*COMPASS*
# *The COMPetitiveness of EuropeAn Short-sea freight Shipping compared with road and rail transport*

## FINAL REPORT

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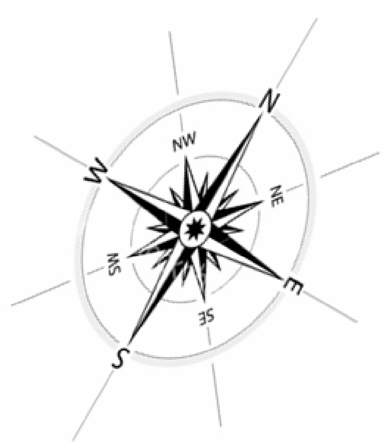


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# Table of contents

# Figures

# Tables

# Preface

In this project TML and NECL analysed the market position of Short Sea Shipping (SSS) and assessed both quantitatively and qualitatively the impact on its competitiveness for various future scenarios. This will enable policy makers to mitigate adverse effects with additional measures, backed with scientific analysis.

In this final report we describe the results of the data collection and analysis, the development and the results of the model used for the assessment of different policy scenarios for short sea shipping and the development and the results of a model focussing on intercontinental shipping.

# Acknowledgement

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# Summary

Maritime transport in Europe has always been a reliable way of moving goods and passenger at a low cost from one place to another. In the current context, all transport modes, including maritime, are called upon by legislators to improve their efficiency and reduce the amount of pollutants emitted into the environment. Road transport has been subject to increasingly stringent emissions standards since the early nineties, while emission standards for maritime transport are/were less stringent.

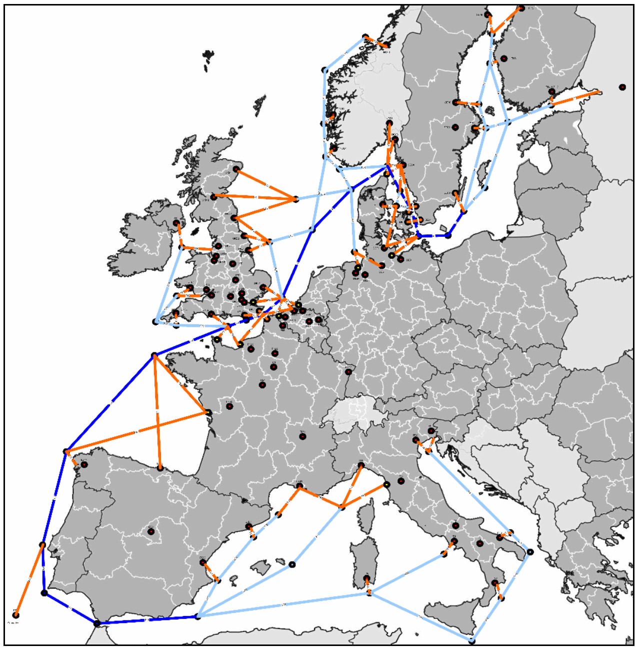
This study had three main objectives:

1. For a selected group of policies targeting improved environmental performance for Short Sea Shipping in Europe, investigate the magnitude of the impact of these policies would be on:
   - Transport costs
   - Transport volumes
   - Emissions
2. Estimate the importance of non-cost drivers on the modal choice of shippers, and how they may change the results of calculations for the first objective.
3. Investigate potential effects these policies may have on trade flows between Europe and other continents.

Data was collected from different research projects performed for the European Commission, as well as stakeholder consultation. The main sources were the ETIS and Eurostat database (transport routes and volumes), the SKEMA study (specific information on maritime transport) and the TREMOVE (road and rail transport costs and emissions) and EMMOSS (shipping emissions) models.

A total of 252 origin-destinations (O/D) pairs were selected for further investigation. For the purpose of this study only Short Sea Shipping (SSS) routes and commodity types that would be sensitive to a change in modal shift were considered. The selection was based both on stakeholders input and also on the data available in the ETIS database. The figure below shows the SSS network subject to the analysis.

**Figure 1: Short Sea Shipping network and OD's**



Cost structure for SSS, road and rail.

As a first step, the study looked into the cost structure of SSS, road and rail transport. For SSS, we distinguish between 4 vessel types: RoRo, LoLo, RoPax Small and RoPax Large. Based on the cost data gathered it can be said that in general rail and SSS are cheaper than road. Note that for road we used an average cost per tonkm - not distinguishing between distance classes. For long distances, working time driving restrictions would decrease average speed and lead to higher (labour) costs. On the other hand, some costs such as storage costs, schedule delay costs, etc. which are typically higher for rail and SSS, are also not included in the cost structure. Apart from transport cost, other drivers like transport time, reliability and commodity type also impact the decision. These decision factors are also reflected in the modal shares in the EU 27[1] – road had a modal share of 45,6%, SSS 37,3% and rail only 10,5%. As factors other than costs also play a role in mode selection transport time and commodity type were also included in the model. However, certain non-cost drivers such as reliability, driving and rest times, etc. could not be included in the cost structure or the model.

Evolutions in transport costs could have various sources, such as the evolution of oil prices, labour costs, technological improvements and European policies to mention a few. With the newly adopted amendments to MARPOL Annex VI, aimed at reducing air pollution from ships, the maritime transport sector could see significant increases in fixed and/or operational costs. In addition, the potential inclusion of maritime transport in ETS (emissions trading scheme) for $CO_2$, NOx and/or SOx could cause further cost increases for the sector. The introduction of policy initiatives such as eMaritime, on the other hand, will lead to a decrease in costs.

[1] DG MOVE, EU-27 Modal split of freight transport in percentage

Policy analysis: impact on SSS volumes

To assess the competitiveness of European short-sea freight shipping compared to road and rail alternatives on the freight routes identified earlier, a model was developed. This model – using nested CES-production function - allows for the choice between a route using mostly SSS (and partly road) or a route using mostly road (but which can also include rail or SSS) for each O/D pair. The choice mainly depends on the evolution in costs.

Such a model requires the setting-up of a baseline scenario (an underlying reference including economic growth projections as well as likely evolutions in other transport modes) and a number of scenarios containing of one or more of the selected policies. In this study, the baseline scenario is based upon the iTREN scenario while the five policy scenarios are:

- Policy scenario A: Sulphur regulation of 0.1% in the ECAs
- Policy scenario B: Sulphur regulation of 0.1% in the ECAs + eMaritime
- Policy scenario C: Sulphur regulation of 0.1% in the ECAs + eMaritme +Greenhouse Gas (GHG) policy
- Policy scenario D: Sulphur regulation of 0.1% in all European seas except the Atlantic Coast + eMaritime +GHG policy
- Policy scenario E: Sulphur regulation of 0.1% in all European seas except the Atlantic Coast + eMaritime +GHG policy + NOx regulation in ECAs

The eventual impact of the aforementioned new regulations can then be assessed by the developed model. We first determined the impact of each of the policy scenarios on the costs of SSS and if applicable on emission factors. Given the price change, the model calculates the effect on the total volumes and emissions. This quantitative assessment is complemented with a qualitative assessment to take into account any non-quantifiable factors.

Overall the first policy scenario – lowering the sulphur content in the ECAs - leads to the largest changes in transport volumes – from only 1% for Ropax Small to 9% for routes where a LoLo is used. We assume that the ship operators switch to low sulphur content fuels to comply with this regulation. This leads to an increase in fuel costs, leading to a rather large increase in total costs – varying from an increase of 6% for Ropax Small up to 29% for LoLo. As our model assumes that the total budget for transport is fixed, road transport volumes also decrease. A price increase for SSS also decreases the budget for road transport as switching to road would not lead to a cost saving. Adding the eMaritime policy somewhat mitigates the decrease in volumes – but the effect is rather small as eMaritime is not expected to lead to high cost decreases. It is assumed to lower port costs by 5% - which leads to a total cost decrease varying between 0.2% (RoPax Small) and 0.4% (RoPax Large and RoRo). The effect of internalising GHG emissions by SSS via a market based instrument at a price of 25 €/tonne $CO_2$ leads to an increase in costs of about 3% (RoPax Small and Large) to 10% (LoLo) and adds an additional decrease in volumes of 0.1% to 3%. Extending the sulphur regulation to other European Seas- except the Atlantic – is not notable in our analysis as this only affects a limited amount of the OD’s included in the analysis. Only the OD’s between France and Italy are affected in our exercise. The NOx regulation has a cost impact of 0.6% (RoPax Large) to 2.5% (LoLo) for newly built ships. The effect decreases over time as the additional costs become less important as other policies start having an impact.

Moreover, as only newly builds are affected, the increase in costs over the whole fleet remains rather limited in the first years after the introduction of the regulation.

The table below summarizes the effect of the different policy scenarios on SSS, when distinguishing between ship type and length of operation.

**Table 1: Overview of model results, by ship type and distance class**

| | Ranges of Operation (km) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ship Type** | **0-50** | | **50-100** | | **100 - 300** | | **300 - 500** | | **500 - 1000** | | **1000 - 2000** | | **2000+** | |
| **RoRo** | | | | | A | -1.18% | A | -3.47% | A | -3.35% | A | -4.83% | A | -7.58% |
| | | | | | B | -1.20% | B | -3.12% | B | -3.29% | B | -4.72% | B | -7.45% |
| | | | | | C | -1.69% | C | -4.52% | C | -4.72% | C | -6.58% | C | -10.26% |
| | | | | | D | -1.69% | D | -4.52% | D | -4.88% | D | -6.58% | D | -10.26% |
| | | | | | E | -1.72% | E | -4.65% | E | -4.99% | E | -6.69% | E | -10.45% |
| **RoPax_Small** | A | -6.33% | A | -0.24% | A | -1.20% | A | -8.92% | | | | | | |
| | B | -6.23% | B | -0.23% | B | -1.18% | B | -8.76% | | | | | | |
| | C | -8.61% | C | -0.35% | C | -1.69% | C | -11.96% | | | | | | |
| | D | -8.61% | D | -0.35% | D | -1.69% | D | -11.96% | | | | | | |
| | E | -8.87% | E | -3.84% | E | -1.73% | E | -12.17% | | | | | | |
| **RoPax_Large** | | | A | -0.68% | A | -2.74% | A | -4.16% | A | -0.83% | A | -6.50% | | |
| | | | B | -0.66% | B | -2.69% | B | -4.08% | B | -0.80% | B | -6.39% | | |
| | | | C | -0.94% | C | -3.99% | C | -5.75% | C | -1.17% | C | -8.83% | | |
| | | | D | -0.94% | D | -4.24% | D | -5.92% | D | -1.17% | D | -8.83% | | |
| | | | E | -0.95% | E | -4.34% | E | -6.03% | E | -1.21% | E | -8.99% | | |
| **LoLo** | | | | | | | A | -3.69% | A | -6.06% | A | -6.60% | A | -7.65% |
| | | | | | | | B | -3.63% | B | -5.96% | B | -6.56% | B | -7.55% |
| | | | | | | | C | -5.07% | C | -8.25% | C | -9.05% | C | -10.41% |
| | | | | | | | D | -5.07% | D | -8.25% | D | -8.84% | D | -10.41% |
| | | | | | | | E | -5.18% | E | -8.41% | E | -9.04% | E | -10.67% |

Taking the RoRo ship first it can be seen from the table that as the distance travelled increases the reduction in cargo volumes increases. Note that the >2000km routes are cargo flows between Finland and the EU27 and the UK. These routes are a special case as the UK is an island and Finland is ostensibly an island nation as well. For this reason, and as we underestimate the road costs over longer distances, it is expected that the actual modal shift will probably be smaller than that predicted by the model. The cargo shifts for the 500-1000km range for the RoRo vessel represent the average cargo shift of 27 different door to door routes in 2025. The average results for the 500-1000km range are skewed by 5 specific routes where due to geographical limitations SSS is the dominant freight transport provider.

The sample of RoPax-Small routes used in the study is small and the eight 50-100km & 100-300km door to door routes only contain four different port to port routes. For these four routes SSS is the dominant freight transport provider due to geographical limitations. The 300-500 km range in fact represents only one origin-destination pair: Finland to Sweden.

The RoPax-Large vessel remains competitive over shorter distance (0-300km) due to its short port turn around times and high frequency of service. However, for the distance travelled increases and assuming a fixed cost per km for road, the cargo losses also increase. The cargo losses for the distance range of 500-1000km are less than expected. This is due to the fact that this sample range only consists of two port to port routes from Norway to Germany where SSS has been shown to be dominant

As distance increases the LoLo vessel suffers a 5% to 11% reduction in cargo volumes. This is due to three reasons: firstly, LoLo vessels are more susceptible to fuel price escalation as fuel forms approximately 47% of their daily costs, and secondly, as distances increase smaller LoLo vessels become less competitive when compared to larger LoLo vessels offering greater economies of scale. As the study only modelled one type of LoLo vessel this level of resolution was not achievable. Finally, we underestimated the costs of road for the longer distances.

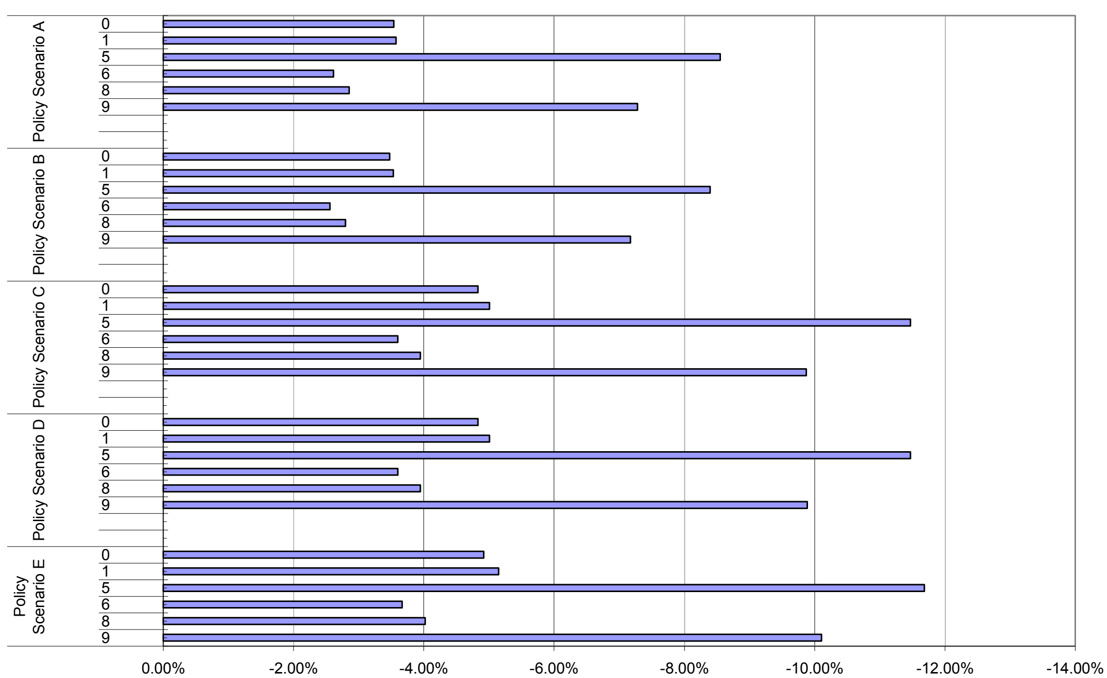
When we translate this to the effect on modal shares between the baseline and policy scenario E, we see clearly that modal shares of the SSS option decrease for all ship types.

**Table 2: Modal share of the SSS option and change in modal share**

| | Modal share | | Change in modal share |
|---|---|---|---|
| Modal share | Baseline | Policy E | |
| LoLo | 34% | 31% | -7% |
| RoRo | 35% | 33% | -4% |
| Ropax Small | 13% | 12% | -1% |
| Ropax Large | 26% | 26% | -2% |

When we distinguish the effect according to the commodity type it is clear that the main type of goods affected are other products (9) – maximum 10.1 % by 2025, metal products (5) – 11.7%. Agriculture products (0), foodstuff (1), building material (6) and chemicals (8) are less affected- with average decreases of about 4 to 5%. This is shown in the figure below.

**Figure 2: Average effect on transport volumes according to commodity type.**



We would like to stress that the model is likely to predict the maximum changes as it only takes into account real monetary costs and time costs, Other factors such as reliability, legislation on driving and rest periods, road and rail conditions, etc. will also affect modal choice.

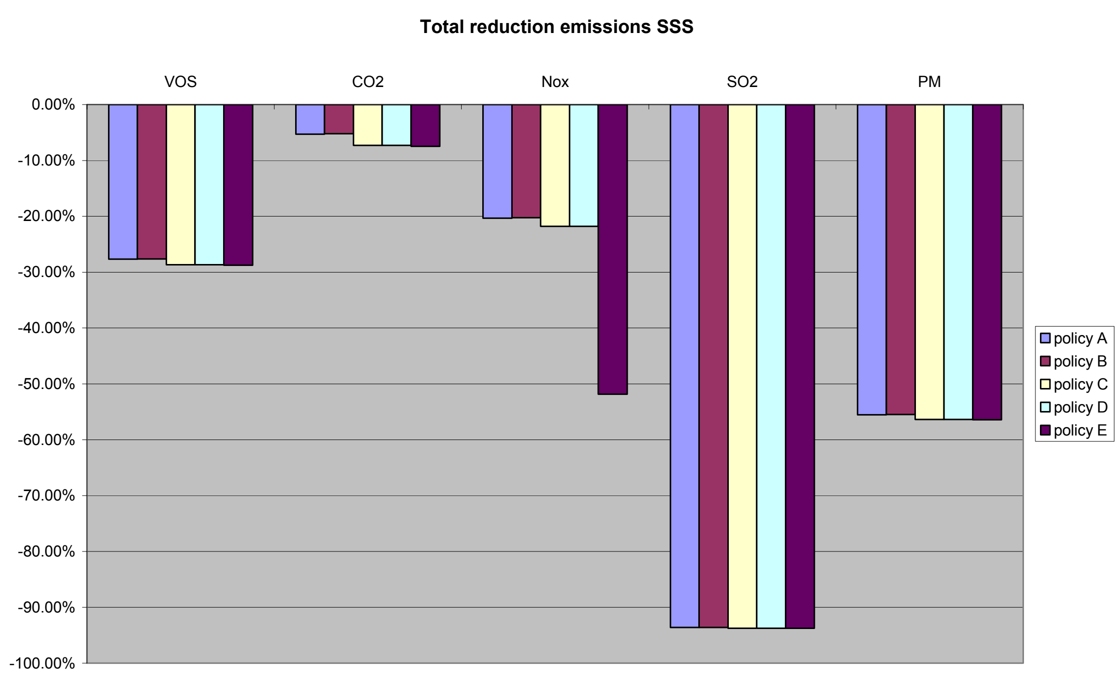
Therefore the qualitative analysis focussed on possible responses ship operators may take. On the one hand they may reduce their speed, leading to a decrease in fuel costs. However, this will also increase their voyage times and might decrease their frequencies, making SSS less attractive. On the other hand, they may decrease their profit margin. This means that the total price increase for the consumer would be lower. However- and especially for LoLos – the price increase would still be enough to lose customers, lowering the base for the payments of capital costs, making a decrease of profit margins an unattractive option.

Policy analysis: impact on emissions.

Some policies, such as the sulphur and NOx regulation and GHG targeted instruments directly and indirectly impact the emissions from SSS. Other policies, such as eMaritime only indirectly affect emissions due to their effects on volumes transported.

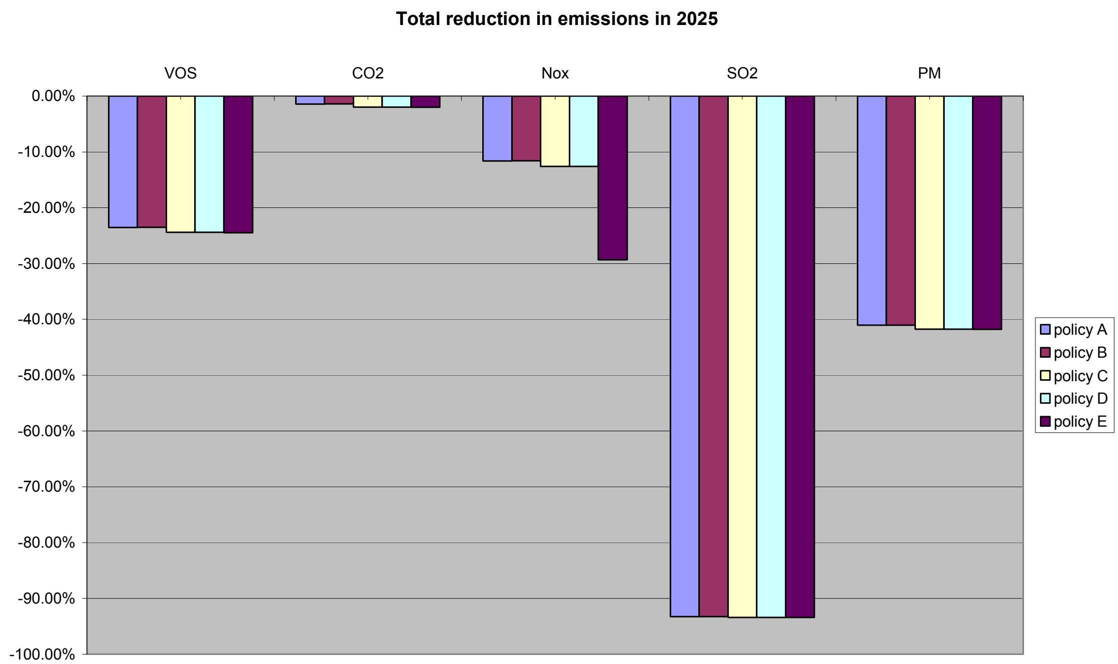
When we focus – as is shown in the figure below - on the relative reductions in SSS emissions (for both options), the effect of the policies is clear. $SO_2$ emissions reduce with more than 90%, while also the direct effect of policy E is evident with a decrease of NOx emissions of more than 50%. Notable is the decrease in the emissions of the other pollutants: PM decreases with about 56%, VOS with 29% and CO2 with 7% in policy scenario E. The reductions in PM and VOS are mainly due to the assumed change in fuel type (from HFO to MDO) as a consequence of the sulphur regulation. The decrease in CO2 emissions is more linked to the loss of volumes transported.

