture companies like ODAL, the share between different transport modes and the amount of energy used for the different transport modes has to be known. The energy use for the transport is also, among other factors, dependent on the load factor, the weight transported and the size (load carrying capacity) of the vehicle used for each transport mode, e.g. lorry, tractor or boat.

The load factors for the transport modes are not known for all the deliveries, there is specially an uncertainty regarding the return trips. Some average figures have therefore been used (unless other is specifically expressed in the text). The load factor used in the calculations for the tractors is based on the assumption that the tractor has a load factor of 95% on the way to the silo and 5% on the way back. This assumption is derived from experiences and discussions with ODAL and SLU. The load factor weight-% for lorries is based on the assumption that the lorry takes 91% on the way to the silo and 20% on the way back. The total load factor becomes 56% for lorries. The load factor is based on statistics from SIKA/SCB and data from NTM and from hauliers used by ODAL (Ljungberg, pers. comm., 2000). No general load factor for boats has been used in the calculations. Specific load factors will be used for the relevant vessels in the samples for estimating transport volume and energy use. A more detailed description of the load factors and energy efficiency is included below and in subsequent sections.

8.3.1. Energy efficiency factors in ASG

ASG has calculated some energy efficiency factors for the transports they use. The transport volume (tonnekm) in the whole ASG group is more than 25 billion tonne kilometres world-wide. The approximate percentage of each transport mode was in 1997: Road 31,5%, Sea 61,1%, Railway 5,2% and Air 2,2%. This necessitates the use of some general energy efficiency factors to calculate the environmental impact. The average energy efficiency values used by ASG, 1997, are illustrated in the table below.

Table 68: ASG's energy efficiency in different means of transport

Type of vehicle	kWh/ tonnekm
Long distance vehicle	0,16
Local delivery vehicle	1,3
Semi-trailer towing vehicle	0,22
Goods train	0,042
Combined train	0,043
Ship	0,056
Ferry	0,11
Cargo plane	6,0

The described energy efficiency of the different vehicle types is about the same as NTM uses (NTM's figures were described in the report from phase 1 of this project.). The exception is for: "Long distance vehicle" (ASG use 0,16, were the corresponding NTM-value is: 0,17), "Local delivery vehicle" (ASG use 1,3 and the corresponding NTM-value is 0,63) and "Semi-trailer towing vehicle" (ASG use 0,22 and the corresponding NTM-value is 0,20). The difference for the "Local delivery vehicle" is considerable and the explanation for the ASG figure is probably due to different prerequisites. It can be noted that this figure has recently been replaced by a figure that is in the same region as NTM's figures (in the year 2000).

In the transport of ODAL's agricultural products, where companies like ASG are involved, specific data are used when such data can be found. Otherwise, the figures above from ASG and NTM are used when calculating the energy use in the transport of grain and likewise, they are used to assess the potential savings through different pilot actions.

Energy efficiency in tractors

Data on specific fuel consumption for tractor engines are generally limited to engine test bench data according to the ISO 8178 test cycle or the ECE R49 test cycle. These data cannot be easily utilised for calculating the fuel consumption for the particular type of transport to be assessed in our case. There are also much data available on fuel consumption for the use of tractors in different agricultural work. This consumption is often expressed in litres per hour or litres per ha (land). On the other hand, there is not much data available for fuel consumption in on-road use of tractors.

A study of transport by tractor on roads (driving in rural areas and on main roads) has been carried out by Hansson et al. (1998). The tractor studied was a Valmet 805 with four-wheel drive and turbo charged 4-cylinder engine having a maximum power of 70 kW (95 hp). The tractor had conventional wheel equipment and was otherwise equipped and adjusted for normal Swedish operating conditions. Data based on this tractor is illustrated in the table below.

Table 69: Facts about an average Swedish tractor (including return trips)

Type of tractor	Type of engine, power (kW)	Payload, average, tons	Load factor weight-%	kWh(fuel)/ tonnekm
Valmet 805	4-cylinder, 70 kW	4,4	50	0,88

The data on the tractor above has been complemented with a larger tractor with the average payload of 7,5 tons and with 10% lower energy use per tonnekm (0,79 kWh/tonnekm). The data regarding energy use for the samples has been calculated based on the weight of the grain delivery and with inter- or extrapolation of the data from these two tractors. The values in Table 69 are based on a fuel consumption of 11,61 l/h and a speed of 27 km/h.

Energy efficiency in lorries

Lorries of two different sizes has been chosen and the data for energy use in the samples has been calculated based on the weight of the grain delivery using inter- or extrapolation. The factors for energy efficiency has been collected from SIKA/SCB, NTM and a study made by Gebresenbet, & Ljungberg (2000) at The Swedish University of Agriculture Sciences.

Description of production & transports

Description of production and transports in Sweden

The total grain production in Sweden was about 6 million tonnes in 1999 according to the Swedish Board of Agriculture (http://www.sjv.se/, 2000). The use of the grain production is shown in the figure below:

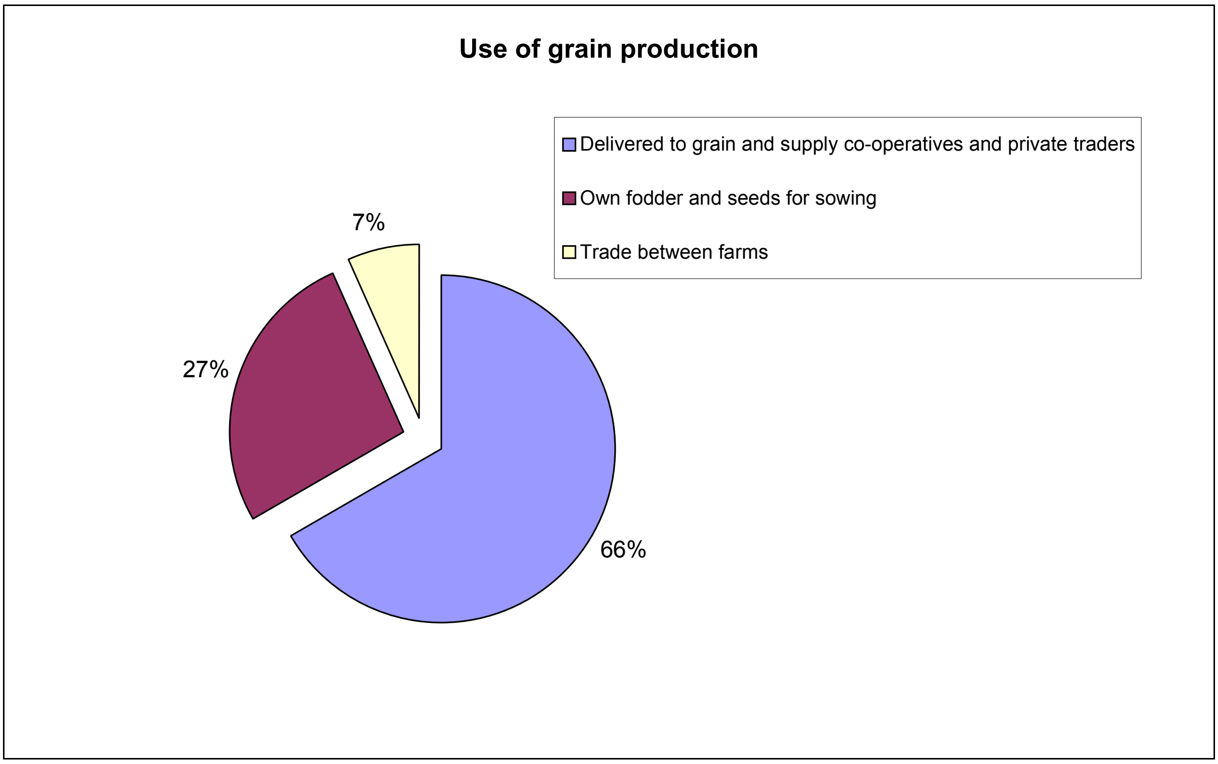


Figure 60: Use of grain production in Sweden, in % (Source: Gebresenbet & Ljungberg, 2000)

As we can see in the figure above, about 2/3 of the production is sold to co-operatives and private trading companies. About 27% is used internally as fodder and seeds for sowing. The rest about 7% is sold between farms.

The grain to "grain and supply co-operatives" and private traders (about 4 million tonnes) is transported mainly with tractors and lorries. The use of lorry transports is larger than the tractor transports. The flow from the farms is higher than the flows to the farms. In addition to these transports, some grain is also delivered by train and boat. About 350 000 tonnes of grain was delivered domestically with boat and about 21 000 tonnes was delivered by trains in 1997 (Gebresenbet & Ljungberg, 2000).

8.3.2. Description of ODAL's transports

ODAL handles (e.g. dries, sells and stores) about 1,5 million tonnes of grain per year. The grain is used for different purposes and sold to different sources. The Swedish Board of

Agriculture buys grain when there is an overproduction in Sweden. Intervention is a way to raise the prices for grain and it is financed through the support from the EU. It is also important to realise that the use of grain varies considerably between years.

ODAL is located in the central region of Sweden and has access to ports both on the West and on the East Coast.

ODAL's grain is transported by farmers, hauliers and transport and logistic companies. Many different owner-operators and transport companies thus own the lorry fleets, tractors and boats. The grain can be transported to a silo by the farmer himself or else it is collected by hauliers contracted through ODAL. The farmers also sometimes transport directly to ODAL's customers. The number of silos in ODAL is about 89.

The flow between the silos and from farmer to silo and to export constitute the transport routes that Ecotraffic and ODAL have studied. This also includes an estimation of the energy use in ODAL for different activities. This has been conducted through approximations of the amount of transported grain (tonnekm) and the energy efficiency of the different transport modes (kWh/tonnekm). The data on the transport volumes (tonnekm) are mainly collected from ODAL, whereas data on energy efficiency of the different transport modes primarily has been collected from SLU and ASG.

General methodology

Our method for the analysis of the transport volumes and energy use is based on dividing the transport chain into three main segments. At the first segment, the energy use in the transport from the farmer to the silo is examined. Segment number two consists of the energy use in the transport from silo to silo. The third segment is the energy use in the transport to export harbour. In a special case study a fourth segment, from export harbour to the import harbour (in a foreign country) is also studied. The fourth level is elucidated through a selected route in the special case study called "Söderköping". Consequently, no total energy use in ODAL can generally be calculated for the fourth segment, but this is done in the first three levels.

Farmer to a silo

To investigate the flows of grain and the energy use from the farmers to a silo, a sample of 80 farmers have been randomly chosen from a population of about 12 000 farmers, who delivered during the harvest time in 1998. The 12 000 farmers represent about 80% of the total farmers during the year so the total amount of farmers is estimated to be about 14 000 in 1998. Based on this sample, an assumption is made for the energy use of the other farmers in the ODAL region. One silo located in Söderköping is studied more thoroughly and the analysis is based on approx. 75% of the number of farmers who have been transporting grain to Söderköping (see chapter 6).

Silo to silo

The destination of the deliveries to a silo is dependent on wrther the deliveries are going to Sweden or are for export. The share which is intended for export is illustrated in the section "To export harbour" (see below). The method for the calculation of energy use for this part of the transport chain is, like in the "farmer-to-silo" step, estimated based on a sample.

Subsequently, and an average transport volume and energy use has been calculated. The sample in the “silo-to-silo” step includes 120 deliveries of about 19 000 total.

To export harbour

A certain fraction of the transported grain "farmer-silo" and "silo-silo" is estimated to be destined to an export harbour based on export data from ODAL.

From export harbour to import harbour (in a foreign country).

The grain is shipped from the export harbours to many different customers and destinations. Most of those customers ennoble the grain (e.g. from malt to malt extract to beer etc.). Then it is sold again to other customers of which some ennoble it again and sell it further. The energy use for this part of the transport chain is difficult to estimate, partly because foreign shipping companies carry out a major part of these transports. transport between an export and an import harbour is described in the analysis of the selected route. The delimitation is to only follow the chain to ODAL’s customers (the import harbour). Further transports, for example within an importing country, will not be studied. This part will be further described in the section “Special case studies”.

8.4. Transport volume in ODAL

8.4.1. Calculation of transport volume in ODAL

In this section, the transport volume (tonnekm) in the transport of grain in ODAL is estimated. As mentioned earlier, the energy use and transport volume is estimated based on samples. Assumed return trips are also be included. However, it should be noted that the focus is on the delivery trips of grain and not the return trips, which mainly include seeds for sowing, fodder and fertiliser. The results from the analysis of the transport volume of the different steps in the transport chain are described in this section. Before reporting the results from the calculations, we will start by making some general comments on grain transports.

Grain transports can be carried out by different types of vehicles. However, the data and statistics are not compiled by ODAL to serve this purpose. Therefore, the data is not complete in that sense that it is always possible to determine what type of vehicle that has been used for the grain deliveries. For example, in some cases several deliveries are pooled together in one group. Therefore, we have classified the deliveries (especially in the data for the farmer-to-silo step where no indications of transport mode was present) based on the quantity of tons delivered. The classification was made after discussions with ODAL (Carlsson, 2000). The division is illustrated in Table 70 below.

Table 70: Classification of data to different transport modes

<15 tons	Tractor
>15tons	Lorry
>300 tons	Boat

The table above indicates that if a delivery in our data material is below 15 tonnes, it is classified as a tractor delivery etc.

Farmer to silo

Transport volume and data

In the first stage, a random sample has been chosen comprising of 80 farmers from the total number of farmers who delivered to ODAL during the harvest period in 1998. From the data describing all the deliveries during the period, which are about 100 000, it was found that the number of farmers was about 14 000 and that they were delivering about 7,0 times each year. These figures are assumed valid for *a normal year* in the ODAL. The data is collected from ODAL's statistics on grain deliveries during the described period (Personal comm., Carlsson and Sjöö, 1999).

Based on the data obtained from the sample regarding the deliveries from these farmers (quantity, transport volume etc.), an average grain transport has been estimated. This has been generalised to be valid for all the farmers delivering to ODAL.

The distances in the sample have been estimated by ODAL. The common method used by ODAL to estimate the distance between the farmer and the closest silo has been to use the known distance between the farmer and the church in the same rural district. Therefore, the distances should be considered as estimates. They are shown in Table 71.

Table 71: Average values per delivery

	Average distance to silo (km), weighted	Average transport volume (tonnes/delivery)	Average transport volume (tonnekm), weighted
Delivery trip	11,4	9,87	113
Return trip	11,4	1,23	14,1
Total		11,1	133

The table above indicates that in the transport mix recorded, about 89% of the volume transported is delivered to the silo and 11% included in the return trip. The average per delivery has been calculated as the total value (distance, volume and transport volume) divided by the number of deliveries. The values for distance and volume has been weighted to account for the fact that the frequency of deliveries varies between the farmers. If the values are not weighted, the average distance becomes 13,7 km while the total average delivery volume is 10,4 tonnes, while it is 9,32 tonnes when return trips are excluded.

There is a certain difference between the average delivery and the average for each farmer. The reason for this inconsistency is that the number of deliveries and the delivered volume is different for each farmer. It is conceivable that the difference is greatest for the distance and the transport volume. The average quantities of deliveries per farmer and the average transport volumes are shown in Table 72. These values are calculated by dividing the total transport volume (tonnes/year) delivered from each farmer, by the number of farmers. A similar procedure has been used for the transport volume (tonnekm).

Table 72: Average transport volume per farmer and year

	Average transport volume (tonnes/year)	Average transport volume (tonnekm), weighted
Delivery trip	69,4	793
Return trip	8,66	99,1
Total	78,0	892

If the values are not weighted, the total average transport volume is 72,8 tonnes, and 65,5 tonnes excluding return trips. These values are about 7% and 6% lower respectively. A possible explanation for the lower volume (in the non-weighted case) is that the farmers living far away from the silos do not have as many deliveries and deliver as much per delivery as the ones living close to the reception silo. It could also be conceivable that the location of the silo was decided taking this situation into account, i.e. the silo was located as close to the greatest grain producers as possible.

Total in ODAL /year farmer to silo

Using the assumption that the average delivery for all the 14 000 farmers in ODAL is similar to the sample of 80 farmers, the total transport volume can be estimated. These results are shown in Table 73.

Table 73: Total transport volume in ODAL/ year

	Average transport volume (tonnes/year)	Average transport volume (tonnekm)
Delivery trip	971 000	11 100 000
Return trip	121 000	1 390 000
Total	1 090 000	12 500 000

If the values were not weighted total and excluding return trips the average transport volume (tonnes) would be about 7% and 6% lower respectively.

The division between different transport modes

The division between the transport volume (in tonnekm) for the different transport modes in the sample above is illustrated in the table below.

Table 74: Division between different transport modes

	#	%	Weighted -%
Tractor	70	88	67
Lorry	10	13	37
Total	**80**	**100**	**100**

As we can see in the table above, the percentage for lorries increases from 13% to 37% when the values are weighted. Observe that the figures in the table above do not include return trips. If return trips are included, the division (weighted) is 41% for lorries and 59% for tractors.

Silo to silo

In the second stage, the procedure has been similar as in the first stage. A sample of 120 deliveries has been chosen out of about 19 000 deliveries. The period is from 970801-980731. The distances have been estimated with a map program using the co-ordinates of the silos as input data. Based on the data obtained from the sample, the following average values were received.

Table 75: Average values per delivery

	Average distance silo to silo (km)	Average transport volume (tonnes/delivery)	Average transport volume (tonnekm), weighted
Delivery trip	70,5	55,3	3 900
Return trip	70,5	8,41	593
Total		63,7	4 500

Lorries cover 116 of the 120 deliveries in the sample (96,5%), sea transport 1 (1%) and tractor transport 3 (2,5%). The data for sea and tractor are considered to be too small to be presented here as averages. However, data for the lorries are presented below:

Table 76: Average for lorries silo to silo

	Average distance silo to silo (km)	Average transport volume (tonnes/delivery)	Average transport volume (tonnekm), weighted
Delivery trip	72	35,3	2540
Return trip	72	8,53	613
Total		43,9	3150

(More about the division between transport modes is presented further down in the report, after the total volume in ODAL has been presented).

Total in ODAL /year (all modes) silo to silo

The calculation of total transport volume in ODAL in this stage, is based on the number of deliveries during the period, which are assumed to be 19 000 a normal year. The result is seen in the table below.

Table 77: Total transport volume in ODAL/ year

	Average transport volume tonnes/year	Average transport volume (tonnekm)
Delivery trip	1 050 000	74 100 000
Return trip	160 000	11 300 000
Total	1 210 000	85 400 000

If the values were not weighted in total and excluding return trips the average transport volume (tonnes) would be about 12% and 14% lower respectively.

There are data available for the total quantity delivered from silo to silo in ODAL but data on the total transport volume is not available for all deliveries. However, the total quantity delivered (at 887 000 tonnes/year) can be compared with the calculated value for the delivery trips of 1 050 000 tonnes per year in Table 10. This provides some estimation of the error in the sampling and calculation, since the difference is about 18%. As a comparison it could be mentioned that the calculated transport volume (tonnes/year) in the farmer-to-silo step was, in between at 971 000 tonnes per year (see table 6).

As mentioned before, lorries cover 116 of the 120 deliveries in the sample (96,5%), sea transport 1 (1%) and tractor transport 3 (2,5%). If the allocation for deliveries is based on transport volume (tonnekm), the result becomes different (see table below).

Table 78: Allocation based transport volume (tonnekm)

	Tr. vol %
Tractor	0,1%
Lorry	62,9%
Sea	37,0%

The sample shows a good compliance regarding the division between different transport modes with the reference value for the whole population concerning the number of deliveries (in %). If the division would be expressed in transport volume (tonnekm) there are no data for the whole population. However, the total quantity during the period 970801-980731 is known and it can be divided between different transport modes.

The most frequently used transport modes from silo to silo in the whole population are shown below (expressed in number of deliveries and tonnes):

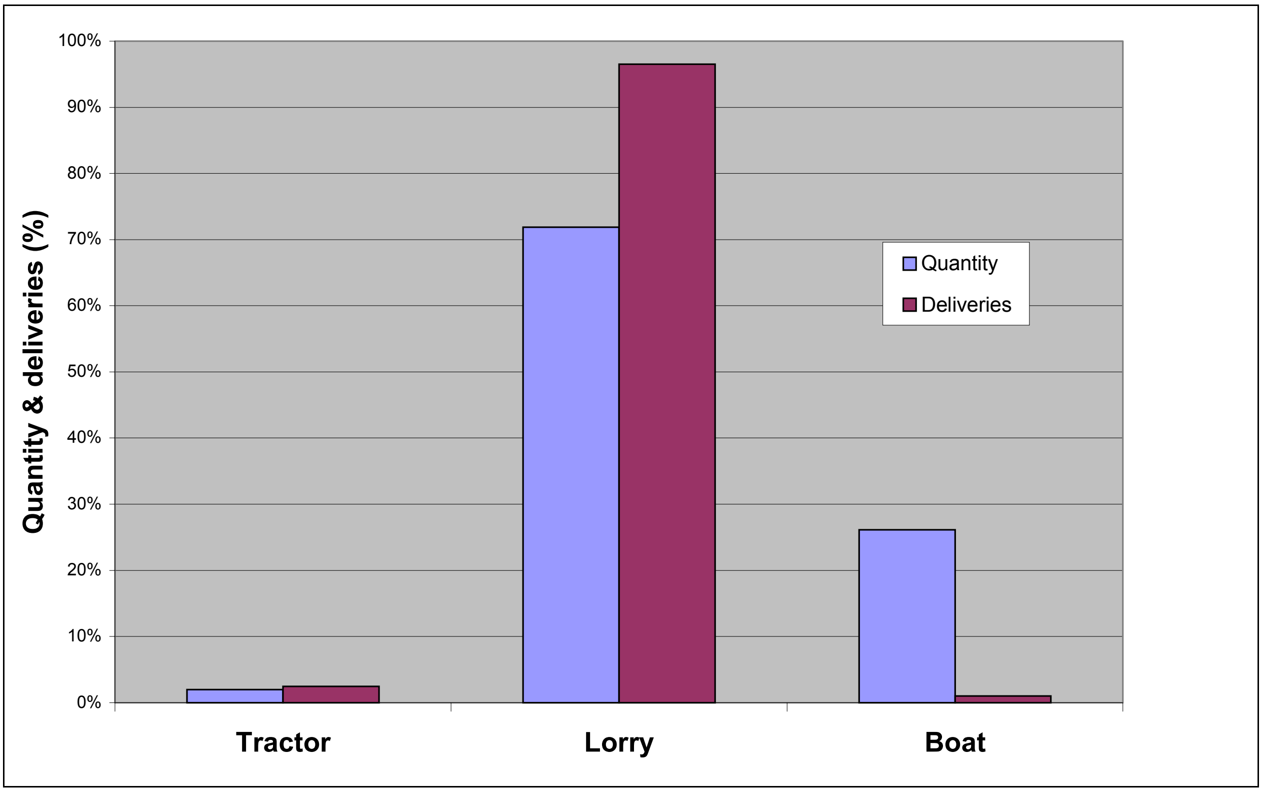


Figure 61: Most frequently used transport mode based on quantity (tonnes) and number of deliveries respectively, in the whole population.

In the figure we can see that lorry is the most frequently used transport mode based on number of deliveries, with about 96,5% of the deliveries. Tractor transport corresponds to about 2,5%. Boat transport represents 1%. However, the quantity on the larger transport modes is significant. When calculating based on transport volume (tonnes) this changes the allocation on transport modes so that boat is responsible for about 26%, lorries for about 72% and tractors for about 2% of the transports.

Type of grain

In the whole population during the period 970801-980731 oats and wheat dominated the number of deliveries and the quantity referred to grain type. The four mostly delivered types of grain for the silo-silo transport level is illustrated in the figure below.

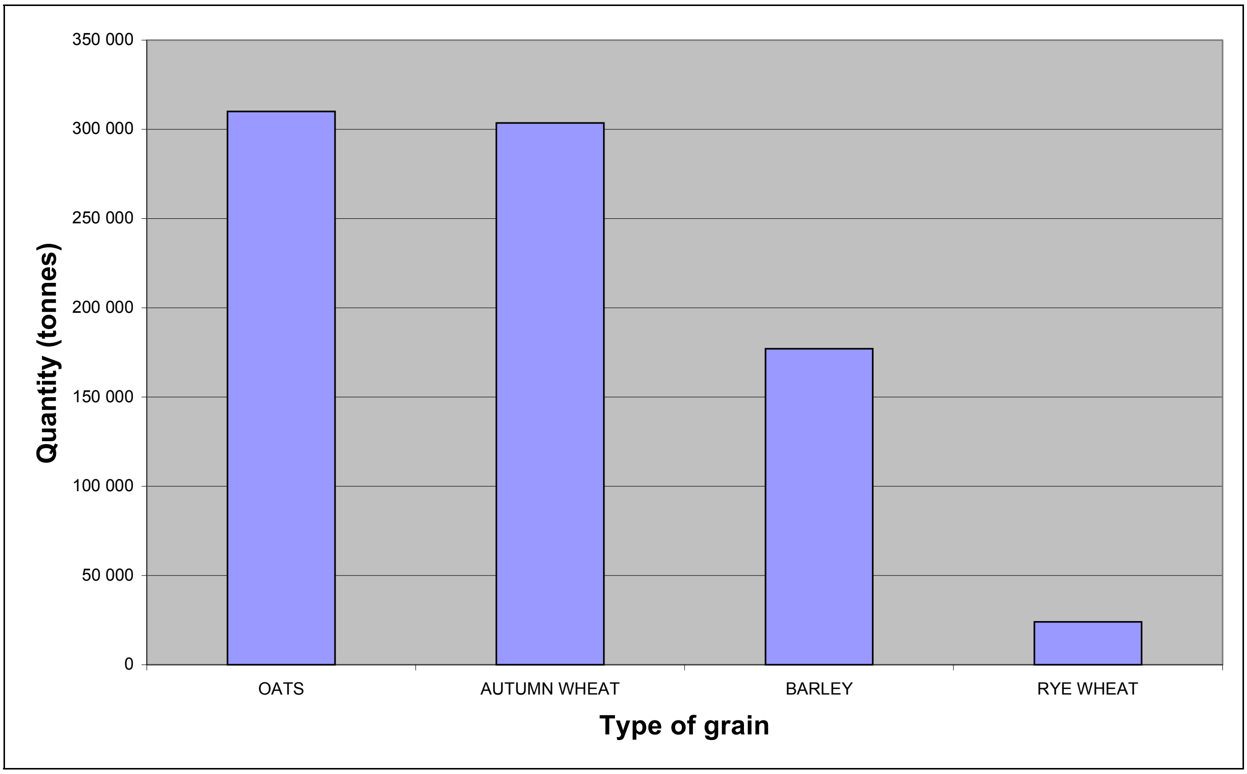


Figure 62: The four mostly delivered types of grain silo-silo (in quantity, tonnes)

During a normal year, wheat is the mostly transported product. This is the case in all steps including "farmer to silo" and "to export" (Thorn, pers. comm., 2000).

To export harbour

The amount of grain for export varies between years and since it is difficult to use the available data to decide how much of the grain that is exported, we have made an assumption after a dialogue with ODAL. According to ODAL (Lennart Vilhemsson, pers. comm., 1999), about 60-70% of ODAL's grain is exported. Some is exported directly from the farmer to the export harbour, and some is delivered to a silo first and later to an export harbour. The assumption is that 65% of all the grain that is delivered by the farmers (and further on in all the links in the transport chain) is exported. We are also assuming that the average distances and transport volumes are the same in the "farmer-to-export" step as in the "farmer-to-silo" step. This is also the case for the silo-to-silo step. Therefore, the data reported below are not showing distances etc., but is presented as totals.

Total transport in ODAL /year (all modes) to export harbour

To calculate the total transport volume in ODAL in this stage, the average total transport volume from the section "farmer to silo" is multiplied with the factor of 0,65. The result is shown in the table below.

Table 79: Total transport volume per year from farmer to export

	Average transport volume (tonnes/year)	Average transport volume (tonnekm)
Delivery trip	631 000	7 220 000
Return trip	78 800	901 000
Total	710 000	8 120 000

About 65% of the total transport volume from silo to silo is also allocated to export harbour. The result is seen in the table below.

Table 80: Total transport volume per year from silo to export

	Average transport volume (tonnes/year)	Average transport volume (tonnekm)
Delivery trip	683 000	48 200 000
Return trip	104 000	7 300 000
Total	787 000	55 500 000

If the two tables above are summarised, the transport volume to export harbour in ODAL/year is found. This is illustrated in the table below.

Table 81: Total transport volume per year to export harbour

	Average transport volume (tonnes/year)	Average transport volume (tonnekm)
Delivery trip	1 314 000	55 400 000
Return trip	183 000	8 200 000
Total	1 500 000	63 600 000

Wheat is the mostly exported product. This is for example exported to Terragona in Spain and Bari in Italy using boats with a payload of about 25 000 tonnes. An approximate estimation is that about 500-700 000 tonnes of wheat, 300 000-400 000 tonnes of Barley and 250 000-300 000 tonnes of oats are exported a normal year in ODAL (Thorn, pers. comm., 2000). A transport route to Terragona in Spain is elucidated later.

Summary calculations of transport volume

The transport volume (in tonnes) of grain in ODAL adds up to about 2 million tonnes. According to a brochure from ODAL (1997) about 1.7 million tonnes of grain were handled. Hence, our calculations might include some overestimation. The transport volume of the return trips amounts to about 1/7 of the grain deliveries. The figures are based on the knowledge that the number of deliveries from silo to silo during a normal year is about 19 000 and that the number of farmers in “farmer to silo” are about 14 000 a normal year. The volume exported represents 65% of the transport volume in "farmer to silo" and "silo to silo". When a subtraction of the 65% from the farmer-to-silo and silo-to-silo step is made, the results can be presented in a different form than the data shown above. The figures can now be summarised, which corresponds to the total transport volume (tonnekm) in ODAL. Table 82 summarises the results according to the calculations described above excluding return trips. Table 83 shows the same figures as in table 15 but including return trips.

Table 82: Average transport volume (tonnekm) in ODAL/ year for domestic use, export and total, excluding return trips

	Farmer to silo	Silo to silo	Total in ODAL
Domestic use	3 890 000	25 900 000	29 800 000
Export	7 220 000	48 200 000	55 400 000
Total in ODAL	11 100 000	74 100 000	85 200 000

Table 83: Average transport volume (tonnekm) in ODAL/ year for domestic use, export and total, including return trips

	Farmer to silo	Silo to silo	Total in ODAL
Domestic use	4 370 000	29 900 000	34 300 000
Export	8 120 000	55 500 000	63 600 000
Total in ODAL	12 500 000	85 400 000	97 900 000

Observe that the column “Total in ODAL” does not include transports outside Sweden (e.g. transport between export and import harbours).

8.5. Energy use in ODAL

8.5.1. Calculation of energy use in ODAL

The energy use for every individual vehicle used for delivery in the sample is not known. Nor is the exact type of each vehicle known. Therefore, the methodology of calculating the energy use has been to interpolate the energy use in the specific delivery. This has been done by using the quantity transported as a base for an interpolation between two basic types of tractors or lorries (This is also described in the section "Energy efficiency factors"). The two tractors used are the ones illustrated in the table below.

Table 84: Energy use in used tractors, including return trips

Vehicle	Payload, average, tons	Load factor weight-%	kWh (fuel) /tonnekm
Tractor 1	4,4	50	0,88
Tractor 2	7,5	50	0,79

The load factor (weight-%) is based on the assumption that the tractor has a load factor of 95% on the way to the silo and 5% on the way back. The maximum payloads for the tractors are 8,8 and 15 tonnes respectively. The data/energy use for the samples has been calculated based on the weight of the grain delivery and with inter- or extrapolation of the data from these two tractors. The energy use in the tractors is partly based on a report by Hansson et.al. (1998). The calculation is also based on the assumption that the energy content in the fuel is 9,99 kWh/l.

Table 85: Energy use in used lorries, including return trips

Vehicle	Payload, average, tons	Load factor weight-%	kWh (fuel) /tonnekm
Lorry 1	7,8	56	0,44
Lorry 2	19,4	56	0,25

The load factor weight-% is based on the assumption that the load factor for the lorry is 91% on the way to the silo and 20% on the way back. The maximum payloads for the lorries are 14 and 35 tonnes respectively. The total load factor of 56% is based on statistics from SIKA/SCB and data from hauliers used by ODAL as well (Ljungberg, pers. comm., 2000). The data/energy use for the samples has been calculated based on the weight of the grain delivery and with inter- or extrapolation of the data from these two lorries.

The energy use for the small lorry is based on adjusted data from NTM regarding a lorry involved in regional transports. NTM used 0,49 kWh/tonnekm for a corresponding lorry with maximum load: 14 tons and a load factor of 50%. Since the data from NTM was for a lorry used in regional transport, it is probably an overestimation of the energy use in grain transport. The energy use for the large lorry (maximum load 35 tons) is partly based on studies made by the Swedish University of Agriculture Sciences collected from Ljungberg (pers. comm., 1999.) at the Department of Agriculture Engineering. The studies showed an average fuel consumption of 4,9 l/100 km. The calculation is also based on the assumption that the energy content in the fuel is 9,85 kWh/l. This energy content is lower than in the previous case, due to the lower density of the diesel fuel used for on-road transport in Sweden in comparison to the diesel fuel used for off-road purpose[73].

[73] More than 90% of the diesel fuel used for on-road transport in Sweden corresponds to Environmental Class 1 (EC1). The Swedish specification for environmentally classified diesel fuels has three classes, where EC3 corresponds to the current European specification of diesel fuel and EC1 is the “best” fuel regarding its environmental effects (EC2 is between EC1 and EC3). However, the density of EC1 is lower than EC3, hence the lower energy content per litre of fuel.

The total transport volume in the previous chapter has included return trips. Since the focus of the report is on grain deliveries, the energy use will be calculated mainly based on transport volume excluding return trips. The return trips often include seeds for sowing, fertiliser etc. In the following tables, the payload will be based on the delivery trips (corresponds to 95% and 91% of the payload for tractors and lorries respectively), since these are the focus in the energy calculation procedure.

However, the choice of transport mode and the route for the delivery trips affects the total load factor and the possibility for return trips. Therefore, the energy efficiency factors will still be calculated as averages between delivery trips and return trips, so that consideration is taken to the lower total load factor. This procedure will be further described in connection with the actual calculation in different levels below.

Farmer to silo

Based on the described way to calculate the energy use above and the transport volume in the sample, some average energy efficiency factors for the sample "farmer to silo" is found. These are described in the table below.

Table 86: Energy use and payload in used transport modes

	Payload, per delivery, tonnes	Aver. energy use kWh(fuel)/ tonnekm
Tractor	7,5	0,88
Lorry	21,1	0,35
Average	9,3	0,68

Table 86 shows that the average payload is much higher for the lorry than for the tractor, as expected. Likewise, the average energy use is much less for the lorry. The potential for decreasing the average energy use is about a factor of 2 (from 0,68 to 0,35 kWh/km). This is, of course, valid under the assumption that the load factors assumed will remain unchanged. Observe that the figures have not been weighted in Table 86. This is one of the reasons why there is a slight difference between these presented energy efficiency factors and the ones in Table 84 and Table 85. Note also that the payload in Table 86 represents 91-95% of the transport volume (tonnes) whilst Table 84 and Table 85 presents an average payload (including return trips) corresponding to 50-56% of the transport volume (tonnes). Using this way to calculate the energy use and the data (transport volume and division between transport modes) from the section above "Calculation of transport volume in ODAL", the average energy use in different cases has been calculated for the sample. The energy use, based on calculated energy efficiency factors and transport volume, is illustrated in the table below.

Table 87: Energy use in ODAL (kWh), farmer to silo

	Energy use/ Delivery	Energy use /farmer & year	Total energy use in ODAL, farmer to silo
Delivery trip	76,8	539	7 550 000

The total energy use in ODAL of grain transport is calculated with weighted data and assuming that the average number of farmers is about 14 000 a normal year.

Silo to silo

The method and the basic energy efficiency factors for lorries and tractors are also used in this section. Energy efficiency factors for each transport mode is also added. In the sample of 120 deliveries, there is only one boat included. This represents about 1% and is in correlation to the whole population. Therefore, the energy efficiency for that particular boat has been calculated. Likewise, the number of tractor transports is three, which also is in correlation to the whole population. It could however be questioned in this case whether the transport has been correctly classified, since the average payload in tractor transport silo to silo is more than double the corresponding payload in the farmer-to-silo step. On the other hand, the data on lorries, covering 116 deliveries should be data that are more reliable. The energy efficiency etc. in the sample is seen in the table below.

Table 88: Energy use and payload in used transport modes

	Payload, per delivery, tonnes	Aver. energy use kWh(fuel)/ tonnekm
Tractor	18,3	0,63
Lorry	35,3	0,21
Boat	1630	0,10
Average	55,3	0,17

As seen in the table above, the payload for the transports excluding return trips is 18,3 for tractors, 35,3 for lorries, 1630 for boats and 55,3 tonnes as an average for all transport modes. The energy use for the tractor transport (0,63 kWh/tonnekm) is clearly lower than in the farmer-to-silo case (0,88 kWh/tonnekm), whereas the difference for the lorries is even greater (0,21 vs. 0,35 kWh/tonnekm).

The load factor (weight-%) for the sea transport is based on the assumption that the boat takes 82% on the way to the silo and 0% on the way back (the average load factor is 41%). The figure is however, according to the ship owner not very representative since the deep draught is a problem in this particular distance. On another route the load factor could be increased to 50% as an average (almost 100% on the delivery trip) and the energy efficiency increases to about 0,075 kWh (fuel)/tonnekm. Sometimes it is also possible to transport goods on the return trips. Similar load factors as in the farmer-to-silo case has been anticipated for tractor and lorry transport (i.e. calculated average total load factors are 50% and 56% respectively).

Using the mix of transport modes described, the average energy use in different cases from the sample has been calculated. The energy use based on the calculated energy efficiency factor and the transport volume is illustrated in the table below.

Table 89: Energy use in ODAL (kWh), silo to silo

	Energy use/ Delivery	Total energy use in ODAL, silo to silo
Delivery trip	650	12 400 000

The total energy use in ODAL is calculated with weighted data and assuming that the average number of deliveries is about 19 000 a normal year. The boat transport has a great impact on the energy use per delivery (about 17 000 kWh compared to the average 650 kWh/delivery and 524 kWh/delivery for lorries), since the delivery volume is so sizeable. On the other hand, it reduces the energy use of the sample per tonne kilometre, which is considerably higher for the lorries (0,21 kWh/tonnekm) and the tractors (0,63 kWh/tonnekm). Lorries in the sample represent almost 97% of the deliveries.

To export harbour

Approx. 65% of the energy use in “silo to silo” and in “farmer to silo” is allocated to the export of grain. The sum of these fractions in illustrated in the table below.

Table 90: Energy use in ODAL (GWh), to export

65% of total energy use in ODAL, farmer to silo	65% of total energy use in ODAL, silo to silo	Total energy use in ODAL, to export harbour
4,91	8,03	12,9

Summary calculations of energy use

The figures are based on the knowledge that the number of deliveries from silo to silo during a normal year is about 19 000 and that the farmers in the farmer-to-silo transport are about 14 000 a normal year. The volume exported represents 65% of the transport volume in "farmer to silo" and "silo to silo".

When subtracting the 65% of the grain that is exported from the farmer-to-silo and silo-to-silo steps, the result for the domestic use of the grain can be calculated. Table 91 summarises the results according to the calculations described above.

Table 91: Average energy use (GWh) in ODAL/ year for domestic use, export and total.

	Farmer to silo	Silo to silo	Total in ODAL
Domestic use	2,64	4,3	7,0
Export	4,91	8,0	12,9
Total in ODAL	7,55	12,4	19,9

Observe that the column "Total in ODAL" does not include transports outside Sweden (e.g. transport between export and import harbours) and that the energy use is concerning grain deliveries. The average energy efficiency in ODAL is estimated to about 0,23 kWh/tonnekm.

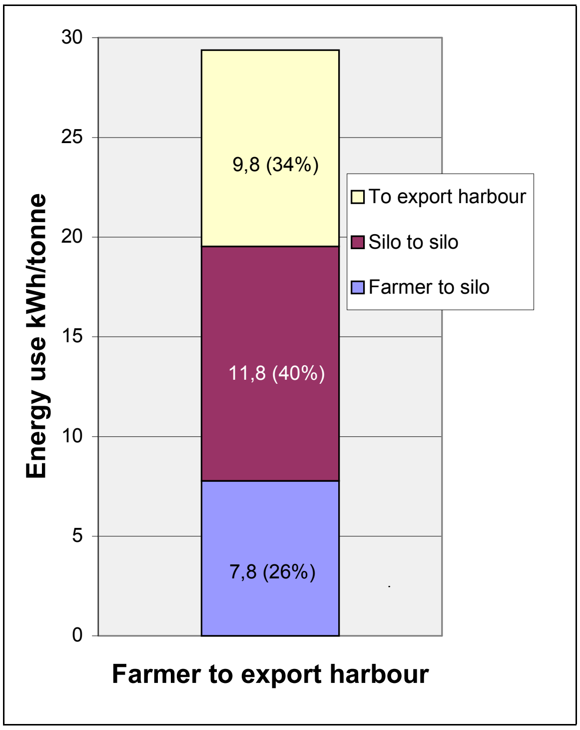


Figure 63 Energy use (kWh/tonne) in different steps in the transport chain, from farmer to export harbour

If the energy efficiency for the different steps "farmer to silo", "silo to silo" and "silo to export harbour" is expressed in energy use per tonne, the results are depicted according to Figure 63.

As we can see in Figure 63, the Farmer-to-silo step has an energy use of 7,8 kWh/tonne. In the second step "Silo to silo" the energy use is 11,8 kWh/tonne. The difference is explained by the longer distance for "silo to silo" 70,5 km compared to about 11,4 km for the farmer-to-silo step. The difference would have been larger if there were not so many tractors with high energy use in the farmer-to-silo step.

The figure accordingly shows the importance of the distance and choice of transport mode. The step called "to export harbour" is a mix of the other two steps and has an energy use that is in between the energy use of the other two steps.

8.6. Special case study “Söderköping”

In the previous chapters, the energy use and the transport volume in ODAL has been estimated. Since the data material, which the estimations is based on, is incomplete and estimations of this kind is not very precise, we have also carried out a more comprehensive study of the transport flows and the transport energy use to and from a silo in ODAL. The chosen silo is located in Söderköping. The data is more specific especially regarding the step farmer to silo and for the added step from “export to import harbour”.

8.6.1. Description of transports and methodology

In the farmer-to-silo step, the approximate distance and transport volume between the farmers and the silo in Söderköping has been calculated based on a sample of 95 farmers. This corresponds to about 75% of the total population (the sample in the previous farmer-to-silo step corresponded to less than 1% of the total population). The reason for not including all farmers was the lack of co-ordinates. The distance between the farmers and the silo in Söderköping has been calculated based on the co-ordinates for the farmers and the silo in Söderköping via a map program. The method to use co-ordinates and a map program should give more exact distances than the method in the previous farmer to silo step. The distances have been multiplied with the number of deliveries and the return trips and the amount of tons of grain to give the total amount of ton-kilometres (tonnekm).

In the silo-to-silo step, i.e. Söderköping to Djurön/Norrköping, the distances are known and the transport volumes (tonnes) are based on the previous step. The energy use for transport is however not specific for this silo-to-silo transport but the same as in the general silo-to-silo step in ODAL.

Regarding the step “from export to import harbour” it can be noted that the exported grain is generally shipped from the export harbours in Sweden to many different customers and destinations. Most of those customers ennoble the grain and then it is sold again to other customers of which some ennoble it again and sell it further. The energy use for this part of the transport chain is difficult to estimate partly because foreign shipping companies carry out a major part of the transports. However, the export chain will be described by an analysis of a selected route associated to Söderköping and between a port in ODAL and a port in a foreign country. The delimitation is to only follow the chain to ODAL’s customers (the import harbour). Further transports, for example within an importing country, will not be studied.

The data from this special case may serve as background in some of the following pilot actions or can be used to compare with the calculations of the general energy use in ODAL.

8.6.2. Calculation of transport volume and energy use

It should be noted that some farmers around Söderköping deliver directly to the larger silo in Norrköping (breaking point about 25 km south of Söderköping, almost none of the farmers north of Söderköping deliver to Söderköping) or Djurön. However, the study is focusing on those farmers who deliver to Söderköping.

The silo in Söderköping receives according to ODAL approximately about 5000 tonnes of grain per year. The farmers transports and delivers, (using tractors), almost all of the grain themselves to the reception plant. Söderköping can receive about 25 different fractions of grain (different sorts and qualities). There are four larger silos in the reception plant where grain can be stored. The grain is collected (finished) in late October and is stored during the rest of the year. After that, the grain is carried away sometime during the spring with lorries to Djurön or Norrköping. More than 95% of the received tons are delivered to Djurön or Norrköping. The allocation is about 50% to each destination (Berglin, pers. comm., 1999). In table 25 some facts about the silo located in Söderköping on which the calculations has been made is illustrated.

Table 92: Deliveries to Söderköping 1997-08-01—1998-07-31.

Amount received (tons of grain) about:	5 000
Number of deliveries (#):	509
Number of farmers (#):	126

If 50% of the grain from Söderköping goes to Norrköping and Djurön, this corresponds to about 2500 tonnes each year. This is a small fraction of the received quantity in Norrköping and Djurön. For example, Djurön has a turnover of about 400 000-500 000 tonnes of grain each year. The fraction from Söderköping to Djurön (about 2500 tonnes) will also be used as example in the energy use of transport from export to import harbour.

Note that the figures above (5000 and 2500 tonnes) are rounded off. The calculations below of the route is based on the average values of transport volume and energy use from the used samples.

Transportation from farmer to Söderköping

Transport volume

The distances in the sample have been estimated by ODAL using co-ordinates in a map program. The distances and transport volume is shown in the table below.

Table 93: Average values per delivery

	Average distance to silo (km), weighted	Average transport volume (tonnes/delivery)	Average transport volume (tonnekm), weighted
Delivery trip	18,9	9,41	178
Return trip	18,9	0,85	16,1
Total		10,3	194

The table above indicates that about 91% of the volume transported (tonnes) are delivered to the silo and 9% included in the return trip. The situation in the previous farmer to silo calculations was about 89% on the delivery trip and 11% on the return trip and the distance was about 11,4 km. The relation between delivery trips and return trips are, however, uncertain and dependent on the assumptions of load factor of the transport modes. The actual return trips load factor could for tractors be less than the calculated 5% (Berglin, personal communication, 1998). This is also the case for lorries. However, the transport mode mix is dominated by tractors.

The average values per delivery have been calculated as the total value (distance, volume and transport volume) divided by the number of deliveries. The values for distance and volume have been weighted so that consideration is taken to that some farmers seldom delivers. If the values are not weighted, the average distance is 17,0 km and the total average transport volume is 9,89 tonnes and 9,12 tonnes excluding return trips. As can be seen in table 27, there is a certain difference between the average delivery and the average for each farmer. The reason for this inconsistency is that the number of deliveries and the delivered volume is different for each farmer. It is conceivable that the difference is greatest for the distance and the transport volume.

The average number of deliveries per farmer in the sample is about 3,7. The average transport volume per farmer and the average transport volume are shown in Table 94. These values have been calculated by dividing the total quantity delivered by each farmer by the number of farmers. A similar procedure has been used for the transport volume.

Table 94: Average values per farmer and year

	Average transport volume (tonnes/year)	Average transport volume (tonnekm), weighted
Delivery trip	35,0	660
Return trip	3,17	60
Total	38,1	720

If the values are not weighted, the total average delivery volume is 36,7 tonnes and 33,9 tonnes excluding return trips. These values are about 4% and 3% lower respectively.

Provided that the average delivery for all the 126 farmers around Söderköping (the number of farmers during the period) is similar to the sample of 95 farmers, the total transport volume can be calculated. These results are shown in the table below.

Table 95: Total transport volume for transport to Söderköping/year

	Average transport volume (tonnes/year)	Aver. Transport volume (tonnekm), weighted
Delivery trip	4 410	83 200
Return trip	399	7 540
Total	4 810	90 800

If the values were not weighted including and excluding return trips the average transport volume (tonnes) would be about 4% and 3% lower respectively.

The division between different transport modes

The division between the different transport modes in the sample above is illustrated in the table below.

Table 96: Division between different transport modes

	#	%	Weighted -%
Tractor	87	92	84
Lorry	8	8	16
Total	**95**	**100**	**100**

As we can see in the table above, the percentage for lorries increases from 8% to 16% when the values are weighted. Note that the figures in the table above do not include return trips. If return trips are included, the division (weighted) is 18% for lorries and 82% for tractors. The transports in the sample around Söderköping are mostly carried out with tractors in a much larger extent than generally in farmer to silo in ODAL (88%).

Energy use "Farmer to Söderköping"

The method and the energy efficiency factors earlier for lorries and tractors are also used as basis in the calculations carried out in this section. Using this way to calculate the energy use and the transport volume and division between transport modes from the section above, the average energy use in different cases from the sample has been calculated. An average for the energy efficiency for this mix is approximately 0,77 kWh/tonnekm. The energy use based on transport volume and the calculated energy efficiency factors is illustrated in the table below.

Table 97: Energy use in transport to the Söderköping silo (kWh)

Energy use/ Delivery	Energy use /farmer & year	Total energy use in Söderköping
137	510	64 300

The total energy use in ODAL is calculated with weighted data and assuming that the average number of farmers is about 126 a normal year.

Transport from the Söderköping-silo to Norrköping/Djurön

Transport volume

After the grain has been stored in Söderköping from late October, the grain is delivered occasionally during the spring with lorries to Djurön or Norrköping. About 50% of the grain in Söderköping is transported to Djurön and about 50% to Norrköping according to ODAL (Berglin, pers. comm., 1999). These transports are generally carried out with lorries. The distance and transport volume etc. between Söderköping and Norrköping and Söderköping and Djurön is illustrated in the table below.

Table 98: Distance and transport volume Söderköping to Djurön and Norrköping respectively

		Average distance to silo (km)	Average transport volume (tonnes/delivery)	Average transport volume (tonnekm)
Djurön	Delivery trip	7,5	35,3	265
	Return trip	7,5	8,53	64,0
	Total		43,9	329
Norrköping	Delivery trip	9,0	35,3	318
	Return trip	9,0	8,53	76,8
	Total		43,9	395

The quantity per delivery and return trip is assumed the same as for lorries in the silo-to-silo transport. It should be noted in the table above that the distance between these particular silos is relatively very short. The average silo-to-silo transport in ODAL is about 70,5 km, which indicates a difference compared to the distance Söderköping to Djurön with almost a factor 10. This assumption could lead to that the energy use is somewhat underestimated, since it is likely that shorter trips have specific higher energy use (per km) than longer trips

Total in the case
The total transport volume in the case from Söderköping to Djurön and Norrköping respectively is illustrated in the table below.

Table 99: Total transport volume Söderköping to Djurön and Norrköping respectively

		Average transport volume (tonnes/year)	Average transport volume (tonnekm)
Djurön	Delivery trip	2 200	16 500
	Return trip	532	3 990
	Total	2 730	20 500
Norrköping	Delivery trip	2 200	19 800
	Return trip	532	4 790
	Total	2 730	24 600

Energy use
The energy use for transport to Norrköping and Djurön is based on the method and the energy efficiency factors earlier used in this section for for lorries. The energy efficiency factor for lorries is assumed to be 0,21 kWh/tonnekm. This factor and the payload per delivery are the same as in the step "silo to silo". The division between transport modes in this transport from Söderköping to Norrköping and Djurön respectively (in the basic alternative, 0-alternative) is based on the division in the step silo to silo. The difference is that no boat transports is expected. When boats are excluded the transport mode mix changes to about 0,2% tractors and 99,8% lorries (weighted figures). Since the difference between this and 100% lorries is negligible, 100% lorries will be used as the transport mix in the basic alternative. Using the

mix of transport modes in the 0-alternative and the described energy efficiency factors, the result becomes the following:

Table 100: Energy use in transport to Djurön and Norrköping from Söderköping (kWh)

	Energy use/ Delivery (kWh)	Total energy use (kWh)
Djurön	54,6	3 410
Norrköping	65,6	4 090

Transportation from export to import harbour

Transport volume

The transport mode from Djurön is (almost) exclusively ship transport (for export). The transport from Djurön to the customer is handled by either ODAL, SLR (Svenska lantmännen) or by the customer. SLR, which is owned by ODAL and other organisations for farmers, sometimes acts as a broker in arranging the transportation. Djurön has a turnover of 400 000-500 000 tonnes of grain each year. The reception plant in Djurön has about 30 customers. An average ship for export takes about 20 000 tonnes. This means in theory about 22-23 deliveries each season.

To follow and estimate all the transports to the customers abroad is complex. Therefore, one route for transporting wheat from Söderköping to Djurön and further to Terragona in Spain/EU will be examined and calculated to illustrate the energy use. In the transport to Terragona in Spain a normal transport is carried out with a ship loading about 25 000 tons. In general, the ship transport for export in ODAL follows a trend of increasing the size of the ships from 25 000 tons to 50-55 000 tons. The energy saving potential seems to mainly stem from the transfer to larger ships. The constraint is connected to the ports were there is not always possible to receive larger ships than those presently used (Thorn. pers. comm., 2000).

Foreign shipping companies normally carry out the transports. The agent for one of the largest companies "Uner and Jönsson" has contributed with data on which the distance, transport volume and partly the energy use for a normal transport has been estimated. This is illustrated in the tables below (Jakobsson, pers. comm., 2000).

Table 101: Transport volume etc. Djurön to Terragona

	Average distance to silo (km), weighted	Average transport volume (tonnes/delivery)	Average transport volume (tonnekm), weighted
Delivery trip	5334	25 000	133 000 000
Return trip	5334	20 000	107 000 000
Total		45 000	240 000 000

The load factor weight-% in for the route to Terragona is based on the assumption that the boat takes 93% (based on dwt) on the way to the port and about 74% on the way back. Note however that the return trips and the associated distance is hypothetical since few ships in this area go directly back to the harbour of origin. In the return trip factor, some positioning transports without load are also included. The general ship on which the calculation is based on has an estimated dead weight ton of about 27 000. The dead weight ton (dwt) is a measure for the load capacity but it also includes bunker oil etc so it is difficult to reach 100% in load factor of the dead weight tonnes of the boat. The load factors have been assumed based on discussions with the shipping agent Uner and Jönsson (Jakobsson, pers. comm., 2000) and the Swedish Shipowners Association (Karlsson, pers. comm., 2000).

Energy use
The method and principles used previously are also used as the basis in the calculations of this section. However, the load factors and transport volume etc. described above is specific for this route. The estimated energy use is illustrated in the table below.

Table 102: Energy use in used boat, Djurön to Terragona, including return trips

	Payload, average, tons	Load factor weight-%	kWh(fuel)/ tonnekm
Boat	22 500	83	0,023

The energy use in the table above (kWh/tonnekm) is somewhat lower than for an average Swedish ship for domestic transport according to NTM (1998-09-28). NTM uses about 0,056 kWh (fuel)/ tonnekm for a large goods ship (>8'dwt) in their calculations. The energy use for the transport from Djurön to Terragona in Spain is calculated, and the result is illustrated in the table below.

Table 103: Energy use in transport from Djurön to Terragona (kWh) per delivery and tonne

	Energy use (kWh/ton)	Energy use/ Delivery (kWh)
Delivery trip	124	3 090 000

If the fraction from Söderköping to Djurön is to be exported, about 2 200 tonnes/year would have to be transported. This is corresponding to about 8,8% of a normal delivery for an export boat. The energy use (kWh) of the Söderköping fraction in transport to Djurön’s customer, Terragona, is illustrated in the table below.

Table 104: Energy use from Djurön to Terragona of the fraction from Söderköping (kWh)

	Energy use (kWh)
Delivery trip	272 000

8.6.3. Total energy use in transport chain in the special case study

In Figure 64, the energy use (kWh/tonne) in different steps in the transport chain from the farmer in the Söderköping region to Terragona in Spain is illustrated.

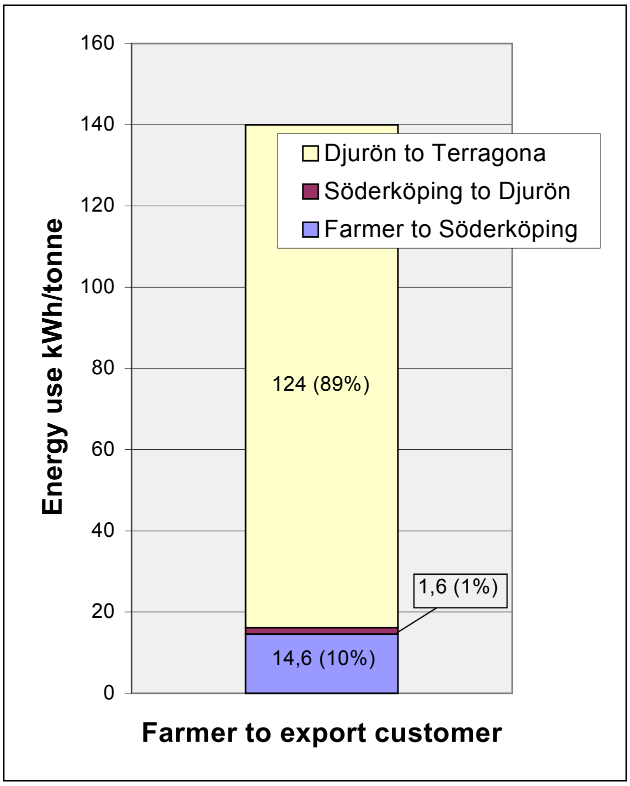


Figure 64 Energy use (kWh/tonne) in different steps in the transport chain from the farmer in the Söderköping region to Terragona in Spain

The first step "Farmer to Söderköping" corresponds to the general case for ODAL "Farmer to silo". Generally, in ODAL this step has an energy use of 7,8 kWh/tonne. The higher value to Söderköping is probably due to more transports with tractors and a longer distance (18,9 compared to 11,4 km). In the second step, "Söderköping to Djurön", which corresponds to the general case for ODAL "Silo to silo" the situation is quite the opposite. The distance from Söderköping to Djurön is almost 10 times shorter than generally in silo to silo in ODAL (70,5 compared to 7,5 km). Generally, this step has an energy use of 11,8 kWh/tonne. In "Söderköping to Djurön the energy use is about 1,4 kWh/tonne.

Note in this special case, that there are only 3 steps to the foreign country. In the general case we have 4 steps "Farmer to silo", "Silo to silo", "To Export", "Export harbour to import harbour". However, sometimes the second storage silo is the "export silo", which is the case in our selected route. Generally, the farmer to silo and silo to silo together adds up to 19,5 kWh/tonne. In Söderköping, the corresponding value is about 16,2 kWh/tonne. It should be noted, accordingly, that the special case is somewhat extreme compared to the rest of the transports in ODAL. This is in the sense that the transport distances are quite different. However, the differences in the farmer-to-silo step and silo-to-silo step in some extent counterbalance each other so that the difference when adding these two steps diminishes. This also illustrates the importance of studying local prerequisites to find where the largest potential to save energy is, since the probable difference between regions is obvious.

In Figure 64, we can note that the total energy use for the route is about 140 kWh/tonne. The second step in the route "Söderköping to Djurön has the lowest energy use 1,6 kWh/tonne and "Djurön to Terragona" the highest energy use 124 kWh/tonne. However, the distance is crucial, if the distance were the same in the latter as in the first step (about 7,5 instead of 5334 km), "Djurön to Terragona" would have an energy use of about 0,17 kWh/tonne.

8.7. Pilot actions within the Swedish case companies

Ecotraffic has investigated possible pilot actions to find the effect of different energy saving strategies. *Potential* pilot actions were described in the report from phase 1 in this project (Andersen et.al., 1999). Together with partners and case companies, Ecotraffic has chosen the following pilot actions:

1. Study of how structural rationalisation; in form of more drying and storage at the farmers and more of transport with lorries and possibly closing of silos; can affect the energy use.
2. Study of how changes in information flow and route planning can affect the energy use.
3. Study of how a changed driving style can affect the energy use.

8.7.1. Pilot action 1: Effect of a structural rationalisation

This pilot action includes a study of the effect when a silo is shut down and the effects of more drying and storing at the farms. It also includes the effect of a change in transport mode e.g. from tractors to lorries which is a probable effect of the closing of silos.

Potential effect of a change in transport mode

Transport volume and energy use
To find the effect of a change in transport mode, the energy use in the special case is used as reference and to describe the current energy use. In the transport of grain today from the farmers to Söderköping, the mix of transport modes is 92% for the tractors and 8% for the lorries. If lorries were to be used in 100% of the cases, the energy use would be reduced. An approximate average for the energy efficiency for this new mix (with 100% lorries to Söderköping) is 0,39 kWh/tonnekm. This is assuming that the transport volume and load factors are the same as before. The energy use based on transport volume and the calculated energy efficiency factor is illustrated in the table below.

Table 105: Energy use in transport to Söderköping with 100% lorries (kWh)

	Energy use/ Delivery	Energy use /farmer & year	Total energy use in Söderköping	Diff. (%)
Current energy use	137	510	64 300	
100 % lorries	69,1	257	32 400	-50%

The difference is about 50% lower energy use compared to the mix of transport modes today. It can also be interesting to see the potential in energy saving when including the transport from the silo in Söderköping to other silos as well. The two cases transport mix that appears is illustrated in the table below.

Table 106: Transport mode mix in the different alternatives

	Case 0	Case 1
Farmer to Söderköping	Lorry: 8% Tractor: 92%	Lorry: 100%
Söderköping-Norrköping/Djurön	Lorry: 100%	Lorry: 100%

As can be seen in the table above, there is no real potential in the silo-to-silo step in Söderköping. Therefore, the energy saving potential in the total chain is somewhat reduced. The energy use and saving potential in different alternatives is illustrated in the table below.

Table 107: Energy use in transport in the different alternatives (kWh)

		Case 0	Case 1	Diff.
Farmer to Söderköping	Per delivery	137	69,1	-50%
	Total	64 300	32 400	-50%
Söderköping-Norrköping/ Djurön	Per delivery	60,1	60,1	0%
	Total	7 500	7 500	0%
Farmer to Norrköping/ Djurön	Per delivery	197	129	-35%
	Total	71 800	39 900	-44%

In the table above, the figures in the step "Söderköping-Norrköping/Djurön" are an average of the energy use in transport to Norrköping and Djurön. The total case one leads to 35% lower energy use per delivery and 44% lower total energy use compared to case 0. The potential, in this case, to save energy is in the farmer-to-silo step, -50%. However, it should also be noted that the use of tractors is somewhat greater in the special case (about 92% compared to about 88% generally in ODAL), so the energy saving potential in farmer-to-silo transport might be a slightly lower. On the other hand there might also be a potential in some routes from silo to silo to save energy, if tractors are used in a larger extent than in the special case.

In the lorry transports between silos it is assumed that the load factor and the average payload is the same as in the silo-to-silo transport. This means that the payload and load factors are larger/higher than in the farmer-to-silo transport. If larger lorries could be used when picking up the grain at the farmers, the potential for energy saving could be even greater.

A study made by Gebresenbet & Ljungberg (2000) also showed that tractors have a higher energy use per unit grain delivered and a longer waiting time at the delivery point. During the harvest season, queues at silos/reception plants are a particular problem for both tractors and lorries. Effects of queuing are higher labour costs, emissions and energy use for idle driving. There is also an additional cost involved, since the vehicles can’t transport any grain when they are stuck in queues. The time used per delivery is greater for lorries but in relation to quantity, the lorries are more efficient. The study showed that the total delivery time was twice as long for tractors compared with lorries. The farmers who deliver with tractors are often transporting the grain directly after the harvest without reloading. The study showed that it is more time-consuming to transport by tractors than to pick up the harvest at the farms and transport by lorries. Direct transport with lorries from farm to silo is generally the most energy efficient option. Despite the extra time for loading and reloading, it was twice as time-effective to go a shorter distance with tractors and then reload to a lorry than to go directly to the silo with a tractor (Gebresenbet & Ljungberg, 2000).

A possibility to reduce the use of tractors would be to collect the grain at the farm with lorries, which have a loose platform body. First, the platform body is delivered to the field and the farmer can e.g. then fill this up with grain directly from the combine harvester. A disadvantage with this concept is that the loading and unloading is relatively time-consuming and that it implies some driving without load. Another possibility is to dry and store more grain at the farm and collect it with lorries.

Is it possible and realistic to replace all the tractor transports on the roads with other transport moeans? If not, what are the major constraints? Interviews with two organisations in the agriculture industry namely ODAL (Johansson, pers. comm., 2000) and The Federation of Swedish farmers, LRF, (Hogfors, pers. comm., 2000) has been carried out mainly regarding transfer of goods between transport means. This is described in the following.