**Figure 3: Relative reduction in total emissions for all OD's for SSS, 2025.**



When we consider the changes in total emissions (this is the sum of all emissions for both options for all origin-destinations and for all modes) with respect to the baseline for the year 2025 we see that the decrease in emissions is still evident, but less pronounced. SO2 emissions still decrease with about 93%, but the other pollutants show a lower decrease. As road has only a limited amount of SO2 emissions, the reduction in SO2 emissions from SSS play a very dominant role. VOS emissions decrease with 24%, PM still with 42%, NOx with 29 % and CO2 with only 2%. In general we see the largest decreases for pollutants where SSS plays a relatively large role in total emissions and vice versa. Moreover, as we focus on OD's where SSS plays an important role, the share of emissions from road and rail with respect to total emission is relatively small – even in the baseline.

**Figure 4: Relative reduction in total emissions for all OD's for all modes, 2025.**




<u>Policy analysis: impact on intercontinental trade</u>

Finally, an assessment of the potential impact on European imports and exports (especially regarding to trade in low value goods), by adding international trade considerations – probably medium to long term – is added to the results of the previous analysis. With ECAs as they are now, the sailing between European ports and other continents becomes only marginally more expensive (the journey through ECAs are only a small part of the total trip). While this leaves SSS at a risk of losing activity to more fuel efficient Deep Sea Vessels making extra stops, other aspects than explicit costs (flexibility, opportunity costs, load factors) will likely temper this effect. Hence, it is not expected that changes in entry/exit points or shifts in modal balance (SSS to land) will take place.

Given the marginal cost increase of maritime transport and the marginal share of maritime transport cost in end user prices, the new legislation will cause negligible cost increase to end user prices.

# Glossary

BBL Oil Barrel
BC Base Case
CES Constant Elasticity of Substitution
$CO_2$ Carbon Dioxide
COMPASS COMPetitiveness of EuropeAn Short-sea freight Shipping compared to road and rail transport
ECA Emission Control Area
ETIS European Transport Policy Information System
DSV Deep Sea Vessel
DWT deadweight
ECA Emission Control Area
EDIP model European Model for the Assesment of Income Distribution and Inequality Effect of Economic Policy
EGR Exhaust. Gas Recirculation
EMMOSS Emission model for inland shipping, maritime transport and rail
ETS Emission Trading System
EU European Union
FC Fuel Consumption
GDP Gross Domestic Product
GHG Green House Gases
HFO Heavy Fuel Oil
IMO International Maritime Organisation
LoLo Lift on, Lift off ships (container ships)
MARPOL International Convention for the Prevention of Pollution from Ships
MDO Marine Diesel Oil
MT Metric Ton
NECA NOx Emission Control Area
NECL Nautical Enterprise
$NO_x$ Nitrogen Oxides
OD Origin Destination
RoRo Roll on, Roll off ships with primarily unaccompanied freight
RoPax RoRo vessel for cargo and passengers
SECA SOx Emission Control Area
SCR Selective Catalytic Reduction
$SO_x$ Sulphur Oxides
SSS Short Sea Shipping
SSV Short Sea Vessel
TEU Transport Unit
TML Transport & Mobility Leuven
TREMOVE model A policy assessment model to study the effects of different transport and environment policies on the transport sector for all European countries
TRANSTOOLS model detailed network analysis tool for transport in the EU

# Timing of the project

| Data | Event |
|---|---|
| 18 11 2009 | Signing of contract |
| 28 12 2009 | Kick- off meeting with the Commission |
| 01 02 2010 | Progress meeting with the Commission |
| 26 02 2010 | Stakeholder workshop |
| 07 07 2010 | Submission of Draft Final Report |
| 13 07 2010 | Progress meeting with the Commission |
| 18 08 2010 | Submission Final report |

# 1 Introduction

## 1.1 Background and objectives

With the newly adopted amendments to MARPOL Annex VI, aimed at reducing air pollution from ships, the maritime transport sector is susceptible to significant increases in fixed and/or operational costs. In addition, the potential inclusion of maritime transport in ETS (emissions trading scheme) for $CO_2$, NOx and/or SOx could cause further cost increases for the sector. These evolutions are in line with policies to reduce the environmental impact of transport, among others by internalizing external costs. This policy is of course applicable to all transport modes, yet the timing of application is not the same for all modes. For example road pays some external costs through excise duties and has been subject to increasingly stringent emission standards since the early nineties, while electric rail is already subject to ETS for fixed installations.

Each stage in the process can cause shifts in competitive position of the different modes. The magnitude of the shift depends on a number of factors, but it is evident that a cost increase for one mode, ceteris paribus, will put that mode's market share under pressure. Short Sea Shipping (SSS) competes for volume with road and rail transport (unlike intercontinental maritime transport, which has very little actual competition), so the cost increases as described above may cause a backshift from maritime transport to road and/or rail.

To determine the magnitude of a possible modal shift we need to answer the following questions:

- What are the factors affecting modal choice? In general road transport has the advantage of offering high flexibility, door-to-door delivery, little chance of cargo loss or damage and frequent departures. On the other hand, road transport is rather expensive. Therefore rail and ships mainly attract low value goods. One of the goals of this study is to investigate which factors are most important in the modal choice made by shippers. Apart from transport cost, other drivers like transport time, reliability and commodity type also impact the decision.
- Which routes and market segments are most susceptible to modal shift? Containerized traffic over short distances seems to be the most susceptible as they have more alternatives, while bulk over large distances will most probably not be affected. Even if no 'real' modal shift happens, a reduction in the distance of the waterborne leg might occur. In this study we will focus on those goods and markets most likely to be affected.
- What are the factors driving modal shifts? Immediate shifts are not expected due to the relatively low cost of freight transport, particularly over the sea. Moreover, long term contracts also play a role. Our quantitative analysis mainly focuses on the effect of changes in prices and time costs, but is complemented with a qualitative analysis to take other factors into account.
- What will be the exact design of the policies and will they be complemented with other policies aimed at reducing the risk of modal shifts?

The main objective of this study is to assess the competitiveness of European short-sea freight shipping on specific freight routes where it is in direct competition with road and rail alternatives. This will be done by the development of a model which allows for different market evolutions. Scenarios include economic growth projections, as well as likely evolutions in other transport modes. The eventual impact of new regulations can then be assessed. By obtaining an insight into the cost structure of SSS and competing modes, the effect of relative cost changes is determined by feeding these into the model, which takes account of the factors determined above. This analysis will then be complemented with an assessment of the potential impacts on European imports and exports.

In summary, the outcome of this study is threefold:

- A quantitative assessment of the likely evolution of the relative competitive situation of SSS and road/rail transport, based on the modelling exercise.
- A qualitative assessment of the likely evolution of the relative competitive situation of SSS and road/rail transport. Any non-quantifiable impacts on the competitive position of SSS are added to the quantitative assessment.
- An assessment of the potential impact on European imports and exports (especially regarding trade in low value goods), by adding medium to long term international trade considerations to the results of 1. and 2.

## 1.2 Methodology

The research steps can be divided into three phases: a data collection phase, a scenario construction phase and an analysis phase.

The first step of the methodology is to collect the necessary data. The goal of this is twofold. Firstly, the data allows us to gain insight into the structure of the transport market for SSS. Using available literature, statistics and transport databases, information is gathered on the main origin-destination pairs, the routes on which SSS can play a role, the main commodities transported and the vessels used for SSS transport. Secondly, the data is further used to develop cost functions for all relevant modes – SSS, road and rail. The costs are split up as far as possible to allow for an assessment of the impact of changes in certain types of costs – for example, changes in the fuel cost.

Some aspects of the transport market may not be directly quantifiable, but still have an effect on market position of the different modes. These include, but are not limited to, time, reliability, distance and frequency. Data on these aspects was also collected.

During this data collection phase we also organised a stakeholder meeting (26 February 2010). This allowed for a validation of the preliminary results of the data collection and of the further study methodology.

In the second stage, we analyse the effect of different policy options on SSS volumes and emissions. First, the data collected will be integrated to form the baseline and five coherent scenarios, which realistically represent potential evolutions of the relevant market up to 2025.

The emission reduction measures, both quantitative and qualitative, will then be added to these scenarios. Through an ad hoc model, both simple and highly detailed, all quantitative effects will be calculated. In a second step, non-quantifiable effects will be assessed, to obtain a coherent view on the competitive position of SSS in the future when the emission reduction measures come into force.

The third stage consists of an evaluation of the effects of policies on trade between Europe and the rest of the world. Though demand shifts are not immediately expected, intercontinental ships may decide to call at different harbours, causing further shifts within the European domestic market. This work relies on a more qualitative analysis, highlighting the key trends to be expected.

### 1.3 Structure of the report

The next chapter discusses the results of the first phase, the data collection and the analysis. The following chapter deals with the second phase and includes a discussion of the model developed, the background, baseline scenarios and policy scenarios and outlines the results of the assessment. The final chapter outlines the model used for the analysis of the impact on trade and discusses the main results.

# 2 Data collection & analysis

The goal of this chapter is threefold. Firstly, an analysis of the SSS market is made. Secondly, a detailed cost breakdown is made for the relevant modes (rail, road and SSS). The expected evolution of the costs will also be mapped. Finally, the non-cost drivers are identified and quantified insofar as possible.

This analysis allows for a clear picture of SSS market and its position compared to it competitors (road and rail). Moreover, the output will also be used as a starting point for the model which will be developed in the next chapter. For the use of this data in the model, some of the cost data needs to be aggregated. This is already done in this chapter.

## 2.1 Stakeholder consultation

In order to calibrate existing cost breakdown data a survey was constructed and circulated to transport operators for completion. The survey had three distinct objectives for all modes;

- determine current cost breakdown data (in Euros)
- determine expectations on future price increases (in percentage)
- determine relative importance of mode choice characteristics

The survey was designed such that transport operators of all modes could complete the majority of questions, and so that the output could be readily modelled. This dual aim necessitated compromises from the respondents. This resulted in an initial poor response from some transport operators.

The survey (see annex 1 for sample) was hosted online to facilitate completion and circulated to industry representatives identified by the EC and project participants. Following the circulation of this survey an invitation from the then Head of DGENV/C3 unit Mr. Philip Owens was issued inviting representatives to attend a stakeholder meeting in Brussels on the 26$^{th}$ of February 2010 where the results of the survey would be presented.

There was a very positive response to the invitation to the stakeholder meeting and all modes were adequately represented and provided valuable input to the project. Following the stakeholder engagement presentation, meetings were set up with ship owners who wished to contribute cost data outside of the survey structure.

Transport costs delineated in studies recently completed by the Finnish Centre for Maritime Studies and the Swedish Maritime Authority, and, cost data available from the recently updated Drewry Shipping Consultants cost report were also used to calibrate the cost data used in the COMPASS model.

## 2.2 Data on SSS market

### 2.2.1 SSS Cargo Origin-Destination Selection

As specified in the tender documentation the ETIS cargo flow database was interrogated to determine the major SSS origin to destination pairs for Europe, including trade with Russia.

The ETIS database specifies the origin and destination of all cargo flows that contained a SSS leg for 2005. The original database was built around data for the year 2000 and updated five years later to reflect 2005 cargo flows. The ETIS database country resolution was at the NUTS-2 level and 10 NSTR commodity classes. The land distances used were from the port of entry/departure to the major industry/population centre within each specific NUTS-2 area.

The sea distances used reflect the actual distances of shipping lanes, excluding the use of inland waterways (Kiel Canal, etc.).

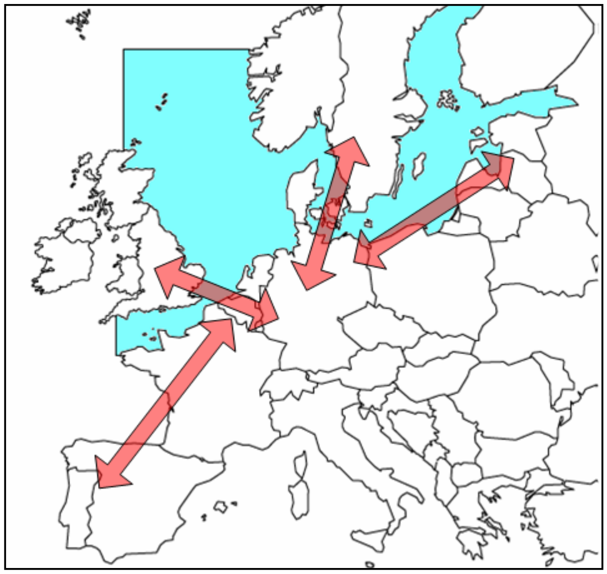
### 2.2.2 Shortsea Shipping Route Selection

The ETIS database lists all SSS departure and arrival ports for all commodity types. For the purposes of this study only SSS routes that would be sensitive to a changes in modal shift were considered.

Following this assumption it was necessary to approach the route selection from two sides. Firstly, expert opinion and input from industry representatives was used to determine the routes particularly sensitive to changes in modal split. Secondly, the ETIS database was used to ensure only priority routes were selected, with emphasis being given to routes with larger cargo flows.

Contribution from stakeholders was elicited initially through the circulation of a detailed questionnaire (see annex 1 for sample). The results of this questionnaire and the following outline cargo corridor diagrams were presented at a stakeholders input meeting on the 26th of February 2010 in Brussels.

**Figure 5: Initially selected internal freight corridors where modal shift may occur**

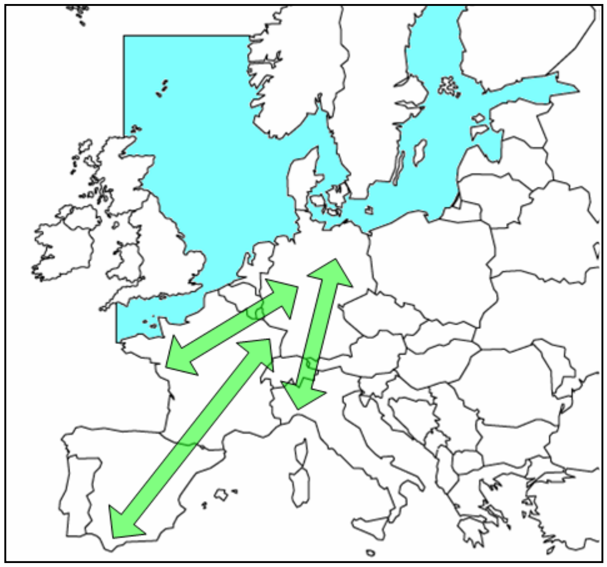


It was proposed to include routes where there was potential for a drop in cargo volumes due to cost increases.

**Figure 6: Internal freight corridors where cargo volumes may reduce**

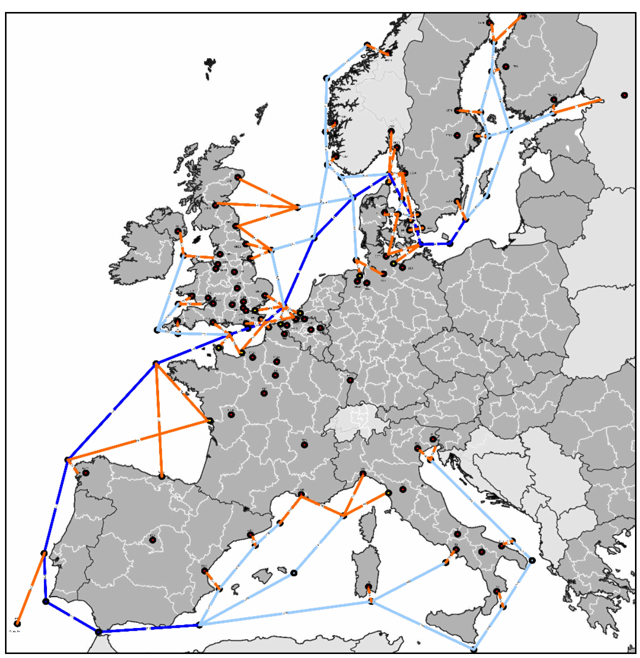
Routes that may see significant changes in cargo flows due to potential changes in European cargo entry points were then also included in the analysis.

**Figure 7: Freight corridors that may increase disproportionately**



The corridors proposed were accepted by the stakeholders as representative and appropriate. During, and following, the input meeting a number of new corridors were suggested and examined to determine if their cargo volumes and other characteristics justified their inclusion. The outcome of this consultation process combined with the information contained within the ETIS database resulted in the construction of the following SSS network diagram. The black dots in this figure denote the origins and destinations.

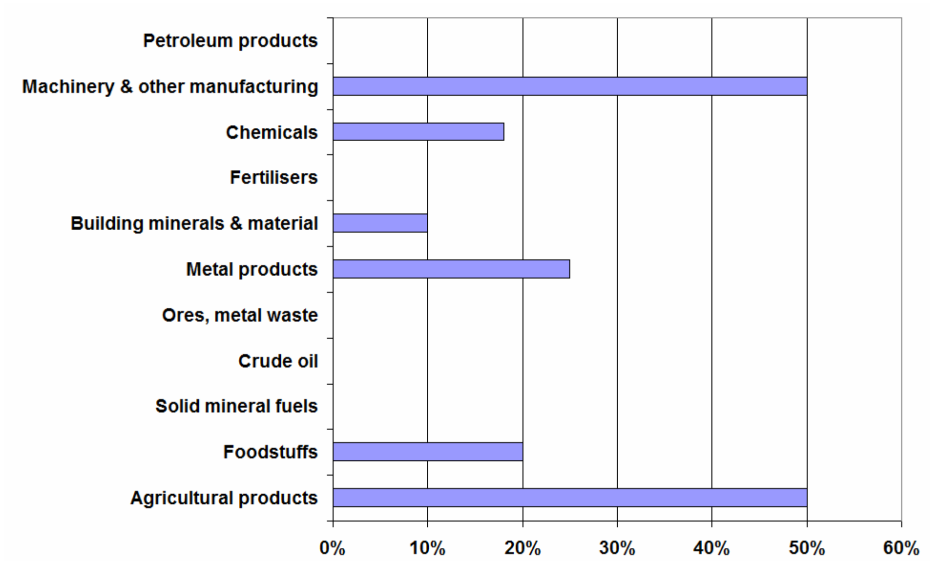
**Figure 8: SSS Network diagram**



### 2.2.3 Commodity Selection

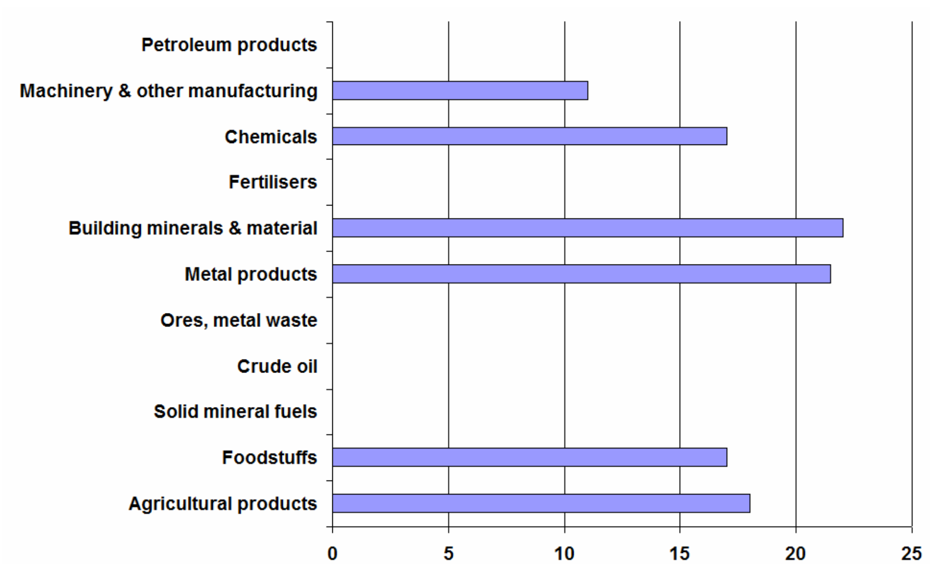
As previously mentioned only commodities that are typically susceptible to modal shift were selected. Such commodities are primarily described as medium value, durable goods capable of being containerised or loaded into a truck. As the ETIS database contained the tonnes transports of each commodity (according to NSTR classification) it was first necessary to determine the quantity of each commodity that was unitised. This was achieved using figures from a UN study (Smeets, P. 2008) for the port of Rotterdam. The following two bar charts display the percent of each commodity unitised and the average weight per TEU for unitised commodity.

**Figure 9: Percentage of Cargo Unitised**




Source: Smeets, P. (2008)

**Figure 10: Average weight per TEU**




Source: Smeets, P. (2008)

These figures were applied to the ETIS database in order to determine the priority of various SSS routes in Europe. This resulted in the selection of 24 country-to-country corridors containing 252 distinct OD pairs. Annex 2 shows these 252 origin-destination pairs, including the commodities transported, the ports used, the sea distance, the TEU transported and the share in total EU SSS freight.

### 2.2.4 Vessel Selection

Given the large range of vessels on the specified routes it was determined that four broad classifications of ship would be used to represent the SSS fleet in Europe. These ship types were chosen as they represent distinct operating models, reflect the majority of ships transporting cargo capable of modal change and are capable of berthing in a large number of ports. The high level characteristics of these ships are described in the following table.