Possibilities to change transport mean from tractors to lorries

The limitations in transferring goods from tractors to lorry transport (to silo) according to ODAL are mostly dependent on if the farmer can dry and store on the farm and if the lorry can reach the harvest storage on the farms (sometimes the roads are to poor). It is also dependent on if there are any available lorries, which are not reserved since there can be a shortage in the most hectic harvest time. An advantage with lorries instead of tractors is that a lorry can replace about 6-7 tractors according to the informant at ODAL (Johansson, pers. comm., 2000). If lorries carry out 50% of the transports today, maybe 75-80% could be possible in 10 years. The additional 20-25% is considered to be difficult to reach. Examples of reasons for this are that the farmers must perhaps get special equipment or improve the road to the farm so that a lorry can collect the harvest. To achieve the mentioned potential ODAL, stimulates the farmers to let a lorry pick up their harvest by offering them a higher price for the harvest. During the last 4 years, the amount of tractor transports has, as a result of this, been more than halved. (Johansson, pers. comm., 2000) So there is a relevant sector for transferral of goods between transport modes. Even though 100% lorries is not realistic in the short term maybe 80% can be possible within 10 years

Potential effect of more drying at the farms

An increase in the drying of grain at the farms instead of at the silos, is more or less a prerequisite for the closing of silos. Closing silos can also be advantageous if more farmers chose to dry the grain at the farms. A study of the effect of more drying at the farms is therefore of interest. If the grain is dried at the farm, the water content in the grain is reduced and the transport volume (tonnes) is reduced correspondingly. This should also lead to a potential for energy saving. To find out the size of this energy saving potential is the main objective in this section.

Background
Today, ODAL have different reception plants for different qualities of grain. The system today is mainly that the farmer sells whenever and to whom he wishes. ODAL seldom has the knowledge of the quality of the grain until it is delivered. A problem with not knowing the quality of the grain is that some silos, intended for certain qualities, will be full while others are more or less empty. This means that many lorries may have to travel a long distance before they can deliver the grain to a silo which is not full (generally, the farmer can always deliver to the nearest silo. Further transports are carried out by ODAL).

The quality of the grain determines the use of the grain (low quality is used as fodder, high quality is used as e.g. flour etc.). Accordingly, after the different qualities have been stored they are sold for some of these different purposes. The system today makes it somewhat difficult to plan the activities (including transports). To solve this problem, ODAL tries to make more contracts with the farmers in advance so that they know approximately how much grain of a certain quality they will receive.

About 40% of the grain are presently purchased through contracts. ODAL also wants to encourage the farmers to dry and store the grain until it is delivered. If the farmer stores and dries at home, and conduct tests of the quality at the farms, ODAL can more easily keep record of the different qualities and directly transport them to a suitable receiver. It also means that ODAL gets a lower storage cost. The farmer who gets a higher storage and drying cost is compensated for this. The compensation is paid as an increment on the price for the grain. The increment is 1/11 –2000 around two SEK/dt. This is under the condition that the grain is dried to a water content of 14 %. The farmer can also plan his activities better and knows where to put the grain and could speculate in prices for the grain more effectively as well.

If one is going to load a larger fraction of the harvest on lorries, instead of tractors (the effect of closing silos), without drying some difficulties, appear. For example, you have to transport it fast so that you can dry the harvest fast (at least within three days otherwise there might arise some toxins in the grain). Therefore, you also have to have a large capacity of lorries available, since many farmers harvest at the same time, due to the short harvest season in Sweden. This is of course costly if the lorries can't be effectively used for other purposes in the off season. The peak in grain deliveries in the autumn also makes it difficult to find products for return trips (Ljungberg, pers. comm., 1999, regarding silo in Norrköping). The peak in grain deliveries in ODAL is illustrated in the figure below.

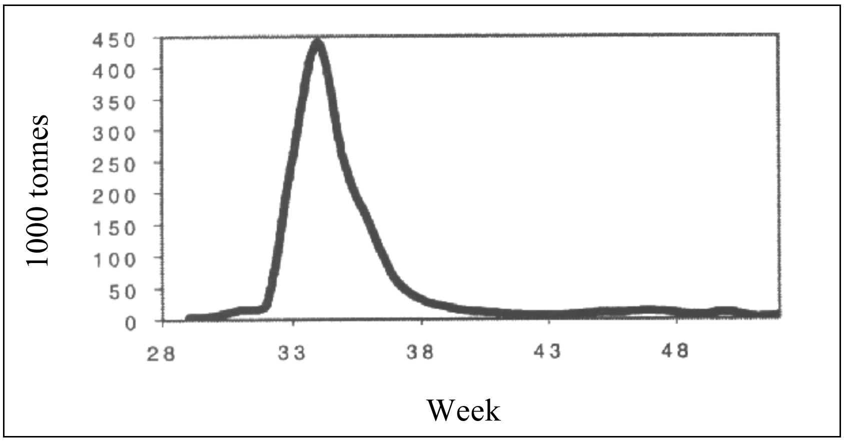


Figure 65: Deliveries of grain per week to ODAL, tonnes (Annual report ODAL, 1997)

A normal year about 60% of the grain is delivered during the harvest season, although the climate can change this figure quite significantly between years (in 1997 was about 80% delivered during the harvest season). If the grain is dried and stored on the farm, transports with return trips can be easier to organise. If the grain is dried at the farmers, the emissions from the transport can be reduced. On the other hand, the emissions from the farmers drier might be higher than from ODAL's drier. Generally if the traditional type of hot air dryer, with oil as fuel, is used, the difference is marginal. The energy use for drying grain with these types of drier is approximately 1,85 litres of oil per %-unit and ton of dried grain, regardless of size of the drier (Regnér, pers. comm., 1999). The figures include an efficiency loss of 15-20%. If the grain is dried from a water content of 21% to 13,5%, the fuel consumption in this type of drier is about 13,9 litres of oil per ton dried product. This corresponds to an energy use of about 139 kWh/tonne, which can be compared with the energy use for a transport from Söderköping to Terragona in Spain using about 140 kWh/tonne.

However, the large dryers sometimes have a possibility to use other energy sources instead of oil since they are often localised closer to larger cities. For example, they might be able to use waste heat, steam, district heat or natural gas. The cost for investing in a pipeline for, e.g. natural gas, to the farmers is too large, due to the distance[74].

In ODAL's case, mostly hot air dryers with oil as fuel are used. The possibility to use other fuels than oil is dependent of location and no general assumption can be made in this case. Therefore, the difference between different sizes of dryers will not considerably effect the energy use and emissions in this general analysis.

The pilot action

The pilot action is to approximately assess how much energy ODAL could save by buying more through contracts and how logistics and planning could improve through these means. The pilot action will be based partly on the special case in Söderköping. In this pilot action, it is illustrated what happens with the energy use with a change in the amount of dried grain at the farmers (leading to less transport volume).

The pilot action includes a study with three alternatives.

- The basic alternative (0-alt.) is to mainly use tractors (see mix in the table below) with un-dried grain to Söderköping and lorries to Norrköping/Djurön.
- The 1- alternative is to deliver undried grain with lorries to Söderköping and to Norrköping/Djurön.
- The 2-alternative is to deliver dried grain to Söderköping and undried to Norrköping/Djurön with lorries (this case is hypothetical since it is more logical to also transport dried grain between Söderköping and Djurön/Norrköping).
- The 3- alternative is to deliver dried grain to Söderköping and to dried grain to Norrköping/Djurön (dried at the farm) with lorries.

The different cases are illustrated in the table below.

Table 108: Transport mode mix and drying point of the grain in different alternatives

[74] It should be recognised that the Swedish natural gas pipeline grid is undeveloped (due to the lack of domestic natural gas sources) and covers only a small portion of the populated areas in Sweden.

	Case 0	Case 1	Case 2	Case 3
Farmer to Söderköping	Lorry: 8% Tractor: 92% (undried grain)	Lorry: 100% (undried grain)	Lorry: 100% (dried grain)	Lorry: 100% (dried grain)
Söderköping-Norrköping/Djurön	Lorry: 100% (undried grain)	Lorry: 100% (undried grain)	Lorry: 100% (undried grain)	Lorry: 100% (dried grain)

To simplify the study, we are assuming that the cases 0 and 1 and energy use previously calculated are identical with the cases 0 and 1 in the table above. It is assumed that he grain to be dried from a water-content of 21% to 13,5%. A factor is used to calculate the transport volume of dried grain based on the undried grain. The factor is 0,9133 (0,79(1+0,135/0,865)). The energy use based on these prerequisites in the different alternatives is illustrated in the table below.

Table 109: Energy use in transport in the different alternatives (kWh)

		Case 0	Case 1	Diff.	Case 2	Diff.	Case 3	Diff.
Farmer to Söderköping	Per delivery	137	69,1	-50%	63,1	-54%	63,1	-54%
	Total	64 300	32 400	-50%	29 600	-54%	29 600	-54%
Söderköping -Norrköping/ Djurön	Per delivery	60,1	60,1	0%	60,1	0%	54,9	-9%
	Total	7 500	7 500	0%	7 500	0%	6 850	-9%
Farmer to Norrköping/ Djurön	Per delivery	197	129	-35%	123	-38%	118	-40%
	Total	71 800	39 900	-44%	37 100	-48%	36 400	-49%

In the table above, the figures in the step "Söderköping-Norrköping/Djurön" are an average of the energy use in transport to Norrköping and Djurön. It could be noted that Case 2 and 3 would reduce the energy use in “Farmer to Söderköping” with 54% compared to case 0. The energy use in “Söderköping to Norrköping/Djurön” can, as an effect of more drying, be reduced by about 9% in case 3. The total reduction of the route (Farmer to Norrköping/Djurön) is 38%/delivery and 48% as a total in case 2 compared to case 0. The reduction of the route in case 3 comparing with case 0 is 40% per delivery and about 49% as a total.

Accordingly, the table above shows the increase in energy saving potential as an effect of more drying of the grain before transportation. Note however that case 0 shows a situation where no grain is dried before transport (with the exception of the return trip goods). This can not generally be considered as the situation in ODAL. The potential is therefore changing between silos and the potential illustrated here should be seen more as an example rather than the actual potential in ODAL or the Söderköping route.

Case 3 farmer to Söderköping compared with case 1 shows *the probable effect of the drying* on the energy use in the whole route. The energy saving potential of drying per delivery and total is about 9% farmer to Söderköping. The effect of more drying at the farm also increases the possibility to go directly to the final reception plant or the customer. This can also reduce the time used for reloading.

Possibilities for drying more at the farms
As mentioned earlier, ODAL stimulates the farmers economically to dry more at the farms. The constraints are often that the farmers in some cases have to purchase special equipment and/or improve the road to the farm so that a lorry can collect the harvest. There is also a demand from ODAL that the height beneath the loading equipment must be at least 3,60 m (Johansson, pers., comm., 2000). However, if the economical incitements are strong enough this should not be a problem.

A potential problem is also that the quality of the grain is somewhat uncertain, as described earlier. However ODAL is working to solve this problem and is nowadays selling special equipment for measurement of grain quality. The farmer who dries the grain can send a sample with mail to ODAL. The analysis of the sample is, to a great extent, automatic. The analysis of the grain samples takes about one day (can take longer if many arrive at the same time) and can be used by ODAL's sales section to e.g. estimate the quality of the grain and transport need in different areas. This system has been in use in ODAL for about half a year (June 2000) and is an important prerequisite of more use of IT for e.g. route planning and transfer to more energy efficient transport modes. The introduction of MOVEX, which is a business system (computer software), will also help to follow-up the transport flows in ODAL. To be assured of the quality, ODAL visits the farmers traditionally and conduct quality tests of the grain to be delivered. ODAL also perform tests when the grain is delivered and makes controls of the farmers dryers. ODAL also informs the farmers about methods for how the farmer should measure the quality of the grain.

Pilot action 2: Effect of use of IT based systems
The second action is a study of how changes in information flow and route planning could affect the energy use". This includes an investigation of to what degree improved logistics can optimise the use of most energy-efficient route choices and how the load factor can be raised by improved return trips. The study has mainly been carried out in contact and co-operation with the Swedish University of Agricultural Sciences (SLU). Gebresenbet & Ljungberg (2000) has in a pilot study equipped a number of lorries with Global Positioning Systems (GPS). GPS is a satellite based navigation system primarily developed for military use but is now accessible for civilians. The system provides latitude and longitude positions and altitude over sea level. Using signals from at least three satellites and a GPS portable receiver, the position and speed of moving vehicles can be determined. Route-planning program has been used to analyse the data in the pilot action.

Background

The use of IT based systems is a new area which could be used in a larger extent by transport planners to save energy. GPS and GIS (Geographical Information System) in combination with mobile telecommunication can e.g. make it possible for transport planners to keep record of the position of different vehicles. With transport information systems, disturbances in the transport can be reported, new assignment can be divided to the closest vehicle and routes can be changed due to new circumstances. In general, transport companies are not using IT-systems like this (e.g. route programs and GPS-systems). Therefore, a question is if such equipment can reduce the energy use.

In our previous calculations, the return trips with the used vehicles have been assumed to vary depending on vehicles. With our calculated transport mode mix, the transport volume of the return trips amounted about 1/5 of the weight of grain deliveries generally in ODAL. The return trips to the farms generally include seeds for sowing, fertiliser and fodder. However as described above these transports are often carried out with other vehicles than the ones delivering grain.

There is no potential to reach full load on the return trips for all the deliveries to the farms. It is, to a large extent, the same actors who sell fertiliser, fodder and seeds for sowing and the ones who buy the grain. A problem is that the terminals for fertiliser and factories for fodder and seeds for sowing and reception plants for grain are spread in a large area. For example, seeds for sowing is mainly transported from a central storage in Västerås and fertiliser is mainly transported from Köping. About 90% of the deliveries are delivered by lorries and about 10% are delivered by tractors from ODAL's shops by the customers. It is also a problem that many farms today are so specialised so that not many farms buy fodder and sells grain in any significant extent.

Today, ODAL are using hauliers for their transports. The hauliers are organised in three haulier associations. These are "Sveaåkarna, Vestab, and ÖMT and they have the responsibility for the transports and transport planning. ODAL receive the orders and forwards these to the hauliers. A certain haulier association has the main responsibility for transports in particular geographical area, although this association sometimes is operating in others areas. The transport planners have the responsibility to allocate the orders between the different hauliers, which then allocate them between their vehicles/drivers. There is a certain competition between the hauliers and this could be a problem in the co-ordination of goods and return transports. Some information can be difficult to get for the transport planners. The transport planners do e.g. seldom know of transport orders and routes arranged by others than themselves.

If a third party is involved which co-ordinates the transports with IT-equipment. The transports could be organised according to the figure below.

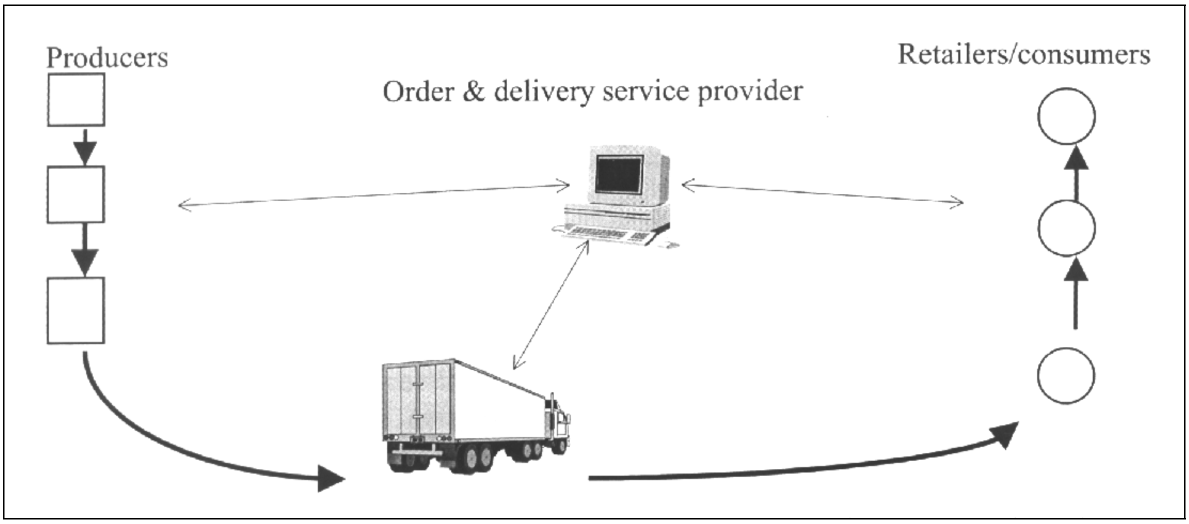


Figure 66: A distribution system in which a third party is used to co-ordinate the transports (Source: Gebresenbet, 2000)

The thick and thin arrows in Figure 66 illustrate the material and information flows between the actors respectively. The practical organisation can be an obstacle or an advantage for co-ordination of goods. Even if there are no competition between different haulier organisations, there can be other reasons for choosing own vehicles rather than other hauliers vehicles. In this aspect, it could be an advantage to use a large independent company such as ASG and similar companies as a third party to handle the distribution and logistics.

However, even if there are available flows of goods in both directions and/or flows of goods that could be loaded together at all times, there can still be obstacles for co-operating these transports. Examples of such obstacles are:

- The shape of the goods; bulk goods is difficult to load together with other types of goods.
- Technical limits; for example the demand for temperature etc.
- Competition.
- Regulations for handling certain types of goods; e.g. provisions and animals.
- Resistance against change and factors of uncertainty.

The flows of grain in opposite directions are mainly found in the step "silo to silo" and return trips are found here to some extent and in the surrounding area. In some periods other type of transports can be prioritised for example during the harvest period. The main goal is often during this period to transport grain from the farms to the silos. Some loading via different types of goods is occurring when lorries are used for deliveries of goods in sacks and on pallets to the farms. These lorries can also be used to collect grain from the farms. However the problem is that the flows in opposite directions not is available at the same time of the year. The majority of the grain is delivered in the early autumn during a few weeks, while fertiliser is delivered mainly during the autumn and the winter. The fodder is as previously mentioned delivered all year (Gebresenbet, 999).

The collecting of grain can be combined with deliveries of fodder in bulk. In addition, some other types of goods like building materials are in some extent used for return trips. As mention earlier, a large part of the grain is delivered with tractors, which makes it more difficult to load or combine with other types of goods. The most common scenario today is, according to The Federation of Swedish farmers, LRF, (Hogfors, pers. comm., 2000) that the transporting company uses different lorries when collecting the grain and when delivering fertiliser and fodder to the farmers. Fodder is often delivered with a lorry using a number of boxes, which are unloaded pneumatically. Grain transport is mainly delivered with lorries that are "high limbed" (so they can tip over the platform body).

In a fusion in the agriculture industry between different farmer organisations some years ago, the main aim was to be able make the transports more effective. In the beginning after the fusion the common transport company delivered fertiliser and fodder and picked up the grain harvest from the farmers. In the county of Jämtland, there were also unattended stations out in the countryside where the farmers were able to pick up for example fertilisers themselves. Nevertheless, they co-ordinations of the transports to the same place were soon shut down. The main reason was probably according to Hogfors (pers. comm., 2000) that they transporting company found that the rhythm between in and out transport was too diverse and that the gain in co-ordination was too small. Hogfors points out that the same lorry could be used for both receiving (grain) and delivering (fertiliser/fodder) transport if the grain (bulk cargo) is loaded in sacks and the fertiliser/fodder is loaded in sacks on pallets (general cargo).

A conclusion is that it is important to make more farmers dry and store at the farms so that the peak in deliveries of grain can be reduced. It is also an advantage if more lorries can be used if the size of the return trips is to be increased and the energy use (kWh/tonnekm) is to be reduced. Accordingly, an increase of the load factor is also achieved in the organisation and route system of the transports. The potential in using IT based systems will be examined in the following pilot action.

Pilot action

A pilot action was carried out in the regions around Norrköping and Uppsala in 2000 by Gebresenbet & Ljungberg, SLU. Both these regions are within the ODAL area. Measurements were made of grain transports and distribution of goods. Gebresenbet & Ljungberg did also some other studies of other types of goods like distribution of meat and milk. Our interest and report will, however, only concern the relevant results for the grain deliveries and return trips. Places for deliveries and collecting were registered with GPS-equipment. Quantity and type of goods were also noted. The project also included a mapping of flows of goods. In Uppsala was also noted the use of time for loading and unloading and waiting in queues was also recorded. The study included 19 lorries, 4 tractors and 34 routes. Six of the routes where carried out with continuous route registration.

The evaluation of the results was made by software for route optimisation. DPS WinLogiX was used for total optimisation of systems with several routes were also the numbers of vehicles are optimised and DPS RouteLogiX Pro was used for optimisation of separate specific routes.

Possibilities to save energy by using IT based systems

The pilot actions showed that there is a large potential to save energy in some cases. Some examples that have showed a large potential for energy saving are:

- Route optimisation have a large potential and can shorten routes and transport distances by up to 29%. Long routes with many stops for load and reload has the largest potential.
- Co-ordination of distribution of goods (e.g. fodder) and grain collection at the farms.
- A possibility to reduce the number of vehicles by optimising many routes together.
- Use of appropriate and in some cases flexible vehicles that can carry many types of different goods.

Route optimisation has, as mentioned above, different effects depending on the distance and number of stops. On more simple routes the driver can generally decide which route is the shortest and fastest. The routes regarding grain deliveries are generally often only between one location for collecting and one for delivery. Many routes were studied in the pilot action. In one example, a possibility to reduce the distance with generally about 6-7% was identified. However, the total distance of some routes could be reduced by about 23% or by up to 28% of the driving time. However, although most routes in the pilot action could not be reduced at all it is observed that also simple routes can sometimes be optimised and reduced. The important factors for the size of the reduction is the total distance and number of stops. It is also clear that the potential for reduction is larger if more vehicles and transports are involved in the optimisation for example during the harvest season.

In another study by Gebresenbet (2000) in the same area, both distance and time could be reduced by about 34% in some routes if optimisation was made before the distribution. This report also showed that about 20% of the drivers planned their route perfectly without extra IT based systems. The results also indicated that it seemed easier to plan the route well in suburbs or regions/rural areas than in towns. The total optimisation of the transports involved in the study reduced the routes, the total distances and the number of vehicles with 58%, 39% and 42% respectively.

However, the high reduction results described above generally concern transports of provisions in general e.g. transports of bread and meat. The possibilities for return trips for grain transports will probably not always reach this potential for example depending on what vehicle that is used. The lowest possibilities are probably between farmer and silo. It would be desirable to be able to load grain at every delivery of return trips so that the load factor could be maintained high. An obstacle today is that sanitary problems must be solved e.g. via some kind of sacks, plastic containers or some other new technique.

Other areas where IT based systems could be of use are in the identifying goods e.g. with bar codes. Two-dimensional bar codes can be used to reduce the time for loading and reloading and to improve the possibilities for co-ordination and transport planning etc. However, it is important to standardise protocols and to increase the security to be able to use these techniques. The Swedish transport industry is using electronic business communication to high extent and it is working more and more with standardisation of electronic documents for invoices and other similar information exchange. About 70% of the larger transport companies have declared that they already have or will have bar codes on their goods within a year. More research needs to be done in this area to clarify the benefits in reduced energy use due to more use of bar codes (Gebresenbet, & Ljungberg, 2000).

8.7.2. Pilot action 3: Effect of a changed driving style

The designation “ecodriving”, i.e. an economical driving style, has the objective of changing the driving behaviour in order to decrease the fuel consumption and exhaust emission.

Ecodriving could be beneficial for the transport company or owner-operator, since the fuel cost is a major portion of the expenses that could be influenced.

Background and introduction to ecodriving

The concept of economical driving style was originally conceived in the USA but much of the present work in Europe emanates from several countries such as Belgium, Finland, the Netherlands, Switzerland and United Kingdom. The concept of "ecodriving" was introduced in Sweden using the basic ideas and education package that had already been developed in Finland. Several Swedish Governmental Authorities and organisations teamed up with their counterparts in Finland and the concept was thereafter introduced in Sweden as well.

Ecotraffic (Ahlvik, 1999) has carried out an inception study for the Swedish National Road Administration (SNRA) on the potential decrease in energy use by changing the drivers behaviour (i.e. driving style). The study has also listed some of the activities in this area in Europe. Some of the material cited here is from the literature survey in that study.

Theoretical potential and limitations

The maximum available road power corresponds to an efficiency of 37%. The minimum efficiency corresponds to situations as, for example, curb idle. Engine friction, cooling losses and exhaust are the major losses. Transmission losses are of less importance. Therefore, for a certain power, the most favourable strategy to reduce the fuel consumption is to run the engine in the optimum load and (engine) speed range. Other methods to reduce the fuel consumption include alteration in the driving pattern. This could be achieved by changing the acceleration scheme and reducing the losses of inertia in braking. The potential of alteration of the driving pattern is somewhat reduced in congested transport compared to less dense traffic. In the former case, there is not much option for the driver but to follow the transport flow. Likewise, the potential for reducing the fuel consumption is also less in highway driving.

In order to gain some understanding about the theoretical potential of improvement in fuel consumption by changing the driving style, the specific fuel consumption in the engine load and speed range considered according to Moser et al., 1994.

In general, the lowest possible fuel consumption can be achieved by running on low engine speed when the required engine power is below 350 kW. The road load power needed on a flat road is far less than this level. The reason why a reduced engine speed and increased load (for constant power) is not beneficial in the power range between 150 and 350 kW is twofold. First, the engine is probably optimised for about 1 200 r/min (camshaft design, injection advance, turbocharger, etc.). Second, since the engine is turbocharged (the standard feature of all modern heavy-duty engines), the air-fuel ratio is rather low (lower than optimum) at high load below 1 200 r/min and this increases the fuel consumption. In general, the optimum engine speed falls into the range of 1 000 to 1 600 r/min. Within the mentioned range, it is generally beneficial to reduce the engine speed as much as possible and to increase the load as much as possible for any given power. The exception is the area of high load below 1 200 r/min mentioned above, where the speed should not be reduced to 1 000 r/min.

The conditions shown in the description of the driveline above clarifies that a gearshift strategy can be found that minimises the fuel consumption. A strategy that maximises the engine load and keeps the engine speed within the range of 1 000 to 1 600 r/min (preferably 1 200 to 1 400) is beneficial. Another important factor, as mentioned above, is the alteration of the driving pattern in order to accelerate as efficiently as possible and to reduce the braking losses as much as possible. Some examples of results will be given below that highlight the potential of these means.

Methodology in the study

In the project planning of this project, it was decided to carry out some practical pilot actions in co-operation with the case companies. After some discussions, an investigation of the potential for ecodriving was chosen as one of the pilot action. Ecodriving for drivers of light-duty vehicles was first introduced in Sweden based on a concept from Finland. The organisation for the driving schools in Sweden (STR) has been the principal organisation involved in the education of teachers and organizing the courses for the drivers. A subsidiary company of STR, EcoDriving International, was founded to handle this business.

Some activities on ecodriving have also been carried out in Finland to educate drivers of heavy-duty vehicles. However, it was felt in Sweden that a more comprehensive education material was needed for the drivers of heavy-duty vehicles. Considerable work was invested in this task by EcoDriving international and TYA, an organisation dealing with working environment (and education in this area) within the framework of the transport workers unions. Therefore, the possibility of initiating an education of these drivers was considerably delayed from the timeframe (about one year) originally anticipated. In the winter of 2000, the programme for the education was more or less ready and the education of the teachers started. Discussions were then initiated in the spring of 2000 between Ecotraffic, EcoDriving International and the case company SJ/Svelast in order to investigate the possibilities for running a pilot test for some selected drivers of Svelast. However, due to several reasons, the decision of the participation of SJ/Svelast in such a programme was delayed until the fall of 2000. Therefore, it was not possible any more to carry out this programme within the timeframe of our project. It was also thought that the fall and winter with varying weather conditions was not an ideal time of the year to carry out such a programme.

Since the opportunity to carry out a practical demonstration within one of the case companies was not possible, an alternative approach was taken. It was decided to collect and assess some of the preliminary and principal investigations carried out by EcoDriving International during the spring and summer of 2000. These data were kindly made available to the project team by EcoDriving International. Some of the results already collected in the previously mentioned study by Ecotraffic are also reported here.

Results

DaimlerChrysler and its subsidiary Mercedes Benz (light and heavy-duty vehicles) has carried out an extensive investigation about the potential of changing the driving style. Some of these results were reported by Renner (1998) at a conference organised by SNRA in the fall of 1998. Tests were carried out by using Mercedes Actros, a heavy lorry, which is quite representative of long-distance lorries used. Although the driving pattern may differ from the driving pattern in the Nordic case companies, the results should be possible to generalise to these conditions as well.

To motivate the driver to save fuel, a man-machine interface (MMI) is needed to provide the relevant information. Three major categories of driving situations have been identified where the fuel saving potential is significant. These are cruising (at constant speed), downgrade driving and acceleration. Mercedes has noted that the information to the driver at cruising speed is an indication that the driver should make the most efficient gear selection (see figure 12 above). This could be made by using a gear indicator. In downgrade driving, it is important to select the right gear and to use the service brake in order to avoid wasting any fuel (using the fuel cut-off for a motored engine). The driver should waste as little inertia as possible in entering the levelled section again. Making the driver aware of the vehicle inertia, the topological characteristics and transport flow pattern is important in order to utilise this insight for fuel saving. During acceleration, it is important to reach the constant velocity with *high* acceleration. This is definitely against common sense about economical driving, where the recommendation has been to drive “as if you had an egg between your foot and the accelerator pedal”. Heavy-duty vehicles often have many gears and, therefore, it is usually beneficial to skip some of the lower gears. The importance of the strategy in acceleration has been shown by Renner in the previously mentioned publication. The following four different strategies have been investigated.

- Strategy 1: shifting too late, too high engine speed
- Strategy 2: optimal shifting
- Strategy 3: too frequent shifting in low gears
- Strategy 4: engine speed is too high

In the future, more “intelligent” on-board computers could have several functions integrated in the system that may serve the driver with the necessary information. It is also conceivable that this data could be sent from the on-board computer to a host computer at the operator’s office to further analyse the data. In this assessment, a continuous improvement of the driving style could be initiated based on this analysis. A potential problem that cannot be neglected in this respect is that the drivers might feel uncomfortable with the supervision from the office. In summary, technology will not be the limitation in the future, provided that the MMI can be handled in a smooth way.

8.8. Discussion and Conclusions of the Swedish pilot actions

The principal purpose of the study of energy use in ODAL was to provide an overall idea of the approximate amount of energy used in different parts of the transport chain. The transport chain has been divided into the steps “farmer-to-silo”, ”silo-to-silo”, “to export”, and, in the special case, also “from export harbour to import harbour”. The figures in different parts of the chain are partly uncertain and can differ up to 20% or more, especially since the transport volumes differ considerably between years and regions in ODAL. However, the data could be used to show, which the areas of main energy use are, and the potential for energy-saving activities. The important factors in energy saving, such as the choice of transport mode and distance between producer and consumer, etc., are also highlighted via the study of energy use and pilot actions.

8.8.1. Energy use in ODAL

It can be noted that about 1/3 more energy is used in the “silo-to-silo” step (11,3 GWh/year) compared with the “farmer-to-silo step” (7,41 GWh/year). The distance is also longer in the “silo-to-silo” step. The average energy efficiency in “silo-to-silo” is however larger, about 0,15 kWh/tonnekm, compared to 0,67 kWh/tonnekm for “farmer to silo”. The “farmer-to-silo” step includes more use of tractors, which are also assumed to have a lower load factor than lorries. About 65% of the grain in ODAL is exported and the energy use for transport to export harbours in Sweden is about 12,2 GWh/year.

The special case study called “Söderköping” illustrates the great effect of a short transport distance and high-energy efficiency of the transport mode. The special case has more than 50% higher energy use per delivery (about 136 kWh compared to 84) compared to the average for the general farmer-to-silo transport case. The main explanation for this is the more frequent use of tractors as the transport mode and a longer average distance to the silo (about 18,9 km compared to 11,4 km). The average energy efficiency in the special case is about 0,77 kWh/tonnekm.

The importance of short transport distance and high-energy efficiency is also illustrated in the examined special route from a farmer delivering to Söderköping and further to Djurön and Terragona in Spain. The calculations showed that almost 90% of the energy use is attributed to the sea-route segment from Djurön to Terragona, even though ships have the highest energy efficiency. Therefore, efforts undertaken to improve the energy efficiency of ships could be interesting. In the transport for export by ship in ODAL, the employment of ships of increasing size from 25 000 tons to 50-55 000 tons is occurring. The constraint is, however, in ports were it is not always possible to receive ships larger than those presently used.

The calculations in the special case also showed that there was a large potential for energy savings in the farmer-to-silo step. The study revealed that although the distance in this step was only about 0,4% of the total transport distance, the energy used was almost 10% of the total energy use for transport (kWh/tonne).

8.8.2. Pilot actions

There is a potential to reduce energy use by replacing tractors with lorries in the first “farmer-to-silo”step according to our calculations and assumptions. The special case study showed a potential for about a 50% reduction by using only lorries. However, it should also be noted that the use of tractors as the transport mode is somewhat larger in the special case (about 92% compared to about 88% generally in ODAL). Consequently the potential for energy saving in the farmer-to-silo step might be slightly lower generally in ODAL. On the other hand, there might also be some potential to save energy in some routes in the silo-to-silo leg if tractors are used to a larger extent than in the special case Söderköping to Norrköping/Djurön.