**Table 3: General ship Characteristics**

| | |
|---|---|
| **LoLo** | Medium to long range ship serving container ports<br>Carrying capacity between 500 and 700 TEUs |
| **RoRo** | Medium to long range ship serving RoRo ports<br>Carrying capacity approximately 200 trailers and 12 drivers |
| **RoPax-Small** | Short range ship servicing high frequency passenger focused routes serving RoRo ports. Carrying capacity approximately 30 trailers and 1000 passengers |
| **RoPax-Large** | Short to medium range ship with passenger focused routes serving RoRo ports<br>Carrying capacity approximately 300 trailers and 1000 passengers |

For each OD we allocated the relevant vessel.

### 2.2.5 Total Cargo Volumes Selection

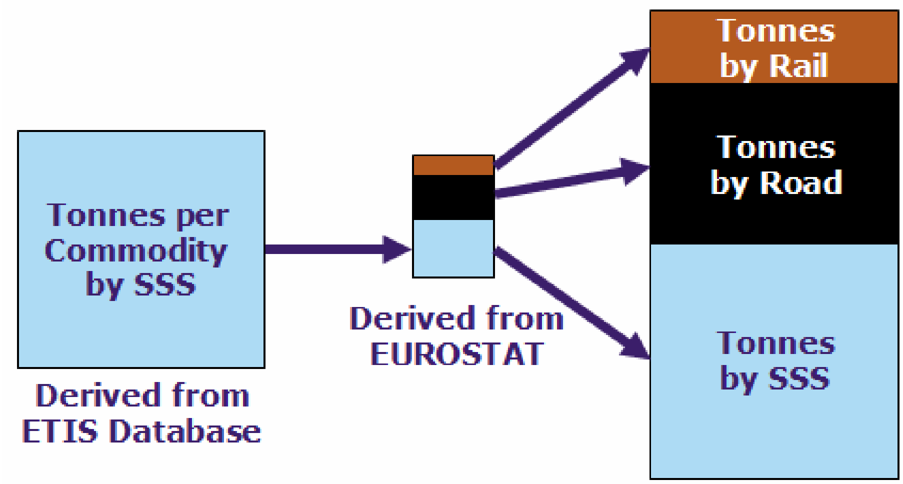
The ETIS database provides a detailed breakdown of the volumes of cargo transported via SSS by commodity type. In order to determine the volumes of cargo transported via road and rail (by commodity) on the selected OD routes, modal-split data from Eurostat was used.

The data from Eurostat provided the import and export modal-split (by commodity) between each member state and the rest of the EU27. The data also provided the exact modal split per commodity type for trade with Norway and Russia and any EU27 member state.

These modal splits per commodity type were then checked and revised using national statistics in the case of Finland and the UK due to their higher reliance on SSS than other member states.

Using the cargo volumes obtained from ETIS and the modal splits obtained from Eurostat it was possible to infer the cargo volumes per commodity type being transported on the same OD routes via road and rail. The following figure pictorially represents this calculation process.

**Figure 11: Calculation of cargo flows by land modes**




### *2.3 Cost developments for all relevant modes: rail-road-SSS*

Transport costs are one of the most important drivers for modal choice. Hence, this section focuses on the transport cost, and its breakdown, of the three relevant modes: SSS, rail and road[2]. The cost breakdown is important to allow for policy assessments at a later stage. For example, the new IMO regulation on sulphur is expected to have an impact on fuel prices or on capital and running costs. The effect on demand and – possible – modal shifts will then not only depend on the magnitude of the fuel price increase, but also on the share of the fuel costs in the total costs. Furthermore the expected cost increase due to the new regulations and some other relevant policy and market trends will be quantified. So, for each mode we first discuss the current cost breakdown and the expected evolution in the baseline scenario. This baseline scenario is discussed in more detail in the next chapter.

Two preliminary remarks are to be made. Firstly, the focus in this section lies on monetary costs, while the model – discussed further on – also takes into account the time costs. Secondly, for rail and road we have opted to use European averages. In theory, country based costs could be used. Given that costs are not that different between the different European countries it would make the model more difficult to handle, without contributing much to the overall picture. Route specific costs, such as a toll to cross the Oresund Bridge, will be taken into account in the modelling exercise but not in this overall overview.

All costs are expressed in €2005.

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[2] Inland Waterways were not included in this analysis.

### 2.3.1 SSS

#### a Current cost breakdown

The cost structures of the four ship types were derived from Drewrey's and NECL's ship cost databases, and, from consultation with industry representatives via the survey and meetings. The results of this consultation are displayed in the following four pie charts.

**Figure 12: LoLo container ship cost structure**

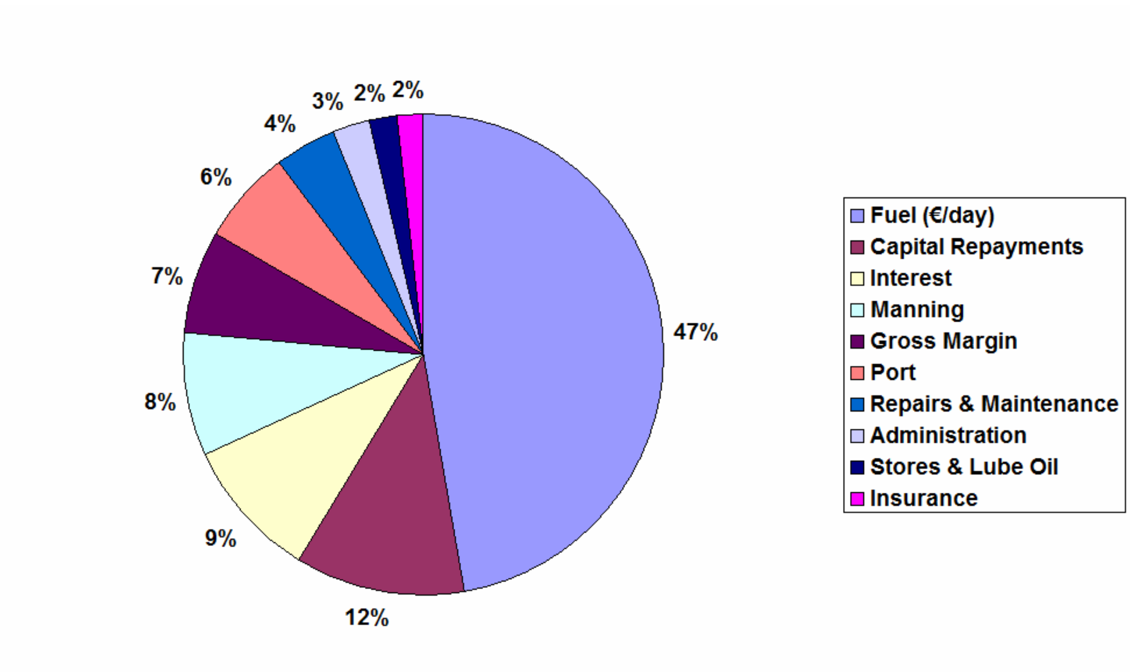



**Figure 13: RoRo ship cost structure**

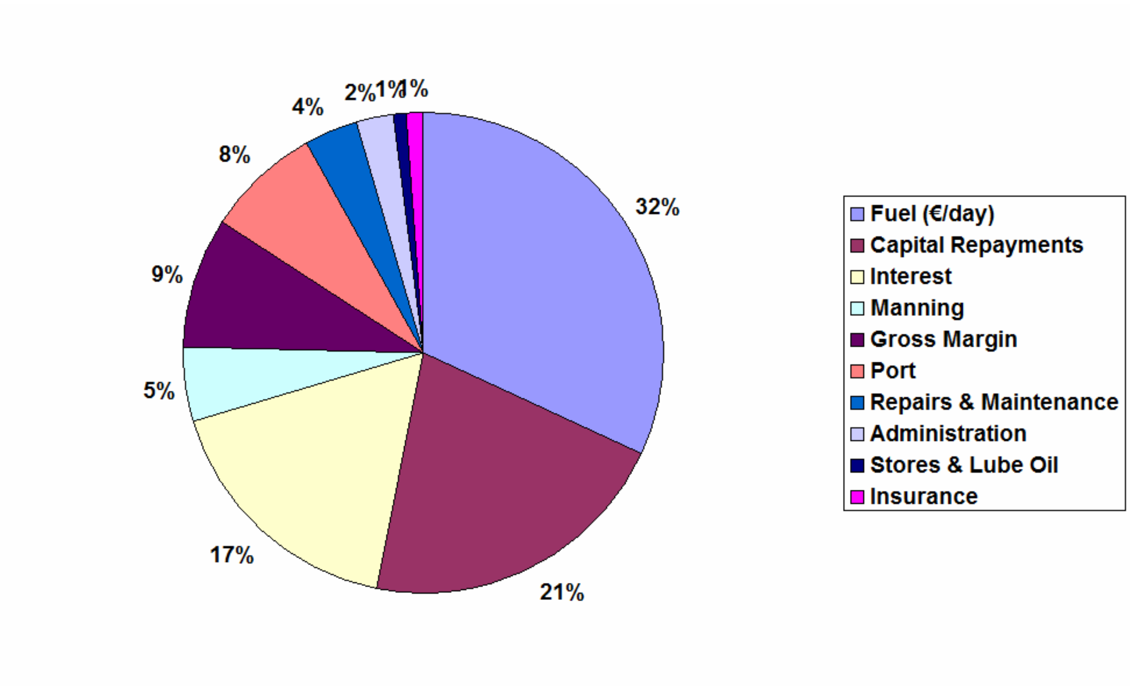


**Figure 14: Small RoPax ship cost structure**

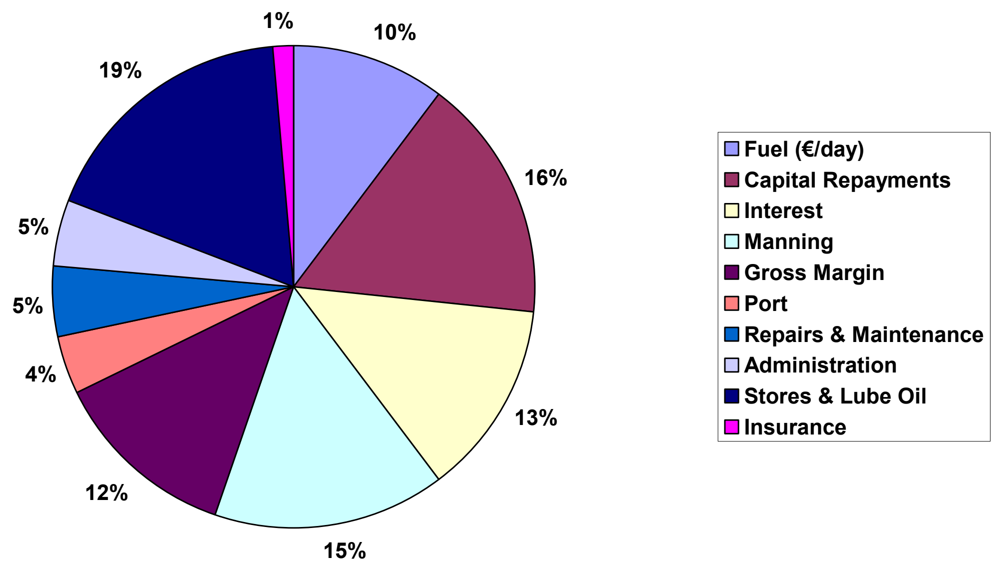
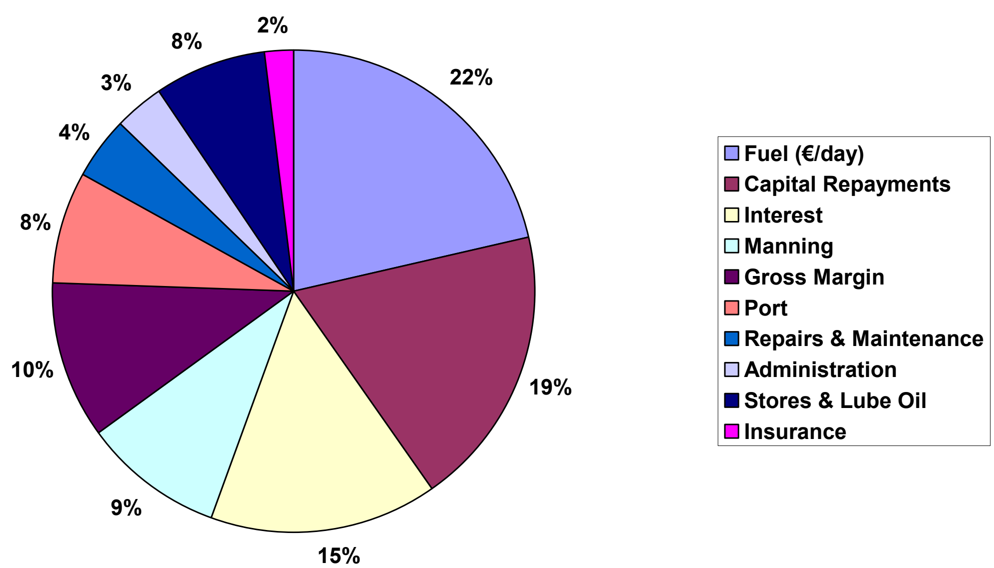



**Figure 15: Large RoPax ship cost structure**




The cost breakdowns illustrated in the previous pie-charts are based on the following absolute cost figures shown in Table 4.

**Table 4: Absolute cost breakdown per ship type**

| Cost Structure (€/day) | | | | |
|---|---|---|---|---|
| **Ship Type** | **LoLo** | **RoRo** | **RoPax-Small** | **RoPax-Large** |
| **Size (TEUs & Trailers)** | 600 TEUs | 200 Trailers | 40 Trailers | 290 Trailers |
| **Guide DWT** | 11,000 | 10,000 | 3,000 | 12,000 |
| **Manning** | €1,588 | €1,901 | €3,300 | €7,500 |
| **Insurance** | €313 | €443 | €300 | €1,500 |
| **Repairs & Maintenance** | €802 | €1,382 | €1,000 | €3,300 |
| **Stores & Lube Oil** | €351 | €328 | €3,800 | €6,000 |
| **Administration** | €504 | €870 | €1,000 | €2,700 |
| **Capital Repayments** | €2,189 | €7,960 | €3,476 | €14,945 |
| **Interest** | €1,799 | €6,543 | €2,857 | €12,286 |
| **Gross Margin** | €1,283 | €3,302 | €2,675 | €8,199 |
| **Port** | €1,200 | €3,000 | €850 | €6,000 |
| **Fuel (Ton/day)** | 28.0 | 37.9 | 7.0 | 53.3 |
| **Fuel (€/day)** | €8,924 | €12,079 | €2,231 | €16,987 |
| **Speed (knots)** | 14.0 | 17.5 | 8.0 | 22.0 |
| **Full Cargo Weight (Ton)** | 7,200 | 2,800 | 1,000 | 7,250 |
| **Total (€/day)** | **€18,952** | **€37,807** | **€21,488** | **€79,417** |

To enable the use of the cost structure data within the ad-hoc model it is necessary to convert the €/day figures into €/tonkm. This is achieved by dividing the cost per day (€/day) by the number of kilometres covered per day (km/day). The resultant €/km cost is then divided by the carrying capacity of the ship in tonnes, generating the €/tonkm figure. The number of kilometres per day was calculated for each of the 252 routes modelled and took account of loading and unloading times. Costs per tonne km vary by route and ship type, making the comparison with road and rail rather complex. The following graphs display the calculated €/tonkm values.

**Figure 16: Costs RoRo vessel in €/tonkm according to sea distance**

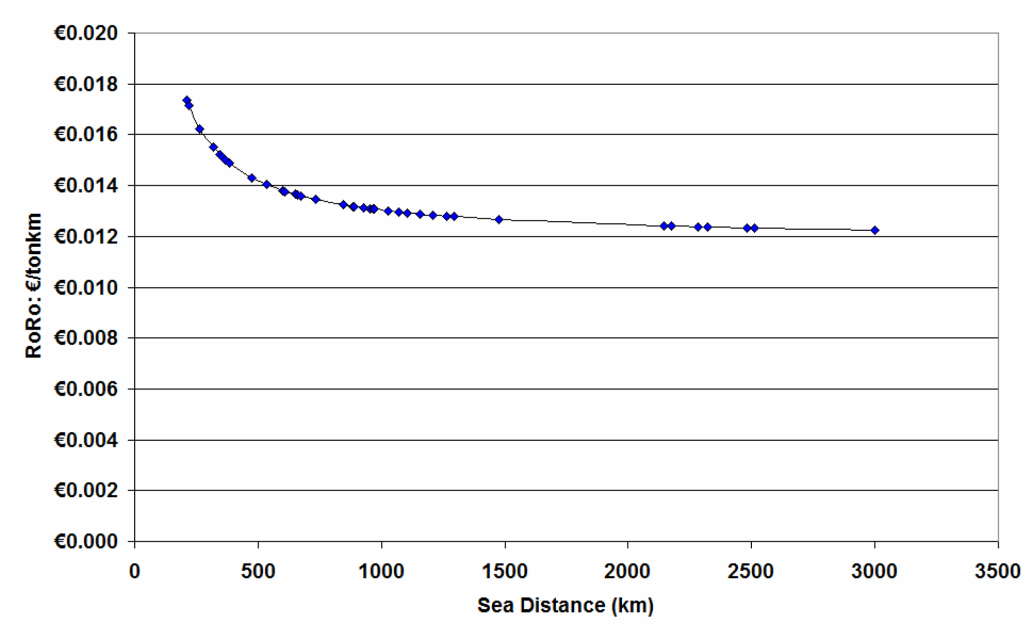



**Figure 17: Costs RoPax Small vessel in €/tonkm according to sea distance**

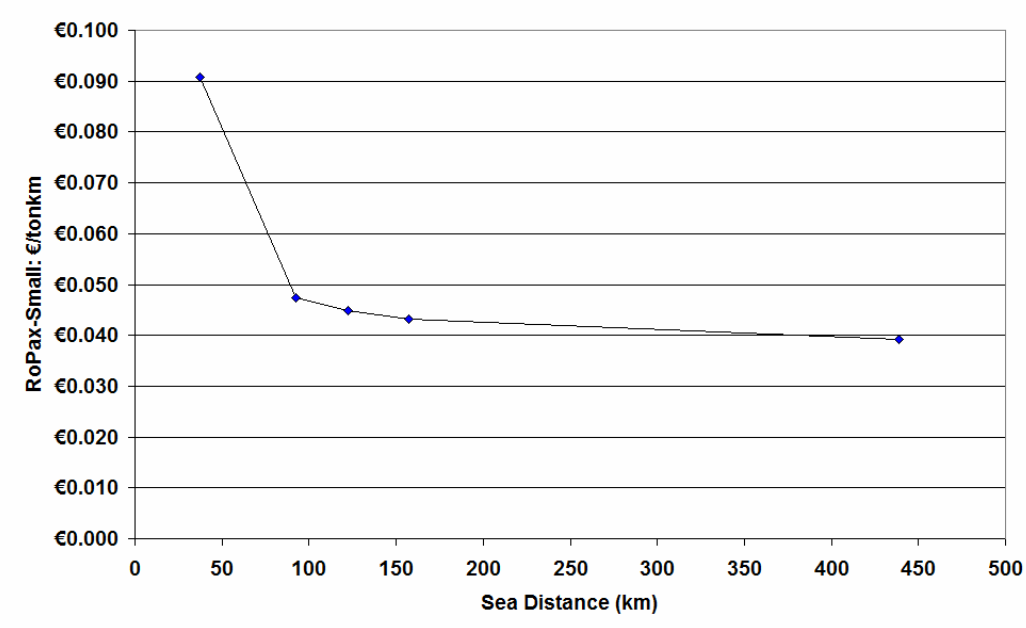


**Figure 18: Costs RoPax Large vessel in €/tonkm according to sea distance**

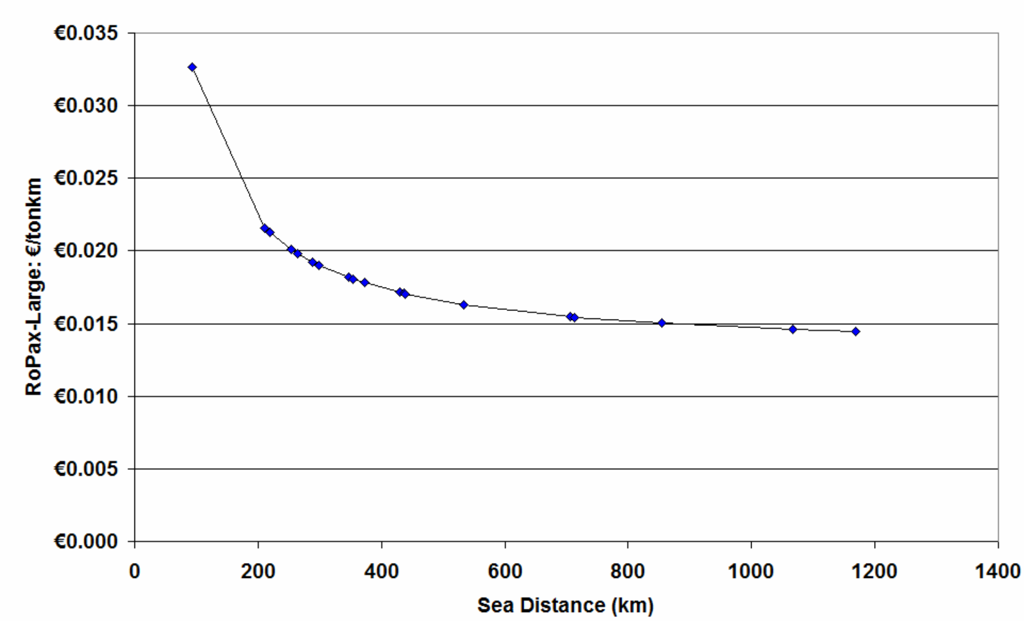
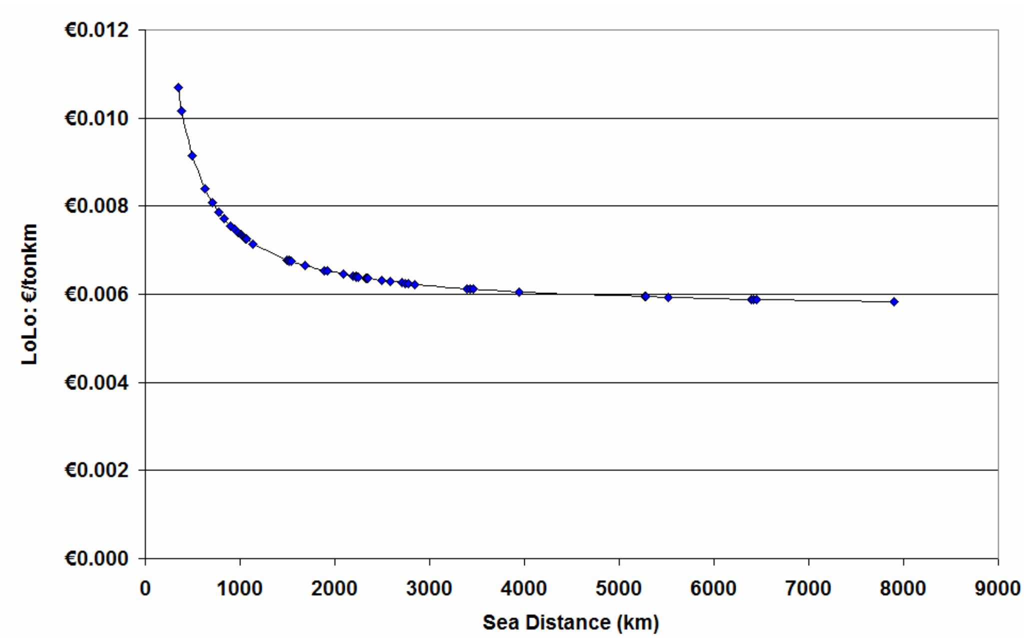
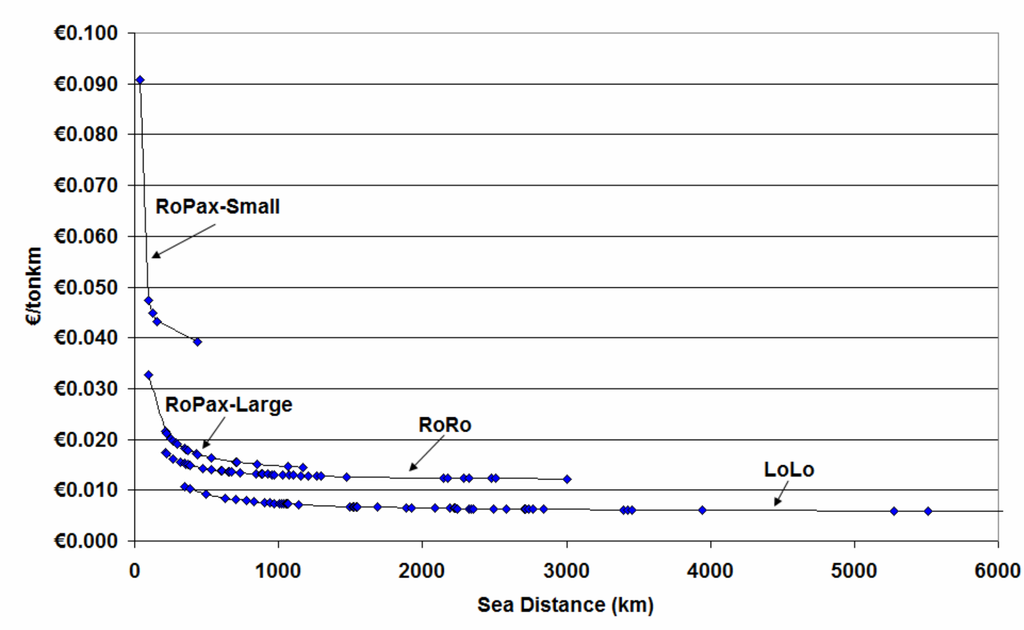



**Figure 19: Costs LoLo vessel in €/tonkm according to sea distance**




The four previous graphs superimposed on each other results in the following chart. This chart highlights the relative competitive ranges of each of the services.

**Figure 20: Costs in €/tonkm for the different vessels according to sea distance**




### b Expected evolution in costs

For SSS we will not include any major evolution in costs in real prices in the baseline. In the baseline we assume that the fuel price follows the same evolution as the fuel price of road and rail transport.

When we consider the expected evolutions in costs as stated by industry representatives (Table 5) the most significant cost development expected is fuel price escalation. However, this escalation is due to the new MARPOL regulations – which is not an element of the baseline but of a policy scenario. As apart from the results of the survey, there are no other sources pointing to the same costs evolutions, we decided not to include these expectations with respect to interest costs, loading and unloading costs and taxes within the baseline[3].

[3] Including these costs in the baseline would lead to the following effect: Increasing other costs than fuel costs lowers the impact of the policy measures; decreasing them increases the impact. The reason is that the expected increase in (fuel and/or capital) costs due to the policies will become relatively less important.

**Table 5: Cost evolutions that will impact SSS operating in Europe**

| Cost Element | Expected % change by 2025 based on 2010 costs | Rational |
|---|---|---|
| Interest | +30% | Current interest rates are very low to stimulate growth. Additional costs are being put on financial institutes and these costs will be passed on to the customers. |
| Fuel<br>-1.5% Sulphur:<br>-0.1% Sulphur:<br>-Change from 1.5% to 0.1% Sulphur: | <br>+70%<br>+50%<br><br><br>+200%- +300% | The upward oil price trend seen before the 2008 market slump has re-established itself and it is set to continue due to ongoing demand. This price recovery and subsequent increase is captured in Purvin & Gertz (2009), although the shippers expect a higher increase in fuel costs from switching to the 0.1% Sulphur than the Purvin & Gertz report. |
| Labour | In line with inflation | . |
| Port & Canal | In line with inflation | |
| Loading & Unloading | -20% | Due to improved work practices and the development of new loading/unloading technology. |
| Maintenance | In line with inflation | |
| Insurance | In line with inflation | |
| Taxes & Vat | -20% | Due to expected favourable tax reductions to stimulate transfer of cargo from land to sea. |

### c Policy Influences

The policies that are expected to impact transport costs are detailed in the following table. In chapter 3 we discuss the policies included in the policy scenarios into more detail.

**Table 6: Policy influences**

| Policy Heading | Description | Quantified Impact |
|---|---|---|
| MARPOL | Cost increase associated with the change to a more expensive fuel type or the installation and utilisation of exhaust scrubber technology. This increase will only impact SSS. | As per fuel prices. |
| Eurovignette | Once fully implemented by member states this will result in a cost increase for road users. The recent approval of the External Costs amendments to the Eurovignette Directive also opens the doors for rail to be charged under a polluter pays principle. | 2%[4] |
| Emissions Trading Scheme | Though currently exempt it is expected that a Carbon trading scheme will eventually be introduced for the transport sector. | Current carbon prices for member states are €15-€20/ton. |
| Ballast Water | If implemented this policy will only result in a small cost increase for SSS. | 0.2%[5] |
| eMaritime | The EU eMaritime initiative is aimed at fostering the use of advanced information technologies for working and doing business in the maritime sector. It is expected that this initiative will reduced delays in ports through more efficient documentation submission and review processes, and, improved coordination of inspections by authorities. | Maximal 20% [6]decrease in port cost |
| NECA | This policy incorporate the cost impact of the application of Tier III standards for ships constructed on or after 1 January 2016 and sailing in the Baltic Sea, North Sea/English Channel and/or Mediterranean Sea applies. | Additional annual cost of about € 166000-297000[7] per ship |

[4] Based on analysis carried out in the Commission study: SKEMA (2010) 'Impact Study of the future requirements of Annex VI of the MARPOL Convention on Short Sea Shipping', Grant Agreement No. TREN/FP7/TR/218565/"SKEMA.

[5] Based on analysis carried out in the Commission study: SKEMA (2010) 'Impact Study of the future requirements of Annex VI of the MARPOL Convention on Short Sea Shipping', Grant Agreement No. TREN/FP7/TR/218565/"SKEMA.

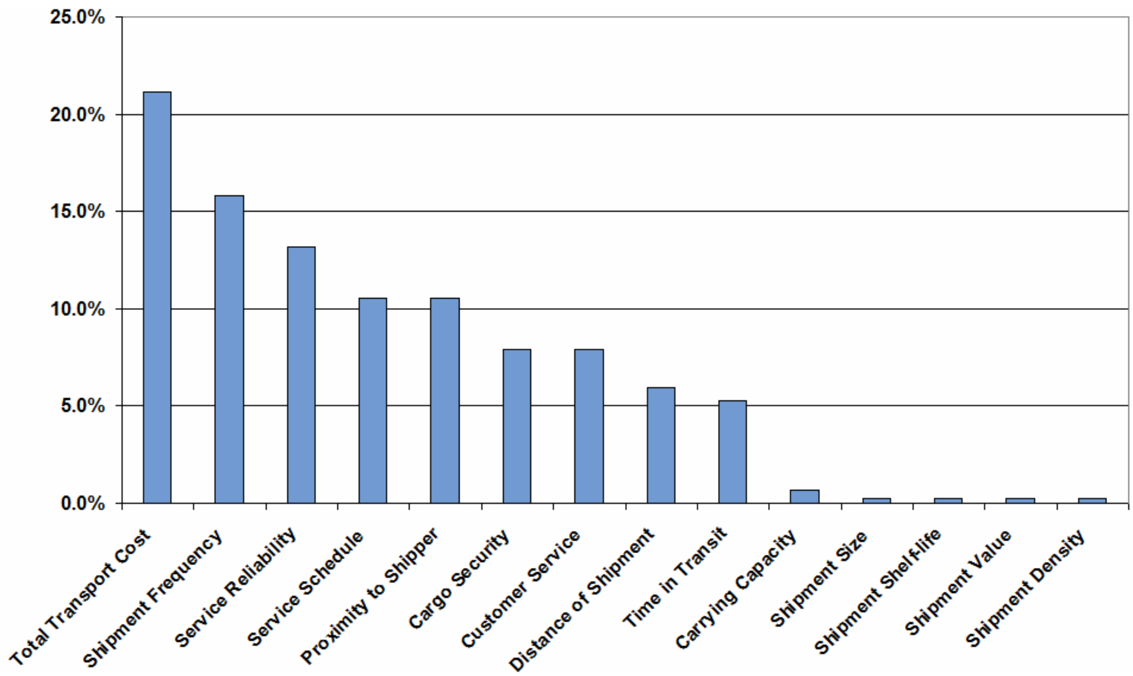
[6] Based on survey carried out for COMPASS

[7] AEAt study(2009)

#### d Non Cost Drivers

A literature review of modal choice drivers was carried out and 14 factors were presented to transport stakeholders in the form of a survey to determine the relative importance of each factor. The following graph displays the stated importance of each factor, where the sum of all factor weights is 100%.

**Figure 21: Importance of cost and non cost drivers**




From this figure it is clear that both monetary and time costs play a dominant role. Though these costs are the decider for the purposes of modelling, the additional factors were reviewed in conjunction with the model's prediction.

### 2.3.2 Rail

#### a Current cost breakdown

In general, little publicly available information is available for rail. We have chosen to use the data which was collected for a cost benefit analysis of the railway line Iron Rhine between Belgium and the Netherlands. The advantage of using this data is twofold. Firstly, the information is very detailed. Secondly, the data used was checked with some Belgian, Dutch, German and French railway undertakings. The drawback of this data is that firstly, it is probably more valid for central European countries than for other countries. Secondly, comparison with other – albeit scarce – data, shows that these costs appear to be at the low end. For example, ECORYS (2004) gives information on total revenue from freight transport and the total amount of tonkm driven in a year. This information is based on company accounts for a selection of countries. Revenue divided by tonkm leads to prices around 0.04-0.08 €/tonkm.

For rail we consider three types of costs

- average fixed costs (€/h): cost of the locomotive, wagon, personnel and overheads
- average variable costs (€/trainkm): infrastructure fee, shunting costs. Depending on the baseline scenario this average cost could also include an externality tax for future years.
- average energy cost (€/trainkm): distinguishing diesel from electric traction. For the model we will not distinguish diesel from electric traction, but use a weighted average. For future years, this average will take into account the expected evolution in electrification.

Note that taxes are not included for rail, as rail is mostly exempt from them.

The next two tables show the assumptions for the costs of the locomotive and the wagon used for the calculation of the average fixed cost:

**Table 7: Assumptions for the operator costs for locomotives**

| | diesel | electric |
|---|---|---|
| type | Class 66 | BR 152 |
| purchase price per piece (including safety system) (€) | 2469882 | 3252011 |
| number of locomotives | 1 | 1 |
| depreciation (number of years) | 20 | 20 |
| maintenance costs (%) | 6.25 | 6.25 |
| insurance costs (%) | 1.5 | 1.5 |
| rest value (%) | 10 | 10 |
| number of working days | 300 | 300 |
| number of working hours/day | 6.5 | 6.5 |

Source: Delhaye ea (2009)

**Table 8: Assumption for the operator costs for wagons**

| | container | | general cargo | | wet bulk | | dry bulk | |
|---|---|---|---|---|---|---|---|---|
| | diesel | electric | diesel | electric | diesel | electric | diesel | electric |
| type | Sgns 691 | Sgns 692 | Hbbillns 305 | Hbbilns 306 | Zaces | Zaces | Falns 183 | Falns 183 |
| number per train | 29 | 29 | 25 | 25 | 18 | 18 | 30 | 30 |
| loading capacity per wagon (TEU) or tonne | 3 | 3 | 28.5 | 28.5 | 58.3 | 58.3 | 65 | 65 |
| rental price per day | 21.40 | 21.40 | 17.39 | 17.39 | 24.70 | 24.70 | 15.85 | 15.85 |
| number of working hours per day | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 |

Source: Delhaye ea (2009)

For the personnel costs we only include the cost of a driver – using a cost of 50 €/h. Other personnel costs are assumed to be included in the shunting costs.

On top of the above three cost elements, an overhead of 20% is assumed. The sum of these costs leads us to the average fixed operator cost as denoted in Table 9.

**Table 9: Average fixed operator costs**

| | container | | general cargo | | wet bulk | | dry bulk | |
|---|---|---|---|---|---|---|---|---|
| | diesel | electric | diesel | electric | diesel | electric | diesel | electric |
| average fixed costs (€/h) | 178.56 | 179.82 | 144.26 | 145.52 | 146.06 | 147.32 | 151.76 | 153.02 |

Source: Delhaye ea (2009)

The average variable costs include the infrastructure fee and the shunting costs. The infrastructure fee of today varies considerably between different European countries and it is not possible to make a comparison. Even within one country, the infrastructure fee will vary from path to path and from train to train. We assume that the infrastructure fee is equal to 3.3 €/trainkm. This might be somewhat overestimated today, but it is believed that the future infrastructure fee will attain this level. The order of magnitude is realistic as an example for Belgium shows that for a given path the infrastructure fee was equal to 2.32 €/trainkm[8].

For the shunting costs, we assume a cost of 411.65 €/train for diesel and electric trains, including the personnel costs. In order to get a cost per trainkm, we assume that the average international trip is about 1000 km long. Possible additional shunting costs for electric trains related to the first and the last km are not included as this requires detailed information on the possibilities of each relevant shunting station.

The sum of the infrastructure fee and the shunting cost gives us the average variable cost, as shown in Table 10

**Table 10: Average variable operator costs**

| | container | | general cargo | | wet bulk | | dry bulk | |
|---|---|---|---|---|---|---|---|---|
| | diesel | electric | diesel | electric | diesel | electric | diesel | electric |
| average variable cost (€/trainkm) | 3.71 | 3.71 | 3.71 | 3.71 | 3.71 | 3.71 | 3.71 | 3.71 |

Source: Delhaye ea (2009)

For the energy cost we have applied a cost model, TransCar, that gives for an exogenous crude price the expected diesel price and electricity price for freight rail traction. Today, the oil price is about $72 per barrel[9]. Other major assumptions used in this model are

- electricity is produced with a new power station running on natural gas
- spread between diesel and crude oil is stable
- natural gas prices stand in fixed proportion to crude oil prices.
- $CO_2$ permits are needed for natural gas and for diesel

Using this model allows us to use the forecasts on energy prices used within the iTREN baseline to derive the expected energy cost for future years. Table 11 shows the result for the average energy cost today.

**Table 11: Average variable operator costs for energy**

| | container | | general cargo | | wet bulk | | dry bulk | |
|---|---|---|---|---|---|---|---|---|
| | diesel | electric | diesel | electric | diesel | electric | diesel | electric |
| electric kWh or diesel liter per km | 7.11 | 27.43 | 4.81 | 19.29 | 5.38 | 22.86 | 8.66 | 44.54 |
| cost per kWh or per litre (€) | 0.64 | 0.09 | 0.64 | 0.09 | 0.64 | 0.09 | 0.64 | 0.09 |
| Average energy cost (€/trainkm) | 4.55 | 2.47 | 3.08 | 1.74 | 3.44 | 2.06 | 5.54 | 4.01 |

Source: own calculations

Taking into account the transportation mix for different goods, we can derive the railcosts per good type (NSTR classification). The result is shown in Table 12. The differences between the different classes of goods are due to the different way these goods are transported – rather in bulk or more in containers. The way the goods are transported influences the price of the wagons

[8] Billieu (2010)

[9] www.oil-price.net

and the number of wagons one locomotive can pull. Note that we do not take into account that on certain (hilly) routes an additional pushing locomotive might be needed.

**Table 12: Cost of rail transport (€/h and €/trainkm)**

| | Electric traction | | | Diesel traction | | |
|---|---|---|---|---|---|---|
| | average fixed costs (€/h) | average variable cost (€/trainkm) | average energy cost (€/trainkm) | average fixed costs (€/h) | average variable cost (€/trainkm) | average energy cost (€/trainkm) |
| Agriculture Products and Live Animals | 165.85 | 3.71 | 3.04 | 164.59 | 3.71 | 4.84 |
| Foodstuffs and Animal Fodder | 166.42 | 3.71 | 3.24 | 165.16 | 3.71 | 5.05 |
| Solid Mineral Fuels | 153.02 | 3.71 | 4.01 | 151.76 | 3.71 | 5.54 |
| Crude Oil | 147.32 | 3.71 | 2.06 | 146.06 | 3.71 | 3.44 |
| Ores and Metal Waste | 153.02 | 3.71 | 4.01 | 151.76 | 3.71 | 5.54 |
| Metal Products | 166.42 | 3.71 | 3.24 | 165.16 | 3.71 | 5.05 |
| Crude and Manufactured Minerals, Building Materials | 153.02 | 3.71 | 4.01 | 151.76 | 3.71 | 5.54 |
| Fertilizers | 147.32 | 3.71 | 2.06 | 146.06 | 3.71 | 3.44 |
| Chemicals | 163.57 | 3.71 | 2.26 | 162.31 | 3.71 | 4.00 |
| Machinery, Transport Equipment, Manufactured Articles And Miscellaneous Articles | 162.67 | 3.71 | 2.10 | 161.41 | 3.71 | 3.81 |
| Petroleum Products | 147.32 | 3.71 | 2.06 | 146.06 | 3.71 | 3.44 |

Source: own calculations based on Delhaye ea (2009)

For the development of the model in the next chapter, it is more useful to have the costs stated before in €/vkm or per tonkm. This is done by dividing the fixed costs (per hour) by the speed. For 2010, we assume an average speed of 62.48 km/h[10]. Note that in the policy scenarios, speed will be treated as a parameter which can be changed. This leads to the costs in €/tonkm as shown in Table 13.