Using only lorries is not realistic in the short run. It is clear that it is necessary to get more farmers to dry on the farm. Sometimes road conditions are also too bad for lorries to be able to reach the farms. Another factor is the availability of lorries, which cannot be taken for granted, since there can be a shortage during the peak harvesting time. To achieve the potential, ODAL provides incentives to farmers who transport their grain with lorries by giving them a higher price for the harvest if it is dried at the farm and collected by lorries. During the last four years, the amount of tractor use for transport has, as a result of this, been more than halved. So there is a relevant area for transferral of goods between these transport means. Even though 100% use of lorries is not a realistic goal in the short term, perhaps about an 80% use factor can be possible within 10 years.

In the “silo-to-silo” step, the share of tractor transport is already so low, 0,1%, (in tonnekm) that there is limited potential in this step to further reduce the energy use by substituting tractors with lorries. A relevant question, therefore, is: Can more energy efficient sea or rail transport be used instead of lorry transport? For ODAL and the agriculture industry it seems difficult to transfer many more shipments of goods from road to rail, especially if shipments are to be loaded directly on rail at the silos. One alternative is to load first on a lorry and then on railway. The average distances are however generally too short to suit railway transportation. About 70-110 km is an average distance from silo to silo or customer (according to the previous energy analysis). The study indicates that 150 km could be a reasonable distance to transfer from road to rail. However, it could be less if the reloading systems are highly efficient.

The opportunities to transfer more goods to sea transport are also limited. Crucial for the use of sea transport is the distance and the nearness of the harbours to the silos and customers. In addition, the cost is important. This makes sea transport for distances under about 100 km currently uninteresting. Also regarding sea transport, reloading is considered expensive. Ships are already used as much as possible for routes greater than about 100 km. A general problem with intermodal transport is that reloading is often very expensive. Reloading alone can involve as much cost as a shipment of 50-100 km or even more.

For the fraction of grain that is aimed for export there is also a potential for realising energy savings. There is, for example, a potential to reduce the amount of tractors used for transport that come directly from the farmer (which accounts for about 40% of the total energy used in the transport chain from farm to export harbours). The potential for energy saving by using lorries instead of tractors partly depends on the higher energy efficiency for lorries compared with tractors and partly on the assumed higher average load factor for lorries.

There is also a potential for energy saving with more drying at the farms according to one of the pilot actions. The energy saving effect of drying at the farms can be about 9-10% in a route in ODAL. Drying at the farm mainly favours switching from tractor to lorry transportation, which is more energy efficient, and also gives the farmer better opportunities to sell when the price is high, among other things. ODAL generally encourages drying by giving better prices for grain, which is delivered during the off-harvest season by lorries. Another effect of doing more drying at the farm is that it also increases the possibility to go directly to the final receiving plant or the customer. Drying and storage at the farms is also necessary to be able to increase the load factor, reduce empty return trips and improve transport planning and co-ordination possibilities.

The potential effect of using more IT-based systems to reduce energy use in the agricultural industry is also interesting. In studies, route optimisation has been shown to have a large potential and can shorten routes and transport distances by almost 30%. Long routes with many stops for loading and reloading have the largest potential. Routes involving grain deliveries are generally only between one collection and delivery location. Studies indicate that it could be possible to reduce the distance in such routes by about 6-7%. However, other routes could be shortened by more than 20% of the distance or up to 28% of the driving time. There is also a possibility to reduce the number of vehicles by making a total route optimisation. Co-ordination of the distribution of goods (e.g. fodder) and grain collection at the farms is also possible and can reduce the energy use. However, there are some obstacles, e.g., there is a need for vehicles that can carry different types of goods in a sanitary way. The part of the transport chain that has the best chance for an increased load factor and co-ordination with the shipments of other types of goods is probably from silo to silo.

The transport organisation can be important for the co-ordination of diverse goods shipments. Today different haulier organisations are used by ODAL. It could be easier to increase load factors and shipment co-ordination if a large independent company such as ASG or similar companies were used as a third party to handle the distribution and logistics in ODAL. When using many haulier organisations there can be competition between the haulier organisations or other reasons for choosing your own vehicles rather than other hauliers' vehicles, all of which diminishe the opportunities for optimal shipment co-ordination.

It is important that the transport company used has IT-support for transport planning, e.g., GIS, GPS and programmes for route planning, to support operational efficiency and good communication with the drivers. Good communication between the transport planner and the driver also improves the possibility for more efficient loading and reloading.

A change in the driving style, i.e., ecodriving, could have a significant impact on fuel consumption. Tests on a limited number of drivers indicate that the potential in this area is about 10% for cars and slightly less for lorries. The National Swedish Road Administration support research in this area and the organisation for driving schools in Sweden (STR) has been the principal organisation involved in the education of teachers and organising the courses for drivers. Some limited experience is already available from the first groups of educated drivers. The development of IT and MMI support in vehicles will enable further improvement in this area in the future.

9. Measures and actions in regional policies

9.1. Methodology for analysis of measures and actions in regional policies

Phase 3 of the project has constituted of ten main tasks:

1. Preliminary identification of the actors (All 3 partners). This included an exchange of the results obtained.
2. Preparation of guide for first interview round (WNRI)
3. Identification of key informants in each actor (All 3 partners)
4. Send out the questions for the first interview round to the informants (All 3 partners)
5. Carry out first round of interviews by phone and e-mail (All 3 partners)
6. Preparation of guide for second interview round (WNRI)
7. Send out the questions for the second interview round to the informants (All 3 partners)
8. Carry out second round of interviews (All 3 partners)
9. Summing up the results (All 3 partners)
10. Write final report from Phase 3 (WNRI)

The interview guides used for the first and second interview round are enclosed as Attachment 1 and 2 respectively.

The results from the first interview round formed the basis for the questions which was asked during the second round of interviews. The report covers the results from the cases in Norway, Finland and Sweden. The focus has been on finding common issues among the tree countries.

In order to identify the measures and actions on regional level, the interviews have been supplemented with a study of relevant literature. The choice of literature and informants for interviews are based information from persons in different societal levels (national, regional and local).

In the report the result from the literature research, the choice of the informants and the result from the interviews with the informants is accounted for. The first description of the literature in the area will serve as a background and also to some extent clarify the role of different agents in the field of transport mode change. The approach of a thorough literature review was mainly used for the Swedish conditions.

Some of the studied literature is on EC level and on national level (including national strategies and aims etc.). This is relevant since the measures and actions on a regional level often is the result of breaking down national measures, actions and principles.

The structuring of the measures and actions has been guided by the question of what they (the measures and actions) are directed towards. Expressed in another way; where the measures and actions could have an affect.

The main structuring thereby is a differentiation between 3 types of measures and actions:

1. General for road to rail/sea transfer
2. Specific for road to rail transfer
3. Specific for road to sea transfer

9.1.1. The interviewed actors

In this document, the term "actor" is used for the agents active in the field of transport mode change. This includes both public and private actors. A list of all interviewed actors, the name of the informants and their position is shown in Table 110.

Table 110 The interviewed actors

Actor	***Interviewed person***	***Position***
Møre og Romsdal county administration, Dept. of Communication	Jan Stavik	Consultant
Ålesund city administration, Dept. of planning	Odd Humblen	
	Kjell Sandli	Head of Planning and Budgeting department
Directorate for Maritime Affairs	Harald Tronstad	Head of Regional Coastal Administration, NW Norway
Ålesund regional development association	Magne Gjørtz	Consultant
Norwegian State Railways (NSB), Goods division	Kjell Owrehagen	Director of transport in market division, responsibility for combined transport
	Knut Brunstad	Director of products in marked division
	Marit Thorsen	Director of the Information Service
Marintek, Division of Machinery and Technical Operations (counting 80 people)	Atle Minsaas	Research Manager – Logistics Group
	Kjell Olav Skjølsvik	Senior researcher machine group. Environmental aspects of sea transport (Emissions from combustion processes)
Norwegian Shipowners' Association	Johnny Tollefsen	Section head, the association's expert in intermodal transport
Finnish National Road Administration (Finnra), Central administration	Raimo Tapio	Deputy Director
Regional Council of Kymenlaakso	Ari Pietarinen	Project Engineer
Transfennica, Managing Director's Headquarters	Anna-Leena Puolanne	Project Manager
The Confederation of Finnish Industry and Employers	Maire Kaartama	Specialist advisor, logistics and transport policy
The Finnish Railways (VR)	Kari Hassinen	Goods Transport Manager
The Port of Kotka	Dirk Bequart	Marketing Director
The county of administrative board in Stockholm (CABS), Unit for sustainable society development, Dept. for environment and planning	Björn Fallström	Investigator in communications
	Ola Carlsson	Assistant to communications investigator
ASG, Executive staff, environment	Magnus Swahn	Environmental manager
Swedish National Maritime Administration, Staff industry and shipping policy	Lars Vieweg	Department director
Federation of Swedish farmers (LRF), Section for economical and political rules	Sven Hogfors	Energy-, transport- and climate policy expert
Rail Combi/SJ	Thore Johansson	Managing director
ODAL, North region	Olle Johansson	Region manager

A description of the field of work for the actors is given below:

Møre og Romsdal county administration

The case company Wågan Transport is located in Møre og Romsdal county. The county is one of the largest fish exporting counties in Norway. Møre og Romsdal county administration is involved in facilitating the access to sea transport of goods from Norway to the European continent. This is carried out by improving the sea transport and the coupling between sea and land based transport.

Ålesund city administration

Ålesund city is located in Møre og Romsdal county. Ålesund is a large fish exporting city. The harbour in Ålesund is a central point of for road/sea mode transfer, but there is no railway connection to the city.

Norwegian Directorate for Maritime Affairs

The Norwegian Directorate of Maritime Affairs is a subordinate agency under the Norwegian Ministry of Trade and Industry. The Directorate is the competent Norwegian authority for maritime affairs.

Ålesund regional development association

Ålesund regional development association (ÅRDA) is owned by the 6 municipalities Giske, Haram, Skodje, Sula, Ørskog and Ålesund. The main activities for ÅRDA are co-operative and development within the areas municipal services and regional industrial development. The interviewed informant was from the section for municipal production, where the main activity is to initiate and carry out inter-municipal co-operation and efficiency efforts.

NSB Goods

NSB Goods has an interest in transferring goods both from road and sea. It is mainly the goods that is transported over long distances that attracts the strongest interest.
NSB Goods offers the different transport products:

- "CombiXpress" (combined/intermodal transport)
- "Vognlast" (goods transport in single carriages, often on side tracks)
- System trains (complete trains between two customers)
- Express goods (similar to the express mail system for parcels)

The "Vognlast" product has been and still is the most common form for goods transport by rail. With this system, single carriages are transported between two customers. This form of gods transport is primarily intended for industrial needs. In order for the "Vognlast" to function efficiently, large volumes are required to be transported between customers who each have side tracks at their disposal.

Combined transport (CombiXpress) is a product that was introduced by NSB Goods in 1997. It implies standardised transports in fixed carriages going in routes between specified terminals. The customers buy fixed space in the trains through long-term contracts, or rent from day-to-day if the transport needs are variable. CombiXpress is used for various types of load carriers (semi-trailers / swap body[75] / sea container), with the common property that they are liftable (so-called 'Huckepack'), and thereby suited for transfer between different modes of transport.

Marintek

Marintek is a research company in the SINTEF Group, and delivers marine technology research and development services. The business areas include:

- Shipping
- Shipbuilding
- Offshore Marine Industry
- Marine Industry

Norwegian Shipowners' Association

The Norwegian Shipowners' Association is the employers' organisation for ocean-going shipping and companies involved in floating and movable offshore activities. The informant from the Norwegian Shipowners' Association has intermodal transport as expertise. Transfer of goods from road to sea, and intermodality, are integrated activities of the association.

Finnish National Road Administration (Finnra)

The Finnish National Road Administration maintains public roads and provides for safe and convenient travelling in Finland.

Regional Council of Kymenlaakso

The regional Council of Kymenlaakso[76] is composed of 13 towns and municipalities. It is a joint authority responsible for regional development and planning. The duties of the Council are based on the Regional Development Act and Building Act.
Together with various bodies and organisations, the Regional Council of Kymenlaakso establishes a development strategy for Kymenlaakso. Regional development programmes are drawn up on the basis of this strategy. The development strategy together with regional programmes compose the development plan for Kymenlaakso. The Regional Council is also the regional operator for the European Union's structural funds (Regional Council of Kymenlaakso www-pages 30.12.1999).
Finland's Regional Councils are joint municipal authorities operating according to the principles of local self-government. The Councils operate as the authorities for regional development and as units for regional planning and looking after regional interests (The association of Finnish local and regional authorities www-pages 30.12.1999).

Transfennica

Transfennica is a shipping company with fast scheduled liner services between the main European trading ports and Finland. It is owned by forest industry companies.

[75] Swap body look like an ordinary container, but is equipped for inter-modal transport, i.e. can be lifted with fork lorry or by the use of trucks with grip arms ("bandlift").
[76] Kymenlaakso is a region of some 200,000 people in the south-easternmost Finland

The Confederation of Finnish Industry and Employers

The Confederation of Finnish Industry and Employers (TT) safeguards the interests of companies in manufacturing, construction, transport and other service sectors related to industry. The Confederation represents its members in business and industrial, economic, trade and social policy.

The Finnish Railways (VR)

VR Ltd, together with its subsidiaries, handles and develops railway transport and related transport operations. VR Cargo is the rail goods division of the Finnish Railways VR Ltd. VR Cargo's most important customers are the forest, chemical and engineering industries.

The Port of Kotka

The Port of Kotka is a general port with service capacities along with facilities for the loading and unloading, as well as the intermediate storage, of almost any type of goods. The Port of Kotka has specialised in serving the Finnish wood-processing industry as an export port for finished products and as an import channel for raw materials (The Port of Kotka www-pages 3.1.2000).

The county of administrative board in Stockholm (CABS)

The counties of administrative boards are co-ordinators on regional level of governmental interests with connection to communications. They are regional co-ordinators of planning of different transport modes. This role as co-ordinators has been more increased during the 90-ties. The role as co-ordinators does also include co-ordination of infrastructure and transport with settlements, environment and regional development etc. In the planning has lately economical and physical planning been more integrated.
The counties of administrative boards are responsible for some of the planning of investments in roads, railways and to give permits for goods traffic, establish transport regulations, also for sea transport etc. They are also in charge of the structural funds for example the economical contributions to the agriculture industry.

ASG AB

ASG is a large transport- and logistic company and is also one of Sweden's case companies in this SAVE-project.

The Swedish National Maritime Administration (NMA)

The National Maritime Administration is responsible for the safety and the navigability of the shipping in Sweden etc. The National Maritime Administration should according to the government participate actively in the national and *regional* planning of infrastructure. Especially concerning the relationship between the infrastructure of the sea transport and the infrastructure of the land transport (Proposition 1997/98:56, p. 129).

The NMA's should also facilitate the prerequisite for planning between different transport modes (this can be more difficult if only a local or regional actor does the planning).

Federation of Swedish farmers (LRF)

The Federation of Swedish farmers (LRF) is the interest and industry organisation for Swedish farmers, forest owners and the agricultural co-operative movement. LRF's task is to create the conditions for efficient, market oriented and competitive companies. By advancing the economic interest of farmers and developing rural communities, the conditions are also created for promoting and satisfying social and cultural interests.

Rail Combi

Rail Combi is part of the Swedish State railways cargo group and is working as a subcontractor to the haulage contractors. The business concept of Rail Combi is to increase the quality and efficiency on the combination of trains and lorries. The company is marketing, producing and developing combined transports with detachable load carriers, e.g. trailers and containers.

ODAL

ODAL is a trade and industry company which is owned by about 25 600 farmers in the middle region of Sweden and is also one of Sweden's case companies.

9.2. General measures and actions for mode transfer

The general measures and actions for mode transfer from road to rail and sea has been structured into 6 main categories:

1) EC Regional and Structural funds
2) National, Regional and Local Transport Plans
3) Areal planning
4) Economic measures
5) Eco-labelling and environmental strategies
6) Co-operation

9.2.1. EC Regional and Structural funds

EC regional and structural funds are being incorporated to a large extent into national and regional plans. This is carried out in an effort to reduce the bureaucracy associated with these type of funding systems. Regional Councils co-ordinates the money from EC structural funds. They also implement and co-ordinates local projects which support the regional development programme and strategies.

In this section we describe the EC structural funds and give examples of their use from Finland, and then from Sweden. Norway also participates in programmes funded by EC structural funds, such as the Interreg-programme.

The Interreg programmes are one of EC's means of supporting regional development through the community's regional and structural funds. The main aim of Interreg II is the following formulation (CORDIS database, 2000):

> *"Assisting both internal and external border areas of the European Union in overcoming the special development problems arising from their relative isolation within national economies and within the Union as a whole; to complete selected energy networks and to link them to wider European networks; to promote the creation and development of networks of cooperation across internal borders and, where relevant, the linking of these networks to wider Community networks in the*

context of the Single Market; to assist the adjustment of external border areas to their new role as border areas of a single integrated market; to respond to new opportunities for cooperation with third countries in external border areas of the European Union".

The use of the EC regional and structural funds in Norway

None of the six informants in Norway had any opinion on the importance of EC funds as an instrument to achieve increased mode change from road to sea and rail, and improved direct sea-rail connections. They did not express any opinion of the relevancy of their institution to influence the EC funds or not.

The use of Interreg III A, B and C programmes in Norway
The informant from Ålesund city administration considers the Interreg programmes to be important as a measure to achieve increased mode change from road to sea and rail and improved direct sea-rail connections. It was also expressed an interest for the institution to take part in such programmes.

Møre og Romsdal county has taken part in Interreg-programmes, and it is relevant for the institution to continue this activity also in the coming years. The institution also takes part in the Nordic Transport political Network (NTN).

The Norwegian National Coastal Administration (not the Regional) is working with EC programmes, specifically Interreg. The informant considers this work to be important, but the responsibility for this activity is placed outside the informants field of work.

The informant from NSB Goods was not involved in either Interreg programmes or other ways of distributing EC's structural funds. NSB is however following closely EC's efforts to establish transport corridors through Europe, and the informant is of the opinion that it would be useful for NSB to investigate how the Structural funds could be utilised in this field of work.

Norwegian Shipowners' Association is funding research and development through grants for research and development, among others to Marintek and Norwegian School of Economics and Business Administration. Norwegian Shipowners' Association also participates in Interreg programmes.

Marintek conducts research and development in logistics. This type of research often includes full scale demonstration of new technological solutions. The informant from Marintek is of the opinion that EC should spend R&D resources at demonstrating new and promising solutions in this field, even though this might constitute a conflict with the free competition principle of the Union.

The use of the EC regional and structural funds in Finland

EC funds are regarded as an important instrument only if the focus of the funded projects is right. The funding on regional level is found as an important action. On the other hand, there is concern that the funding harms the competition at the goods transport market. In addition, it is mentioned that the supporting of the mode change by EC funds must not be neutralised by road transport promoting EC incentives.

The possibilities to influence EC funding varies among interviewed bodies. Transfennica has a possibility to indirectly influence, for example through Finnish Ministry of Transport and Communications as well as through different organisations in the branch. Finnra can also indirectly influence. The Regional council of Kymenlaakso has more direct possibility to influence than the other actors, since the regional development strategy is prepared by them. In addition, the Regional council can affect through:

- focusing the development projects
- the tasks of secretariat
- own projects
- statements

One way to influence is also by launching projects, which the EC can fund, and take care that their focus and scope promote the mode change.

There are in Finland relatively few projects funded by EC regional and structural funds in the field of transport and its infrastructure. Some examples are however the road to the port of Kotka Hietanen and the transport system in the port of Mussalo (Kotka).

At the Finnish Ministry of the Interior, regional development and its coordination are the responsibility of the Department for Regional Development. Regional discrepancies in the level of development are addressed through national regional policies and the EC regional and structural policies applicable to Finland.

Both local and central government are responsible for regional development. Regional Councils set up by the municipalities act as regional development authorities and are responsible for drawing up programmes for their areas jointly with other regional bodies (Finnish Ministry of the Interior WWW-pages 24.2.2000).

The use of Interreg III A, B and C programmes in Finland
Some informants see the Interreg programmes as an important measure. Some others were not aware of these Interreg programmes, so they didn't have an opinion. The informant at Finnra finds the Interreg programmes as important on programme level but thinks that currently ongoing projects are not essential when the transfer of goods transport from road to rail and sea is regarded. Regional council of Kymenlaakso is the co-ordinator of Interreg programmes (as well as other regional councils). Thus the Regional Council of Kymenlaakso regards Interreg programmes as a significant factor when the development of mode change is in question.

Other measures and types of funding that are considered to be important, and are connected to funding through the Interreg programmes, are:

- National private funding
- State funding
- Development banks
- Co-operation and co-operative projects with various actors

The Interreg II A programme for the Coastal Zone of South Finland includes projects in which also the Regional Council of Kymenlaakso is involved, e.g. such common projects of Finnish and Estonian regions as the so-called 3+3 projects. A project for small and medium size enterprises (SMEs) called Business Opportunities for Development includes partners from four countries, Finland, Estonia, Sweden and Russia. A special tourism project in the frameworks of the so-called 3+3 projects is called Blue Corridor.
Interreg II C programme including projects of the Regional Council of Kymenlaakso:

- E18 project
- PSSD (Planning System for Sustainable Development)spatial planning project.
- Balticom project

The Common Secretariat of the Interreg II C programme for the Baltic Sea Region is working in Rostock, Germany (Regional council of Kymenlaakso WWW-pages 24.2.2000). EC regional and structural policies are implemented in Finland through the following regional objective programmes:

- 6: development of regions with an extremely low population density
- 2: converting the regions seriously affected by industrial decline
- 5b: development and structural adjustment of rural areas

In addition are EC regional and structural policies are implemented in Finland through the following objective programmes, which are applicable to the whole country:

- 3: combating long-term employment and facilitating the integration into working life of young people
- 4: facilitating the adaptation of workers to industrial changes
- 5a: facilitating the development and structural adjustment of rural areas

Objectives 6, 2 and 5b cover 53,6 per cent of the country's total population. Between 1995 and 1999 Finland received approximately ECU 1.7 billion from the Structural Funds. About one half of these funds are directed at regional objectives. The objective 6 region receives around on third of the total support.
In order to qualify for EC assistance, each Member State must submit development programmes following jointly agreed strategies to the European Commission. The Commission assesses these plans and compiles a Single Programming Document (SPD) for each of them which specifies maximum amounts of EC support. About 90 per cent of the entire Structural Funds' budget is used to finance Objective programmes.

The EC funding that Finland receives is entered in the State Budget. Shares of funding from the Structural Funds are written into the income and expenditure items of the responsible ministries on a fund-by-fund basis as shown in the following table:

Table 111 EC funding in Finland and their responsiple ministries

Ministry of the Interior	European Regional Development Fund (ERDF)
Ministry of Labour	European Social Fund (ESF)
Ministry of Agriculture and Forestry	European Agricultural Guidance and Guarantee Fund, Guarantee Section (EAGGF-G)
	Financial Instrument for Fisheries Guidance (FIFG)

Financial support from the EC must always be matched by some degree of national funding. This is the concern of the ministries, local authorities, companies and other private-sector sources. The ministries responsible for the Structural Funds also allocate the EC funding to these ministries (Finnish Ministry of the Interior WWW-pages 24.2.2000). In just under five years, over 20,000 projects have been implemented in Finland with financing from the EC's regional objective programmes. Definitive figures on the number of enterprises set up with the support will only be available when the projects have been completed. Preliminary estimates indicate that the projects have helped to set up over 3000 enterprises, and they have contributed to creating or safeguarding almost 35,000 jobs. By the end of 1998, project funding totalled almost FIM 17 billion, FIM 3.6 billion of which came from the EC structural funds. Finland's experiences from the first structural fund period are positive. The new programmes to be implemented in 2000-2006 and increased resources mean new opportunities for regional development (Finnish Ministry of the Interior WWW-pages 24.2.2000). The most important transport projects in 1998-2002 from the Kymenlaakso Development Programme are:

(The projects typed in bold are the most important ones)

- **Improving the road E18 (Highway 7)**
- **The Highway 6, improvements from Koskenkylä to Kouvola**
- Railway from Kotka/Hamina - Kouvola to the Russian border (Vainikkala), construction of transport interchanges
- **The Ports of Kotka and Hamina, increases in capacity and entry roads**
- **Riihimäki-Kouvola-Vainikkala rail, speeding up the passenger transport**
- Locks of Kimola and Voikkaa
- Highway 12
- Highway 15
- **Expansion of air goods operations in Utti**
- **Logistic centre for railway transport in Kouvola**
- Highway26

Funding of the Development Programme of Kymenlaakso:
The Development strategy as well as funding plan is divided into three priorities. They are:

- Priority I: Development of know-how required by information society.
- Priority II: Development of international production and service centre.
- Priority III: Development of community structure, environment and culture.

Most transport projects are included in Priority III. Funding of Priority III is presented in *Table 112*.

Table 112 Priority III Funding in 1999 (Source: Regional Council of Kymenlaakso 1997).

Priority III total (Development of community structure, environment and culture) in 1999 (Million FIM)	
State	111,4
EC	44,1
Municipalities	90
Private	5
Total	250,5

Objective Programme 2 funding for time period 2000-2006 is 1 725 FIM / inhabitant (873 €) which makes approximately 155 Million FIM (22 Million FIM per year) for the Objective 2 region in Kymenlaakso (Tarja Arajärvi, Ministry of Interior, 28.2.2000). Objective 2 Region in Kymenlaakso has 89 600 inhabitants.

The use of the EC regional and structural funds in Sweden

Sweden has no authority which co-ordinates all the EC's aims and polices in the transport sector. The different authorities (for example the transport administrations and the counties of administrative boards' etc.) are handling the policies affecting their area. Regarding the structural funds, some counties have the responsibility for funds in different targeted areas (or aims, for example geographic aims 5 and 6). There is also a structural fund delegation in each county of administrative board. The terms are about to change and the program documents for the target areas. New program documents for the period 2000-2006 is presented shortly. The local politicians and trade and industry, based on the guiding principles from the EC, put the program documents together. The preliminary versions have indicated interest in infrastructure issues and the development of sustainable transport systems. One of the intermediate goals in the programs target 1-area (North region of Sweden) is development of 10-12 new transport infrastructure projects. Also research projects are desired.

An example of an identified problem is that the standard of the railway tracks has to be increased to be able to develop the potential of goods transport in the region. This will also increase flexibility and the larger load capacity of new goods trains. There is also need for more rational handling of the goods in the ports, according to the preliminary program documents. The informant at ASG considers that EC funding is interesting as long as they attack and solve the actual problems. ASG is not focusing on influencing the EC, but on optimising their business activity based on the present conditions.

The informant at NMA regards that EC funds are important instruments, but considers that they are not in a position to influence the EC funding. NMA are, however, interested in participating in different EC projects.

The informant at ODAL considers that EC funds are only interesting if they finance the improving of tracks, fairways or roads. ODAL is not trying to influence the EC in any direction.

EC funds are important and could be used, e.g. to finance costly new ideas according to Rail Combi´s informant. This can be necessary for e.g. railway infrastructure projects. Rail Combi is not lobbying directly against EC but sometimes gets documents for consideration. The reason for not lobbying more is because Rail Combi considers it too costly.

CABS regards EC funds as important and considers that it would be possible for CABS to influence EC, but considers that issues of this kind is too costly today. The organisation of the structural funds is not much different from how many other EC programmes are organised, according to CABS. Much of the obstacles to improve the infrastructure and benefit combined transport can be found in the process to seek the funding and how to interpret EC's intentions and criteria's for how to write a successful proposal. It can also be a problem to co-ordinate many different partners and making everyone do their share. The CABS are themselves involved in an Interreg II-project and considers it difficult to unite the actors involved in the project. A possible way to benefit the building of more infrastructures and minimise bureaucracy is if more of the responsibility for the payments etc. is moved to local departments.

LRF stated that EC funds that improve railway and sea infrastructure are important. In Sweden there is now also an ongoing investigation, that is concerning Public Private Partnership (PPP). PPP is a way to finance investments before the capital is found. This means that the capital is collected from e.g. the governmental budget during the coming 20 years. A disadvantage with PPP is that there is not much room for other investments the coming 20 years. So it is difficult according to the informant to decide the best way to finance infrastructure. LRF tries to influence EC and other funding institutions to put more effort into improving the roads in rural areas.

New structural fund-program documents for the period 2000-2006 will be presented shortly. These plans could offer insights into potential mode change opportunities. The bureaucracy and the proposal procedures associated with these plans are however complicated, and a simplification is desirable.

The use of Interreg III A, B and C programmes in Sweden
ASG's informant has no experience of these specific programmes but generally thinks that the problem is more concerning the adjustment to customer requirements. ASG has worked with other EC programmes but considers that the effect of these has been limited in the area mentioned. It could be interesting not only to identify the problems in this area but also to solve the problems, for instance to try more to change the negative attitudes towards sea and rail transport among buyers of transport services.

It could also be interesting if the cranes used in intermodal transport could receive some kind of support or external financing, since these cranes are so expensive and still crucial for intermodal transport, especially on shorter distances. This support could be from both national and international sources.

NMA considers the EC Interreg III A, B and C programmes as important and has participated in several projects in these programmes. It can also be interesting for NMA to participate in developing and implementing these programmes further.

The informant at ODAL has not been in contact with these programmes but regards that programmes of this kind should not be necessary. Other measures and types of funding are not either very interesting. More important are structural decisions regarding infrastructure.

The informant at Rail Combi has not been in contact with these programs but considers that it could be interesting to participate in developing and implementing these programmes further. However, Rail Combi is often a co-proposer and not co-ordinator in programmes of these kinds and this will probably also be the trend in the future. It is considered important to receive support to be able to try new ideas, for example, regarding intermodal transport. It was also expressed the importance of the programmes being outlined so that the actions in the programmes are controlled in order to be implemented properly.

The informant at CABS considers these programmes as important and the programmes are also relevant for CABS to be involved in and implement further. CABS is today involved in Interreg programmes. The programmes should, however, according to the informant be more stringent on what should be done and focus on improving e.g. the infrastructure. Other important funding is, e.g. the funding from KFB and NUTEK.

The informant at LRF stated that these programmes are probably important but the informant has had marginal experience of these programmes. LRF has contacts with different programmes and has also contacts in the EC, Brussels. The important thing for the Swedish government and also the EU is to improve and modernise the railway and sea infrastructure via programmes or other measures.

9.2.2. National, Regional and Local Transport Plans

In this section the measures and actions in the form of transport plans are presented. First the national transport plans in the three countries are considered, then the regional and local transport plans.

National transport planning in Norway

The national political goals for transport, as e.g. the Norwegian national transport plan, is not well enough realised through active prioritising and public measures and actions. This is particularly the case for sea transport, according to the Norwegian Shipowners' Association.

Ålesund city administration stated national transport planning as important in order to achieve increased mode change from road to sea/rail and improved direct sea-rail connections. It is of high relevancy for the institution to influence national transport planning in this direction. This is already done in the form of written documents and verbal argumentation. This is an issue where local politicians have contact with members and groups of the Parliament, Government and central politician organisations.

Møre og Romsdal county also consider national transport planning as important. It is the opinion of this actor that sea transport should be treated as the other transport sectors (rail and road), and obtain financing as them. So far, the Ministry of Fishery has had the responsibility of sea transport. According to the informant at Møre og Romsdal county, a better solution would be if this responsibility was transferred to the Ministry of Communication. The very limited economic support to sea transport is mainly used for improving fishery harbours, and not node points for road and sea transport of goods. This situation is hurting sea transport and intermodal transport.

The Regional Coastal Administration stated that national transport planning is very important in order to achieve increased mode change from road to sea and rail and improved direct sea-rail connections. The informant is however not content with the implementation of the national policies by local politicians and institutions. These actors were described as mainly self-centred. The informant pointed to a lack of understanding for the efficiency of the various transport modes and the corresponding infrastructure in a region. It is considered highly relevant for the Regional Coastal Administration to influence the national transport planning in this direction. The process of national transport planning is considered a good start, but the most important aspect is the implementation of the plan. The institution participates in this planning process, in co-operation with harbours administrations and regional road administrations. Participating in regional and local planning processes, and giving comments to ended plans, are also important ways of influencing road to rail/sea mode change and increased use of intermodal transport solutions.

For NSB Goods is national transport planning highly important as a mean to improve the conditions for intermodal transport and modal shift from road to rail. The last national transport plan represents a breakthrough for a policy aiming at larger market shares for intermodal road/rail transport. It has resulted in larger grants for extending railway line profiles (tunnels, power transmission lines). NSB Goods is working closely with politicians, bureaucracy and pressure groups in order to influence the contents of the national transport plan.