[10] Source: TREMOVE model

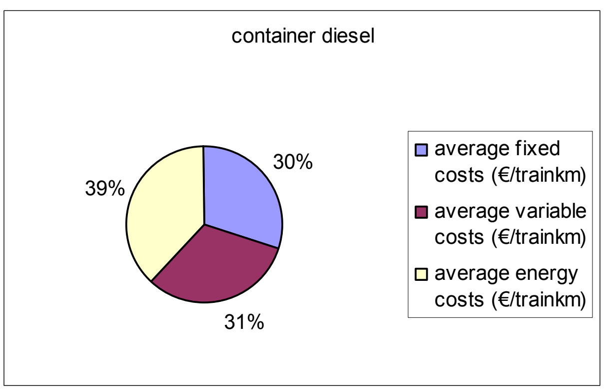
**Table 13: Costs rail transport in €/tonkm -2010**

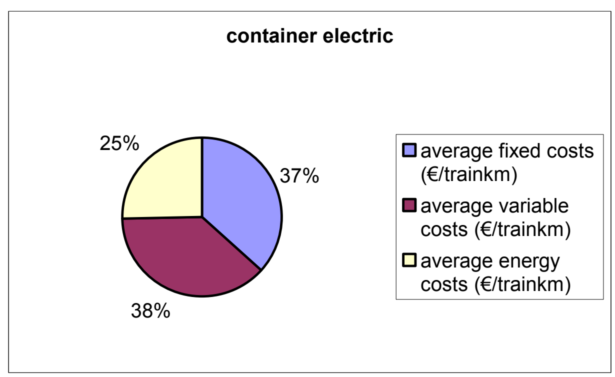
| | | electric | diesel |
|---|---|---|---|
| 0 | Agriculture Products and Live Animals | 0.0066 | 0.0078 |
| 1 | Foodstuffs and Animal Fodder | 0.0067 | 0.0079 |
| 2 | Solid Mineral Fuels | 0.0060 | 0.0068 |
| 3 | Crude Oil | 0.0048 | 0.0056 |
| 4 | Ores and Metal Waste | 0.0049 | 0.0056 |
| 5 | Metal Products | 0.0067 | 0.0079 |
| 6 | Crude and Manufactured Minerals, Building Materials | 0.0060 | 0.0068 |
| 7 | Fertilizers | 0.0048 | 0.0056 |
| 8 | Chemicals | 0.0061 | 0.0072 |
| 9 | Machinery, Transport Equipment, Manufactured Articles And Miscellaneous Articles | 0.0081 | 0.0096 |
| 10 | Petroleum Products | 0.0048 | 0.0056 |

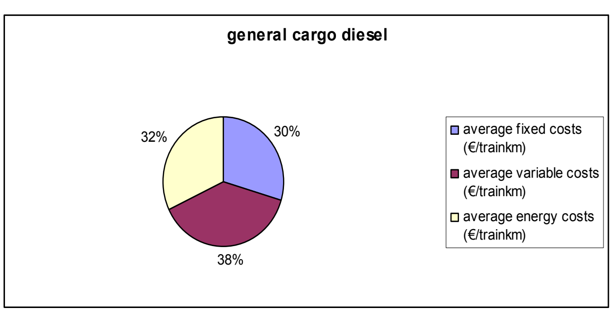
Source: own calculations

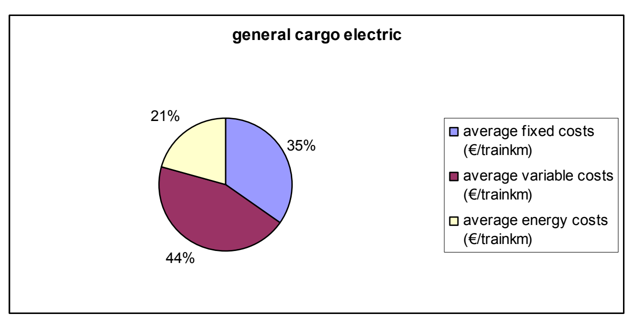
When we consider the cost break down, as shown in the figures below, we see that for rail we should distinguish between diesel and electric traction. For diesel traction, the energy cost is the most important with 39% of the total costs. For electric traction, the energy cost is the least important with only 25% of the total costs. Note that for dry bulk, the energy costs are the highest – also for electric traction, while for wet bulk and general cargo, the main cost element are the average variable costs.

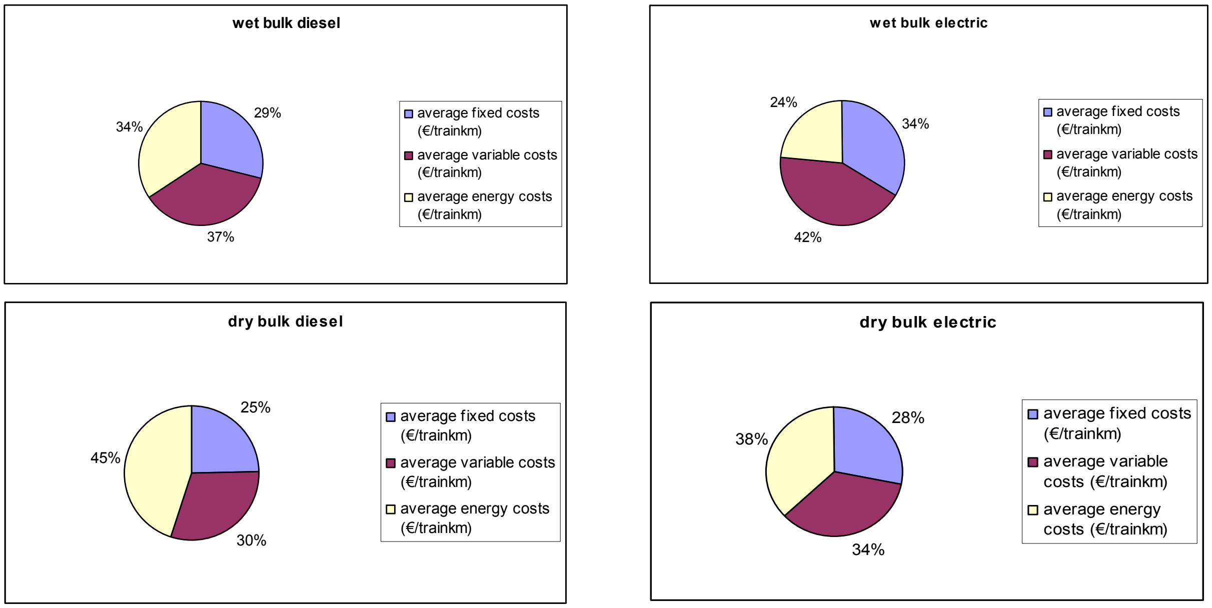
**Table 14: Cost break down for rail**






Source: own calculations

For reasons of simplicity we use one average cost function for each European country, for the average power source mix. The average division in energy consumption in Europe is based on data retrieved from Eurostat[11], which gives detailed information on the number of vkm of freight rail using different types of energy. On average, today, 32% of all freight rail traffic happens with diesel; 68% with electric traction. The table below then shows the costs figures that will be used later on in the analysis.

**Table 15: Average cost rail (€/tonkm) – year 2010**

| | | Average cost (€/tonkm) |
|---|---|---|
| 0 | Agriculture Products and Live Animals | 0.0070 |
| 1 | Foodstuffs and Animal Fodder | 0.0071 |
| 2 | Solid Mineral Fuels | 0.0063 |
| 3 | Crude Oil | 0.0051 |
| 4 | Ores and Metal Waste | 0.0051 |
| 5 | Metal Products | 0.0071 |
| 6 | Crude and Manufactured Minerals, Building Materials | 0.0063 |
| 7 | Fertilizers | 0.0051 |
| 8 | Chemicals | 0.0064 |
| 9 | Machinery, Transport Equipment, Manufactured Articles And Miscellaneous Articles | 0.0086 |
| 10 | Petroleum Products | 0.0051 |

Source: own calculations

[11] Eurostat (2010); Hauled vehicle movements by source of power, data retrieved 01/07/2010

#### b Expected evolution in costs

We assume that the costs of rail will remain constant in real terms over time. The only exception is that we could allow for a policy in which the infrastructure fee is increased with an externality tax equal to 0.005 €/tonkm in 2020 and 0.010 €/tonkm in 2030[12]. Based on the actual difference in emissions by diesel and electric trains, and assuming a stepwise introduction of this tax, the following taxes can be applied:

**Table 16: Externality tax**

| | diesel | electric |
|---|---|---|
| year 2020 (€/tonnekm) | 0.008 | 0.0035 |
| year 2030 (€/tonnekm) | 0.016 | 0.007 |

Source: own calculation based on ASSESS

If information is available on the expected shares with respect to traction, this could also be included in the analysis.

### 2.3.3 Road

#### a Current cost breakdown

For the road costs, we rely on the information available within the TREMOVE model. This model gives detailed information on the cost structures for trucks. Costs and taxes vary between different European countries. As for rail, we will use a European average – weighted at the number of tonkm. We do not distinguish between different distance classes. However, for longer distances (over 500 km) additional costs might occur linked to compulsory rest periods[13] or the use of two drivers to allow for non-stop road haulage service. The latter costs are not included in the costs – leading to an underestimation of (especially labour) costs for longer distances.

For road we make a distinction between taxes and costs and more specifically between

- repair costs
- purchase costs
- labour costs
- labour tax costs
- insurance cost
- fuel cost
- registration tax
- ownership tax
- network tax
- insurance tax
- fuel tax

[12] ASSESS study (2005)

[13] Regulation (EC) No 561/2006 of the European Parliament and of the Council of 15 March 2006 on the harmonisation of certain social legislation relating to road transport and amending Council Regulations (EEC) No 3821/85 and (EC) No 2135/98 and repealing Council Regulation (EEC) No 3820/85 (Text with EEA relevance) - Declaration

The table below shows these costs and taxes in euro per tonkm for a truck >32 tons. Given the scope of the study – international transport and possible modal shifts to and from SSS, this type of truck seems to be the most relevant.

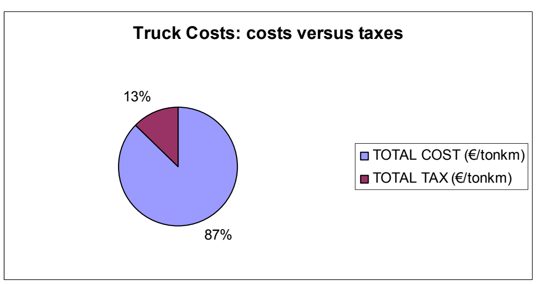
**Table 17: Costs road – truck >32 tons**

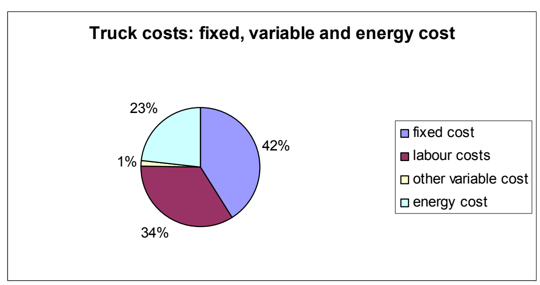
| €/tonkm - EU average | |
|---|---|
| COST (€/tonkm) | |
| repair | 0.0098 |
| purchase | 0.0241 |
| labour tax | 0.0184 |
| labour | 0.0172 |
| insurance | 0.0064 |
| fuel | 0.0154 |
| TAX (€/tonkm) | |
| registration | 0.0001 |
| ownership | 0.0017 |
| network | 0.0016 |
| insurance | 0.0011 |
| fuel | 0.0090 |
| TOTAL | 0.1046 |

Source: TREMOVE

When we consider the cost breakdowns – shown in the figures below – we see that about 13% of the road freight costs consist of taxes. When we split the cost up into fixed costs, labour costs, other variable costs and energy costs we see that – on average - about one third of the costs are labour costs. For longer distances, the share of the labour costs would be higher. The energy cost is about 23% of total costs.

**Figure 22: Cost break down road transport**




### b Expected evolution in costs

For the expected evolution in costs we take over the assumptions within the TREMOVE baseline – version 3.3 which corresponds to the iTREN baseline scenario. A list of the policies included can be found in Table 21 in chapter 3. It is important to take into account these policies as some of them, for example ecodriving, will have a direct effect on the users' cost. As one can see from the table below, total costs will slightly decrease over the years. As taxes remain rather constant, this is due to a decrease in the cost and more specifically in the fuel costs due to efficiency improvements of the engines.

**Table 18: Expected cost evolution road transport (truck >32 tons)**

| COST (€/tonkm) | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| repair | 0.0098 | 0.0093 | 0.0093 | 0.0094 | 0.0095 |
| purchase | 0.0241 | 0.0225 | 0.0224 | 0.0226 | 0.0228 |
| labour tax | 0.0184 | 0.0168 | 0.0168 | 0.0169 | 0.0169 |
| labour | 0.0172 | 0.0157 | 0.0157 | 0.0158 | 0.0158 |
| insurance | 0.0064 | 0.0062 | 0.0063 | 0.0064 | 0.0066 |
| fuel | 0.0154 | 0.0119 | 0.0124 | 0.0130 | 0.0132 |
| TAX (€/tonkm) | | | | | |
| registration | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| ownership | 0.0017 | 0.0015 | 0.0015 | 0.0014 | 0.0014 |
| network | 0.0016 | 0.0016 | 0.0033 | 0.0033 | 0.0032 |
| insurance | 0.0011 | 0.0010 | 0.0011 | 0.0011 | 0.0012 |
| fuel | 0.0090 | 0.0081 | 0.0079 | 0.0077 | 0.0076 |
| | | | | | |
| TOTAL COST (€/tonkm) | 0.0913 | 0.0825 | 0.0830 | 0.0841 | 0.0848 |
| TOTAL TAX (€/tonkm) | 0.0134 | 0.0123 | 0.0138 | 0.0135 | 0.0134 |
| TOTAL (€/tonkm) | 0.1046 | 0.0947 | 0.0968 | 0.0976 | 0.0982 |

source: TREMOVE

### 2.3.4 Comparison of costs between modes

Comparison between costs is not straightforward as costs were derived from different sources and as costs for SSS vary largely between vessel types and distance covered. From the costs found, it seems that in general rail and SSS are cheaper than road – although the 'maximal' price for RoPax Small of (about) 0.09 €/tonkm is close to the costs of road – about 0.1 €/tonkm. Moreover, when we consider modal shares in the EU 27[14] – road had a modal share of 45,6%, SSS 37,3% and rail only 10,5% - it is clear that other factors than costs also play a role. The most important factor according to our survey – apart from the costs – is the speed of the transport. Therefore, our model will also include the time cost and hence the speed of the transport modes.

When we consider the relative importance of the fuel costs we note that:

- for SSS the share of the fuel costs vary between 10% (small RoPax) and 47% (LoLo)
- for diesel rail the share of the fuel costs vary between 32% (general cargo) and 45% (dry bulk)
- for road the fuel share is about 23%.

Note that the costs described above focus on the actual cost of transporting a good[15]. Schedule delay costs, the costs of transhipments, the costs of storage, etc. are not included. These costs are of particular interest for modes such as SSS and rail and would hence decrease the cost difference with the road mode. In the sensitivity analysis we will show how the results may change if we introduce – in a simplified manner - these type of costs into the model. Due to lack of general data it was not possible to include these costs explicitly into the model.

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14 DG MOVE, EU-27 Modal split of freight transport in percentage

15 Although the cost of loading and unloading is included in the price per tonkm for SSS

# 3 Scenario analysis

The goal of this chapter is to analyse the effect of different scenarios on the competitive position of SSS compared to road and rail. This chapter therefore first discusses the scenario development. Next, the quantitative analysis, including the development of the model, the cost effect of the policies and the results of the modelling exercise are discussed. Finally, this quantitative analysis is complemented with a qualitative assessment.

## 3.1 Scenario development

When building a scenario one can make a distinction between elements which should be taken as a given and elements which can be part of a policy. Given the focus of this study, elements which are taken as a given include GDP, oil prices, population, etc… These elements are included in a so called '*background scenario'*. Note that it is possible to have different background scenarios – for example by assuming different economic growth paths.

Elements which can be influenced are typically part of the "*policy scenarios*". One important policy scenario is the *baseline*. This baseline consists of the policies which are already decided on and to which other policy scenarios will be assessed. The other policy scenarios then contain the policies of which one wants to know the effect. In this section we first explain the background scenario, next we discuss the baseline. In a final section we discuss the policies and the policy scenarios.

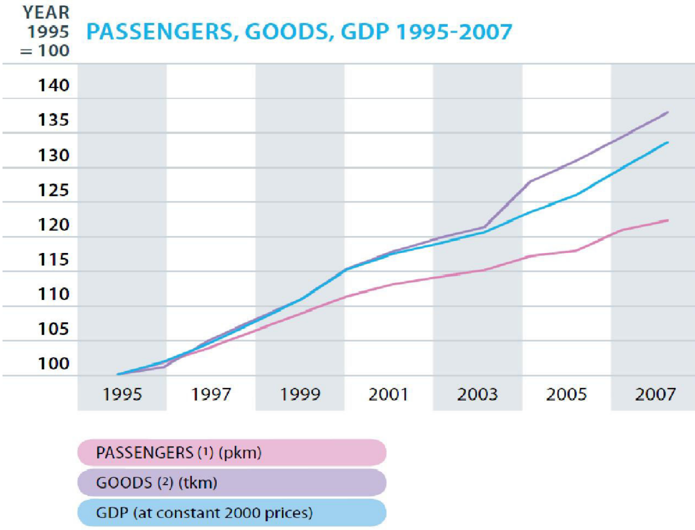
### 3.1.1 Background scenario

In the background of policy decisions is the global economy, which is more often than not controlled by forces too great to be readily manipulated by policy makers. A number of dimensions can thus be seen as exogenous (but possibly interconnected).

#### a GDP

The main relevant dimension for the COMPASS project is probably GDP growth. A link between GDP evolutions and the transport market has been extensively demonstrated in literature as well as statistics (Figure 23).

**Figure 23: Passengers, goods and GDP, 1995-2007**




Source: Statistical pocketbook DG TREN 2009

Several EC projects have looked into GDP evolutions over the past years, some of which also made the connection to transport and different transport modes (e.g. TRANSVISION). To assure consistency between this and related projects, we have opted to stay within GDP and transport projections that have been made within DG MOVE and DG ENV. Transport & Mobility Leuven was involved in the iTREN-2030 project for DG MOVE[16], which set up a harmonized baseline between 4 of the main models used in EC transport research: TRANSTOOLS, ASTRA, POLES and TREMOVE. At the starting point of the COMPASS study, the FP6 iTREN research project, under the auspices of DG TREN (now DG MOVE) was meant to deliver a common starting point for future studies on transport, and hence was chosen as the reference for the COMPASS project's background scenario.

The "Integrated" scenario in iTREN (INT) accounts for the recent crisis. The model used to estimate GDP evolutions is ASTRA. The projections for GDP are as follows:

[16] http://ec.europa.eu/research/fp6/ssp/itren_2030_en.htm

**Table 19: Expected GDP evolution**

| GDP evolution | 2005-2010 | 2010-2020 | 2020-2030 | 2010-2030 |
|---|---|---|---|---|
| EU27 | 0.3% | 1.9% | 1.1% | 1.5% |
| EU15 | 0.3% | 1.8% | 1.0% | 1.4% |
| EU12 | 1.1% | 3.6% | 2.6% | 3.1% |

Source: iTREN

Country-level projections are available in iTREN D5.[17]

#### b Fuel price

As fuel is one of the main cost components for all transport modes, price changes can have a significant impact on the eventual demand for transport. Though highly subject to short term variations, projections in the medium to long term are essential to any transport scenario.

The iTREN integrated scenario (INT) also made estimates of oil price evolution, using the POLES model. These are relative annual changes, not including inflation, at the price level of 2005.

**Table 20: Expected Oil price evolution (in $€_{2005}$)**

| Oil price evolution | 2005-2010 | 2010-2020 | 2020-2030 | 2010-2030 |
|---|---|---|---|---|
| EU27 | 15.9% | -1.7% | 1.4% | -0.1% |

Source: iTREN

This evolution is supported by the following rationale[18]:

"After more than a decade of cheap oil at around 20 US$/barrel, prices have steeply risen to peak at about 150$/bbl in 2008. After 2008, fossil fuel prices decreased, supported by the global economic downturn, to less than 50$/bbl. Currently they are rising again to 80$/bbl based on better economic outlooks and expected oil demand.

There is a general consensus among the experts that the rise of energy prices should be regarded as a structural condition due to the foreseeable trend of demand and supply. The rising demand from fast developing regions and uncertainty about the future availability of cheap resources suggest that crude oil prices will not fall back to the low levels observed before 2007. It is therefore assumed that they rise from present prices and then remain at high levels at around 80 €2005/bbl in 2020 and almost 90 €2005/bbl in 2030. The oil price in the INT Scenario follows the trend in the IEA World Energy Outlook (WEO). The WEO projects an oil price of around 74 €2005/bbl in 2020 and 85 €2005/bbl in 2030 [IEA, WEO 2009]."

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[17] http://isi.fraunhofer.de/isi-de/projects/itren-2030/download/iTREN_2030_D5_Integrated_Scenario.pdf
[18] iTREN Deliverable 5, 5.11, p.95

It could be argued that fuel price is not just a background variable to transport, as it generates an important part of the demand. However, within a limited interval, demand changes do not have a significant impact on fuel prices.

#### c Other

Other dimensions can be identified as variables for the scenarios, e.g. population size and age structure, employment,… However, their impact on the subject of this study, i.e. the competitiveness of Short Sea Shipping, is not expected to be significant enough to justify incorporating them in the scenarios.

### 3.1.2 Policy scenarios

In any kind of prospective policy analysis, particularly when wider scopes and longer time horizons are considered, the use of scenarios gives a better insight into the policy's overall effects, and the sensitivities it faces. Therefore, in the COMPASS project, five policy scenarios are to be developed apart from a baseline scenario. In this section we first discuss the baseline and then turn to the policy scenarios.

#### a Baseline scenario

For the baseline scenario we use the policies included within the iTREN projects. This allows us to use the growth rates for the different modes in the EU as a base for the projection of transport volumes on the selected origin-destination pairs. The following table shows which policies are included in the iTREN integrated scenario.

**Table 21: Policies included in the baseline scenario**

| Sector | Content | Period | Level |
|---|---|---|---|
| Emission | Fuel quality directives | 1994, 1996, 2000, 2005, 2009-2030 | Base: CEN |
| Emission | NEC directives | 2004-2030 | Based on directive 2001/81/EC |
| Emission | Eco driving by driver training and GSI | 2008-2030 | Assumed similar % of new sold road vehicles with GSI, % fuel consumption reduction, % of vehicle purchase cost increase |
| Vehicle | Euro V | 2012-2030 | Euro V |
| Vehicle | LPG, CNG cars | 2008-2030 | |
| Vehicle | Euro 5, 6 for cars | 2009, 2014 | NOx, PM target |
| Vehicle | Euro 5, 6 for LDV | 2010, 2015 | NOx, PM targets |
| Emission | Yearly 1% Improvement of HDT fuel efficiency ($CO_2$ emission) | 1997-2030 | ACEA suggestion |
| Transport | User charging trucks implemented as road charges on interurban network (not only motorway) | 2020-2030 | Country based values, depending on Greening transport package proposal |
| Transport | User charges cars implemented as road charges on interurban network (not only motorway) | 2025-2030 | Country based values based on truck charges and ratio between car and truck marginal costs |
| Transport | Harmonisation of fuel prices (resources cost, excise duty, vat) | whole | POLES level |
| Transport | City tolls | 2025-2030 | 0.357€/vkm for peak period (pk) |
| Transport | Liberalisation: 3rd railway package (gradual opening up of int. rail services to competition) | 2010-2030 | -2% of rail passenger costs (source: quantification in the ASSSESS) |
| Vehicle | Binding $CO_2$ emission targets for cars | 2009-2030 | 2012-135<br>2015-130<br>2020 to 2030-105<br>*supplementary measures (LRRT, LVL,...) are applied so that the targets decrease furthermore by 10 gr/km to reach:<br>2012-125<br>2015-120<br>2020 to 2030-95 |
| Vehicle | Binding $CO_2$ emission targets for LDV | 2009-2030 | LDV:<br>2012-181<br>2016-175<br>2020 to 2030-135 |

Source: iTREN

Very few of these policies affect the SSS transport market, e.g. no mention is made of maritime ETS for $CO_2$, NOx or SOx.