Also Norwegian Shipowners' Association is making much effort in lobbying in connection with the national transport plan. The informant from this actor is however of the opinion that the national transport plan actually is an *infrastructure* plan more than a *transport* plan. Instead of setting premises for how society's transport needs should be met, NTP focuses on building roads. In that way national transport planning is biased, and only to a limited extent prepares for intermodal transport.

The informant from Marintek points to the national transport plan as being an important tool for outlining the intermodal transport policy. Traditionally, the national transport plan has focused on road transport, but there have been signs of a new orientation towards somewhat more intermodal transport friendly choices. Nevertheless, the most important actors in this policy field are still forceful spokespersons for road transport. Marintek contributes with specialist reports as background for outlining national transport plans in Norway.

Norwegian national political guidelines

The informant from Ålesund city administration is of the opinion that national political guidelines for co-ordinated land-use and transport planning is needed, but this is not sufficient to achieve increased mode change from road to sea and rail and improved direct sea-rail connections. It is however relevant for the institution to further influence the national political guidelines in this direction.

The informant from Møre og Romsdal county did not express any opinions regarding how often the guidelines are used in the planning processes. The informant was of the opinion that the guidelines for national transport planning was not very relevant for the planning for sea ports, since most harbours are located within cities.

The Regional Coastal Administration stated that the national guidelines for increased mode change from road to sea and rail and improved direct sea-rail connections are very important. They were characterised as actually playing a central role. This actor argued for strategies and measures to reach the goals in the national transport plan.

The informant from NSB Goods expressed that – apart from the national transport plan – national political guidelines in the transport field have limited effect. There are no guaranties that such guidelines are being followed when it comes to concrete decisions at local or regional levels regarding area use or budget priorities.

Norwegian Shipowners' Association is, for principal reasons, sceptical to governmental guidelines and regulations of this kind, but admits that a political decision to encourage environmental friendly transport, demands some regulations. In this perspective, there is a need for comprehensive solutions in transport policies, which also include national political guidelines for co-ordinated land-use and transport planning.

The informant from Marintek pointed to what is already said regarding the need for political understanding for intermodal transports and spatial demands related to harbour activities.

National transport planning in Finland

In Finland there appears to be a lack of policies and strategies for mode changes at a national level. However, in their transport policy The Finnish Ministry of Transport and communications requests additional funding for infrastructure and maritime transport (The Finnish Ministry of Transport and Communications www-pages 26.6.2000):

"At the end of 1998, the Ministry of Transport and Communications prepared an operating strategy and financial plan that includes the Ministry's proposal for expenditure ceiling for the administrative sector. According to that the total funding for the administrative sector in 2000 would be FIM 7.66 billion (EURO 1.29 billion) and would then by 2003 be reduced to approximately FIM 7.25 billion (EURO 1.22 billion). The operating strategy and financial plan also includes another proposal according to which the level of funding would be higher. The most significant supplements the Ministry will request comprise additional funding for transport infrastructure and for maintaining the competitiveness of maritime transport. It is the view of the Ministry of Transport and Communications that at least the present level of funding for public transport be maintained."

The national transport planning in Finland is however considered very important by almost all interviewed actors in Finland. It is considered relevant for all the interviewed actors to influence national transport planning, but the measures vary. Transfennica (like other transport companies) can affect transport planning mainly by lobbying for issues they consider important. Finnra can influence directly through own decision in national transport planning. It has the following measures, among others, to affect:

- Co-operation
- Own planning (yearly etc.)
- Implementation of plans

The Regional Council of Kymenlaakso has the following possibilities to influence:

- Development strategy of transport in Kymenlaakso
- Transport system planning of Kymenlaakso
- Co-operation with other regional councils of southern Finland

The Port of Kotka can influence national transport planning with the help of membership in strategic planning groups on national level. Within the Confederation of Finnish Industry and Employers (TT) influencing the national transport planning is considered difficult, since it is not an easy task to find actors who could participate in this activity. In addition, the fair competition in the transport sector could be considered as a barrier for this activity.

Finnish national political guidelines

Informants at the shipping company Transfennica as well as at Finnish National Road administration regards national political guidelines as an important measure, and they both think that it is relevant activity of their bodies to influence the national political guidelines. The regional council of Kymenlaakso is in position to influence the national political guideline with the help of the development strategy of Kymenlaakso. Another opinion expressed was that the market factors have to play the most significant role. The informant at the Port of Kotka was of the opinion that the market factors can be influenced by the national political guidelines but they shouldn't be dictated. In addition, the informant at TT pointed out that lack of national guidelines doe not have an effect on weaknesses in co-operation between different modes of transport. The nodes of the transport system covering all modes of transport are required in transport of goods in general, and some this sort of nodes already exists.

National transport planning in Sweden

In Sweden the government's plans for the transport sector in the following years are e.g. described in the government proposition "1997/98:56". This proposition includes transport policies to reach a sustainable development in the transport sector. A proposal for aims and strategies etc. on governmental level, which is relevant on regional level, is also partly described in this proposition. The environmental aims are divided in overall, intermediate aims and part aims. The overall and intermediate aims are indicating the level of long-term ambition. The part aims are corresponding to suitable steps towards the long-term aims.

The overall Swedish transport policy aim is to ensure a providing of welfare economical efficient and long-term sustainable transports for the citizens and the trade and industry. Intermediate long-term aims are:

- An accessible transport system
- A high transport quality
- A safe traffic
- A good environment
- A positive regional development

No separate aims on efficiency are set since efficiency is considered to be included in the overall aim. Regarding a good environment the following part aims, relevant to the transport sector, has for example been set:

- The CO_2 -emissions from transports should year 2010 have been stabilised at 1990:s year's level.
- The NO_X -emissions from transports should by year 2005 at least have been reduced by 40% compared to 1995:s year's level.
- The Sulphur -emissions from transports should by year 2005 at least have been reduced by 15% compared to 1995:s year's level.
- The emissions of VOC from transports should by year 2005 at least have been reduced by 60% compared to 1995:s year's level.

In another Swedish government proposition (1996/97:53), about infrastructure for future transports, the following intermediate aims for a period to 2007 was for example set::

- The number of occasions of disturbance on the most affected railway distances should be diminished with at least 50%.

- The highest lawful axletree load shall be increased from 22,5 ton to 25 tons on railway distances with extensive system transports.
- The load profile on the relevant railway distances (those with 25 tons) shall be increased.

The acceptance of the proposition has also led to the acceptance of some new principals in how to deal with transport of goods. The aims and strategies etc. has in many cases been delegated to different public authorities and bodies to develop them further, in some cases to break down aims and in other to set aims based on some overall principles.

The latest overall Swedish environmental aims were accepted by the parliament 29 April 1999 (described in prop. 1997/98:145). 15 aims have been set. Some of them have connections to environmental problems associated to the transport sector. One such aim is "limited climate change". The actions in this area are focused on stabilisation of the CO_2 concentration in the atmosphere at 550 ppm.

The Swedish parliament has also decided that the emissions from fossil sources should by the year 2000 be stabilized at 1990 year's level and subsequently diminish. An example of possible action to reach this target is "Support to benefit energy efficiency".

The Swedish government has set up an "Environmental target committee". The committee shall in June 2000 present its proposals for intermediate aims and strategies to reach the relevant environmental aims. The report from the environmental target committee shall form the basis for the coming environmental proposition from the government.

The Swedish government considers a welfare economical pricing to be a fundamental mean of control. If this can't accomplish the desired effects, then other means of control should be used. The government considers the following to be among the main means of control:
- Economical (pricing of transports, principles for allocation of means, subsidies of traffic)
- Regulations & information
- Research and development
- Aim control of the national transport administrations
- Negotiations and agreements

The Swedish government regards planning mainly to aim at, co-ordinate and give priority to actions within infrastructure and actions within the transport system in a perspective including all transport modes. A priority is also to strengthen the connection between the investment plans in infrastructure and the transport associated with the infrastructure. More influence of the planning process for infrastructure has been assigned to the counties of administrative boards and the regional self-government bodies. The idea in for example railway transport is that investments should been done based on welfare economical circumstances.

The Swedish government has also initiated a goods transport delegation, which is attached to the government. The delegation has the task to follow the development in the goods transport area and give propositions to the government. The delegation should also develop a good transport strategy, which includes all transport modes, analyse issues regarding development for combined railway transport and make the transport system more efficient and ecologically sustainable. The government also want to elucidate the governmental role.

There has been a Swedish state subsidy since 1971 on transports of goods in some parts of the country, of regional policy reasons. This subsidy has concerned road and rail transports.

Today there is a proposal to extend this to also include sea transports of goods. In May 1999, the government gave SIKA, CAA, SNRA, National Maritime Administration and the National Rail Administration the mission to accomplish national strategic analysis. The mission has been compiled in a report (publicised in November 1999), called SAMPLAN report (1992:2) "Strategic analysis- Final report of the governmental assignment about the direction of the infrastructure planning for the period 2002-2011". The strategies are concerning the focus and the planning of infrastructure for the period 2002-2011. In the analysis (which SIKA has co-ordinated) also opinions has been included from counties of administrative boards, regional self-government bodies, the Environmental Protection Agency, the Board of Housing, Building and Planning, the National heritage board and the National Board for Industrial and Technical Development. The task has mainly been to analyse 12 strategic areas and 3 alternative directions. Frames and overall directions for the national and regional plans are determined, mainly regarding roads and railroads (tax financed). The 3 main directions that have been analysed are 1) Focus on Regional development, 2) Welfare economics and 3) transport safety and environment. The report/analysis has stated that it is difficult to reach all aims. Since the financial frames are fixed, a prioritisation of aims and strategies is necessary. The report is mainly to be used as a basis for the coming governmental proposition, which is expected in March 2000 and does not give specific proposals for strategies but a background of the effect of different strategies.

ASG consider national transport planning as one of the factors that are not very important for them in order to transport more goods with the transport modes rail and sea. More important is the demand from customers regardless of the nationality of the delivery locations. However, the national planning is more important for some transport modes like the railway since the planning and financing of the infrastructure is crucial and costly and also to some extent underdeveloped.

The influence on national transport planning is carried out through lobbying, which is handled by "the Swedish International goods Association". Large organisations like ASG, SJ and BTL also have the possibility to affect the governments propositions since propositions, often are sent to these organisations for consideration.

NMA consider this as important and NMA is participating in national transport planning together with the other National Administrations in respective area and SIKA. However, the informant regards that the rail is more prioritised than sea transport and considers that the effort in the sea area could be more focused in certain areas. One could, for example, focus on that the harbours in Gothenburg and Trelleborg, which are important hubs in Sweden, are functioning well. One example is that NMA has a project that is aiming at improving the fairways around Gothenburg.

ODAL consider that national transport planning is not so important for ODAL and that they operate based on given conditions. However, ODAL points out that the building of fairways, railway tracks and roads are important and that national transport planning is important in that aspect. It would be valuable if some of the fairways could be improved so that larger ships could be used. ODAL tries to affect the transport planning by lobbying against, e.g., NMA.

National transport planning is important according to the informant at Rail Combi, especially in order to be able to co-ordinate between different transport modes. Rail Combi has tried to influence national transport planning, e.g. via newsletters that has been distributed to some members of the parliament in Sweden but the results has been of marginal importance.

The informant at CABS considers national transport planning as important and that this is a relevant area for CABS to be involved in. CABS affects the planning by making infrastructure plans and CABS also comment documents that they get for consideration and initiate investigations of different kinds.

LRF consider that a well functioning system should be a mix between the national transport planning and the free market economy. The informant regarded that they influence the national transport planning today by being part of the reference group for the coming transport infrastructure proposition from the government.

Swedish national political guidelines

The informant at ASG considered that national political guidelines are important. The national guidelines must, however, also harmonise with the guidelines from EC. ASG also wants to affect these guidelines via lobbying.

The informant at NMA regarded this as an important area concerning, for example, guidelines for infrastructure planning. It is also an area in which NMA works together with the other National Administrations in respective area and with SIKA.

The informant at ODAL stated that national political guidelines could be important if they led to better infrastructure in e.g. the fairways. However, the informant considers that there is a lack of economical resources in ODAL to more actively influence these guidelines.

Rail Combi considers national political guidelines as important. The guidelines have, for example, importance for the systems for fees and costs in the transport sector. It is also important that these guidelines are harmonised with the guidelines of the surrounding countries. It is relevant for Rail Combi to influence the guidelines but they feel that their possibilities to influence them at the moment are relatively small.

CABS consider national political guidelines as important and regard influencing them as relevant activities for them to take part in. The guidelines can e.g. be influenced by their work with regional planning.

The informant at LRF regards that national political guidelines are important and it is relevant for LRF to influence national political guidelines. However LRF is not willing to give preference to railway or sea transport at the expense of road transport.

Regional and local transport planning in Norway

Improved co-ordination of the port-, road-and rail structure is possible through the preparation of county plans for transport in Møre- og Romsdal county. The regional Transport Plan for this county include issues such as:
- Port structure
- Linkages
- Route initiatives

Land-use planning both within the municipalities and counties are important measures in creating the foundations for intermodal transport and the increased use of sea- and rail transport. Other actors in addition to the municipalities, such as the Directorate of Coastal Affairs in Norway, and the county administrations have an influence on the municipal Land-use plans. They have the possibility of making comments to the plans during the planning process. The Ministry of Environment is the supervisory authority for all Land-use planning in Norway. It appears that the opportunity to make comments to Land-use plans is under-utilised in Møre- og Romsdal county administration, while it is often used by the Directorate of Coastal Affairs regarding planning processes in Ålesund municipality.

The informant from Ålesund city administration considers rail as of little interest for the industry in Ålesund. As an instrument, land use planning will not favour transferral of goods to sea transport. It is a potential instrument to increase road transport, but used in a right way land use planning could stimulate sea transport and connection between road and sea.

Ålesund city administration has an interest in using land use planning as an instrument to stimulate conversion to sea transport of goods. This could be done by land reservation for harbour (and harbour facilities) and connecting roads in formal land use plans. The community have the opportunity to start such plan work themselves, or to support others.

The informant in Møre og Romsdal county administration stated that land use planning is important to improve the connection between road and sea, especially in the town Ålesund. The connection between rail and road is good enough, and intermodal transport connection between rail and sea is of little interest for the county.

Møre og Romsdal county administration takes part in land use planning by making a transport plan as a part of the total county plan. The philosophy in the transport plan is to give some signals to the local planning, but not to do the planning work. The communities have the leading role in the land use planning process. The county administration could invite to a co-operation, not give orders. The part of the county administration is also to involve other actors as national authorities and the transport users in the process.

On direct question about the county administration possibilities to stop local land use plans in conflict with the county plan the answer was positive. When the county transport plan is finished the administration has this opportunity.

The informant from the Regional Coastal Administration stated very clearly land use planning as important in order to achieve increased mode change from road to sea and rail and improved direct sea-rail connections. The Administration could take part in this in two ways: 1) Giving support to land use planning work in small communities with little capacity and competence. 2) In bigger community they have to stimulate understanding that intermodal transport (especially road and sea) need land to be developed.

For NSB goods area planning is of great importance for location of goods terminals. Trondheim goods terminal, in the third largest city of Norway, is an example of current interest. The existing terminal is too small to serve an expected increase in transport volumes. The terminal is situated by the harbour, and in order to give optimal conditions for intermodal transport in the future, NSB goods wants the terminal to be extended. Local area conflicts have occurred, and resulted in a long lasting political fight between to alternatives: Extending at today's location, or moving the terminal to a location separated from the sea. If the last alternative is chosen, this will be a severe obstacle for development of intermodal transport between sea and rail. Area planning is carried out within the framework of the local democracy, which tends to work slowly. In this particular case, the time factor might be a major threat to the possibilities of developing effective intermodal solutions.

Norwegian Shipowners' Association is aware of the central role of area planning in harbour development. In their opinion Oslo Harbour, the biggest transport harbour in Norway, is about to lose its importance due to municipal area planning. National authorities should have superior responsibility for the development of large harbours, as such harbours are serving a surrounding country, which extends the host city.

The informant from Marintek also uses the plans for moving the rail goods terminal in Trondheim as an example of the impact area planning may have upon the conditions for intermodal transport. Space in the harbour area is a prerequisite of developing a successful link between sea and rail. Long distance between rail goods terminal and the sea will inevitably lead to increased road goods volumes, at the expense of sea and rail.

Old harbours in the inner cities are often less efficient because of poor road connections. Also new harbours are often designed without sufficient attention has been paid to the total communication system. In this respect there is a lack of understanding among many planners and politicians for the spatial needs of intermodal transport.

Regional and local transport planning in Finland

In Finland land use planning is considered an important action almost by all informants. Interviewed bodies, especially Finnra and Regional Council of Kymenlaakso, find it important to take part in land-use planning work. For Transfennica (shipping company) it is relevant to participate in land-use planning related to e.g. new ports and enlargement of the old ones. There are various measures which cam be used in planning. Finnra is of the opinion that the most important way to act is co-operation, both at regional and national levels. For Transfennica (as for other private companies as well) the most important way to affect is to negotiate with other participators, for example with the port administration and port operators (partners who own the land and the infrastructure). As a regional public body which is responsible for the land use planning in Kymenlaakso, the Regional Council of Kymenlaakso has also many other possibilities to affect land-use planning. In addition to the actual land-use planning the most important measures are:

- Other planning in the region
- Negotiations with different authorities
- Participating in the transport infrastructure planning
- Traffic strategy for the Kymenlaakso region
- Separate development projects

The development policy depends very much on the accepted utilization policy for land areas and on regional planning. For example, reservations for railroad and road areas promote the development policy selected. The Regional Council co-ordinates the interest related to the use of land areas between different districts and also ensures that environmental aspects are being considered (The Regional Council of Kymenlaakso www-pages).

The Port of Kotka sees the land-use planning as important, as well. It can take part in it by investing in the construction of a multimodal terminal and rail infrastructure in the port terminal area. TT considers the land-use planning a less useful measure, at least when the local land-use planning is in question, since the transport mode change is not a local problem, except for the combined terminals for different modes of transport.

Regional and local transport planning in Sweden

Some relevant results from the report/analysis regarding the Swedish regional level are now accounted for. An overall Swedish aim on the regional level is:

The transport system shall promote a positive regional development by equalising the differences in development possibilities in different parts of the country and also to counteract disadvantages due to long transport distances.

At the moment, no part-aims for regional development exist. The regional policy aim in transport policy is delimited to concern development or support in the transport system in certain vulnerable regions. The government considers that it presently is difficult to establish comprehensive part aims for the transport policy contribution to the regional development, due to lack of knowledge about the connections between regional political effects and the methods of analysis presently used. The importance to develop the knowledge about these connections and the connections between investments in infrastructure and regional development and establish better indicators and measures, which can be the basis for part aims in this area, is emphasised by the Swedish government (SIKA report, 1999c).

Some of the problems that the counties of administrative boards have experienced have been compiled in the SAMPLAN report (1999b). According to the report, some counties consider that the railroads are less used for goods transport e.g. due to lack of maintenance, which affects the accessibility. Crowding etc. between person- and goods transport and shortcoming in carrying capacity on roads and railroads is also by some counties regarded as a problem. In the north part of Sweden, the development of a heavy transport net for the railroads is considered important.

Some counties have stressed absence of co-operation between the different actors of the transport system. The structure with terminals is regarded as undeveloped or non-existent in some areas. In some regions goods transport by road is the only alternative (SAMPLAN report, 1999b).

A regional strategic analysis will be initiated on initiative from the government. The mission goes to the counties of administrative board and other regional self-government bodies, established in some counties (Proposition 1997/98:56, p. 91).

The counties of administrative board have a role to co-ordinate and anchor the “county plan” for regional transport infrastructure. Support is given to planning by the SNRA and the Swedish National Rail Administration. SIKA has the responsibility to see if the “county plans” has corresponded to the demands of the government and parliament and to suggest improvements in the prerequisites and planning of the counties of administrative board.

The main purpose of the regional strategic analysis is to break down the national aims to regional aims and priorities adjusted for regional prerequisites and needs. The counties also generate regional action plan for the railways within each county. These actors will also have the possibility to take actions to reach the preliminary direction for the development, which has previously been analysed.

No strategies or part aims is set in the transport sector on regional level, but in general the counties expect that the expansion of fast train connections will decrease the transport time for goods. In the SIKA report 1999c it is also emphasised that the co-ordination between the transport modes could be an important factor to reach the intermediate aim of regional development.

In another SIKA-report (SIKA, 1999, The direction of…) some opinions from the counties is described. Improvement of the capacity of roads and railways are suggestions that many counties mention as ways to improve the terms for goods transport. The counties do not generally consider investments in infrastructure as important as the maintenance and operation. The will to invest in infrastructure is increased with a larger budget, especially concerning railway traffic. The counties propose that they will receive the possibility to finance the ports and fairways. Better train operation is also an important area.

The Swedish aims on reducing the number of killed and wounded in transport has transferred some funds from the railway to the road sector (due to the larger amount of killed and wounded in this sector). Also the increase/decrease in passenger transport on rail is affecting the goods transport on rail since these, in great extent, is going on the same tracks as the passenger transport.

The counties are also noting that other activities than investments in road and rail infrastructure are important for achieving a satisfying regional development. Many of these activities are however beyond the present regulations for the counties of administrative board.

Another important factor is an increased co-operation between the different actors of the goods transport system. The logistic system and the connection between different transport modes are considered important. Several counties also mention the importance of developing the infrastructure around the ports. For this purpose they want funds from the government. Financing of port investments is today a matter for the local interested parties and the municipality. However the ports can be important for the whole region and should accordingly be treated as a regional matter (i.e. the counties wants to be able to use regional funds). The size and construction of the fairway charges is also pointed out as a problem.

In another report, about the new aims in the transport sector (SIKA 2000), the work group of the project (Swedish National Rail Administration, NMA, SNRA and the counties etc.) has proposed that more studies should be made about the regional aspects of goods transports, in development projects.

ASG's perspective is to optimise their activities based on the present conditions. On the long term they want to affect the conditions but their main focus is not on land-use planning. ASG can only influence indirectly e.g. point out for decision-makers that certain routes have problems of different kinds. Since land-use planning is not among their main business areas the interest to take part in such work is limited.

NMA does not consider land-use planning as very important and it is not something that NMA puts much effort in and take part into since it is not in their main business area.

The informant at ODAL started with declaring that he is not convinced that sea and rail transport is better than road transport other than maybe in some specific areas. However if one is convinced that sea and rail transport is desirable, then land-use planning could be interesting. If it is shown that positive results can be accomplished, then ODAL is interested to take part in such work (e.g. try to influence the localisation of railway tracks), however, this is not the case today. If ODAL wants to affect land-use planning then they take direct contact with the person in charge. ODAL has no specific departments dealing with external issues of this kind.

The informant at Rail Combi considers land-use planning as important. In Sweden has e.g. the railway tracks been located in the centre of the communities, which is not always that efficient. Therefore, land-use planning is important to be able to create an efficient transport system not least between different transport modes. Rail Combi takes part in such work mostly via lobbying and the informant also regards that the planning of land-use and infrastructure is functioning better today. The lobbying can be addressed to for example the Swedish National Rail Administrations or different municipalities.

The informant at CABS considers land-use planning as important and it is of interest for CABS to take part in land-use planning. CABS is working with land-use planning by developing different plans e.g. a plan for investments in transport infrastructure in the county. They also get the municipal plans for infrastructure for consideration. CABS also perform investigations and reports in different areas, which is presented for important actors in the transport sector.

The informant at LRF considers that in their business area, road transport is indispensable and land-use planning is not that important. But it is of course important to plan the land-use to save land from unnecessary exploitation. For export with e.g. boat land-use planning could also be important. LRF regarded that it is interesting for their organisation to take part in land-use planning, for example, by commenting different infrastructure propositions and also to influence decision-makers earlier in the process.

9.2.3. Involvement of organisations and other actors

Ålesund city administration tries to get national harbour status for Ålesund. This is a decision that the government makes, and they therefore need an active involvement from the national authorities. They also ask for a more active policy-making and actions from the National Road Authorities to develop better connection between road and sea transport.

Møre og Romsdal county is trying to involve all relevant actors, both from the authorities in all sectors and all levels to private companies. They want to involve more actors to co-operate. The administration also co-operates with other county administrations to improve harbour development, and they are working at EC regional level (Interreg).

Møre og Romsdal county consider these actors to be relevant:

- Ålesund harbour authorities and Ålesund city administration
- The regional development office
- Regional Coastal Administration
- National Road Administration
- The co-operating council for west and south Norway

- The regional council for northern-Norway
- Ministry of Regional Development
- Ministry of Communication
- Politicians in regional and national government.
- Nor-cargo
- Sunnmøre Goods
- Confederation of Norwegian Business and Industry
- Nordic Transport-political Network.

The Regional Coastal Administration stated that the users of the infrastructure have to be involved more than today both in the national and the regional transport planning. All kind of transport-companies is relevant in these issues.

NSB goods has in recent years focused on co-operation with other actors with interests in intermodal transport:

- Truck transport companies
- The Norwegian lorry Owner's Organisation
- Two environmentalist organisations
- Jernbaneforum (lobby organisation for rail interests)
- Customers

NSB goods is of the opinion that there is no need to include actors that have not been included before, but there is a certain potential for extending existing contacts.

NSB goods considers themselves and lorry transport companies to have mutual interests in developing intermodal transport chains. Therefore the contact between the rail and lorry companies should be deepened out.

Collaboration with customers in order to improve the conditions for intermodal transport is important for NSB Freight. This can be done by localising customers and rail terminals close to each other.

Our informant from Norwegian Shipowners' Association points at the fact that the responsibility for sea transport is spread between numerous public actors. From his point of view, too many public authorities are involved in regulation of sea transport and by that way also intermodal transport. First priority for Norwegian Shipowners' Association is to move the responsibility for sea transport from the Ministry of Fisheries to Ministry of Transport, where all other transport modes belong. By doing this, the conditions for a forceful intermodal transport policy should be drastically improved.

There is no need for including more private actors in the effort for boosting intermodal transport.

Marintek also calls attention to the fact that a vast number of companies, organisations and other actors are involved in facilitating intermodal transport. Therefore there is no need for additional actors to be included.

One other actor in Norway was suggested:

- Jan Tore Pedersen, jantp@online.no, tel. 6493 0735, project co-ordinator for IPSI, earlier employed in Kværner. Currently independent consultant in Drøbak with close personal connections in DG VII. Much used by Marintek.
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In Finland the interviewed actors expressed the opinion that there could be many other actors involved. It is important to get the whole transport chain represented, from consignor to consignee. It was also expressed that the transport companies' perspectives must be taken into consideration. Relevant actors to participate are:

- Industry/trade
- Shipping companies, the Finnish Railways, trucking companies
- Freight forwarders
- Constructors of means of transport

In addition, it was expressed that the road administration and regional councils should participate more than what is the case at present.

The informant in the Regional Council of Kymenlaakso pointed to the Ministry of Transport and Communications and the Finnish Maritime Administration as important bodies.

UPM-Kymmene Seaways was also seen as an essential body to interview.

In Sweden ASG consider that the most important issue for rail transport on both national and international level is to offer a sufficient quality of the railway transports/solutions. Lobbying has been used frequently previously for convincing different actors of the quality of the transports, but now it is important to also prove the quality in reality. The most important actor is considered to be the customer.

NMA stated that they consider that the most important actors and organisations are already involved today and that the most important issue for NMA is to have an influence on the political decisions.

ODAL considers that the involved actors today are the relevant ones, and no further involvement is necessary. ODAL stated that the important issues are to make the railway and sea transport cheaper and more interesting for the customers.

Rail Combi states that it is desirable to include as many actors as possible especially those with interest in railway traffic. The road transport has already many spokesmen. Rail Combi suggested that the Swedish National Road Administration (SNRA) actively could take more responsibility for the planning of an increase in intermodal transports. Rail Combi did not identify any specific new actors.

CABS regards that it important to involve more organisations, e.g. the Swedish Association of Green Motorists, since these are well-informed about transport economy and regional matters. Another important actor is the Swedish Society for Nature Conservation although the informant thinks that their perspective can get too narrow and sometimes only aim to protect certain species in the cities regardless of the transport situation.

LRF regards that it could be important to involve more actors, although no specific new actors were mentioned.

Bo Wallin, section chief, responsible for transport political issues at the Swedish Ministry for Industry, Employment and Communications was also pointed to as important to get involved.

9.2.4. Economic measures

In Møre og Romsdal the Ålesund regional Development Association (In Norw. "Ålesundregionen Utviklingsselskap") points to the possibility of making mode changes by changing the factors important for transport mode choice. The most important factors are considered to be price, time and service. In their economy calculations, these factors are important in addition to the capital investments in facilities, port structures and terminals. The transport situation on the European continent is in addition a factor. By changing the framework for their choice e.g. through fees, taxes and transport restrictions, desired mode changes can be encouraged.

The Regional Coastal Administration in Norway considers economic measures as important. Prices and dues in the transport sector are considered to be related to society costs from different transport modes.

Finnish Railways (VR) has been using economic measures for investing in terminals in Helsinki and Turku. An appropriate intermodal terminal is also needed in Oulu, but there is no financier for this yet. Infrastructure supporting intermodal transport and transferring transport of goods from road to rail and sea also needs to be developed and improved. All essential nodes should have an appropriate terminal where transferring of containers, swap-bodies etc. from one mode of transport to another can be performed efficiently. Both local and national support and financing is necessary to facilitate this. Logistics centres generate new services and thus improve locally employment. This is the reason municipalities also should be interested in supporting them. The gross margin in intermodal transport appears to be too low for private intermodal operators to build terminals. Therefore, the business based financing of new terminals appears to be highly improbable. Consequently, the support of policies and economic measures is needed to build a comprehensive terminal system.

The results from the interviews in Sweden points to a potential for mode-transfer from road to sea and rail. Many actors are interested, but however only if economically feasible.

The Swedish NMA regards that the transport policy rules could have been more neutral from a competitive point of view regarding charging and cost responsibility etc. What the NMA can affect, being a governmental authority is the transport policy rules e.g. the fees for infrastructure. They consider that Sweden could have the same principles for the pricing of transport regardless of transport mode. For example has air and sea transport in Sweden requirements on full coverage of costs for the infrastructure through fees on the users of the infrastructure. Both the National Maritime Administration and the Swedish Civil Aviation Administration are state owned companies and must cover all its costs. On the other hand the Swedish National Road Administration and the Swedish National Rail Administration are also state owned companies but are financed via the taxes. This is of course affecting the costs for different transport modes.

Intermodal transports and transferring of goods from road to rail and sea transport is considered to be on the edges of NMA's business area. However the NMA considers that the transport policy rules also affects intermodal transports since the choice of the cost of different transport modes is determined by these rules. The market has to get the right price signals. For example, if a railroad from the northern part of Sweden to the West Coast is built, and some wood is going to be transported by this mode, the full cost for the infrastructure is not paid. In addition is there financial support given from the government for this transport. This makes railway a more interesting alternative than transporting the wood by sea along the East Coast. Charge for external effects is important and the NMA points out that in other parts of Europe this is the working method (with similar charging systems for all transport modes).

According to the Swedish NMA, the transfer of goods to more energy-efficient modes is a central issue for the forwarding agents and the transporting companies, who acts based on market conditions.

9.2.5. Eco-labelling and environmental strategies

It appears, particularly from the interviews in Sweden and Finland, that the increased use of eco-labelling in transport creates incentives for mode transfers from road to sea and rail. The importance of having an environmentally sound logistic chain appears to be increasing. In Norway the interviews revealed a more reserved attitude towards this aspect.

The informant from Ålesund city administration does not consider eco-labelling of transport as important to achieve increased mode change from road to sea. Consumer interest of eco-labelling is considered of little importance. This interest is not large enough to influence the transport sector. It is not considered relevant for Ålesund city administration to take part in developing such a system. If this could be done as apart of the system of "environmental lighthouse", which the institution already takes part in, it could however be relevant.

Møre og Romsdal county consider it difficult to state that eco-labelling is an efficient measure for achieving increased mode change from road to sea. It was expressed a willingness to try out a system of eco-labelling of transport, but if the costs for this are high, a serious assessment should be carried out before implementing such a system.

The Norwegian Regional Coastal Administration stated that eco-labelling is important as a mean to achieve increased mode change from road to sea and rail and improved direct sea-rail connections. Such a system will make the advantages from sea transport visible. It is also relevant for the institution to take part in a work of developing eco-labelling of transport. Other factors, such as safety and availability, were however stated as being equally important.

The informant in NSB Goods had doubts about that the Norwegian market is ready for the implementing of eco-labelling of transport. The argument that rail has the advantage over road transport of environmental reasons, was expressed as being important just to a minor group of NSB Goods' customers. Rather than eco-labelling, NSB goods rather considers Environmental Management Systems (ISO 14000) or similar standards, as a potential strategy to achieve increased mode change from road to rail.

According to Norwegian Shipowners' Association there would be no drawback to eco-label sea transport, but there would hardly be an important advantage connected to eco-labelling either. If sea transport obtained such a label, other transport means would most likely follow up with their own labels. Hence the effects might neutralise each other.