It is important to know which policies are already decided on and hence belong to the baseline and the policies of which one wants to analyse the effect. For example, the decision to have a lower sulphur level in maritime fuel is already decided on and hence belongs, in theory, to the baseline scenario. However, we want to assess the effect of this decision, so it should not be included in the baseline but in a policy scenario. Hence, no specific SSS policies are included in the baseline.

### b Policy scenario's

In this section we describe the policies which will be included in the quantitative analysis. The effect that these policies have on the cost structure of SSS is described in a subsequent section.

#### b.1 Policy 1: MARPOL

Until 2010, Annex VI to MARPOL 73/78 limited the sulphur content of marine fuel oil to 1.5% per mass and applies in designated SOx Emission Control Areas (SECA). The SECAs include the Baltic Sea, the North Sea Area and the English Channel. A new provision for the further reduction of sulphur content of marine fuels specifies a maximum sulphur content of 1.0% by 2010 and 0.1% by 2015. This policy implies a maximum sulphur content of marine fuels of 0.10% (by mass) for the SECAs and 3.50 % outside the SECAs starting in 2015. In the baseline, a sulphur content of 1.50% in the SECA and 4.50% outside the SECA is considered.

#### b.2 Policy 2: eMaritime

The EU eMaritime initiative is aimed at fostering the use of advanced information technologies for working and doing business in the maritime sector. It deals not only with the interoperability of electronic systems but with processes and the human element. It is recognised that the most important challenges relate to organisational aspects and managing the change, DG MOVE (2010).

The ultimate goal of e-Maritime is to make maritime transport safer, more secure, more environmentally friendly and more competitive by improving knowledge, facilitating business networking and dealing with externalities.

The suggested approach for the e-Maritime initiative is the development of an e-maritime Strategic Framework and Service Oriented Architecture providing a coherent view of the way Maritime Transport could operate at some future date.

The Main Measures are as follows:

- M1: Guidance, support, best practices, information on benefits of interoperable ICT systems
- M2: Actions to define e-maritime standards
- M3: Measures to support the implementation of National Single Windows or European Single Window

- M4: Measures to support stakeholders in implementing the necessary eMaritime ICT infrastructure

Proposed support measures are:

- M5: Actions to support the intelligent use of data
- M6: Actions to optimise traffic in and around ports
- M7: Actions to support e-services fro seafarers
- M8: Measures to support ship-shore broadband communication

It is expected that this initiative will reduced delays in ports through more efficient documentation submission and review processes, and, improved coordination of inspections by authorities. This initiative promises to offer numerous benefits to national authorities, however, that impact is outside the remit of this study.

b.3 Policy 3: GHG policy

Different options exist to reduce GHG emissions from maritime transport. CE Delft (2009) investigated 5 policy instruments

- a cap and trade system for maritime transport emissions
- an emission tax with hypothecated revenues
- mandatory efficiency limits per ship in European ports
- baseline and credit system based on efficiency index
- voluntary actions

In this analysis the focus lies on market based instruments – hence on the first two instruments.

An emission cap-and trade system in maritime transport could either be closed (i.e include only maritime emissions) or open (i.e including more sectors). An open system can be integrated in an existing system such as the EU ETS or be a self-standing system linked to other systems by for example mutual recognition of emissions allowances.

An emission tax would require ships or ship operators to pay a tax on emissions. The environmental effectiveness of this measure depends on the way revenues are spent. The revenues can be used for mitigating emissions in the shipping sector or in other industries or it can be included in the fiscal budget. We assume that the revenues are earmarked for climate change mitigation. Different designs are possible and are discussed in the CE Delft study (2009).

As both instruments lead in theory to the same result and as there is no decision on the exact instruments we will assume that the same approach as used with the airline industry will be extended to shipping and use the first option - a cap and trade system - for the analysis of a GHG policy.

b.4 Policy 4: extension ECA to all European seas except Atlantic Coasts

This policy implies that the Sulphur regulation of 0.1% will be in force for all European Seas except the Atlantic Coast.

b.5 Policy 5: Inclusion of NOx into the ECA regulation (NECAs)

This policy incorporate the cost impact of the application of Tier III standards for ships constructed on or after 1 January 2016 and sailing in the Baltic Sea, North Sea/English Channel and/or Mediterranean Sea applies. The other – existing- ships are assumed to be of the TIER I or TIER II standard. The table below shows the difference between the different standards.

**Table 22: NOx emission limits (g/kWh) with n=engine maximum operating speed**

| TIER | Date | n<130 | 130≤n<2000 | n≥2000 |
|---|---|---|---|---|
| TIER I | 2000 | 17 | $45*n^{-0.2}$ | 9.8 |
| TIER II | 2011 | 14.4 | $44*n^{-0.23}$ | 7.7 |
| TIER III | 2016 | 3.4 | $9*n^{-0.2}$ | 1.96 |

Source: www.dieselnet.com

Using these five policies we constructed 5 policy scenarios:

- Policy scenario A: Sulphur regulation of 0.1% in the ECAs
- Policy scenario B: Sulpur regulation of 0.1% in the ECAs + eMaritime
- Policy scenario C: Sulphur regulation of 0.1% in the ECAs + eMaritime +GHG policy
- Policy scenario D: Sulphur regulation of 0.1% in all European seas except the Atlantic Coast + eMaritime +GHG policy
- Policy scenario E: Sulphur regulation of 0.1% in all European seas except the Atlantic Coast + eMaritime +GHG policy + NOx regulation in ECAs

### 3.2 Quantitative analysis

Given the specific focus on SSS, we have developed a model which takes into account the relevant drivers for modal choice between road, rail and SSS. The idea is that firms choose the cheapest option, minimising both monetary and time costs, under certain constraints. We will model the choice using Constant Elasticity of Substitution functions and link emission factors to the outcomes of the model.

#### 3.2.1 Model structure

We have made a small network model which allows for the analysis of possible modal shifts between SSS, road and rail for the selected OD's. Mode choice is modelled with a Constant Elasticity of Substitution (CES) tree. Given the modal choices, emissions are calculated using emission factors.

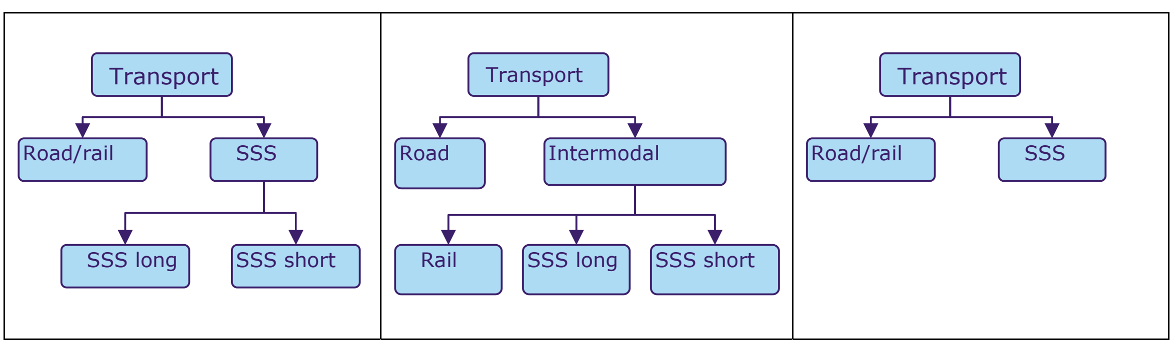
In CES functions, the elasticity of substitution is supposed to be constant, whatever the initial bundle of goods that is considered. The higher this elasticity, the better substitutes the modes are. The use of a CES function has several advantages:

- The assumption of constant elasticity of substitution is realistic for moderate changes in demand levels relative to the baseline
- They can be calibrated with a minimum of data: elasticities of substitutions and observed prices and quantities.
- They are a consistent aggregate of discrete choice behaviour when the number of decision makers is sufficiently large. Discrete choice behaviour is a commonly used approach to modelling choice between mutually exclusive alternatives, as is the case with transport.

A drawback of the CES functions is that their mathematical structure implies a constant elasticity of demand with respect to income. This makes them less suited for forecasting travel demand. However, we use forecasts for demand from outside the model. Hence, in this case, this is not a problem.

The model structure can be tailored to each OD as not all options are feasible for each route. Different outlines are possible. Some examples are show in the figures below.

**Figure 24: Possible outlines of the model**




The first figure shows a nested tree function in which the firm first chooses between the option "road/rail" and the option "SSS". "Road/Rail" means that a truck is used all the way from origin to destination without including a short sea section. For some links there is a combination with rail, for example the Channel tunnel. "SSS" means that a combination of road and SSS is opted for. Within this option, the firm can then choose whether to go for a long SSS part and a short road part or vice versa. This structure is most relevant in cases where RoRo is considered. In figure 2 the first choice is to go intermodal or not. Once this choice is made, rail is – for certain routes – also an option. This structure is most relevant for transport of bulk – and to a lesser extent - for container transport. The first two figures show so called nested CES trees while the last figure shows a flat CES-tree in which – on the same level, a choice is made between the different modes. A nested CES tree has the advantage that substitution possibilities are better modelled, but the disadvantage that it also requires more information on the substitution elasticities at each level. The last figure shows the setup we will use in modelling exercise. For each OD we define two options: a road option and a SSS option. The road option stands for the option where road counts for the most km, but also rail and SSS (over short distances) are used. The SSS option stands for the combination of road and SSS transport, but in which SSS is the most important mode.

Within the set-up of the baseline, the lower nodes of the tree need to be fed with both transport quantities, transport prices and the elasticity of substitution. The quantities are described in the previous chapter. The relevant transport price which is the base for the choices of firms is the generalised price of the transport types and is discussed in the next paragraph.

### a Generalised price

Transport demand and modal choice is derived from the user price and user price differences. The generalised price is the input for the lowest level of all branches in the (nested) production function. It depends on the transport policy and indirectly also on the transport quantities – for example in the case of congestion.

The generalised price is the sum of three elements:

- Costs; this is the price producers receive.
- Tax or subsidy; in this case the taxes for road transport
- Time cost

All per km or tonkm travelled.

The first two elements were discussed in the previous chapter. Hence, in this section we focus on the time cost. The time cost in this model is equal to the cost of the in-vehicle time, multiplied by values of time in euro per hour or per tonhour. The in-vehicle time is determined by the speed, a parameter which can be changed in the scenarios[19]. The values of time are based on the values used within the TRANSTOOLS model and are shown in the table below. The values of time depend on the type of good, but not on the transport mode.

[19] In theory, a congestion function could be included. Speed would then be a function of transport volumes. We opted not to do this and use the predicted speed evolution used in the TREMOVE model, which does include a congestion function.

**Table 23: Value of time (€/ton/hour)**

| | | Euro / ton / hour |
|---|---|---|
| 0 | Agriculture Products and Live Animals | 0.0119 |
| 1 | Foodstuffs and Animal Fodder | 0.0124 |
| 2 | Solid Mineral Fuels | 0.0011 |
| 3 | Crude Oil | 0.0065 |
| 4 | Ores and Metal Waste | 0.0062 |
| 5 | Metal Products | 0.0086 |
| 6 | Crude and Manufactured Minerals, Building Materials | 0.0009 |
| 7 | Fertilizers | 0.0047 |
| 8 | Chemicals | 0.0281 |
| 9 | Machinery, Transport Equipment, Manufactured Articles And Miscellaneous Articles | 0.1350 |
| 10 | Petroleum Products | 0.0071 |

Source: TRANS-TOOLS model.

This value of time is transformed into a cost per km by dividing by the speed of the relevant vehicle. Table 24 shows the speeds which we will assume in the reference scenario and the policy scenarios. Note that the speed of road is assumed to decrease over time due to increasing volumes and hence congestion. This average speed does not take into account the driving rest regulation and hence overestimates the speed for longer distances. Note that if we assume a working week of 48 hours, a truck can do maximum 2900 km/week when applying these speeds. Due to policies increasing the interoperability of rail, the speed of freight rail is assumed to increase. The speed of SSS is kept constant – although changing the speed could be a way for operators to change their costs and emissions.

**Table 24: Assumed speeds (km/h)**

| | | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| **Road** | | 59.97 | 59.26 | 58.58 | 57.98 |
| **Rail** | | 62.48 | 64.07 | 65.67 | 65.7 |
| **SSS** | **LoLo** | 25.93 | 25.93 | 25.93 | 25.93 |
| | **RoRo** | 32.41 | 32.41 | 32.41 | 32.41 |
| | **RoPax Small** | 25.93 | 25.93 | 25.93 | 25.93 |
| | **RoPax Large** | 40.74 | 40.74 | 40.74 | 40.74 |

Source: TREMOVE & Review of Published Vessels Speeds

In order to determine the price per km for the options using a combination of road, SSS and/or rail, a weighted average has to be made as a SSS route will typically also include some 'before-and-after' transport via road. In order to determine the weights, we attached the length of the different route sections for all origin-destination pairs and for all route sections. For road we used

Google maps as a source, for SSS we used the routes shown in Figure 8 and for rail we relied mostly on the infrastructure maps available in the relevant network statements. These distances also allow us to calculate the total price for each origin-destination and for each option.

#### b Elasticities

The use of CES functions requires the input values of substitution elasticity values. We will assume that these values are equal for all countries and all years. We use an elasticity of substitution of 0.5. The SKEMA deliverable – task 1(2009) showed that elasticities differ not only with respect to the type of good, but also with the type of change – in costs, distance, speed and time. In our model we can differentiate the substitution elasticity with the type of good, but not with the type of change. The own price elasticity, which is not an input but an output of our model, is around 0.5[20].

#### c Calibration of the model

Using a CES function, allows us to write the transport volumes using the following equation:

$$q_i = \frac{\left(\frac{\alpha_i}{gp_i}\right)^{\sigma} Y}{\alpha_i^{\sigma} gp_i^{1-\sigma} + \alpha_j^{\sigma} gp_j^{1-\sigma} + \alpha_k^{\sigma} gp_k^{1-\sigma}}$$

Where

$q_i$, the volume of mode i

$\alpha_i$, Keller's alpha for mode i

$gp_i$, the generalised price for mode i

$\sigma$, the elasticity of substitution

Y, the total budget spent on transport, equal to $\sum_{x=i...k} gp_x q_x$

Keller's alpha $\alpha_i$ is indexed to the lower level and sums to 1 for all adjacent nodes with the same associated node one level up. In the case of a flat CES tree, this means that $\sum \alpha_x = 1$

During the calibration, we use the information on current generalised prices, volumes and elasticities to derive Keller's alpha for all modes. Once this variable is known, we can change the generalised price in the simulation, and by using the equation above calculate the effect on volumes. As a result we get the effect on tonkm. A decrease in tonkm can be interpreted as a decrease in the number of tons transported, or a decrease in the number of km or both. This should be seen within the whole logistic process. In the short run, loading factors could increase, transport flows could become more combined, etc. In the long run, logistic centres and/or production centres might change location – although given the share of transport costs in total production costs this seems less likely. Our model does not allow for modelling this type of

[20] The price elasticity is a measure which shows the responsiveness (or elasticity) of the quantity demanded of a good/service is to a change in its price. More precisely, the own price elasticity gives the percentage change in quantity demanded in response to a one percent change in price (holding constant all the other determinants of demand, such as income). The elasticity of substitution is the change in demand for that good with respect to the change in the price of some other good, i.e. a complementary or substitute good.

logistic changes, it merely predicts the expected effect on tonkm assuming that the total budget spent on transport remains fixed over the policies[21]. This is a typical assumption in this type of models as the focus lies on modelling modal shifts ceteribus paribus.

This approach also implicitly assumes that demand is lower than supply and hence that all cost increases are passed through to the consumer. If the costs are not passed, this means that the profit of the shippers would decrease, but there would be no – or a smaller - effect on modal shifts, etc.

### d Emission module

Given the vkm or tonkm from our model, we can calculate the effect on emissions. This will be done by using emission factors. The emission factors only include the direct emissions. The emissions from well-to-tank[22] are not included. Note that some policies, such as sulphur requirements will directly impact these emission factors. If this is the case, the emission factors will be changed accordingly. Other policies will only have an indirect impact on emissions, for example, by lowering total demand.

We consider the following pollutants:

- VOC
- $CO_2$
- NOx
- $SO_2$
- PM

The next paragraphs describe the emission factors used in the baseline and in the different policy scenarios for SSS, road and rail respectively.

#### d.1 <u>SSS</u>

As before we consider 4 types of ships

- a LoLo with a capacity of 600 TEU and 11000 DWT
- a RoRo with a capacity of 200 Trailers and 10000 DWT
- a small RoPax with a capacity of 40 Trailers and 3000 DWT
- a large RoPax with a capacity of 290 Trailers and 12000 DWT

For the **LoLo ship** we used the containership C2C SPICA as a reference ship as the main characteristics correspond. In Vanherle (2008) the fuel consumption and the emissions were calculated in detail for this ship. The results are shown in Table 25. Over the years emission

[21] This does not mean that the budget for transport is fixed over the time. As demand increases, transport flows increase and the total budget/amount spent for transport increases.

[22] Information on well-to-tank emissions are available within the TREMOVE model for road and rail, but we have no information on the well-to-tank emissions of SSS. To keep the comparison clear, we decided to exclude them for all modes.

factors are decreasing as we take into account certain policy measures and expected changes in the fleet composition. For the reference scenario the table below applies for a LoLo ship.

**Table 25: Emission factors for a LoLo ship for the years 2010, 2015, 2020, 2025 (kg/tonkm) in the reference scenario**

| EF (kg/km) | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.00001 | 0.00001 | 0.00001 | 0.00001 |
| CO2 | 0.01693 | 0.01693 | 0.01693 | 0.01693 |
| Nox | 0.00035 | 0.00034 | 0.00032 | 0.00031 |
| SO2 | 0.00014 | 0.00014 | 0.00014 | 0.00014 |
| FC | 0.00543 | 0.00543 | 0.00543 | 0.00543 |
| PM | 0.00002 | 0.00002 | 0.00002 | 0.00002 |

Source: own calculations based on Vanherle (2008)

Table 26 shows the emission factors assuming a 0.1% sulphur content. Note that decreasing the sulphur content also affects other pollutants such as VOS, PM – and to a smaller extend CO2. This is caused by the change in type of fuel.

**Table 26: Emission factors for a LoLo ship for the years 2010, 2015, 2020, 2025 (kg/tonkm) in the policy scenarios including policy 1**

| EF (kg/km) | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.00001 | 0.00001 | 0.00001 | 0.00001 |
| CO2 | 0.01693 | 0.01695 | 0.01695 | 0.01695 |
| Nox | 0.00035 | 0.00032 | 0.00030 | 0.00029 |
| SO2 | 0.00014 | 0.00001 | 0.00001 | 0.00001 |
| FC | 0.00543 | 0.00543 | 0.00543 | 0.00543 |
| PM | 0.00002 | 0.00001 | 0.00001 | 0.00001 |

Source: own calculations based on Vanherle (2008)

For the RoRo category we did not find a matching vessel in previous detailed emission studies. Therefore we matched the fuel consumption per day and the size of the ship with the categorisation available within the EMMOSS model. Using this model, we then determined the fuel consumption (in kg/km) and the emission factors, as shown in the tables below.

**Table 27: Emission factors for a RoRo ship for the years 2010, 2015, 2020, 2025 (kg/tonkm) in the reference scenario**

| EF (kg/tonkm) | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.00004 | 0.00003 | 0.00003 | 0.00003 |
| CO2 | 0.03309 | 0.03309 | 0.03309 | 0.03309 |
| Nox | 0.00086 | 0.00080 | 0.00076 | 0.00074 |
| SO2 | 0.00030 | 0.00030 | 0.00030 | 0.00030 |
| FC | 0.01063 | 0.01063 | 0.01063 | 0.01063 |
| PM | 0.00006 | 0.00006 | 0.00006 | 0.00006 |

Source: own calculations using the EMMOSS model

**Table 28: Emission factors for a RoRo ship for the years 2010, 2015, 2020, 2025 (kg/tonkm) in the policy scenarios including policy 1**

| EF (kg/tonkm) | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.00004 | 0.00003 | 0.00002 | 0.00002 |
| CO2 | 0.03309 | 0.03319 | 0.03319 | 0.03319 |
| Nox | 0.00086 | 0.00064 | 0.00061 | 0.00059 |
| SO2 | 0.00030 | 0.00002 | 0.00002 | 0.00002 |
| FC | 0.01063 | 0.01063 | 0.01063 | 0.01063 |
| PM | 0.00006 | 0.00003 | 0.00002 | 0.00002 |

Source: own calculations using the EMMOSS model

For the small RoPax vessel we used the same approach as for the RoRo vessel. Using EMMOSS we derived the following emission factors:

**Table 29: Emission factors for a small RoPax ship for the years 2010, 2015, 2020, 2025 (kg/km) in the reference scenario**

| EF (kg/tonkm) | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.00003 | 0.00003 | 0.00002 | 0.00002 |
| CO2 | 0.03062 | 0.03062 | 0.03062 | 0.03062 |
| Nox | 0.00073 | 0.00063 | 0.00053 | 0.00050 |
| SO2 | 0.00025 | 0.00025 | 0.00025 | 0.00025 |
| FC | 0.00982 | 0.00982 | 0.00982 | 0.00982 |
| PM | 0.00003 | 0.00003 | 0.00003 | 0.00003 |

source: own calculations using the EMMOSS model

**Table 30: Emission factors for a small RoPax ship for the years 2010, 2015, 2020, 2025 (kg/tonkm) in the policy scenarios including policy 1**

| EF (kg/tonkm) | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.00003 | 0.00002 | 0.00002 | 0.00002 |
| CO2 | 0.03062 | 0.03069 | 0.03069 | 0.03070 |
| Nox | 0.00073 | 0.00056 | 0.00047 | 0.00045 |
| SO2 | 0.00025 | 0.00002 | 0.00002 | 0.00002 |
| FC | 0.00982 | 0.00982 | 0.00982 | 0.00982 |
| PM | 0.00003 | 0.00002 | 0.00001 | 0.00001 |

source: own calculations using the EMMOSS model

The large RoPax could be matched, based on vessel size and fuel consumption with a ship like the ToR Petunia. Emissions for this vessel were calculated in detail in Notteboom ea (2010). The results are shown in Table 31 and Table 32.