Norwegian Shipowners' Association is aiming at environmental differentiated charges. For instance should ships with tanks for catching hazardous waste be favoured with less harbour dues (i.e. not have to pay harbour dues for 'environmental tonnage').

Marintek expressed that the environmental profile of transport is becoming more and more in focus by transport buyers, especially abroad. In addition to emissions, factors such as noise and risk should be emphasised in this regard. Eco-labelling in this case is legitimate if sea transport is performed with high efficiency (that is with good logistics). Otherwise high emissions per ton cargo might be the result.

A manifestation of the growing importance in Finland of having an environmentally sound logistic chain can be found in the Kymenlaakso Regional Council's strategy, which is derived from environmental principles, and aims at privileging rail and sea transport. Projects, like decreasing a number of bottlenecks and reducing other weaknesses, are focused on greening of the whole logistic chain.

The paper industry, which is this SAVE-project's case in Finland, is an industrial sector that could take advantage of a green image of transport by rail and sea. This could have influence on the strategic company choices for transport mode in this sector. Paper industry however has two different classes of transports connected to it:

- The transport of large rolls: they are not so well suited for container (for unitised) transports
- The sheets: they are suited extremely well for container transports

Thus, a significant part of exported paper isn't well suited for intermodal transport like containers. Nonetheless, the number of container transports is still increasing in the case company UPM-Kymmene.

The friendliness to environment appears to have become a competitive factor. Environmentally sound transport chains will increasingly be rather a reality than a benefit in a business environment. But energy saving and other environmental issues are not the most important things for customers yet. Nevertheless, customers are increasingly showing interest in environmental friendliness of the transport chain of the products they've bought. Thus, the goods forwarders are pressured to take to whole transport chain into consideration. The significance of such criteria will probably increase in future. Energy saving and reduction of the use of fossil fuels are important from an environmental point of view. There is however a need for more research in developing tools for measuring and comparing different modes of transport as well as whole logistic chains.

The examination point of view must however always be kept in mind. Is a logistic chain examined for the country or origin or from the whole export transport chain's point of view, and is it examined for example from the point of view of the costs, environment or damages?

The possibility of future demands going in the direction of environmental certification of goods according to a cradle to grave principle might be a way of obtaining desired mode change.

A system for eco-labelling is considered important by most of the interviewed actors in Finland. The possibilities for developing such a system are however viewed as difficult. The Regional Council has the possibility of participating in developing an eco-labelling system, but only at the level of the region's transport system. A transport company has also many possibilities to take part in developing eco-labelling, but there is no general measures present aiding in this task. The main problem with eco-labelling systems, from the Finnish point of view, is the difference between Finnish export transports and Central European ones. An eco-labelling system has to be fair in order so that geographic location would not be of large significance. The transport of Finnish export products (as well as Nordic products in general) to e.g. the Central European market requires more transport kilometres than the products manufactured in Central Europe. The TT views that when the eco-labelling system is developed, it is essential to participate in this work, in order to ensure that the different national characteristics are taken into consideration.

In addition to eco-labelling of transport, the existing environmental standards (e.g. ISO 14001) are considered to be a part of the basic policy of the companies in Finland.

In Sweden it is evident from the interviews that if more actors could demand transports or label their own transports with the label “Good Environmental Choice” from SSNC, as a part of their environmental work, the actors can point out their environmental achievements to the customers before they discuss the price so that this knowledge will influence the customer’s decision.

Rail Combi consider that in the future probably more companies will demand that their transports will be marked as “Good Environmental Choice” and that this can be included in the companies transport policies. Rail Combi also regards that it is important that the customers become aware of the environmental problems so that it is natural for the customers to buy environmentally friendly products. If the eco-labelling system documented how the product has been transported, the customers could more actively choose products that have been transported in an environmentally friendly way.

Even though Rail Combi has the eco-label “Good environmental choice” for some of their transports, they have not experienced any greater demand for these transports. However, the company has not used the label as much in their marketing yet. On the other hand, many foreign transporting companies have old lorries and it would be of value to have an international eco-labelling system for different transport modes, which compete with each other. It is relevant for Rail Combi to take part in the development of such a new eco-labelling system, for example by sharing the experiences which Rail Combi has gained, and work in the direction of making the system as uniform as possible.

The informant at ASG considered that eco-labelling is very important. ASG believes that it is important to establish a number of criteria’s that should be fulfilled to be able to classify a transport as an eco-labelled transport. To make the classification based on the transport mode is not desirable according to the informant. ASG cannot directly develop such system but can take part and influence decision-makers. This has also previously been done.

NMA stated that eco-labelling of transports could be important to create debate and opinion. NMA could, for example, contribute with some materials as input in the eco-labelling process but it is not relevant for them to more directly take part in developing such a system.

The informant at ODAL stated that it is more important that the transporting companies can meet the legal demands. ODAL also pointed out that it would be difficult to establish a system that is neutral and does not favours specific transport modes. The environmental level of a transport also changes when the load factor changes and this happens all the time for transporting companies. It is not today a relevant activity for ODAL to take part in developing eco-labelling systems according to the informant.

CABS regard eco-labelling as important and consider it as a relevant activity for them to take part in. CABS could, for example, initiate and/or finance pilot projects.

LRF regard eco-labelling as important and it is also a relevant field of work for LRF to take part in developing such a system for the transport sector. LRF could participate by offering their services, but it is more doubtful that LRF is willing to help finance such projects in other ways.

9.2.6. Co-operation and co-ordination of the actors

Many of the interviewed actors consider that an increased co-operation between the different actors of the goods transport system is important. The logistic systems and the connection between different transport modes require good cooperation.

“Ålesund Havne- og Transportforum” was established by Ålesund city administration to improve the co-ordination between the different actors, and is a forum for regional actors both from export companies, transport companies and local and regional authorities. The forum is a network stimulating information and co-ordination between the participants. Other purposes is to take part in development of Ålesund harbour, give input to political and administrative institutions and contribute to improve the competitiveness of harbour and transport businesses in the community. The work was however started only recently, and only limited results are obtained so far.

Møre og Romsdal county administration consider that there is a large potential in improving co-ordination of the transport chain, but many actors make this difficult. The most important task is considered to develop transport centres. In addition to land use planning, is co-operation important to develop necessarily facilities such as terminals, logistic- and goods handling systems. Well functioning co-operation across organisations and companies is needed. New organisation models could also be relevant for this.

The Regional Coastal Administration stated that co-ordination along the whole transport chains is very important in order to achieve increased mode change from road to sea and rail and improved direct sea-rail connections. The administration is taking part in such work, e.g. the transport plan works in Møre og Romsdal county and other communication authorities. In Trondheim however, the location planning of a new rail goods terminal appears to go in wrong direction, without connection to the sea.

Potential candidates who were pointed out to lead the co-ordination work in Norway are the Regional Road Administration and the Regional Coastal Administration.

NSB Goods’ largest customers are transport agencies / forwarding agents. In addition, there are several small customers operating as independent actors. These tradesmen and industry companies would have benefited from co-operating in order to handle larger transport volumes.

Improved intermodal transport services could have been obtained if lorry companies to a larger extent realised that they have common interests with NSB Goods in combining lorry and rail transport.

From the Norwegian Shipowners' Association's point of view, co-ordination between all various actors in the transport field is important, especially considering today's outsourcing trends. In Norway most buyers of transport services are aware of ship as an important transport mode. Not so in continental Europe, where most shippers only think in terms of road transport. The need for improved co-ordination in order to strengthen intermodal (sea) transport is therefore more pronounced in Europe than in northern Scandinavia.

Marintek's view on efficient transport chains is that they demand closely integrated alliances between the different links. A steady and efficient flow of goods is an imperative in all logistics. Commercial partners seeking each other based on mutual dependence and interest can only obtain this. Good information technologies are useful tools in this process.

Enhancing the co-operation between actors is also an important strategy at Finnra. Even though the particular intermodal and rail/sea transport strategies are absent, the co-operation strategy can have impact on improving access to rail and ports. If there was a body that would be responsible for the entire transport chain, it would be easier to optimise it on the whole.

In Finland, the co-ordination and co-operation is seen as an important measure within the public bodies, especially the co-ordination at the system level. The Finnish Ministry of Transport and Communications should have the leading co-ordinator's role. In private sector the co-operation can be more problematic, since the question of competitors and business secrets may arise quite quickly. However, the private companies could participate in co-ordination as well, if the leading co-ordinator is some impartial organisation. Also the railway operators are considered to have a significant role in co-ordination. The public bodies find the co-ordination of the whole transport chain important as well, at least at the system level. The problems for private companies are the same as in previous question. Often the obstacle for co-operation is the fact that companies do not want to reveal their business plans etc. to the competitors. An impartial organisation as a co-ordinator could make the participation in that kind of work more attractive.

The possibility of improvement in intermodal transports by facilitating better cooperation between different actors also appears to be relevant in Sweden. This would be a challenge for both the government and the other involved actors. For example one suggestion is to create incentives for discussions and create meeting arenas such as seminars and conferences.

The counties of administrative boards in Sweden have a challenge to improve the co-ordination of the infrastructure, traffic, regional development, planning of investments in roads, railways, establish better transport regulations, also for sea traffic.

Co-ordination between the actors in the transport sector is important according to ASG. The co-ordination between the Swedish National Rail Administration and the Swedish State Railways is crucial for the possibility to transport more goods on rail. It is also important to ensure that goods transport is not under-prioritised compared to passenger transport.

ASG also pointed out that informing themselves on the conditions in other countries in Europe and the conditions at different operators, is a way that ASG could participate in more co-ordination between actors. This knowledge has the potential to give ASG ideas of how to better organise the transports, which also benefits the customers regarding rail and sea transports. The organisation that was pointed out to have the lead co-ordinating role for this work is the Swedish National Rail Administration. Co-ordination in the whole transport chain including reloading and controlling all the links in a transport chain is regarded as a substantial problem by ASG. It is also, as previously mentioned, important for ASG and railway/sea operators to provide better reliability and quality of the rail- and sea transports so that these transports can be as a good an alternative as lorry transports. The problem is often that the railway or sea transports cannot correspond to the requirements of the customers (e.g. a fast delivery).

The informant at NMA considered co-ordination important in every way, also in the whole transport chain. NMA takes part in such co-ordination and has the potential to participate more in the infrastructure planning of the transport sector including harbours and railways etc. The infrastructure is considered particularly important for the intermodal transports. More co-ordination is necessary between NMA, the SNRA, the Swedish National Rail Administration, the CAA and SIKA (Swedish Institute for Transport and Communications Analysis). SIKA was also pointed to as a potential co-ordinator, and is actually carrying out aspects of this task relatively well today.

The informant at NMA commented that maybe the use of new Internet technology could improve the co-ordination between the actors in transport chains. Applications could be to use Internet technology to be able to increase the load factors and to minimise empty return trips. The co-ordination in the transport chain is considered important by ODAL. ODAL however wants to handle the co-ordination between relevant actors themselves, and the informant is of the opinion that the co-ordination is sufficient today at ODAL.

Co-ordination in the whole transport chain is an important issue according to the informant at Rail Combi. The informant at Rail Combi stated that it is important with better co-ordination, even though they co-ordinate and co-operate rather well with other companies and that the most suitable transport mode often is used for the actual distance and type of goods. Between the Swedish Road Administration and the Swedish Rail Administration there are however possibilities for improved co-operation. On the governmental level there is a lack of co-ordination and control at the moment. It is important that the roads are planned also in relation to the rail and harbours so that intermodal transport could be of interest. Rail Combi also wanted to take part in co-ordination especially regarding intermodal transports. The kind of institution that should have the lead co-ordinating role is unclear. It is possible that a new governmental authority could be the solution or if SIKA could be given a more extended activity in this area. Forwarding agents has probably a better possibility to co-ordinate the whole transport chain than Rail Combi. Rail Combi wants to take part in more co-ordination but is presently more functioning as a subcontractor for their part of the transport chain.

CABS regarded it important with better co-ordination between the actors. It is also of interest for CABS to take part in more co-ordination. CABS suggested that the different national transport administrations together with CABS could take a common co-ordinating responsibility. SIKA could possibly also be used as a complement for example to conduct investigations. The informant at CABS considered co-ordination in the whole transport chain as important. CABS are involved in co-ordination and thinks that it is important with more co-ordination. For example, it is important to establish more intermodal transport centres.

CABS could have a role to investigate the background for such an establishment and CABS could e.g. also financially support local initiatives.

LRF commented that co-ordination is important and that LRF is interested in taking part in more co-ordination. It was also expressed that organisations representing different transport modes should take more responsibility for the co-ordination according to the informant. The informant at LRF considers that co-ordinating is important and regards that the co-ordination with SJ has been difficult historically. It is also important for smaller hauliers to co-ordinate their transports to be able to compete with larger forwarding agents. Organisations representing different categories of business like wood industry, slaughter industry and the grain & milk industry could take more responsibility for the co-ordination. LRF is also interested to take part in more co-ordination.

9.2.7. Harmonising of standards and regulations

Ålesund city administration, Møre og Romsdal county administration and The Regional Coastal Administration consider it important to harmonise standards and regulations as a mean to achieve increased mode change from road to sea and rail and improved direct sea-rail connections. Particularly the container standardisation is considered important for making the sea transport more effective. Møre og Romsdal county administration has brought this issue into the Nordic Transport-political Network and central authorities in Norway.

For NSB goods, harmonising of rail infrastructure throughout Europe is the most important initiative in this field. Differing standards for rails, gauge (narrow/wide), and signal systems are hindrances for effective flow of rail goods. Rail transport is also restrained by old-fashioned rules on operation of railways. In a way there is a struggle between two systems: The administration of traditional goods wagons (characterised by low speed, many stops, frequently re-combinations of train sets) and express goods (carried by huckepack/swap bodies in high speed between main destinations, with relatively few stops).

Norwegian Shipowners' Association expressed that harmonising of standards between the transport modes is of vital interest. To achieve increased use of intermodal transports, one single consignment note should follow the goods from sender to receiver. Today different rules and forms for road, rail and sea transport is complicating the establishing of intermodal transport chains. For sea transport, the bureaucracy is particularly problematic. This can be illustrated by an example: If a Swedish ship with a Swedish captain sails from England to Oslo, the captain will have to fill in 20 different forms from when he arrives until he can leave.

Transport of dangerous goods is another example: Differential treatment between transport modes regarding reporting and precautionary measures, forces hazardous goods from sea over to cheaper road transport. Instead of transporting dangerous goods in open sea, such transport is done by lorries on roads with heavy transport passing through densely populated areas.

Sea transport will meet new challenges as the result of the introduction of the Schengen Agreement. The Schengen Implementation Agreement (SIA) has so far been signed by 13 of the 15 current EC member states, as well as Iceland and Norway. This agreement on police co-operation and abolition of EC internal border-controls, means that harbours in the future will represent the strongly guarded outer border of the Schengen area, while land borders gradually will be built down as administrative obstacles for transport. This process emphasises the need for harmonising regulations between transport modes in order to achieve increased mode change.

Marintek expressed that today's different rules for different transport modes is a barrier for mode shift from road (and rail) to sea. Sea transport faces general obstacles regarding customs clearance. In this field there is a need for harmonising on the rules. Transport of dangerous goods is another example: The international regulations for sea transport of hazardous waste (International Maritime Dangerous Good Code, IMDG), is far more rigid than the corresponding regulations for road transport (ADR) and rail transport (RID).

In Finland, the harmonisation of standards and regulations is considered very important among the interviewed actors. The informant from Finnra is however of the opinion that the standards are not essential regarding transport mode change. TT participates in developing and harmonising standards, particularly in projects that concern the measuring of service level in transport chains. The Port of Kotka views the harmonisation of railway operations as being of greatest importance. All actors did find it important to participate in developing the harmonisation of regulations and standards.

In Sweden, the informant at ASG regards that standards are important, and is of the opinion that it is possible today to work with the present standards and regulations. It is also possible, according to the informant, that some stakeholders in this business could use the discussion about harmonisation as an excuse for not making more effort themselves. ASG has historically worked on influencing the development of standards, but only to a limited extent.

NMA consider that it is important to harmonise safety and environmental standards and regulations. NMA is co-operation with the other Nordic countries in trying to harmonise other standards, such as safety regulations.

ODAL consider that it is important to develop harmonised standards in some areas, for example, the width of tracks in different countries. Also the taxation of the transport sector in different countries should be more harmonised.

Rail Combi consider the harmonisation of standards important, and that the lack of standardisation is a problem today. For example load carriers are seldom adapted for more than one transport mode, which makes intermodal transports more difficult and less effective. Rail Combi tries to influence inspecting authorities to develop better standards and the informant also considers that inspecting authorities generally could take the responsibility for more harmonisation of standards.

The informant at CABS considers it important to harmonise standards and regulations and regards that this is a relevant work area for CABS, to some extent, to be involved in. One example is when deciding the design of charges for different County Public Transport Authorities.

The informant at LRF regards that more harmonisation of standards and regulations is important. The profile of the wagons in railway transport is an potential area for standardisation. LRF is participating in a group that is discussing standardisation where LRF are declaring their special requirements. However, harmonisation is probably more of an issue for organisations representing different types of business or larger companies.

9.3. Specific measures and actions for road to rail transfer

This chapter contains material on measures and actions to encourage transfer of goods from road to rail. From the interviews in Norway is appears to be few political measures aiming at this mode change. Of the measures, which exist, almost all apply only within the rail companies themselves.

Rail has a disadvantage relative to road for short distances, and are only rarely an option for distances <300 km. The low flexibility of rail is a problem in this regard. Organisational problems, which can e.g. reduce the possibility to efficiently control the choice of transport mode, also exist due to "outsourcing". This is the situation for the Swedish case-company ASG.

Other identified actors and knowledge sources for rail transport have been identified during the interviews and literature search, and include:

- Combi-Verkehr (Germany): Similar to NSB CombiXpress
- Hupac (Switzerland): Handles much goods transport between North Germany and Italy.
- SweCombi (Sweden): One of the most proactive in new goods transport solutions in Skandinavia. Collaborates with NSB, currently as a customer, but a more close collaboration in the future is possible.
- UIRR (International Union of Combined Road-Rail Transport Companies) has strong position in the EC system and national governments in order to lay the foundations for more combined goods transport.
- Staffan Tornfors on the Swedish Forest Industries Federation in Stockholm. Works full time with co-operation matters.
- Per-Åke Arvidsson on SkogForsk, Uppsala. Works together with Swedish Forest Industries Federation and LRF in many projects, trying to affect the Swedish transport polices.
- NUTEK
- KTH's railway group, Oskar Fröjd
- KFB (Kommunikationsforskningsberedningen)
- Nordic Rail Group
- HEMKÖP's reports about results from pilot actions made by forwarding companies. Example is the report from pilot actions with light-combi transports, which also has been documented by researchers at Chalmers University of Technology.
- The Swedish Society for Nature Conservation (SSNC)
- Companies like Electrolux, ICA etc.
- Environmental reports from SJ
- Literature about "Good Environmental Choice" from SSNC.

The measures and actions for road to rail transfer is grouped into five main categories. They are:

1) Rail transport infrastructure improvement
2) Increasing frequency of rail departs
3) Adjusting delivery volumes to suit rail sizes
4) Co-operation between actors
5) Information on rail transport

9.3.1. Rail transport infrastructure improvement

The growth in person transport by rail is problematic for the goods transport. Particularly the increase in high-speed passenger trains causes problems for the increase in goods transport. These trains often get first priority in order to utilise the high speed. Goods trains will have to wait, on order to let the faster passenger trains pass. A growth in goods transport by rail will thereby face increasing capacity problems on the European rail network.

In order to increase the capacity of the rail transport corridors there are major changes to be made, and many measures that can be used. The actions and measures that the interviews identified to be important have been categorised in six types:

1) Enlarging tunnels
2) Separate rail for goods transport
3) New bridges
4) New trains
5) Mode transfer points/terminal improvements
6) Other measures and actions for rail goods transport

Enlarging tunnels

The transport of semi-trailers on train demands larger space than traditional "vognlast" and system trains. This implies that some tunnels need to be enlarged to facilitate this type of combined transport. In Norway as of February 2000 it is only the rail lines Oslo–Trondheim and Oslo–Stavanger where the tunnels are large enough. In August 2000 Raumabanen (Dombås – Åndalsnes) will also be ready for such transport. Further plans include the opening of parts of Nordlandsbanen (Trondeim-Bodø) before the end of 2000 for this type of transport. More long-term plans exist for Oslo-Bergen, but this requires much work due to the many tunnels on this route. It is the responsibility of The Norwegian National Rail Administration to carry out these changes in the rail infrastructure.

Separate rail for goods transport

The increased use of rail for goods transport will also require more sections with double tracks where trains can meet or pass each other. It is a strategy in NSB Goods to put pressure on The Norwegian National Rail Administration to speed up the construction of such rail lines. The length of trains must not exceed the length of the double track sections. In many cases, particularly for trains carrying parcel goods are short double track sections barriers to the full utilisation of the locomotive power.

During the years 1994-1997 many bottlenecks in rail transport have been eliminated in Finland. The construction of a double track between the segment of Inkeroinen-Juurikorpi, has in addition to removing level junctions, other improvements of the railway, arrangements of the customs and border crossing station of Vaalimaa, improved the rail system.

As mentioned earlier, is the conflict between person- and goods transport becoming a problem. Many counties in Sweden expect that the expansion of fast train connections will decrease the transport time for goods. Double tracks will be necessary in large sections of the rail system, in order to meet the demand for faster passenger trains. In the north part of

Sweden, the development of a separate heavy transport net for the railroads is considered important.

The Swedish State Railways (SJ) and the National Rail Administration have high costs for the infrastructure e.g. sidetracks. The cost for the maintenance seems to be the problem. SJ is accordingly to a great extent removing these tracks. Further negotiations to maintain the sidetracks are in many cases necessary to secure sufficient infrastructure for further use of the rail mode for grain transport in Sweden. However, the question of who is going to pay the cost for the tracks is a problem in most cases.

New bridges

The two new bridge projects, Fehmarn Belt and Øresund, can have large impacts on the possibilities for transferring of goods from road to rail. Both could make rail transport a more attractive mode choice.

New trains

2-stories rail wagons for transport of containers and semi-trailers are necessary for the increased use of rail as the preferred transport mode in the future. The investments in new trains are the responsibility of rail companies.

New and more powerful locomotives will also be necessary to increase the length of trains that thereby can carry more goods. This is particularly the case for bulk transports.

Axle load limits both for current rail lines and carriages will have to be higher in the future. A large part of the carriages being used today in Norway are old and often modified equipment. Two-axle container-carriages today have a maximum load capacity of 29 tonne. They can carry two containers. Brewery-containers are often in the18-19 tonne weight range. A two-axle carriage can thereby only take one brewery-container, and the rest of the available space cannot be utilised due to the problem of uneven weight distribution. New types of equipment and compatible load limits are necessary to improve the energy-efficiency of the rail mode, and thereby make it a more attractive transport mode.

Private companies like Transfennica have no political measures, but as an example of block train tells (below), it is possible for a private company to achieve real changes in the logistic chain.

An example from Finland where co-operation between actors have shown to be essential is when Transfennica participated in developing a block train from Antwerp to Italy in the early 90's. Bureaucratic railway administrations proved to be a problem, and it took nearly two years to overcome the various bureaucratic obstacles. The situation may be better nowadays, but it is likely that it still need improvements. Nevertheless, once the project had been accepted, the technical phase of making it operational ran very smoothly. The concept of the block train is the following one: Railway companies are offering their services for bringing the wagons rented by the principal from A to B. A result of this cooperation has been the investments by Transfennica in documentation and information management in order to run the systems smoothly.

- The Finnish Railways (VR) has also objectives concerning block trains and the development of the Russian transport (container block trains from the ports of Finland mainly to Moscow). Since Finland has identical rail gauge as Russia, reloading at the border is unnecessary. The goal is also to get trailers transported on the same train.
- Containers via the Trans-Siberian Railway to Nakhodka Vostochny, the container port of the Far East. Use of this concept will be increased and made more efficient.

From a shipping company's point of view, intermodal transport is regarded as essential. This is the background for Transfennica's large investments in containers.

In Sweden an improvement in the grain transport by train would be that SJ could start offer grain wagons themselves. Today these are rented from other countries.

For goods transfer by rail to be a long-term option it is necessary that today's distances by diesel trains will be replaced by trains driven by electricity produced from renewable sources of energy (hydropower, wind power and solar power).

Mode transfer points/terminal improvements

The terminals in the cities often have a central location, often in areas with high road transport density. This often results in less then optimal efficiency of the goods transfer. transport jams and long wait periods before and after the loading is common. NSB Goods has the following strategies regarding this:

- Channelling of the transport to avoid the peak rush hours
- Relocation and consolidation of the goods terminals.

A transition into using combined transports will require different and more area demanding terminal infrastructure than the handling of traditional goods transport by train required. This will include dedicated forklifts with larger capacity than currently in use. The informant from NSB Goods is of the opinion that it will take many years to build up the combined transport system KombiXpress to a profitable level. This is necessary before further investments can be made in new equipment, both carriages and terminal infrastructure.

NSB Goods is planning the further expansion of the central rail terminal for goods in Oslo, the Alnabru terminal. The Ministry of Transport and Communications supports the plans, and area is available, but there is a growing potential for conflicts with local residents.

The logistic centre for railway transport in Kouvola, Finland is an example of a project undertaken by a regional county in order to improve the infrastructure for rail transport of goods.

For ODAL and the agriculture industry, it appears to be difficult to transfer much more goods from road to rail, especially if the transport is to be loaded on rail directly at the silos. A possibility is to load first on a lorry and then on railway. The average distances are however probably too small, about 70-100 km, according to previous energy analysis. Rail Combi indicated that below 100 km there is no real chance to compete with road transport. The longer the distance, the more cost efficient is rail transport. A rule of thumb in ASG has been that a transport over 300 km can be suitable for rail transport. The informant at ASG is nevertheless doubtful if this distance is the correct one. LRF indicated that 150 km could be a reasonable distance to transfer to rail from road. It could be less if rational reloading stations exist.

Rail companies have the sole responsibility for the operations of the rail terminals in Norway and Sweden. An example from Finland where this is not the case is found in Kymenlaakso, where the regional council is supporting the building of a railway logistics centre.

In Sweden there are today two large passages for rail transport from the inland to the coast. One passage is located around Sundsvall. The other one goes from Dalarna down to Gävle. For the railroad to compete economically there should probably be at least 150 miles from the forest to the industry. When reloading everything has to be rational, no one should have to wait and no extra lorries should have to go there for the reloading (they should be stationed there all the time).

LRF’s comment on intermodality is that it generally is very expensive to reload. A reload can cost the same as a transport of 50-100 km or even more. A lorry, which has a full load, takes at least 0,5 hour to unload (if the driver does it himself with a crane). It is also common that the drivers have to wait at the reloading stations. If a certain type of large cranes is used the reloading can go much faster. On the other hand these cranes are very costly. No revolutionary new technical development is expected so it seems difficult to make this process much cheaper.

Other measures and actions for rail goods transport

According to the decision of the Ministry of Transport and Communications in Finland, general plans for aligning railways will be made for the sections between Kerava-Lahti and Lahti-Mikkeli. The section Kerava-Lahti is the first to be developed. The speed level in the rail transport to St. Petersburg will be increased as a result of this. In its decision, the Ministry also proposed that if the community structure seems to change a great deal in southeast Finland, or if the transit transport to Russia grows considerably, the coastal railway alternative may still become the preferred choice.

Concerning the improvement on infrastructure in Swedish railways, LRF suggests trying more with unattended stations (especially when dealing with wood products). Another problem area for the railway is that sidetracks have more often been removed than invested in. The removing of tracks seems to be a cost matter for SJ and the National Rail Administration.

ODAL has historically only used rail to a small extent. The incitements to use more rail transport have been small. SJ hasn’t offered tracks but has rather removed tracks unless ODAL has paid for them to stay. The new necessary rail infrastructure has not been built regarding goods transports. Of the about 80 silos in ODAL only 5 have railway tracks to them. If ODAL hadn’t financed the tracks close to these 5 silos, they would not have any tracks left. One main problem is that there must also be tracks to the customers. There is option of using intermodal transport due to the lack of tracks to the customers, but this implies extra reloading costs.

Rail Combi makes together with other companies in this sector a list every year of what they think is important to invest in. The Swedish National Rail Administration then receives this list and allocates the governmental funding.

An important measure for the EC is to enjoin the member states to reduce the differences in transport systems (width of track, electricity system, harmonise load profiles, bureaucracy and rules etc) and make it possible to use the transport mode (e.g. the same train) throughout the whole Europe. These differences in national systems for transport constitute thereby barriers for the increase in rail transport in Europe.

9.3.2. Increasing frequency of rail departs

Combined transports imply a streamlining of the goods transport, where faster and more frequent departures are needed. This will be a challenge for all rail operators, where timelines are critical. The demand for increased frequency of departs has for example resulted in that the CombiXpress – trains has fixed departure times and carriages.

9.3.3. Adjusting delivery volumes to suit rail sizes

In order to facilitate a transfer of goods transport from road to more energy efficient rail it is necessary that goods volumes and carriage types are compatible. The railway companies must be able to offer the right carriages for the type of goods to be transported. Measures to facilitate this are viewed as crucial among many of the informants.

9.3.4. Co-operation between actors

Today, there are many public actors within the transport sectors, but their area of activity and responsibility are not well co-ordinated. The work carried out within the transport area has been, and still is very much separated into individual sectors. An example of this from Norway is the separation of responsibilities between rail and trains. The Norwegian National Rail Administration (Jernbaneverket) is responsible for the rail infrastructure while Norwegian State Railways (NSB) is responsible for goods operations and rolling stock (locomotives and carriages).

Good co-operation between goods and the passenger transport is necessary for an efficient transition to increased use of goods transport by rail. The routes for goods transport must be harmonised with the passenger routes. Low flexibility in the goods transport can partly be due to the limited possibility for making changes in the routes schedule.. In Norway changes can normally only be made when the routes for person transport are revised, which is twice a year. Additionally, the changes in the route schedules have to be submitted six months in advance. This low flexibility is a challenge for increased goods transport by rail. Co-operation between the different actors is important in order to harmonise the routes and thereby facilitate the desired mode changes.

The lack of co-operation between the different rail operators is also a problem pointed to by ASG. Transport with all modes (road, rail and sea) in the same transport has not met ASG's requirement in most cases, other than perhaps in some special cases for example like when a bridge is involved (like over Öresund).

Another example of the difficulties associated with cooperation is the negotiations between LRF and SJ about prices for goods transports etc. During the years these negotiations have not led to any major breakthroughs. ODAL has also negotiated with SJ on several occasions. About 10 years ago this lead to some transferral of goods to rail. This co-operation is however ended. Negotiations about sidetracks could also be an initiative. The sharing of the costs between the different actors is however a major barrier.

9.3.5. Information about rail transport

More information about rail transport to the customers is important to make this mode a more likely choice. Rail Combi e.g. has on their web-site a possibility for the customers to calculate the effect on the environment with different transport modes. The potential customers can free of charge decide their environmental profile. This service is used frequently. A similar database for transports in Norway will be available on the NSB Web pages shortly.

The Port of Kotka has in addition to being a major sea harbour also the function of promoting intermodal and rail transport.

9.4. Specific measures and actions for road to sea transfer

As pointed to in the report from the Nordic Transportpolitical Network (NTN)" in the InterregIIc-programme does the "simple interconnections" and "loose couplings" give sea transport an advantage compared to other modes of goods transport (Hansen et al, 2000). The number of operators and the risks can be held down compared to rail in many cases. For example is white goods transported from Greece to Sweden by boat because the risk for e.g. loss of goods is reduced compared to land (road) transportation.

From the interviews in Norway the sea transport can be characterized as having many measures and plans associated with it, but few decisions are made regarding changes. The measures are characterised by:

- Being linked to public planning systems
- Being linked to land-use planning
- Being linked to public economic measures
- Having many involved actors (also private) in the planning processes
- Being related to the European Spatial Development Planning (ESDP) system, where sustainable development criteria have high priorities. There is a separate ESDP report for each EC country.

9.4.1. Shipping lines as agents for carrying out mode change

The shipping lines are in general positive to intermodal transport / the expansion of sea-based goods transport systems in Europe. In Norway the most important shipping lines in this respect are SeaTrans, DFDS, NorCargo and LysLine

9.4.2. Research and Development activities in transport mode change

Apart for the activities at Marintek, maritime research in Norway is carried out at Norwegian School of Economics and Business Administration in Bergen, and at Møreforsking Molde. Both apply a macroeconomic approach. Agderforskning is in addition carrying out modelling research for maritime goods transport.