**Table 31: Emission factors for a large RoPax ship for the years 2010, 2015, 2020, 2025 (kg/km) in the reference scenario**

| EF (kg/tonkm) | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.00004 | 0.00003 | 0.00003 | 0.00003 |
| CO2 | 0.03222 | 0.03222 | 0.03222 | 0.03222 |
| Nox | 0.00086 | 0.00077 | 0.00073 | 0.00073 |
| SO2 | 0.00030 | 0.00030 | 0.00030 | 0.00030 |
| FC | 0.01035 | 0.01035 | 0.01035 | 0.01035 |
| PM | 0.00006 | 0.00006 | 0.00006 | 0.00006 |

source: based on Notteboom ea (2010)

**Table 32: Emission factors for a large RoPax ship for the years 2010, 2015, 2020, 2025 (kg/tonkm) in the policy scenarios including policy 1**

| EF (kg/tonkm) | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.00004 | 0.00002 | 0.00002 | 0.00002 |
| CO2 | 0.03222 | 0.03232 | 0.03233 | 0.03232 |
| Nox | 0.00086 | 0.00061 | 0.00058 | 0.00058 |
| SO2 | 0.00030 | 0.00002 | 0.00002 | 0.00002 |
| FC | 0.01035 | 0.01035 | 0.01035 | 0.01035 |
| PM | 0.00006 | 0.00003 | 0.00003 | 0.00003 |

source: based on Notteboom ea (2010)

For policy 5 - the NOx regulation, we will assume that – following a linear replacement rate- a certain % of the ships complies with the TIER III standards. The other ships are assumed to be of the TIER I standard. The table below shows the emission factors for ships complying with the TIER III standards.

**Table 33: NOx emission factors for TIER III**

| Nox EF (kg/tonkm) | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| LoLo | 0.00035 | 0.00031 | 0.00026 | 0.00021 |
| RoRo | 0.00086 | 0.00062 | 0.00047 | 0.00037 |
| RoPax Small | 0.00073 | 0.00053 | 0.00031 | 0.00022 |
| RoPax Large | 0.00086 | 0.00056 | 0.00038 | 0.00030 |

Source: own calculations

The tables showed the emissions per tonkm. In order to come to emissions per tonkm we divided emissions per km through the loading as stated earlier. This also implies that if policies have an effect on the utilisation rate, the emission factor per TEU or tonkm will also change.

d.2 Road

We use the TREMOVE version 3.3. emission factors for road. These emission factors are based upon the COPERT IV emission calculation methodology. We use weighted European average emission factors – hence the factors take into account the average fleet composition, the average age, average EURO norm, the average network, etc. These emission factors, shown in the table below, also take into account the measures part of the baseline, discussed further on in this document.

**Table 34: Emission factors for truck >32 tons for the years 2010, 2015, 2020 and 2025 (g/tonkm)**

| g/tonkm | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.013 | 0.008 | 0.002 | 0.001 |
| CO2 | 62.792 | 57.812 | 52.833 | 50.725 |
| Nox | 0.547 | 0.408 | 0.269 | 0.154 |
| SO2 | 0.000 | 0.000 | 0.000 | 0.000 |
| FC | 20.013 | 18.426 | 16.839 | 16.167 |
| PM | 0.013 | 0.009 | 0.005 | 0.005 |

Source: TREMOVE version 3.3

d.3 Rail

As for road, we also use TREMOVE as an input for the emission factors. The emission factors are averaged for the energy mix – and hence give the weighted emissions of both diesel and electric traction. The emissions for rail in TREMOVE originate from the TRENDS database and the MEET and EX-TREMIS projects and take into account the train types and the age distribution. The emission factors are shown below:

**Table 35: Emission factors for freight rail for the year 2010, 2015, 2020 and 2025 (g/tonkm)**

| g/tonkm | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| VOS | 0.011 | 0.011 | 0.011 | 0.011 |
| CO2 | 8.148 | 8.091 | 7.932 | 7.984 |
| Nox | 0.003 | 0.003 | 0.003 | 0.003 |
| SO2 | 0.001 | 0.001 | 0.001 | 0.001 |
| FC | 2.597 | 2.579 | 2.528 | 2.544 |
| PM | 0.005 | 0.005 | 0.005 | 0.005 |

Source: TREMOVE version 3.3

When we compare the emissions in kg/tonkm between the different modes it is clear that SSS is more polluting than road and rail. However, it should be taken into account that these emission factors assume a loading factor of 100% for SSS. In reality, this will be lower and hence emissions per tonkm will even be higher for SSS.

**e Output of the model**

The main output of the model is the expected change in volumes and emissions due to a policy change. In practice the following steps are made to simulate a policy:

1. Setting of the policy and analysing the effect on
    a. generalised price of each mode
    b. the emission factors for each pollutant and each mode
2. Adapting the generalised price in the model and deriving the expected changes in volume using the calibrated alpha's and assuming a constant transport budget
3. Applying the relevant emission factors and calculation of the emissions – using the change in demand from the previous step.

This means that mainly policies can be analysed which have an influence on the different cost drivers (for example the fuel cost, purchase cost, time costs…) and/or which have an impact on the emissions directly (for example emission standards).

### 3.2.2 Selection of OD

The choice model described above will then be applied to the selection of 21 out of the 24 corridors incorporating 232 OD routes. The routes originating from Russia (Russia-Belgium, Russia-Italy, Russia-Sweden) were removed as the roads available do not offer a real alternative. These 232 ODs represent 20.22% of the cargo that was transported by SSS in 2005 and represent the cargo that is capable of travelling on different modes. Figure 8 showed the routes for the different OD pairs when SSS is chosen as an option.

In order to apply the model we determined for each of these OD's:

- the number of the modes for each options – for example transport going from or through Finland will always use a certain quantity of SSS and transport going to the UK will involve a rail section in the road option.
- the volume transported for each option in the baseline
- the length of each segment of modal choice for each option.
- the average generalised cost of each option. The average generalised cost is weighted at the relative trip length of each mode and takes into account specific costs such as the toll on the Oresund bridge.

The table below shows for one of the 18 corridors the type of information collected for 2010:

**Table 36: Freight transport of commodity type 9 from Sweden to Germany in 2010**

| Origin | | Destination | | SSS route | | | | | | | | | | | Road alternative | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Mode Stage1 | Port-1 | Mode Stage2 | Port-2 | Mode Stage3 | Tons | sea distance (km) | road distance (km) | price sea (€/tonkm) | price road (€/tonkm) | weighted price (€/tonkm) | Tons | road distance (km) | weighted price (€/tonkm) |
| SE | Malmo | DE | Lubeck | Road | Malmo | SSS | Wilhelmshaven | Road | 19116 | 883 | 278 | 0.062 | 0.107 | 0.073 | 89791 | 1504 | 0.116 |
| SE | Malmo | DE | Lubeck | Road | Malmo | SSS | Kiel | Road | 14614 | 298 | 87 | 0.051 | 0.107 | 0.064 | 68647 | 1504 | 0.116 |
| SE | Goteborg | DE | Lubeck | Road | Goteborg | SSS | Wilhelmshaven | Road | 18257 | 672 | 278 | 0.052 | 0.107 | 0.068 | 85758 | 786 | 0.125 |
| SE | Goteborg | DE | Lubeck | Road | Goteborg | SSS | Kiel | Road | 12257 | 437 | 87 | 0.052 | 0.107 | 0.061 | 57572 | 786 | 0.125 |
| SE | Malmo | DE | Kiel | Road | Malmo | SSS | Kiel | Road | 12309 | 298 | 0 | 0.011 | 0.107 | 0.011 | 57815 | 435 | 0.140 |
| SE | Malmo | DE | Kiel | Road | Malmo | SSS | Wilhelmshaven | Road | 12087 | 883 | 278 | 0.010 | 0.107 | 0.033 | 56776 | 435 | 0.140 |
| SE | Goteborg | DE | Kiel | Road | Goteborg | SSS | Kiel | Road | 40145 | 437 | 0 | 0.009 | 0.107 | 0.009 | 188566 | 723 | 0.127 |
| SE | Goteborg | DE | Kiel | Road | Goteborg | SSS | Wilhelmshaven | Road | 30144 | 672 | 278 | 0.010 | 0.107 | 0.038 | 141590 | 723 | 0.127 |

Source: own calculations

For this example, we take into account that the road only option makes use of the Öresund Bridge, which comes at an additional cost. Today, the cost (including VAT) of crossing this bridge is 134 euro for a truck with a length between 9 and 20 meters and 201 euro for a truck with a length larger than 20 meters[23]. These are the maximum prices – frequent user prices are available. We use a price of 163 euro[24] and divide it by the road distance and the load factor to come to a price per tonkm. Hence, for short distances the cost of crossing the bridge will be relatively higher.

Other origin destinations – for example going or coming from the UK, also include a rail part. The cost of this is also included.

### 3.2.3 Impact of the policies

Before we can run the model we need to determine the effect of the policies on both the generalised price and the emission factors. Given the effect on the generalised price we then calculate the effects on volumes and modal shifts using the model.

[23] http://uk.oresundsbron.com/page/60

[24] Sensitivity analysis showed that lowering this price to for example 80 euro per crossing does not affect the main outcome of the model.

### a Impact of the policies on the generalised price

#### a.1 Policy 1: MARPOL

There are 2 main abatement possibilities to lower the sulphur content towards 0.1%. The first is the use of low sulphur fuel, as the emission of sulphur dioxide is directly proportional to the sulphur content in the fuel. Most of the high sulphur fuel (with a sulphur content of 1-3.5%) used in ships today is heavy fuel oil (HFO) or residual oil. The fuel currently available with 0.1% S is typically marine gasoil, which is much more expensive than HFO. However, it is possible that if demand increases for this type of fuel, the price will decrease as a result of economies of scale. Most studies (Purvin and Gertz (2009), AEAt study (2009) ) do not take this effect into account.

The second option implies the use of scrubbers. The principle is that the sulphur is captured at some point in the exhaust. For more details on the possible scrubber systems we refer to the AEAt study.

The choice of the abatement technology will determine the effect on the generalised price:

- for the costs of the use of a scrubber in combination with high sulphur fuel we base ourselves on the costs stated in the AEAt study. The most important parameters determining the costs for scrubbers are
  - are they installed in a new vessel or retrofitted to an existing vessel
  - the system: an open or a closed circuit scrubber systems. Closed systems have additional costs for the purchase of NaOH and fresh water. These costs depend on the sulphur content of the fuel.

  The costs of a scrubber exist of
  - investment cost: about 100-200 €/kW for new installations and 200-400 €/kW for retrofit installations
  - additional use of fuel of about 2%
  - maintenance cost (and purchase of NaOH (about 0.5 €/liter – 15 liters per MWh installed engine capacity is needed to reach 0.1% sulphur content) and fresh water for closed systems)
  - cost for disposal of sludge: depending on the size of the ship these costs vary between 1600 and 13300 euro per year. They are included in the operating and maintenance costs.

  The following table summarizes the costs for the use of a scrubber –and shows that annual costs vary a lot.

**Table 37: Scrubber technology cost to reach 0.1% S**

| | Technology specification | Investment (k€/vessel) | Lifetime (year) | O&M (k€/vessel) | Fuel cost (k€/vessel) | Annual cost (k€) |
|---|---|---|---|---|---|---|
| New | Open | 1148 | 15 | 28 | 41 | 167 |
| New | Closed | 2296 | 15 | 198 | 41 | 595 |
| Retrofit | Open | 2296 | 12.5 | 28 | 41 | 301 |
| Retrofit | Closed | 4592 | 12.5 | 198 | 41 | 862 |

Source: AEAT study (2009)

- for the cost of using low sulphur MDO, 0.1%: the main parameters influencing the costs of fuel relate to sulphur content of crude oil as well as the necessary investments in refinery capacities. The vessels using the fuels are assumed to be subject to relatively small cost increases of adapting to different fuels. In theory boilers that are constructed for the use of HFO cannot be used with MDO without modifications. The modifications needed must be assessed individually for each boiler. As no information is available on the number of boilers that need modifications nor on the costs, this is not taken into account. Purvin and Gertz (2009) estimated the effect on fuel costs for different levels of sulphur and for different years as follows:

**Table 38: Price per ton for maritime fuel from 2010 to 2025**

| Year \ Fuel Sulphur Content | €/Ton 1.50% | €/Ton 1.00% | €/Ton 0.10% |
|---|---|---|---|
| 2010 | €281.75 | €293.91 | €492.11 |
| 2015 | €399.60 | €411.76 | €656.24 |
| 2020 | €424.74 | €434.34 | €705.83 |
| 2025 | €466.38 | [25] | €752.99 |

Given the large variation on cost estimates for the prices of scrubbers and the fact that they are more difficult to combine with the last policy (which will be discussed furthering section a.5), we have opted to assume the use of low sulphur MDO as the solution for reaching the MARPOL standards in the further analysis. We base the cost increase[26] from switching from a 1.50% sulphur fuel to a 0.10% sulphur fuel on Purvin and Gertz (2009), as stated inTable 39. These percentages will be applied to the fuel costs used in the reference scenario, this is, on top of the expected oil price evolution, which was taken over from the iTren scenario. Hence we do not apply the overall increase in prices over time as assumed by Purvin and Gertz (2009). In the scenarios we only use the increase in fuel costs due to switching fuel type. Note that over time,

[25] Figure not required for this study

[26] In the reference scenario we base the evolution of the prices on the iTREN scenario to be consistent with road and rail. This evolution does not completely correspond with the results of Purvin & Gertz (2009). Therefore, we only use the relative costs increases as stated by Purvin & Gertz (2009).

the cost increase reduces and that the % stated are lower than what was stated by the stakeholders in Table 5 – they predict an increase in fuel cost of 200%.

**Table 39: Cost increase fuel due to new MARPOL regulation (1.0 % S in 2010; 0.1% starting from 2015)**

| | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|
| 1S/ 0.1 S vs 1.5 S | 4% | 64% | 66% | 61% |

Source: based on Purvin and Gertz (2009)

Using these percentages and the relative importance of the fuel costs for each ship type, the next table shows the effect on total costs of shipping.

**Table 40: Expected increase in total costs due to the new MARPOL regulations**

| | LoLo | RoRo | RoPax Small | RoPax Large |
|---|---|---|---|---|
| 2015 | 30.24% | 20.52% | 6.67% | 13.74% |
| 2020 | 31.16% | 21.14% | 6.87% | 14.15% |
| 2025 | 28.94% | 19.63% | 6.38% | 13.14% |

Source: own calculations

It is obvious that the price increase is the highest for those ship types for which fuel represents an important part of the costs, such as for LoLo (47% of daily costs are fuel costs) and RoRo (32% of daily costs are fuel costs). Hence we expect to see a larger effect on transport volumes when these types of ship are used.

a.2 Policy 2: eMaritime

Based on the survey carried out as part of this study ship operators expect to see a 20% drop in port related costs by 2015. It is expected the majority of these improvements will be as a result of technological and operation improvements within the ports. As the cost impact of the e-Maritime initiative has not yet been evaluated it is cautiously assumed that it will provide 5% of the expected 20% drop in port related costs. Port related costs vary between 4% (RoPax small) and 8% (RoPax Large and RoRo), hence total costs decreases are limited to about 0.2% to 0.4%.

a.3 Policy 3: GHG policy

CE Delft (2009) estimated – albeit for somewhat different vessel types - that both a trading scheme and an emission tax would lead to an increase in operational costs of – on average – 33% of the fuel costs by 2030. This means a total cost increase of about 8-17% and an increase in operational costs with 16-23%. The administrative costs for the shippers is expected to be relatively low compared to the operating costs of shipping as it is mainly verifying the data that is already routinely monitored.

We calculate the cost implications of a GHG policy for the vessel types used in our assessment for two €/tonne of $CO_2$ rates;

- 25€/tonne of $CO_2$ and,
- 55€/tonne of $CO_2$

As the tonnes of $CO_2$ emitted are a direct function[27] of the tonnes of fuel consumed by a ship (listed in section 2.2.1) it is possible to calculate the percentage cost increase for each of the ship types modelled. These results are displayed in the following two tables.

**Table 41: Expected cost increase at 55 €/tonne $CO_2$ and 700 US$ of fuel in 2030**

| Ship type | Increase in total costs | Increase in operational costs (O&M +bunker cost) |
|---|---|---|
| LoLo (600 TEU) | 21% | 25% |
| RoRo (200 Trailers) | 16% | 23% |
| RoPax-Small (40 Trailers) | 6% | 8% |
| RoPax Large (290 Trailers) | 11% | 16% |

Source: own calculations

**Table 42: Expected cost increase at 25 €/tonne $CO_2$ and 700 US$ of fuel in 2030**

| Ship type | Increase in total costs | Increase in operational costs (O&M +bunker cost) |
|---|---|---|
| LoLo (600 TEU) | 10% | 12% |
| RoRo (200 Trailers) | 7% | 10% |
| RoPax-Small (40 Trailers) | 3% | 4% |
| RoPax Large (290 Trailers) | 3% | 7% |

Source: own calculations

These cost increases lie in the range of the CE Delft results.

The current price of CO2 is about 15 euro/tonne CO2[28]. Hence in the analysis we only use the costs increase at a CO2 price of 25€/tonne CO2. We apply this cost increase starting from the year 2020.

a.4 Policy 4: extension ECA to all European seas except Atlantic Coasts

This policy simply implies that the sulphur regulations are now also in force in the other European Seas. Hence also for the routes using the Mediterranean Sea for example we include an additional fuel cost increase of approximately 60% in 2015. In our example this policy will only affect the France-Italy corridor.

a.5 Policy 5: Inclusion of NOx into the ECA regulation

The inclusion of NOx into the ECA regulation implies that new ships have to comply with the TIER III specifications – from 2016. Several options exist for meeting the TIER III specifications (AEAt study, 2009). The main approaches are based on selective catalytic reduction (SCR) or exhaust gas recirculation (EGR) in combination with other measures such as engine

[27] Tonne of $CO_2$ = [Tonnes fuel used] x [% Carbon per tonne of fuel] x [% Carbon burned] x [mass of $CO_2$ per kmole] /[mass of C per kmole]

[28] http://www.ecx.eu/

modifications, direct water injection (DWI) or the use of fuel-water emulsion. The first technology is already in use, while the second one is still in the development phase. For more details on the technology we refer to the AEAt study (2009). This study also provides cost estimates for two alternatives to reach Tier III – SCR and EGR in combination with engine modifications and DWI. It is possible that other technologies will be cheaper, but it is yet uncertain whether they will be able to reach the Tier III standards.

The costs for SCR depend on the price of urea, which on its turn depends on the future supply and demand. This makes the price of urea very uncertain. The AEAt study (2009) uses a value of 0.2 euro/litre for urea. The combination of EGR with water injection seems to be a cheaper option – although it will lead to an additional fuel use of 2%. The annual cost for obtaining the Tier III regulations, while at the same time reaching a sulphur content of 0.1% is estimated at 166000 euro when using a combination of EGR and WIF (water injection) while increasing up to 297000 euro per year when using the SCR technology. The split up of the costs is shown in the next table.

**Table 43: Tier III cost estimates**

| Tier costs | Technology specifications | Investment (k€/vessel) | Lifetime (year) | O&M (k€/vessel) | Fuel costs (k€/vessel) | Annual costs (k€) |
|---|---|---|---|---|---|---|
| New (0.1% S) | EGR+WIF | 743 | 25 | 15 | 103 | 166 |
| New (0.1% S) | SCR | 949 | 25 | 169 | 0 | 297 |

Source: AEAt study (2009)

The AEAt study points out that there are problems with using high sulphur fuel in combination with NOx abatement technologies. EGR requires very low sulphur content in the fuel or an internal scrubber. At this point of the technology, it seems not possible to use a scrubber for the reduction of sulphur and to abate NOx emissions. Therefore we assume in this scenario that using a low sulphur fuel is chosen as the option to reduce $SO_2$ emissions. Moreover, we will assume that shippers will opt for the lowest cost option and hence assume the use of the EGR+WIF solution. These means they will be faced with an additional annual cost of about 166000 euro. The table below shows how this impacts total costs for the new ships – where we see – due to their relative low capital cost - the largest impact for the LoLo ships.