The Norwegian Shipowners' Association claims that the general competence of sea transport in Norway is weak. This gives the politicians a rather weak decision base in the area. One problem is that researchers with background from land-based transport research have used statistics in a way that is damaging for the sea transport (again according to Norwegian Shipowners' Association).

The Near-coast transport programme (Nærskipsfartprogrammet) was initiated by Norwegian Shipowners' Association. This programme has not quite fulfilled its expectations. It is primarily the largest shipping companies who appreciates the use of this programme.

Annik Magerholm Fet at Møreforsking Ålesund[77] is collaborating with Det Norske Veritas regarding development of tools for Life Cycle Analysis (LCA) of sea transport. This research is on going, with remaining work being on the methods, data gathering and system definitions. The tool is not ready to be used yet. Preliminary results indicate that 80 % of the emissions are from the use-phase of the ships.

The Institute of Transport Economics (TØI) in Norway has carried out research on sensitivity-analyses for transfer of goods between transport modes. This work has been done as input into the National Transport Plan. The question asked was how much the price for one transport mode must increase in order to facilitate transfer to an other (e.g. land to sea). The conclusion was that the elasticity between the various modes is small. TØI did however not recommend that the results from these analysis could be used in decision making. This is symptomatic for the field's knowledge status of today: Large gaps on the basic level exist (modal comparisons and sensitivities).

Marintek's partners

Marintek has several partners that might have an interest in influencing the mode change from road to sea. They are:

- TU Delft (Delft University of Technology / De Technische Universiteit Delft) in Netherland works with development of sea transport concepts.
- Fraunhofer-Gesellschaft, largest technological R&D company in Germany, with strong competence within IT. 8-9000 employees, main office in Münich. Marintek's primary contact is "Fraunhofer Institut Informations- und Datenverarbeitung" (IITB), situated in Karlsruhe (http://www.iitb.fhg.de/).
- Hamworthy KSE (formerly Kværner, now with British owners). Marintek collaborates with the division in Göteborg. Hamworthy KSE AB, Kämpegatan 3, SE-411 04 Göteborg, Sweden, Tlf. +46-31-725 79 00, Fax: +46-31-725 78 00, E-mail: goteborginfo@hamworthykse.com, Internett: www.hamworthykse.com . Hamworthy KSE was the co-ordinator for the IPSI-project.

9.4.3. The Norwegian government's role in stimulating mode change

The Norwegian Parliament / Ministry of Transport and Communications is favouring land based transport. This happens e.g. through subsidies to lorry transport. Due to Norway's membership in the European Economic Area (EEA) direct governmental aid to transport

[77] Fet, Annik Magerholm (1997): *Miljøledelse i livsløpsperspektiv - et bransjeprogram i skipsindustrien, Hovedrapport*. Rapport Å9708. Møreforsking Ålesund.

companies is not longer allowed. I real life these transactions occurs in the form of various measures connected to development of industry, production of particular types of goods etc. This is administered closer to the end-user, as part of the frame support to the counties, with regional differences. It is not an easy task to estimate how large amounts are transferred to land transport in this manner.

Ålesund city administration stated it important with higher national priority of harbours. The economic support from the state have to be more focused to harbour with a great potential of transport or a clear potential for development. The aim has be some harbour with competitiveness. Today the support is not focused well enough to aid in harbour improvements.

The measures and actions for road to sea transfer are divided in 6 main categories. They are:
1) Sea transport infrastructure improvement
2) Port operations
3) Increasing frequency of departs
4) Adjusting delivery volumes to suit ship sizes
5) Cooperation between actors in sea transport
6) Information on sea transport

9.4.4. Sea transport infrastructure improvement

The infrastructure of sea transport is traditionally considered to be the ports, fairways (waterway transport corridors) and the service necessary to be able to use the fairways. Municipalities generally own the ports and take out fees from the users.

The measures and actions associated with sea transport infrastructure improvements has been categorised in 4 main groups. They are:
1) Port improvements
2) Waterway transport corridor improvements
3) Ship improvements
4) Improvements in port access

Port improvements

Measures and actions regarding port improvements can be divided into the following four categories:
1) General port improvements
2) Increasing efficiency in ports
3) Harbour dues
4) Simpler documentation

General port improvements
The National Transport Plan in Norway includes issues as the establishment of National Ports and National Node Points. Ålesund city has in addition an urban port plan that specifies port improvements.

Ålesund municipality has a goal of transferring goods from road to sea due to the fact that it is suggested in the National Transport plan (NTP) that Ålesund should be a national node point port. In the NTP it is stressed that inter-municipal port co-operation is important in the

Ålesund region. The municipality has responded to this by starting the planning of a new section of the port. The municipal council has agreed to develop a new plan for the port in preparation for the selection of the port to achieve node point status. There is a political goal in the municipal council to obtain the status of a national harbour for Ålesund.

A modern port has large area requirements. Ålesund County has in the most recent years emphasised area planning for intermodal transport. This is done both through preparations of a port plan to be finished mid-2000, and through the expansion of the port. A new port section for handling containers was completed in 1994. This has more recently been expanded, and a new port section is added to the south of Ålesund. In addition, a new port section is being planned on the north side of the city (Flatholmen, with an area of approx. 20 hectare). This section has access through a road tunnel. Planned functions in this section include handling of containers, fish port, and possibly roll-on/roll-off operations. The road to the area is financed through co-operation between the municipality and private actors. This road facilitates additional new roads to an industrial area and the new port section, avoiding conflicts with a residential area.

A new law regulating ports can control the development of the port structure. Through this new port regulation the authorities will have an improved possibility for control of the way the ports expand. By establishing a status for the ports, as suggested in the National Transport Plan, the strategies can be managed and measures controlled both horizontally and vertically in the public sector. Ports can obtain the status of national ports, node point ports and regional ports. The status of the port determines what type of public investment support is given for infrastructure development and port access systems. Having a status as a regional port and node point port opens up national public financing support channels. The status of national port strengthens the basis for such support.

The development of efficient node points with easy transfer to other transport modes is important in order to make intermodality an attractive choice. Sufficient area for service functions and managing containers are important. Terminals, distribution functions, storage areas for cooling and freezing of goods, and other support functions are essential.

These node point functions must have competitive prices in Ålesund, compared to e.g. the prices in the Oslo region. Today, much of the goods to and from Møre- og Romsdal is transported via Oslo port.

The Directorate for Coastal Affairs in Norway points to a future situation where there will be increasingly severe restrictions on the lorry transport, and that the sea transport will have to carry more of the goods.

Examples of port improvements in Finland were given in section 2.1 on EC Regional and Structural Funds. Some of the ports have been financed through projects in the Interreg II A-programme for the Coastal zone of South Finland. These improvements include the increases in capacity and entry roads associated with the Ports of Kotka and Hamina.

The Port of Kotka builds and maintains the infrastructure at the port. The most important issue for them is the adequate infrastructure needed by customers. Basis for the strategy and aims are customer needs. In the long run, it is a company (e.g. paper mill), who decides, how the goods are transported. The Port of Kotka promotes intermodal transport, and as a first port in Baltic Sea area, it will become a member of EIA (European Intermodal Association) from 27th January 2000.

The principle in developing the railways in Finland is the improvement of present tracks. Being the rail transport centre of Kymenlaakso and eastern Finland, the terminal operations of Kouvola and road networks have to be developed further. The ports of the region will be developed as a part of the gateway-strategy (Regional Council of Kymenlaakso, 1997).

Kymenlaakso is an international production and service centre whose main aim is to develop as a logistics service centre. Logistics centre includes the whole region of Kymenlaakso and consists of existing ports, terminals, and all logistics companies. In the future, resources will be increasingly focused on integrated logistic chain. One way of integrated logistical thinking is “Straightway”, which is an office for information supply on the possibilities offered by Southeast Finland as Value-Added Logistics Services Centre for the transit transport to and from Russia, the Baltic States, Scandinavia and for the domestic transport in Finland. It provides information and guidance to foreign companies that are interested in finding the right logistics partner or the most optimal industrial plant location in Southeast Finland (Straightway www-pages 29.12.99). StraightWay can be seen as a virtual logistics centre.

The National Maritime Administration in Sweden needs to improve the infrastructure of the sea transport and the infrastructure of the land transport. The NMA could also possibly better facilitate the prerequisites for planning between different transport modes. Likewise could the NMA also affect the transport policies, such as regarding the fees for infrastructure.

Increasing efficiency in ports
The ports need to increase the efficiency if increasing volumes of goods shall be transported by sea. The opening hours of the ports must be flexible enough to facilitate the need for loading and unloading operations. The lack of sufficiently long port opening hours is according to Norwegian Shipowners’ Association a main barrier for sea transport today. Likewise are “old-fashioned” regulations of rights to perform work in ports an example of a barrier lowering the flexibility of the public ports’ function as node points for handling of goods transport.

The transport companies cannot afford to leave the goods overnight and wait for the harbour to open next day if the transport arrives after closing hours. Many types of transport, not the least inter-modal, will require ports to be open at night.

Old agreements between workers’ organisations and employers appear to be problematic for the shipping companies. Examples of this are found in agreements between The Norwegian Confederation of Trade Unions and The Ship Agencies’Association in Oslo (In Norw. “Dampskipsekspeditørenes forening”), affiliated with The Confederation of Norwegian Business and Industry. Modern ships with on-board equipment for loading can only to a small extent utilise this, due to the fact that it is the port workers who according to the regulations shall perform the loading and unloading. Similar regulations also prevail in Sweden to a large extent. For transports by lorries with crane in many cases the lorry driver has to pay the port owners for work that is actually performed by the lorry driver. Another example is in timber transport by self-loading boats. When the timber boat needs to unload and leave, many harbours require notice long time in advance. This causes problems for the shipping company, since exact time for call at port is difficult to estimate (this is e.g. weather- dependent). The examples above indicate that the regulations regarding rights to perform work can damage the developments towards more automated loading and unloading, since the transport companies hesitate to invest in equipment that they will not be able to use. This reduces the competitively of sea transport compared to road-based transport of goods. In contrast to this has the lorry transports grown up since the 1970s without many of the rigid systems and "old-fashioned" attitudes which are prevalent in sea-transport.

One example however of an action in the direction of increasing the efficiency in the ports is found in Ålesund municipality, where a recently established common forum for port and goods co-ordinate the most important actors in the port. The actors participating are the port authorities, goods handlers, port operations, and shippers. Ålesund Port- and Transportforum was established in the first half of 2000 after a proposal from larger private actors wanting a forum for discussing shared interests and questions with the municipality administration. This forum might evolve into having common steering and control functions co-ordinating and possibly improving the efficiency of port operations without reducing the healthy competition between the actors. The need for a co-ordinating actor for the terminal and port operations might be under-prioritised in the National transport Plan.

New technological solutions can strengthen the competitiveness of the sea transport. Particularly E-logistics is pointed out as an interesting potential. E-logistics might make it easier for small and medium sized companies to utilise the potentials of combined transports.

Reducing loading/unloading time and simplified booking routines for inter-modal transports are viewed as the most important actions to facilitate transfer of goods from road to sea transport.

Weak logistics in the ports result in long loading/unloading periods and high costs. This is reducing the competitiveness of the sea transport compared to transport on road. Through automatic systems for loading and unloading, a reduction in the time spent in the harbour could be possible. However, such automated systems require high volumes of goods in order to be cost-efficient.

Marintek has through the EC DGVII -project IPSI (Improved Port-Ship Interface) evaluated automatic systems for efficient loading of roll-on/roll-off –ships. This has been done in order to assess the possibility of reducing the duration of the stays at port. Through this system, it is according to Marintek, possible to compete with road- based systems quite well. Kværner and many other large industrial companies participate as partners in this research project. The concept consists of a network of central terminals ("hubs") connected to "feeder" networks. It would however not be possible in Norway to build many such hubs, and the coastline of Norway would be part of a feeder-network. The main issue in the IPSI project is to utilise the same ship technology for both the hub- and the feeder-networks, such that the automated technology easily could be adapted to the type of goods.

The booking system is more complicated for intermodal than for lorry-based transports. Through IT-based systems for booking and document exchange in transport chains, an important barrier to intermodal transport might be removed. Marintek currently works on developing such IT-systems. The EC and national Norwegian authorities finance this. EC (particularly the directorate for Transport, DGVII) has large funding of research projects aimed at solving the problems of booking intermodal transports. Beginning in 2000 a new EC project named IP (Intermodal Portal) is carrying this research further.

The intermodality regarding grain transport in Sweden is efficient in areas where dedicated plants in the port exist. One example is when the grain goes directly form silos in pipelines to boats. These would be easier to handle than for intermodal systems in the forest industry, where lifting with cranes and forklift are the prevalent loading operations. The costs are however critical for the possibility to create special pipelines etc.

Too many actors involved in running the ports can cause confusion of who is responsible. An example of this is in Sweden, where The National Maritime Administration and the ports are responsible for the total infrastructure of the shipping. In some cases does the NMA fund the cost for investments, buoying and maintenance while in other cases is this done by the ports. Even if the ports are responsible for the costs, the NMA receives charges for the transport in these fairways. This is considered to be causing twisted competition. A possible improvement would be if the responsibility was on the NMA, to keep the fairways, then the NMA could chose to buy the service from other sources, like ports (Ports of Sweden et al., www.shsf.se/sjoremi.htm).

Harbour dues
The lowering of harbour dues is pointed out by Norwegian Shipowners' Association as one of the most important actions to improve land/sea intermodality. This association claims that the reason for the low competitively of the sea transport is found in the high port dues. In comparison, both road and rail transport have subsidised infrastructures: The lorry transport pay less than half of the costs for the road infrastructure. According to the Norwegian Shipowners' Association there is a cross-subsidising between private car users and lorries. This is because the private cars pay an unreasonably high part of road costs compared to what lorry transport pay, when the road wear is considered.

For a typical goods transport by sea from Norway to continental Europe, is the total of the harbour dues in both ends, similar to the costs for the transport itself. To a certain degree is this result of "milking", and the maintenance of an excessive infrastructure. The counties have owned the ports for the last 10 years. All cities by the coast, except from Oslo, have a desire of large ports. The costs for boats in the harbours become unnecessary high due to investments in and maintenance of e.g. large storage buildings. These buildings are not longer necessary because the transported goods now is more of a transit-type. The boats sometimes have to pay for port sections that are of mostly historical value. The counties are in other words too ambitious on behalf of themselves regarding port infrastructure, again according Norwegian Shipowners' Association (Bodø is given as one example on this).

Norwegian Shipowners' Association does not take a definite stand in the question of how harbour dues should be designed. Given an aim to develop effective intermodal transport solutions at sea, the administration of harbour dues is considered as a crucial question. This is because roll-on/roll-off ferries – the only vessel type truly designed for intermodal transport – are discriminated by the measurement system in use. Today's harbour charges are based upon the 'New international tonnage measurement system' that was approved in 1969, and gradually implemented between 1982 and 1994. This measurement system is based upon the principle that harbour dues are related to the hold volume (tonnage capacity below the deck). These rules made sense at the time they were decided in the 1960's, but ship technology has changed a lot since then. Partly as a result of the new international tonnage measurement system, cargo boats today are carrying much of their cargo in containers placed on deck (in many cases as much as 50-75 %). Harbour dues are not paid for this tonnage. In contrast to this, roll-on/roll-off ferries carry all their cargo below deck, and will therefore have to pay two or three times higher harbour dues compared to their competitors.

Public ports in large cities operate with large profit margins. The income for Oslo port for example in 1999 was 200 mill. NOK. The expenditures were only 100 mill. NOK, resulting in approx. 100 % earnings (no depreciation). If the ports instead of operating with such high profits would lower the harbour dues, then sea transport would be more competitive compared to road-based transport.

Ålesund city administration uses the harbour dues to develop the harbour, especially to build new sections of the harbour. They also get investment financing from the state, but this is little compared with the total costs. Reduce in the harbour dues trying to increase the harbour use (sea transport) could therefore be in conflict with harbour improvement (capacity and facilities). A solution could be increase financing from the state or other incomes (parking fee is an important income for some harbours).

Møre og Romsdal county consider that optimal pricing of harbour dues is important, but the informant had not competence in this issue to answer more exactly. From his point of view the most important is to develop the main volume transport mode (sea). There are none railway to Ålesund. 90 percentage of the export from the county is transported on sea and 10 percentages on road. Less than 1 percentage is transported on rail.

The Regional Coastal Administration stated that the income from harbour dues had to be used to develop the harbour. The dues are the basis for investments in the harbour infrastructure.

Marintek's main focus in this respect is to develop competitive sea transport systems. Charges are political issues beyond Marintek's field of activity.

Harbour dues may represent a substantial share of shipping costs when calling municipal harbours. As private harbours not are covered by international payment rules, cargo is shipped to private harbours to a growing extent. In addition to this, private harbours are not covered by the ILO Dock Work Convention, which set limitations on modern harbour services. All in all this makes public harbours less attractive for intermodal use.

High harbour dues for shipping companies are not being followed up with corresponding charges for lorry companies operating in the same harbours.

In Finland, the opinion by the actors is that if it is implemented correctly, the system of harbour dues might be a good system for stimulating sea transport. The market should however be allowed to function "freely". The present harbour and pilotage dues system has transferred transit transport from Finland to other Baltic countries. There is need for changes in harbour dues, but the principles of doing it must be considered very carefully. The general transport pricing principles could be used as a basis. From the shipping company's point of view the harbour dues are too high and they should be reduced as well as pilotage dues. It is important to create an explicit and transparent harbour dues system that internalises the external costs. It is also seen as an essential issue that the basis for the harbour dues is in the wholeness, not only in the single transport performance. According to the TT the harbour due system can't be utilised to strengthen direct sea-rail systems.

The Port of Kotka does not consider the harbour dues an important measure, either, since the bottleneck in sea-rail connections is not related to harbour problems. The main factor in the success of road and the mistrust in rail (or rail-sea) lays in the inefficiency on co-operation and incompatibility between the national rail organisations in trans-border rail operations. The problem should be discussed on the rail side. Harbour dues only count for a small percentage in the total logistics cost, but they are major income for the harbour. Without harbour dues no investments are possible.

The ports in Sweden (also mostly owned by municipalities), have also been increasing their charges and fees. This is a contributing factor to the situation that makes sea transports below about 100 km uninteresting from an economical point of view.

The informant at ASG stated that harbour dues could have an effect when wanting to stimulate e.g. the environmental friendly shipping companies. However the possibility to influence shipping companies that are well adjusted to intermodal transport between rail and sea transport are more uncertain. The informant pointed out that it of course could be possible to stimulate, e.g. ships that can load both lorries and trains and to solve this in a functional manner, but how it should be organised in reality is more difficult to answer.

The informant at NMA considered that harbour dues are very important. The harbour dues could be more adjusted to the market conditions. Today many of the harbours have a similarity to municipal authorities with fixed dues. If there were more competition in this sector, the harbour dues could be more adjusted to free market conditions.

ODAL regards harbour dues as very important. ODAL remarked that the municipal harbour companies are charging high harbour dues. However, the informant considered it reasonable to charge a harbour due, although lower. But how they should be changed and the financing of lower harbour dues is unclear. The fact that they are so high could depend upon, e.g. that some harbour companies are inefficient or in a monopoly position. The informant stated that at least halved harbour dues are necessary for the sea transport to be really interesting.

The important factor according to Rail Combi is that the harbour dues do not lead to advantages or disadvantages for any transport mode. It is important that the harbour dues are fair and that it is not the level of the dues that decide the choice of transport modes, but the suitability. Rail Combi also stated that a reasonable level has been found in road and rail transport and that it now is time to find that level for sea transport. Today the harbour dues are probably too high and it is questionable if the harbours in the south of Sweden should help financing ice breaking in the northern regions of Sweden.

The informant at CABS considered harbour dues as important and it is probably necessary to change the harbour dues. If the government would change the way that they tax goods, the level of harbour dues could also be changed. This change could be part of a governmental harbour strategy, which is missing in Sweden today. A strategy is important to control the flow of goods to and from the harbours and also to co-ordinate the flows from sea transport with of other transport modes.

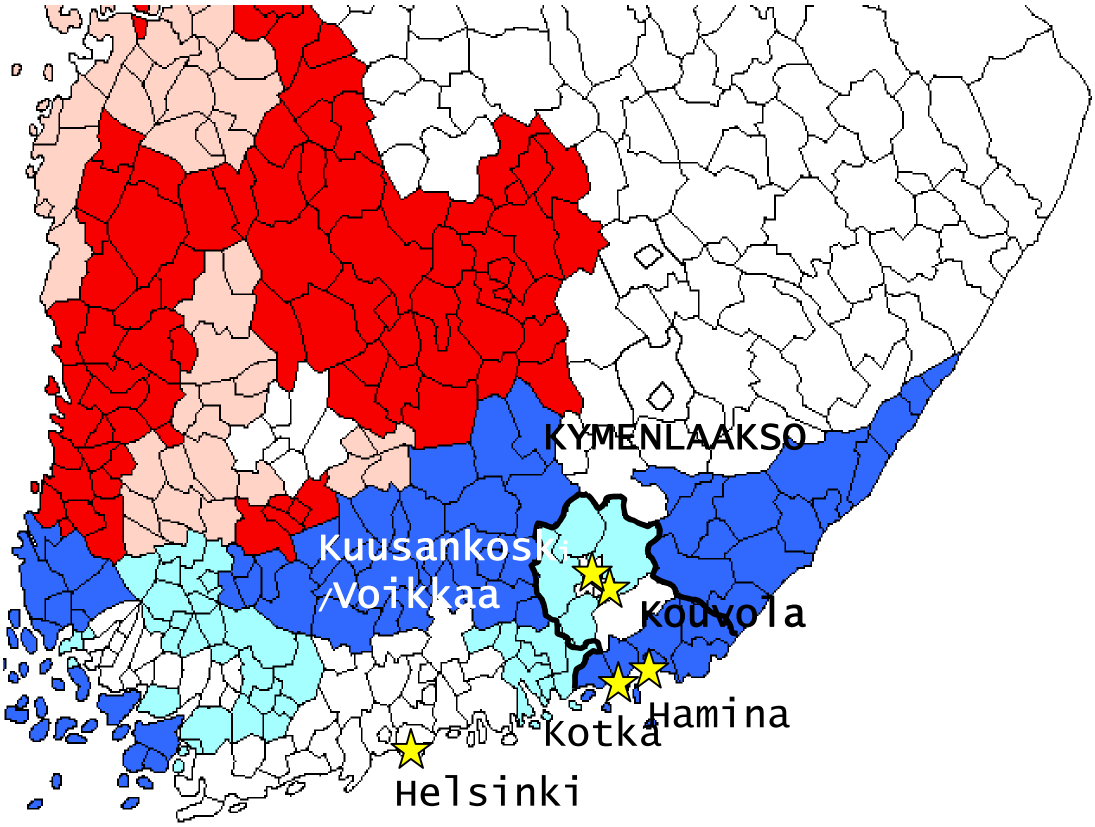
The informant at LRF considered that harbour dues could be important. A suggestion is that the government should subsidise the harbour dues so that these could be reduced. The financing could for example be taken from the governmental budget and not from the other transport modes (e.g. via different charges/fees).

Simpler documentation
Also the simplification of routines for documentation handling is necessary in order to increase intermodal transport. Today, there is extensive documentation requested in transport operations. Inter-modal transports introduce at least one extra link in the transport chain, often resulting in more documentation work. Non-compatible regulations and many different types of documentation demands can be a contributing factor to the choice of road transport door to door, in order to avoid the extra documentation work.

Waterway transport corridor improvements

In Kymenlaakso Regional Council there are many examples of planning to improve waterway transport corridors. This region includes the important export port of Kotka. EC Structural funding is directed to this region through the Objective Programme 2 Regions 2000-2006. A map indicating the location of the regions in this programme is shown in Figure 67.

Figure 67 Objective Programme 2 Regions 2000-2006



There has been much discussion concerning the Finnish inland waterways. The rent agreement of the Russian part of the Saimaa canal will expire in 2013 and now the new alternatives to continue the inland waterway transport are discussed. The main solutions for the future are:

- The reconstruction of the Saimaa canal to enable year-round operating,
- Building of new canals via Mäntyharju and the river Kymijoki and
- The abandonment of the canal transport.

All the alternatives have their supporters. The main participants in the discussion have been the authorities and the canal activists. The used arguments are related to the environmental values, the transport policy of the EC and the shortage in the cargo in the existing canal (Suomen Vesitieyhdistys, 2000).

Regional Council of Kymenlaakso's strategy for the waterborne transport has been the for the building of the Kymijoki canal. The canal would secure the transport of wood by water (from the whole of district of Lake Päijänne and from Central Finland) to the mills. There is no exact building plan yet but the general plan has been made. In the development programme it is said that in the projects of this kind (for example a canal) a readiness to plan infrastructure has to be kept up to date. A concrete project regarding the Kymijoki canal is a study on inland waterway transports and the goods transported via ports of Kotka and Hamina in year 2010. The study is based on the idea that the canal of Kymijoki has been in use for five years, and e.g. following issues are dealt with in it: what kind of transport volumes and equipment will exist in 2010, what costs, and which part of those volumes goes to the ports of Kotka and Hamina. River Kymijoki Canal wouldn't only function as a transport route for industry in Kymenlaakso and the entire Lake Päijänne basin. It would also improve the transport linkage of the region with continental Europe and the interior of Russia. Building a canal at Kimola and a lock at Voikkaa is justified now, as the transports of wood required by the vigorous wood processing industry need such transport routes, and the broad Päijänne boating area could be extended into northern Kymenlaakso (Regional Council of Kymenlaakso, 1997).

Finnish Maritime Administration has supervised and Regional Council of Southern Savo has financed a project that dealt with the development of the year-round inland navigation. The project was financed by the EC's Baltic Sea 2C Interreg -program. VTT Communities and Infrastructure carried out the research and Kvaerner Masa-Yards (Nokelainen et al. 2000) The aim of the project was to examine the functionality and the costs of the new transport system suitable for the outlined Kymijoki-Mäntyharju canal. A capacity of the outlined canal is bigger than the capacity of the existent Saimaa canal and it will be operated year-round. In the project it was also attached an alternative to operate the Saimaa canal year-round. The functionality and costs were compared to the basic system in which all the cargo is transported by road or rail to the Finnish export ports in wintertime. In the research, five transport systems were compared:

- Actual existing system,
- Feeder transport system through the outlined Kymijoki-Mäntyharju canal,
- DAS[78]-cargo vessel system through the outlined Kymijoki-Mäntyharju canal,
- Feeder transport system through the existent Saimaa canal, and
- DAS-cargo vessel system through the existent Saimaa canal.

The transport events were the annual export transports of the mills of StoraEnso in the district of Lake Saimaa. The annual tonnage was 2,5 million tonnes. As a result of the comparison, the costs of DAS-cargo vessel systems were lowest. The index number was 66 in the case of Kymijoki-Mäntyharju canal and 83 in the case of Saimaa when the costs of actual system were assigned 100. The costs of the infrastructure were not included in the comparison (Nokelainen et al. 2000).

[78] DAS=Double Acting Ship: the vessels are optimised for moving forwards in open water and backwards in heavy ice conditions.

Møre og Romsdal county administration has stated a goal of establishing daily departures for transport of goods by ship to the European continent. A route to England via Kristiansund is an additional goal.

In order to facilitate increased transport volumes by sea, it might be necessary to remove rocks, skerries, banks and shallows to improve the sea transport corridors. The largest potential project of this type in Norway is a ship tunnel through the peninsula Stadlandet.

Ålesund municipality points out that more resources are needed for development of new navigation infrastructure for the sea transport corridors. Sections of the coast today are lacking sufficient marking, resulting in high accident risk.

The Directorate for Coastal Affairs in Norway is emphasising the importance of developing a good pilot service with sufficient pilot boats if the sea transport is to increase. The Nordic pilot services have been evaluated, and the Norwegian service scored highest. Maintenance of the high level will however become increasingly important.

Inland waterway transport should be reconsidered thoroughly. It is a special challenge for Nordic climate conditions, with particular significance for Finland. At the moment, a triple transport system[79] is maintained. Nevertheless, all inland waterways are not in use during wintertime, which causes problems for other transport modes. Rail and road transport companies have to be able to provide the transports that can't be performed by water in winter. Consequently, some road and rail transport companies have excess capacity the part of year when all three modes are in use. A definition of policy should be made on the question of how much domestic transport is planned for waterways, and how much is planned for round-the-year modes.

Regarding sea transport in Sweden, there have been discussions about constructing more canals for example between the two lakes Siljan and Mälaren. However, there has been only slow progress in this work, with no construction yet.

An improvement option for sea transport in Sweden could be to take away NMA's demand for extra pilots on certain types of transport. ODAL views this demand as an unnecessary cost for ships that have been going in the same fairways for 20 years.

Ship improvements

New technological solutions can strengthen the competitiveness of the sea transport. New high-speed ships for goods transport are emerging. The AkerMaritim ”base to base-transport” from Kristiansund to the European continent with a speed of 25 knot is an example of this. One consequence of these ships is that a new marking system is required along many segments of the sea transport corridors. These ships are however much less energy efficient than slower-moving ships.

In Finland, Kværner Masa Yards has developed a new DAS tank/container vessel especially for inland waterway transport. Double Acting -principle enables the year-round transport in inland waterways.

[79] Air transport of goods isn't taken into account because of its low transport volumes

Improvements in port access

Large area of access, with good connections to the ports is necessary for increased transport of goods by sea. This is pointed out by Norwegian Shipowners' Association as one of the most necessary actions to improve inter-modality. The road systems connecting the ports with the access area can be a barrier to the increased use of the ports. The lack of good connections of roads can cause access problems to and from the boats. It is evident that the road owners are not supporting increased investing in an infrastructure favouring the use of use of ports and sea transport. Through down prioritising of the ports they are supporting their own mode of transport.

Within Ålesund municipality there are various opinions about the historical development of Ålesund harbour. There are questions about the impact of having a large port within the city. Maybe a location farther away from the centre of the city would have been a better location for an expansive port. This could have reduced the conflicts between residential areas and the port. It also could have resulted in a more efficient port, with less dispersal of the various services. The location near the centre of the city is probably not the most optimal regarding the road transport that a modern port generates.

The Directorate for Coastal Affairs points to the likelihood that if Ålesund obtains a status as a node point port or national port, this would also strengthen other surrounding municipalities. They will be more willing to use Ålesund port. This might also result in a higher priority in the surrounding municipalities for port access road improvements.

In the region of Kymenlaakso, Finland, port access improvement projects include:

- Improving the road E18 (Highway 7)
- The Highway 6, improvements from Koskenkylä to Kouvola
- Railway from Kotka/Hamina - Kouvola to the Russian border (Vainikkala), construction of transport interchanges
-

Finnra has a role in port access improvements through their responsibility for constructing an adequate road network, with prioritisation of the roads into ports. Finnra sees co-operation with other authorities as well as with private bodies in transport sector as the most important aim and measure, particularly for terminal projects that are mostly co-financed.

Several counties in Sweden also mention the importance of developing the infrastructure around the ports. For this purpose they want funds from the government. Financing of port investments is today a matter for the local interested parties and the municipality. However, the ports can be important for the whole region and so should accordingly be treated as a regional matter (i.e. the counties want to be able to use regional financing of the ports).

9.4.5. Port operations

The ports and the terminal operators in the ports are important actors regarding transfer of goods transport from road to sea. In order for the sea transport to be an attractive alternative, the ports and the port operations must be organised well to be able serve its functions. The terminal operators (goods handlers/exporters) have influence on the choice of transport mode.

The port operators are often private firms renting infrastructure from the port owners, and their income is from the goods forwarding. They have an interest in making the transport costs high, as this will increase their income. This might lead the terminal operators to support sending the goods by road instead of using cheaper sea transport. However, in many cases lorry transport might be cheaper, and then one would expect that sea transport is the preferred mode choice among the port operators. At least this appears to be the case in Norway. In Finland, the port operators in export ports handle the rail and road cargo basically in the same way. It appears that in Finland the port operators actually prefer road transport to rail or sea transport.

9.4.6. Increasing frequency of departs

More frequent boat departs are important for the increased use of this transport mode Frequent departs and good regularity is viewed as necessary conditions for the transfer to sea transport.

Sea-based transport systems cannot compete with road transport in Norway for small volumes of goods. The small volumes result in low frequency of departs. Daily departures are necessary in order to compete with road transport. Marintek currently investigates how pooling of industrial goods can give better conditions for increasing the frequency.

The shipping companies are currently establishing sea-bases for goods transport along the coast of Norway. Currently approx. 100 lorries operate between the bases ("across the fjords"). From Stavanger the lorry routes today often go to Eastern Norway and north through the Gudbrandsdalen valley. Marintek is collaborating with Statoil and Hydro in assessing the possibilities of improving the whole base-to-base transport system. It is well documented that a sea-based system with daily departures from Stavanger in the south to Kristiansund in the north will compete well with road-based systems both regarding price and time. Marintek has co-ordinated the shipping companies and the heavy industry (Hydro Agri/Aluminium, Elkem and Norske Skog) in order to increase the volumes of goods for this transport. Fish transport could theoretically also be included in this system.

9.4.7. Adjusting delivery volumes to suit ship sizes

Sea transport is, as previously pointed out, a transport form which requires relatively large volumes of goods per carrying unit. Both the Møre og Romsdal county administration, directorate of coastal affairs, and the Ålesund municipality therefore has a strategy to facilitate larger volumes of goods through intermodal transport.

This however requires co-ordinated development of port- and road infrastructure. Many of the informants in Norway commented that the ports with node point status should have a large area of access, with good connections to the main road system. Specifically the road and ferry- connections with Ålesund needs improvement and bottlenecks in the main road systems need to be removed.

9.4.8. Cooperation between actors in sea transport

The different actors in sea transport are not well co-ordinated. Some of the actors important for this transport mode in Norway are:

- Directorate of Coastal Affairs, with its regional departments. This directorate sorts under the Ministry of Fisheries and is responsible for the infrastructure for sea transport.
- Port authorities have the responsibility of port operations and is formally organised as a part of the municipal administration, but administer their own funds (income in the form of port dues) according to directions given by the national authorities.
- Directorate of Maritime Affairs sorts under Ministry of Trade and Industry and is responsible for health, environment and safety in sea transport.
- The municipal administration has the responsibility for area planning, but only within the frames of the Ministry of Environment.

In order for Ålesund harbour to obtain the status of a node point, it will be necessary to establish a well-functioning cooperation between the municipal administration, transport companies and shipping companies. Ålesund municipality has as a strategy to develop the foundations for a close cooperation between goods- and port actors and shippers. The Directorate for Coastal Affairs has co-operated with each actor in this harbour for many years, but the internal cooperation between the different sectors of the port has been weak. This is true both for public, private and semi-private actors (owners of private sections of the port, shippers and transport companies). Instead of loading all the goods in one location at the port, the ships now often have to load from up to three different locations at the Ålesund port. In other words, an efficient common terminal operation is missing. The background for this situation is partly of competitive origin, weak cooperation over long time, and a piece-by-piece expansion of the harbour. A new collaborative unit is formed by the municipality: "Ålesund Port- and Transportforum". This is done in order to obtain a common co-ordination between the various actors in the port.

The strategy for the Directorate of Coastal Affairs in Norway is to strengthen its planning division to be able to participate more actively in the municipalities' area planning. The strategy also includes strengthening the more superior area planning, on county, regional and national level. A reorganisation process within the Directorate aims at specialising the various regional divisions. Both actions aims at improving the co-ordination with the other national and regional actors in the transport sector.

Another example where the co-operation between actors are important is in connection with ship design. Improvements in this field can only be facilitated through a close co-operation between the ship designers and the Directorate for Coastal Affairs. It is in particular regarding the knowledge of the sea transport corridors that close collaboration between ship designers and the Directorate for Coastal Affairs is important.

Collaboration between shippers and shipowner's associations has an improvement potential. Ålesund city administration points out that there only has been limited co-operation between the Directorate for Coastal Affairs, County administration, shippers and shipowner's associations. For Ålesund city administration it is a relevant field of work to take part in co-operation to achieve increased mode change from road to sea. Møre og Romsdal county administration is a candidate for leading this work, but the informant is of the opinion that the regional section of the National Road Administration would be more suitable. They are one of the most important actor in land-based transport and could fulfil such a role if they really want to stimulate a transferral of goods transport from road to sea.

Conflicts of interests might exist between a municipality that obtains the status of having a national harbour and the functions the port is intended to have. One possible model could be a separation between the responsibility for structure and the operations.

The competition between the two large ports Ålesund and Kristiansund in county Møre og Romsdal might be a problem regarding the selection of status as a national port. The county administration has to prioritise between the two ports, which could be problematic for historical reasons.

In Finland the necessity of co-operation between the following authorities from different transport sectors were identified:
- Finnish Rail Administration (RHK)
- Finnish Maritime Administration
- Ports
- Regional Councils
- CAA Finland (The Finnish Aviation Authority, Ilmailulaitos)
- Ministry of Transport and Communication

Without the co-operation of the various authorities it is not able to gain any improvements towards desired mode change. At a ministry level it is possible to affect aims and strategies. The policy on intermodal transport and transferring the transport of goods from road to rail and sea should according to the Finnish actors be determined at a national level.

9.4.9. Information on sea transport

From the point of view of Ålesund municipality, more information and marketing of sea transport is necessary. This includes more and better information on the various forms of sea transport along the Norwegian coast and to the European continent. The advantages of sea transport are not well known among the public.

Norwegian Shipowners' Association has as one of their tasks to make information on sea transport available to the general public. The environmental aspects of this transport mode are included in this work.

10. Conclusions

The main object of this project is to develop and implement pilot actions, strategies and measures for improved energy efficiency in transport of goods.

The analysis of transport means, transport volumes, load factors and energy use in transport of goods in the 3 Nordic countries has shown that the volumes (in tonnekm) and the energy use have increased rapidly for road transport of goods in all the 3 countries, while sea transport are reduced and rail transport been relatively stable. In terms of road transport of goods the increase appears to have been largest in Norway with a more than doubling of transport volume and four-fold increase in energy use since 1970.

The analysis has shown that Finland approximately has doubled its energy-use for road transport of goods and Sweden also has experienced an increase, although slightly lower than Finland. The prognosis for future road transport of goods calls for a continuation of the strong increase in all the 3 Nordic countries.

The analysis shows that road transport of goods is more energy efficient in Finland and Sweden compared to Norway. The main reason for this difference is probably the more rugged topography in Norway, and the fact that larger lorries are used in Sweden and Finland than in Norway.

The water-transport of goods in Finland experienced a strong loss in energy efficiency between 1970 and the 1990s. In Norway, the energy efficiency of water-transport of good has remained constant at a much higher level then in Finland.

Finland has experienced a continuous increase in energy-efficiency on rail transport between 1970 and the 1990s. Norway and Sweden has not experienced this, and in the case of Norway it appears that the energy use per tonnekm actually has increased the last decade.
The literature survey of energy saving in transport of goods that has been carried out in Phase 1 of the project has identified a wide range of potential actions and measures that are being used as a foundation for designing actual pilot actions in the case companies. The possible energy saving effect of improved logistics has been identified as being very important in this regard.

Case companies in each of the three countries have participated in the project. In Norway the results from the pilot actions indicated that fish transport from western Norway to the continent has an average energy use for down-trip and return trip of about 0,22 kWh per tonnekm. The return trips give lower energy efficiency. This is caused by low load factor. If the load capacity had been fully utilised on return trips, the energy efficiency could be improved to about 0,18 kWh per tonnekm.

Different driving style could have a great influence on fuel use and thereby energy efficiency. Our cases show that non-economic driving could increase fuel consumption with 25 percent. The energy saving potential in today’s lorry transport is greatest in mountain and hilly areas.

Two pilot actions to increase energy efficiency have been carried out:

- actions to reduce energy consumption and to increase the load factor in today's lorry transport
- actions to achieve a transferral of goods from lorries to more energy effective rail- and ship transport.

The result shows that it is possible to reach 5 % reduction in the energy use in the lorry transport at company level. Actions containing information and motivations measures among the drivers is carried out: energy saving course for all drivers, examinations and motivation and competence developing processes. The work has been obligatory for all drivers. An important element is to organise the drivers into groups and set fuel reduction aims for the group and not individually. This gives a constructive competition between the groups to reduce fuel consumption, and focus on teamwork.

For the whole fish export from Norway transported on lorry a 5 % reduction in fuel consumption would give an energy saving effect of about 12.000 tonne fuel or about 115 mill kWh a year. This assumes that our four fish cases to be representative for Norwegian fish export.

Generally commercial companies need an economical motivation to reduce the energy use more than to a level required by public laws and regulations. Such motivation could be from an increase in income or reduction in costs. Reduction in energy use could also be a strategy for developing other competitive advantages (e.g. positive image) to keep their position in the market without particular possibilities to increase income or to reduce costs.

More specifics conditions for reduction of fuel consumption in today's lorry transport:

- actions and strategies has to be suitable with other main processes going on in the company
- the hard competition in the transport sector makes it difficult to spend much time on developing processes as information and motivation of drivers
- the increasing demand for "just in time" deliveries makes it difficult to use the most energy efficient driving style.

During the project period transferral from road to rail and ferry were done for two of the four case routes. Rail based transport with dried cod to Italy reach a reduction in energy use at 60 % compared with lorry based transport. The effect comes from the more energy efficiency train transport used on the whole distance from Western Norway to Verona in Italy. The transport is similar in time efficiency (5% difference) to the lorry-based transport in 1999.

The other implemented action frozen fish to Boulogne SM in France, is based on ferry and train transport. Here the reduction in energy use is "only" about 20 percentage, caused by the train from Åndalsnes to Oslo. The energy saving effect is limited due to the long ferry distance Oslo-Rotterdam. Ferry is less energy efficient than lorry transport.

The other potential transferable alternatives give lager reduction in energy use. Transferrals of goods from road to rail transport in three cases (from western Norway to Poznan, Bremerhaven and Boulogne-sur-Mer) gives an average reduction in energy use at about 70 %. This calculation assumes bridge across the Fehmarn Belt (Rödby- Puttgarden).

For the boat alternative the reduction is at the same level for the transport to Bremerhaven and BSM, when the boat transport to Italy use nearly as much energy as the lorry transport due to the long sea distance. It is important to state that these calculations are based on the assumption of using big boats today used overseas between Europe and America and Europe and Asia.

If all the fish export from Norway to the European continent where transported by train the total reduction in energy use could be about 70.000 ton fuel or nearly 700 mill kWh. This calculation is based on the assumption that our four cases give a representative picture of transport distance and transport mode in the today's fish export.

Specific necessary conditions for transferral of goods to rail in the case company Waagan Transport was the possibilities for reducing costs for wages. Another motivation was to develop a more flexible transport system with road, rail and sea. Rail transport makes it also possible to improve the public acceptance. Positive environmental image might bring new customers to the company.

Another necessary condition is investment in new trailers with the huckepack system adaptable for different transport modes. In autumn 2000 fresh salmon was difficult to include in this system due to non-optimised logistic chain. When the punctuality is improved WT is going to include fresh fish in these intermodal transport chain.

Also Norwegian Railways (NSB) and The Norwegian National Rail Administration have done preparations to established a transferral to train transport by enlarging tunnels and investment in intermodal rail equipment. There is a potential conflict between Cargo trains and public trains in the future. With steady faster public trains there would bee a need for passing lines for trains in same direction.

In year 2000 Waagan Transport was the only transport company using the Åndalsnes-Oslo line for fish transport. When the intermodal transport co-operation between WT and NSB Cargo was published in august 2000, NSB got many inquiries from other transport companies. In 2001 therefore two new large transport companies are going to transfer goods from road to rail using this line. Our case company has apparently started a process among the transport companies resulting a substantial reduce in energy use in transport of goods. In NSB Cargo this process is mentioned as "the Waagan effect".

In Finland the energy use in the case transport chain, from Voikkaa paper mill to the customer in Cologne, Germany is analysed. The energy use is calculated for transporting 8 800 tonnes paper. The amount of raw materials is estimated from their yearly volumes in proportion to yearly production of paper. The energy use includes loading, unloading and other handling of goods except for the possible handling in Germany, which differs from the handling in Finland. The total energy use of the transport chain amounts to 2 971 MWh, which is 0,34 MWh per paper tonne. From the energy efficiency, kWh/tonne-km, it is evident that the train transport in Germany is more energy efficient than the train transport in Finland. This is probably due to the fact that transport distances in this case are shorter in Finland than selected distance in Germany, and that the share of electric locomotives is larger in Germany than in Finland.

According to the calculations in Finland, the most important energy saving actions are:

- Further utilization of return loads
- The use of electric locomotives instead of diesel ones in rail transport

- Transport of large volumes in long distances by rail

Utilization of return loads is an important energy saving action. When looking for further potential for them, all material flows coming to the mill must be taken into account. Owing to nature of timber transport, it is almost impossible to imagine any return loads for them. However, for other raw materials and materials that are used, for example for production of energy at the mill, potential return loads can be identified.

Electric trains are less energy demanding than diesel trains. However, the use of diesel locomotives cannot always be avoided in Finland. Rail transport is essentially more energy efficient than road transport when the volumes are large and the transport distance are long. Advantages of rail transport are smaller when small lots are transported short distances. Nevertheless, the paper mill of Voikkaa produces paper in such amounts in one day in average that train can economically transport it. In Voikkaa's case, there are two ports in almost the same distance from the mill. At the moment, separate trains are going to each port. There could be a possibility to combine trains when the volumes are not energy-economically sufficient.

Due to the geographical location of Finland, the share of sea transport is already large in export chain. Thus, the waterborne transport cannot be increased more since the use of inland waterways is limited during winter. Consequently, a more likely mode change is from road transport to rail transport. However, the transport by lorry cannot always be seen as a most energy-consuming alternative. In train transport the energy use of handlings (e.g. shunting) is often considerable.

The effect of the speed of the ship on the energy use is the most significant factor when the sea transport is in question. Owing to the large share of the sea transport in the chain, the small reductions in fuel consumption can generate remarkable savings when considering the whole chain.

The export chain of the paper is a complex transport chain where responsibility is shared for many partners. The optimisation of selected phases of the chain must be done with care; increase in energy use in one phase can decrease it in another and vice versa. In addition to energy use, other effects of energy saving actions on transport chain must be taken into account. Costs of different transport chains can't be excluded when the chains are compared to each other. Investments needed for changes have to be taken into consideration, too.

In addition, the communication has an important role in efficient transport chain. The great amount of partners and subcontractors create high requirements for data, information and knowledge transfer in the chain. However, the various information systems cause problems and difficulties that have to be solved.

The study of energy use in the Swedish case company ODAL provided an overall idea of the approximate amount of energy used in different parts of the transport chain. The transport chain has been divided into the steps “farmer-to-silo”, ”silo-to-silo”, “to export”, and, in the special case, also “from export harbour to import harbour”. The figures in different parts of the chain are partly uncertain and can differ up to 20% or more, especially since the transport volumes differ considerably between years and regions in ODAL. However, the data could be used to show, which the areas of main energy use are, and the potential for energy-saving activities. The important factors in energy saving, such as the choice of transport mode and distance between producer and consumer, etc., are also highlighted via the study of energy use and pilot actions.

It can be noted that about 1/3 more energy is used in the "silo-to-silo" step (11,3 GWh/year) compared with the "farmer-to-silo step" (7,41 GWh/year). The distance is also longer in the "silo-to-silo" step. The average energy efficiency in "silo-to-silo" is however larger, about 0,15 kWh/tonnekm, compared to 0,67 kWh/tonnekm for "farmer to silo". The "farmer-to-silo" step includes more use of tractors, which are also assumed to have a lower load factor than lorries. About 65% of the grain in ODAL is exported and the energy use for transport to export harbours in Sweden is about 12,2 GWh/year.

The special case study called "Söderköping" illustrates the great effect of a short transport distance and high-energy efficiency of the transport mode. The special case has more than 50% higher energy use per delivery (about 136 kWh compared to 84) compared to the average for the general farmer-to-silo transport case. The main explanation for this is the more frequent use of tractors as the transport mode and a longer average distance to the silo (about 18,9 km compared to 11,4 km). The average energy efficiency in the special case is about 0,77 kWh/tonnekm.

A majority of the informants interviewed in Phase 3 of the project consider land-use planning as an important issue for increased mode change from road to sea and rail and improved direct sea-rail connections. Many of the actors also take an active part in this activity. Some of the private companies like ASG and ODAL in Sweden mainly focus on optimising their business activity based on the present conditions, although they sometimes point out planning problems for decision-makers. The involvement of actors in the land-use planning process is considered important by most of the informants. For the shipping company, for example, it is relevant to participate in land-use planning related to e.g. new ports and enlargement of the old ones. It is considered important to involve other organisations, institutions and actors than those usually participating today, in order to achieve increased mode change from road to sea and rail. Particularly, it is important to get to whole transport chain represented, from consignor to consignee. Planning is important e.g. to co-ordinate the infrastructure between different transport modes. The opportunity to make comments to the municipal area plans appears however to be an under-utilised possibility in Møre og Romsdal county administration. Another potential action, which was pointed out as important, is affecting the counties of administrative boards to improve the co-ordination of the infrastructure, regional development, planning of investments in roads, railways and sea transport.

Harbour dues are regarded as very important by many of the informants. The dues are considered to be too high and a request is a lower due and a harbour due that is more adjusted to free market competition. In addition, it is seen as important to create an explicit and transparent harbour dues system that internalises the external costs. It is also found as an important issue that the basis for the harbour dues is in the wholeness, not only in single transport performance.

It is considered by most actors that good co-ordination between various public and private bodies in the transport sector is important to achieve increased mode change from road to sea and rail and improved direct sea-rail connections. Today the co-ordination has improvement potentials. E.g. are the many actors in sea transport often a source for confusion of responsibilities. A majority of the actors also consider co-ordination between the actors and co-ordination in the whole transport chain as important. Better co-ordination between SNRA and the Swedish National Rail Administration and the Swedish State Railways is mentioned. As lead co-ordination organisation in Sweden is SIKA and the Swedish National Rail Administration suggested. More use of Internet technology is pointed out as a tool for better co-ordination in the whole transport chain. Other examples of how the co-operation in the transport chain this could be done is through creating incentives for discussions and meeting possibilities (e.g. seminars). The co-ordination and co-operation are seen as an important measure particularly within the public bodies, focusing on the co-ordination at the system level. In private sector the co-operation can be more problematic, because of the competitive situation between different actors.

Many of the informants consider Eco-labelling as important but many also point out that it is important that the Eco-label is fair between the transport modes. The significance of environmentally sound logistic chain is increasing. More actors could demand transports or label their own transports with the eco-labels based on cradle-to-grave assessments as a part of their environmental work. The actors can point out their environmental work to the customers before they discuss the price so that this is included in the customer’s decision. Of the many informants that consider eco-labelling as important, many also point out that it is important that the eco-label is fair between the transport modes. It could also be an advantage if the eco-label system is internationally harmonised, that is that the guidelines are equal for neighbouring countries. A system for Eco-labelling is considered an important measure in general, but the measures to develop and affect that kind of systems are seen as difficult. Eco-labelling of transport is also a way that the consumers' opinion can affect the choice of the mode of transport.

Particularly the governmental associated actors consider national transport planning important. The issue of national political guidelines however also raises more contradictory opinions. On the one hand, they are seen as important, but on the other hand, the effect of market factors shouldn't be restricted. Most of the informants also consider national political guidelines important. The national transport plans are however not well enough realised through active prioritisation of public measures and actions. The Swedish goods transport delegation is in the process of developing a national transport strategy which includes all transport modes, analyse issues regarding development for combined railway transport and come with suggestions to make the transport system more efficient and ecologically sustainable. Suggestions will also be carried out how the government and other authorities role can be improved and clarified. There appears however to be a lack of policies and strategies at a national level to facilitate goods transfer from road to rail and sea. There are few public measures for road to rail transfer, while there are many public measures for road to sea transfer. In Sweden, a governmental strategy for the establishment of superior reloading stations between sea and rail transport, is required.

Many of the interviewed informants have not been in contact with the Interreg III A, B and C programmes or other EC funds. However, many of the informants think that the programmes and funds could be efficient for realising new ideas and financing expensive projects and transport infrastructure. New EC structural fund-program documents for the period 2000-2006 is presented shortly and could be important for the transport mode changes from road to rail and sea. It will be important that researchers and actors in Norway, Finland and Sweden and take part in implementing and evaluating the use of these funds. The bureaucracy and the proposal procedures connected to the use of these funds has however a potential for simplification. A possible way to benefit the building of more infrastructures and minimise bureaucracy is if more of the responsibility for the payments etc. is moved to local instances.

If EU could disburse their money via a regional plan or via national plans, this would be favourable for the regional infrastructure. Today there is a possibility to use EU’s funds for part financing of infrastructure that is involved in the county plans. In Finland the regional council of Kymenlaakso is the co-ordinator of Interreg programmes (as well as other regional councils), and finds them as a good measure to promote increased mode change from road to rail and sea. EC-funds are regarded as an important instrument but only if the focus of the funded projects is right.

Harmonisation of standards and regulations are regarded important by a majority of the informants. Examples of areas that should be harmonised are load carriers and profiles, taxation in the transport sector, width of railway tracks, safety and environmental regulations. A general comment is also that it would be an advantage to have an international harmonisation. Many of the informants, e.g. Rail Combi, points to EU’s role in diminishing the risk for loosing goods, by reducing differences between countries and thereby the stops when transporting goods through Europe. EU could enjoin the members to reduce the differences in transport systems (width of track, electricity system, harmonise load profiles, bureaucracy and rules etc) and make it possible to go by the same transport mode (e.g. the same train) throughout the whole Europe.

The counties might receive a possibility to finance ports. The counties might also receive a larger budget to make more investments in the rail and sea sector. It is also a possibility that the plan can help the deployment of some large terminals in Sweden from which the transports can be better organised and also get the train operation to function better.

Another potential action, which was pointed out as important, is to affect the National Maritime Administration to improve the infrastructure of the sea transport and the infrastructure of the land transport. The National Maritime Administration should also better facilitate the prerequisites for planning between different transport modes. What the National Maritime Administration also can affect, being a governmental authority, is the transport policy rules, e.g. the fees for infrastructure.

More information to the customers is important. Rail Combi e.g. has on their web-site a possibility for the customers to calculate the effect on the environment with different transport modes. NSB has a similar database for Norway. The potential customers can free of charge decide their environmental profile.

A general impression after interviewing the informants is that there is an interest to participate in co-ordination, planning etc. and to influence decision-makers but it is also often considered to expensive and time-consuming to do so. It also seems that many of the informants are anxious that the rail and sea transport could obtain an efficiency and cost situation so that sea and rail transport could compete with road transport on their on qualifications. The bureaucracy could also be reduced generally in the transport sector.

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Appendix 1: INTERVIEW GUIDE Phase 3- the first interview

Background
This is a guide for carrying out Step 1 in Phase 3 of the project "Energy saving in transport of goods – a pilot project in rural natural resource based industries" In this phase informants will be used to obtain information on possible regional measures and actions in policies. The informants and their institutions should be related to the individual cases in the three countries.

Phase 3 consists four steps:

Step 1
The proposed guide is for this step, which is the first interview round. After carrying out the interviews, each of the three partners makes a short written report summarising the findings.

Step 2
To develop proposals on measures and actions. This will be in the form of making a written document, which will be a collective task co-ordinated by WNRI. The proposals will cover all the 3 cases, focusing on common issues among them.

Step 3
The second interview with the same informants. A new separate interview guide will be made for this. The goal of this step is to obtain responses to the proposals. All three partners will write a report from this step.

Step 4
Produce the final recommendations based on the proposals from us and the responses from the informants obtained through the interviews. This constitutes the final task of phase 3, and is a gain a collective task co-ordinated by WNRI.

Purpose of this interview round
The main purpose of the interviews is to acquire knowledge of policy measures important for energy efficiency in the transport of goods. This applies both to public and other policy measures which may contribute to: 1) The transfer of goods from road to sea and rail, and 2) increased use of intermodal transport. The interviews should also identify literature and key written documents on these subjects.

Method
We plan to use a direct approach during the interviews. This implies that the informants will know the purpose of the interview before it starts. This interview guide will aid the interview process so that all subjects will be covered in the course of the interview. As the main purpose of the interview is to acquire knowledge from the informant, follow-up questions for further clarification should be used where appropriate. It is not necessary to follow this interview guide strictly, but it is important to cover all the main subjects (the superior questions in bold

type). The informants should receive the questions in advance, and the interview should be carried out according to the main structure shown in the interview guide.

Interview appointment
After identifying possible informants, interview appointments are made by telephone. Time and form of the interview is then agreed upon. In addition, there will be a short briefing on the project, the purpose, and problem issues, as well as making an agreement with the informants that the interviews can be recorded on tape. It is important at this stage to let the informant know that he/she will be given a tape printout, and that the tapes will be destroyed when the project has been concluded.

As the information sought is not sensitive, there should not be a need for raising the question of anonymity in connection with the interview appointment. If the informant however raises the question and wants anonymity, an agreement can be made where the informant can demand anonymity after reading the tape printout from the interview.

How the interview is to be carried out
The informant should be given the main questions (in bold type) from the interview guide on e-mail, and the answers should be returned in the same way. Then a formal interview has to be conducted either by telephone or physical meeting. The idea behind this is to obtain the type of information that only emerges orally. The interview is used to discuss the written answers and ask follow-up questions based on the interview guide.

There should not be any pressure on the informant to give written answers first. If the informant for various reasons does not wish to give written answers, we will proceed by making an arrangement for oral interview where the main questions will be asked first, and then raising the follow-up questions if needed. It is important to create a relaxed atmosphere around the interviews.

Introduction
At the stage of the actual interview, it is important that the interviewer makes an introduction to clarify the framework for the interview:

- Refer to the interview appointment, and find out whether the informant has been given the chance to read the questions. This only applies if no written answers are available!
- Repeat the purpose of the study
- Clarify if there is no objection to using a tape/cassette recorder. Tell the informant that a tape printout of the interview will be sent for approval, and that the tape will be deleted when the project is terminated.

Subjects and questions

1. On the informant

1.1. What is your full name?

1.2. What is your position?

1.3 Which section of your company / institution are you working in?

2. Opening: What could have been done?

2.1. What could have been done to transfer more goods transport from road to rail and sea?

2.2. What could have been done to increase the use of intermodal transport combining road, sea or rail?

2.3. What could have been done to improve the infrastructure for such transport?

3. The field of knowledge

3.1. Do you know what other institutions and businesses are important in terms of policy measures for transferring goods from road to sea/rail?

3.2. Do you know any central persons in such institutions or businesses?

3.3. What publications found in your institution and elsewhere are central on this subject?

4. Aims

4.1. What aims for transferring goods transport from road transport to sea and rail transport can be found in your institution?

4.1.1. What aims for intermodal transport combining road, sea or rail are found?

4.1.2. What aims for infrastructure supporting such transport are found?

5. Strategies

5.1. What strategies for transferring goods transport from road transport to sea and rail transport can be found in your institution?

5.1.1.What strategies for intermodal transport combining road, sea or rail are found?

5.1.2. What strategies for infrastructure supporting such transport are found?

6. Measures

6.1. What policy measures for transferring goods from road to sea and rail can be found in your institution?

6.1.1. What policy measures for increased use of intermodal transport combining road, sea and rail are found in your institution?

6.1.2. What policy measures for improving the infrastructure for such transport are found?

6.2. Are there other central policy measures that apply to other institutions on these subjects?

6.2.1. For transferring goods transport from road to sea and rail?

6.2.2. For increased use of intermodal transport combining road, sea and rail?

6.2.3. For improving the infrastructure for such transport?

7. Actions and initiatives

7.1. What is done for transferring goods transport from road to sea and rail in your institution, and what results can be seen from this work?

7.1.1. What is done to increase the use of intermodal transport combining road, sea or rail in your institution, and what results can be seen from this work?

7.1.2. What is done to improve the infrastructure for such transport, and what results can be seen from this work?

7.2. What problems have occurred in the work with transferring goods from road to sea and rail?

7.2.1. What problems have occurred when trying to increase the use of intermodal transport combining road, sea or rail?

7.2.2 What problems have occurred when trying to improve the infrastructure for such transport?

8. Advantages and disadvantages for businesses and the society

8.1.What advantages and disadvantages will businesses have from increased use of sea and rail transport?

8.1.1. What advantages and disadvantages can you see that the fishing / grain / paper industries will have by increased use of sea and/or rail transport?

8.2. What advantages and disadvantages can you see that the society will have by increased use of sea and/or rail transport?

Appendix 2: INTERVIEW GUIDE Phase 3- the second interview

Background
This is a guide for carrying out Step VII and VIII in Phase 3 of the project ”Energy saving in transport of goods – a pilot project in rural natural resource based industries” according to the structure:

I. Preliminary identification of the actors (All 3 partners). This included an exchange of the results obtained.
II. Preparation of guide for first interview round (WNRI)
III. Identification of key informants in each actor (All 3 partners)
IV. Send out the questions for the first interview round to the informants (All 3 partners)
V. Carry out first round of interviews by phone and e-mail (All 3 partners)
VI. Preparation of guide for second interview round (WNRI)
VII. Send out the questions for the second interview round to the informants (All 3 partners)
VIII. Carry out second round of interviews (All 3 partners)
IX. Summing up the results (All 3 partners)
X. Write final report from Phase 3 (WNRI)

Method for this interview round
The interviews should be <u>simple</u> and <u>focused</u>. We use the same method as in the first interview:

- The informants will know the purpose of the interview before it starts
- It is not necessary to follow this interview guide strictly, but it is important to cover all the main subjects (the superior questions in bold type). All the informants should receive the same questions, and the interview should be carried out according to the main structure in the guide. If some of the questions are not relevant for some of the informants, this can be indicated by answering “n.a.” (not applicable).

It is important to distinguish between measures actors may *decide* and measures actors only may *influence,* directly or indirectly. It is also important to distinguish between actors own decisions and decisions made by other actors. There are 5 different categories of ways by which actors can interact with measures/policies:

1) Actors may <u>decide</u> directly through own decisions
2) Actors may influence <u>directly</u> through own decisions
3) Actors may influence <u>indirectly</u> through own decisions
4) Actors may act/influence/recommend other actors, public bodies, businesses etc.
5) Actors may act/influence/recommend government bodies at higher levels (e.g. EC)

For category 1 and 2 the actors are part of the structure where the means/policy is formed/implemented. For category 3,4 and 5 actors are in the position to influence the forming/implementation of measures/policies. Before the interview you may use time to think trough this related to your interview object. During the interview you must have this structure in mind, and give follow up questions to be able to structure the answers into this kind of understanding.

How the interview is to be carried out
The informant should be given the main questions (in bold type) from the interview guide on e-mail, and the answers should be returned in the same way. Alternatively can a combination of telephone and e-mail, or only by telephone, be used. There should not be any pressure on the informant to give written answers first. If the informant for various reasons does not wish to give written answers, one can make an arrangement for oral interview. It is important to create a relaxed atmosphere around the interviews.

Only short answers are expected for “why/why not” or “how/what” questions.

Interview appointment
Interview appointments are made by telephone. You have to repeat, in a short briefing, the purpose of the project and problem issues. If you want to recorded the interviews you have to make an agreement with the informants at this time. It is important at this stage to let the informant know that he/she will be given a tape printout, and that the tapes will be destroyed when the project has been concluded.

Questions to be answered:

A . Regional/local level

1. Do you consider land-use planning to be important in order to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
1.1. If not, why?
1.2. Is it of interest to your organisation to take part in such work?
1.3. How can you take part in this?

2. Do you consider it important to involve organisations, institutions and actors other than those usually participating today, to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
2.1. If not, why?
2.2. Can you identify relevant actors?

3. Do you consider it important to utilise the system of harbour dues to stimulate sea transport and to strengthen direct sea-rail connections?
3.1. If not, why?
3.2. Is it necessary to change the harbour dues to obtain this?
3.3. What type of changes would this be?

4. Is it important with better co-ordination between the actors in the transport sector to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
4.1. If not, why?
4.2. Is it of interest to your organisation to take part in such co-ordination?
4.3. Which institution do you think could have the lead co-ordinating role?

5. Is it important with co-ordinating efforts along the whole transport chains (supply chain management) to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
5.1. If not, why?
5.2. Is it of interest to your organisation to take part in such work?

B . National/international level

6. Do you consider it important to have a system for Eco-labelling of transport as a mean to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
6.1. If not, why?
6.2. Is it a relevant activity of your institution to take part in developing such a system?
6.3. How can you take part in this?

7. Is national transport planning important to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
7.1. If not, why.
7.2. Is it a relevant activity of your institution to influence national transport planning in this direction?
7.3. How can your institution influence this aspect of national transport planning?

8. Do you think national political guidelines are important for co-ordinated land-use and transport planning, as means to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
8.1. If not, why?
8.2. Is it a relevant activity of your institution to influence the national political guidelines?

9. Do you consider the EC Interreg III A, B and C programmes to be important measures to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
9.1. If not, why?
9.2. Is it relevant for your institution to participate in developing and implementing these programmes further?
9.3. Are there other measures and types of funding that you consider important in this regard?

10. Do you think EC funds are important instruments to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
10.1 . If not, why?
10.2 . Is your institution in a position to influence the EC funding in this direction?

11. Do you consider it important to harmonise standards and regulations as a mean to achieve increased mode change from road to sea and rail and improved direct sea-rail connections?
11.1. If not, why?
11.2. Is it a relevant activity for your institution to participate in developing such standards?

12. Can you think of other issues and measures of importance in achieving increased mode change from road to sea and rail and improved direct sea-rail connections?