**Table 44: Increase in total costs due to inclusion NOx into the ECA regulation**

| | LoLo | RoRo | RoPax Small | RoPax Large |
|---|---|---|---|---|
| increase in total costs | 2.460% | 1.233% | 2.170% | 0.587% |

Source: own calculations based on AEAt

As this regulation only applies to newly built ships the rate of ship renewal is needed. Based on figures from an IMO study (Mikelis, 2007) of the average retirement age of various ships classifications the following table was constructed:

**Table 45: Average ship recycling age**

| Ship Type | Average Ship Recycling Age |
|---|---|
| LoLo (600 TEUs) | 27.8 |
| RoRo (200 Trailers) | 27.8 |
| RoPax-Small (40 Trailers) | 35.7 |
| RoPax-Large (290 Trailers) | 35.7 |

If a linear replacement of ships is assumed this implies that for the RoPax_Large fleet one 35.7th of the fleet shall be replaced in one year, this equates to 2.8% per year, hence 14% every five years. Ship recycling is an economic decision, influenced by freight rates and scrappage values therefore scrappage tends to be cyclical. As these cycles are not known in advance it is necessary to assume an average annual ship replacement rate of 2.8%.

### b Impact of the policies on the emission factors

Of the five policies, two have a direct impact on the emission factors, the MARPOL regulation on sulphur and the inclusion of NOx into the ECA regulations. For the policy scenarios in which these policies are included we change the emission factors as stated before.

### c Impact of the policies on transport volumes: model output

After calibrating the model for the baseline we introduced the price and emission changes as explained in the previous section. In this section we focus on the effects on volumes for the five policy scenarios. Annex 3 contains the relative changes for all policies for all origin-destinations.

#### c.1 General effects

Overall the first policy scenario – introducing a Sulphur limit of 0.1% in the ECAs - leads to the largest changes in transport volumes: -5.54% on average – as it is also causing the largest increase in costs. This policy affects the prices for almost all O-Ds in our model. Only the France-Italy O-Ds are not affected by this policy, as they are outside of the ECA zones in this scenario.
Total costs are expected to increase by about 6% (RoPax Small) up to 30% (LoLo) by 2025. This is a relatively large increase in the fuel costs of SSS – although remember that Purvin & Gertz (2009) do not take into account that increased demand may lead to scale effects and hence this price increase should be seen as a maximum. Notable is that also road transport volumes slightly decreases. As explained earlier, the main reason for this is the fact that total transport budget is fixed in the model and that the price increase is rather substantial. This decreases also the budget

available for road transport. Moreover, as in general road transport remains more expensive than SSS, switching to road transport does not lead to savings in monetary costs.

Adding the eMaritime policy somewhat mitigates the decrease in volumes to -5.45% – but the effect is rather small as eMaritime is not expected to lead to high cost decreases. The effect of internalising GHG emissions by SSS via a market based instrument adds an additional decrease in volumes up to minus 7.54% on average. In the majority of cases there is no difference between policy scenarios C and D. This is due to the fact the policy scenario D is the designation of the Mediterranean Sea and the costal waters of the Atlantic Arc as SECAs. Therefore this scenario only impacts routes originating and terminating between in France, Spain and Italy. The model used in this analysis only contains a limited set of OD using the Mediterranean Sea. The impact of the NOx regulation decreases over time as the additional costs become less important as other policies start having their effect. Moreover, as the cost increase only applies for newly built ships, the cost increase remains relatively low in the first years after the introduction of the regulation. By 2025 the combined effect of all policies leads to a decrease in transport volumes of almost 7.70%.

c.2 Effect per ship type and distance class

The following table summarises the average reduction in cargo volumes over the study period for each of the scenarios A to E based on different ranges of operation for each of the ship types.

**Table 46: overview of model results for the year 2025, by ship type and distance class**

| | Ranges of Operation (km) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ship Type** | **0-50** | | **50-100** | | **100 - 300** | | **300 - 500** | | **500 - 1000** | | **1000 - 2000** | | **2000+** | |
| RoRo | | | | | A | -1.18% | A | -3.47% | A | -3.35% | A | -4.83% | A | -7.58% |
| | | | | | B | -1.20% | B | -3.12% | B | -3.29% | B | -4.72% | B | -7.45% |
| | | | | | C | -1.69% | C | -4.52% | C | -4.72% | C | -6.58% | C | -10.26% |
| | | | | | D | -1.69% | D | -4.52% | D | -4.88% | D | -6.58% | D | -10.26% |
| | | | | | E | -1.72% | E | -4.65% | E | -4.99% | E | -6.69% | E | -10.45% |
| RoPax_Small | A | -6.33% | A | -0.24% | A | -1.20% | A | -8.92% | | | | | | |
| | B | -6.23% | B | -0.23% | B | -1.18% | B | -8.76% | | | | | | |
| | C | -8.61% | C | -0.35% | C | -1.69% | C | -11.96% | | | | | | |
| | D | -8.61% | D | -0.35% | D | -1.69% | D | -11.96% | | | | | | |
| | E | -8.87% | E | -3.84% | E | -1.73% | E | -12.17% | | | | | | |
| RoPax_Large | | | A | -0.68% | A | -2.74% | A | -4.16% | A | -0.83% | A | -6.50% | | |
| | | | B | -0.66% | B | -2.69% | B | -4.08% | B | -0.80% | B | -6.39% | | |
| | | | C | -0.94% | C | -3.99% | C | -5.75% | C | -1.17% | C | -8.83% | | |
| | | | D | -0.94% | D | -4.24% | D | -5.92% | D | -1.17% | D | -8.83% | | |
| | | | E | -0.95% | E | -4.34% | E | -6.03% | E | -1.21% | E | -8.99% | | |
| LoLo | | | | | | | A | -3.69% | A | -6.06% | A | -6.60% | A | -7.65% |
| | | | | | | | B | -3.63% | B | -5.96% | B | -6.56% | B | -7.55% |
| | | | | | | | C | -5.07% | C | -8.25% | C | -9.05% | C | -10.41% |
| | | | | | | | D | -5.07% | D | -8.25% | D | -8.84% | D | -10.41% |
| | | | | | | | E | -5.18% | E | -8.41% | E | -9.04% | E | -10.67% |

Taking the RoRo ship first it can be seen from the table that as the distance travelled increases the reduction in cargo volumes. Note that the majority of the >2000km routes are cargo flows between Finland and the EU 27 and the UK. These routes are a special case as the UK is an island and Finland is ostensibly an island nation as well. For this reason it is expected that the actual decrease in volumes is probably smaller than predicted by the model. Notable is that the volume decrease is larger as the distances increase. Remember that we underestimate the road costs over longer distance, leading to an overestimation of the volume effects on a longer distances. The relationship volume-distance is less clear for the 500-1000 km range. The % shown for this range are an average of 27 OD's. However, the results are skewed by 5 specific routes (between Sweden and Germany) where due to their geographical location, SSS is the dominant freight transport provider.

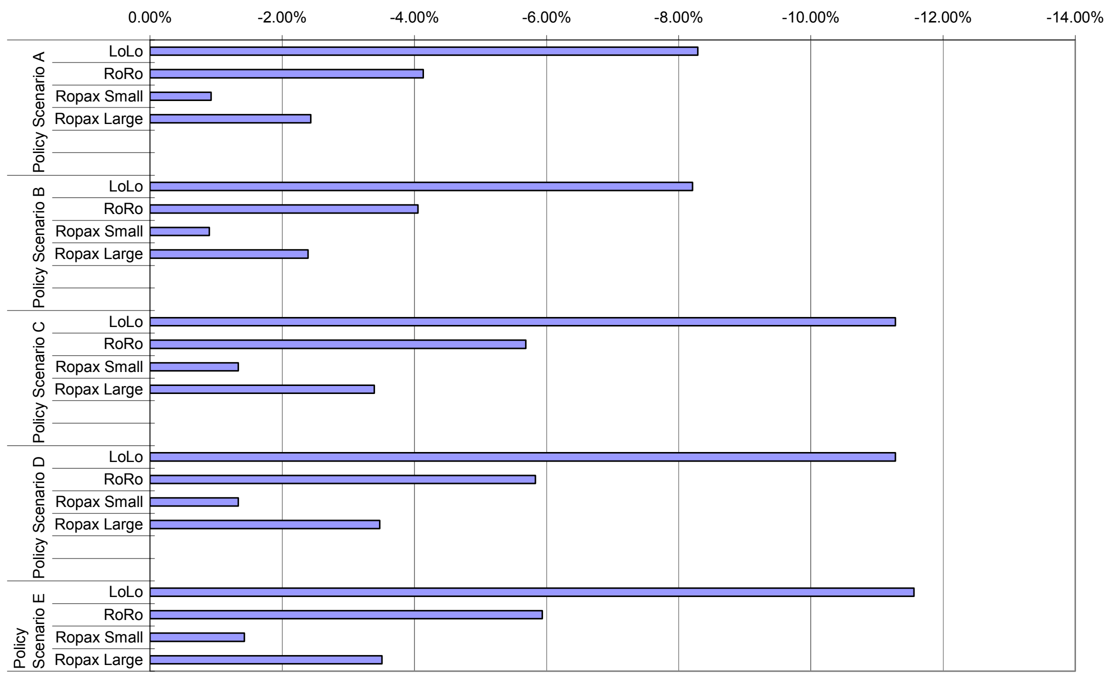
The RoPax Small presents an interesting case; over very short distances (<50km) this services sees a relatively large cargo volume reduction. The routes in question are between Sweden and Denmark where the Oresund Bridge is a readily available alternative to SSS. For the 50-100km & 100-300km distances the RoPax Small remains very competitive due to its short port turn around times and high frequency of service, this enables it to transport a large amount of cargo in a given time period. The transport flows included within the 100-300 km range are transport between the UK and Belgium. In this case the Eurotunnel could – in theory – be a valid alternative. However, even today rail transport between Belgium and the UK remains very limited (EUROSTAT data). Note that the sample for Ropax Small is small and that the 8 door-to-door destinations included in the 50-100 km and 100-300 km range contains only 4 port to port routes. The 300-500 km range only contains one OD pair: Helsinki-Stockholm.

The RoPax Large vessel remains competitive over shorter distance (0-300km) due to a similar rational as the RoPax Small. However, for the distance travelled increase and assuming constant road costs per km, the cargo losses also increase. The 500-1000km range presents a slight oddity due to the apparent small decrease in cargo volumes. This is due to the fact that this range only represents 6% of all cargo carried on RoPax_Large and consists solely of cargo from Western Norway to German. Modal-split data for this route from Eurostat indicate there is a strong bias toward SSS for this corridor. The other distance ranges in the RoPax_Large route pool represent a broader cross-section of routes thereby allowing more general conclusions to be drawn.

As distance increases the LoLo vessel suffers a 5% to 11% reduction in cargo volumes. This is due to three reasons: firstly, LoLo vessels are more susceptible to fuel price escalation as fuel forms approximately 47% of their daily costs, and secondly, as distances increase smaller LoLo vessels become less competitive when compared to larger LoLo vessels offering greater economies of scale. As the study only modelled one type of LoLo vessel this level of resolution was not achievable. Finally, the costs for road over longer distances tend to be underestimated.

The figure below summarizes the effect of the different policy scenarios if we distinguish only according to ship type. It is clear that the effect on LoLos is the highest. This is mainly due to the fact that they have rather low capital costs and hence any cost increase has a relatively high impact.

**Figure 25: Average effect on transport volumes according to ship type, 2025**




When we translate this to the effect on modal shares between the baseline and policy scenario E, we see clearly from Table 47 that modal shares of the SSS option decrease for all ship types. Remember that total volumes decrease for both the SSS and the road option – where the decrease is much lower for the road option than for the SSS option. Again, we see the strongest effect for LoLo.

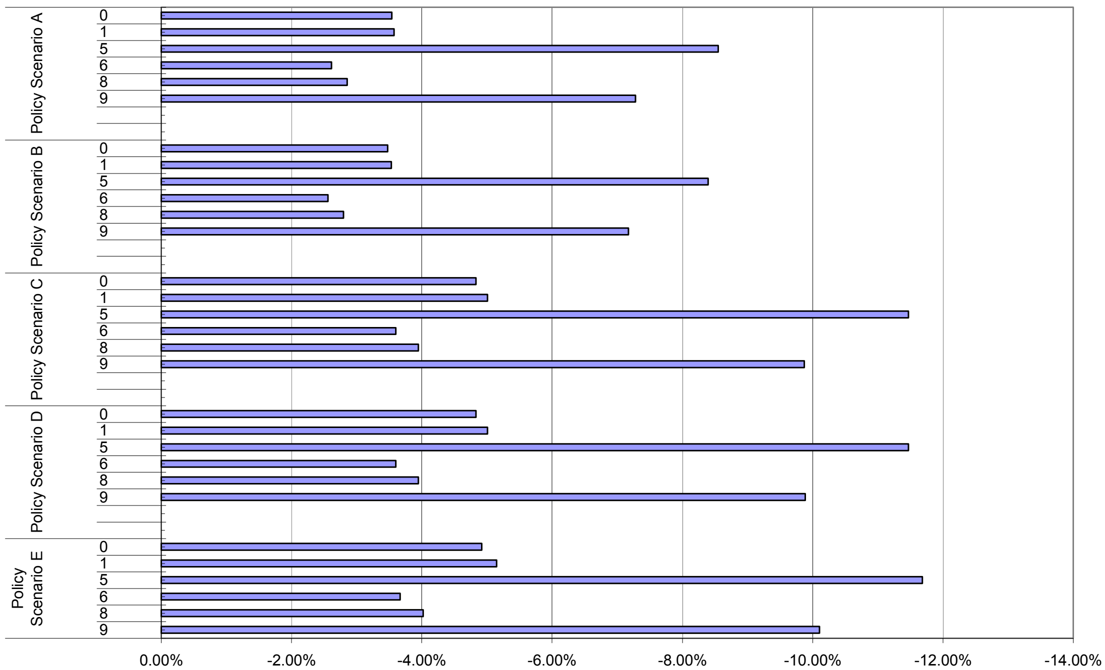
**Table 47: Modal share of the SSS option and change in modal share**

| | Modal share | | Change in modal share |
|---|---|---|---|
| Modal share | Baseline | Policy E | |
| LoLo | 34% | 31% | -7% |
| RoRo | 35% | 33% | -4% |
| Ropax Small | 13% | 12% | -1% |
| Ropax Large | 26% | 26% | -2% |

c.3 Effect per commodity type

From the figure below it is clear that the main types of goods affected are other products (9), metal products (5). Agriculture products (0), foodstuff (1), building material (6) and chemicals (8) are less affected.

**Figure 26: Average effect on transport volumes according to type of good.**




### c.4 Effect per corridor

The second part of Annex 3 contains the detailed effects for all O-D pairs. On a corridor level, we see the close relationship between the ship type and the decrease in volumes. Overall, transport from Scandinavian countries (Finland, Sweden, Norway) to Central Europe (Belgium, Germany, UK) see a sharp drop in volumes of around 10-15%. Most of these transports happen with LoLo en RoRo vessels. Transport over shorter distances show only moderate decreases in volumes. For transport between Denmark and Sweden this is notable as the Oresund bridge is a valid alternative. However, when calculating with the official prices, this becomes a relative expensive alternative over short distances. Also transport between Belgium and the UK remains relatively stable, as the costs increases seem to be relatively low for the type of ships used, and especially over short distances.

### c.5 Sensitivity analysis

Sensitivity analysis showed that:

- decreasing the costs of crossing the Oresund bridge to take into account discounts does not lead to large effects – only when they are nearly zero we see some effects for certain O-Ds.
- increasing the time costs of SSS – both in the reference and in the policy scenarios – for example to take into account schedule delay costs decreases the effect on volumes. The reason is that within the generalised price the monetary part becomes less important. As the policy measures mainly affect the monetary part, which is now relatively smaller, the relative increase in the generalised will be lower than before.

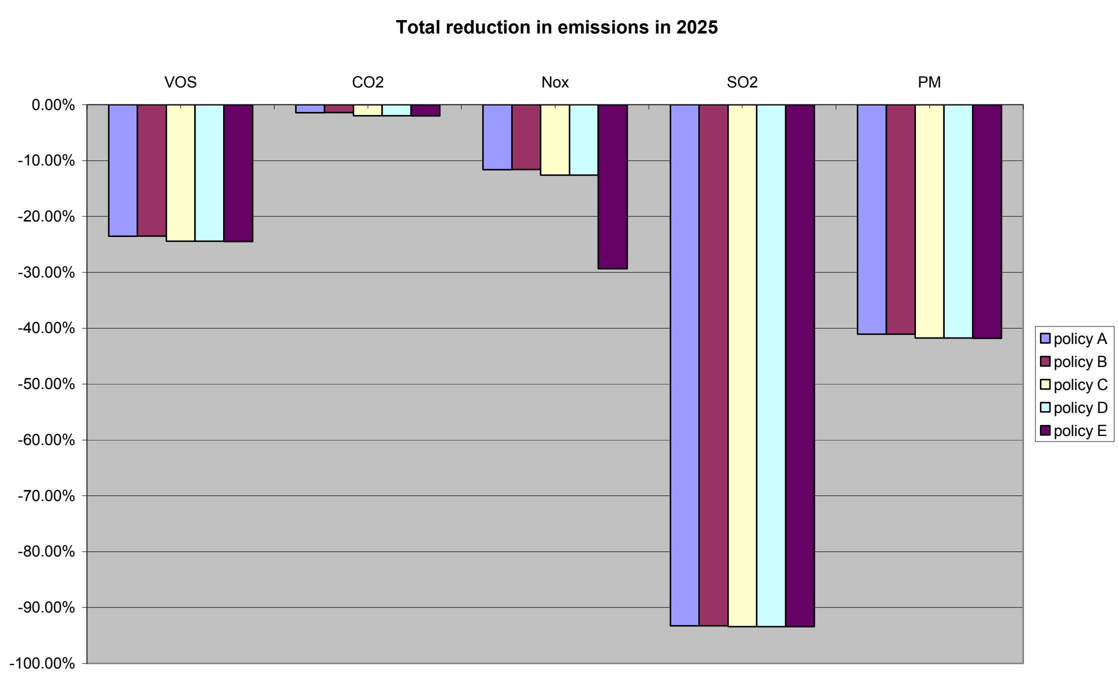
- when the loading factor of SSS decreases, the decrease in volumes becomes larger as the relative cost increase is higher. Less customers should make up for the cost increases due to the policies.
- Increasing the road costs over longer distances would lead to a smaller modal shift

### d Effect on emissions

The figure below shows the relative changes in total emissions (hence the sum of the emissions of both options for all origin-destinations) over all modes with respect to the baseline for the year 2025. More detailed results – showing total emissions- can be found in annex 4. In general the total change is relatively large. Total SO2 emissions decrease with more than 93% in policy scenario E. PM emissions decrease with about 42%; NOx decrease with about 30%; VOS with 24% and CO2 with only 2%. The decrease in SO2 is the largest as this pollutant is relatively more important for SSS than for road and hence SSS play a relatively larger role in total SO2 emissions. The same reasoning applies to PM and NOx. The decrease in CO2 is lower as it is not directly affected through the policies and as emissions from road and rail play a relatively larger role.

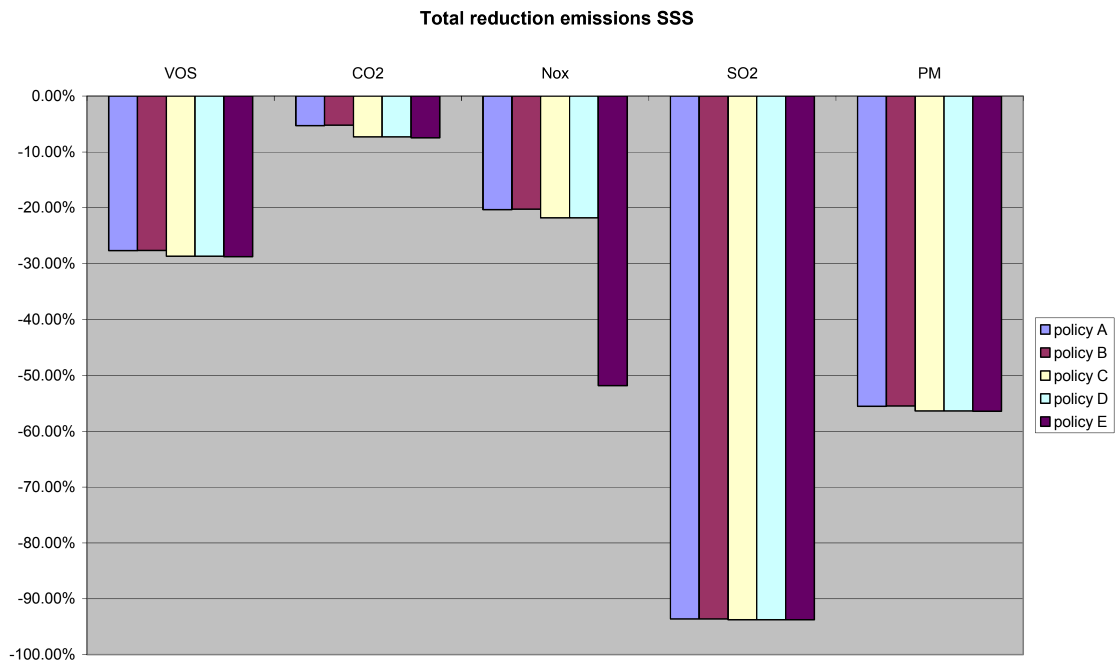
Following the effects we saw on the volumes, policy A leads to the highest decrease in emissions, followed by policy C. As this graph also includes the NOx emissions from road and rail the effect of policy E is less pronounced. The effect of policy D is limited as only a few of the ODs analysed are affected by this policy.

**Figure 27: Relative reduction in total emissions for all OD's and over all modes, 2025.**




When we only focus – as is shown in the figure below - on the relative reductions in SSS emissions (for both options), the effect of the policies become slightly larger. Again, the reduction in $SO_2$ emissions is most notable, but also the direct effect of policy D on NOx emissions is clear from the picture. The other pollutants also show a rather large decrease ranging from 8% for CO2 till almost 60% for PM emissions. This is due to the SO2 regulation which is assumed to lead to a switch from HFO to the cleaner MDO.

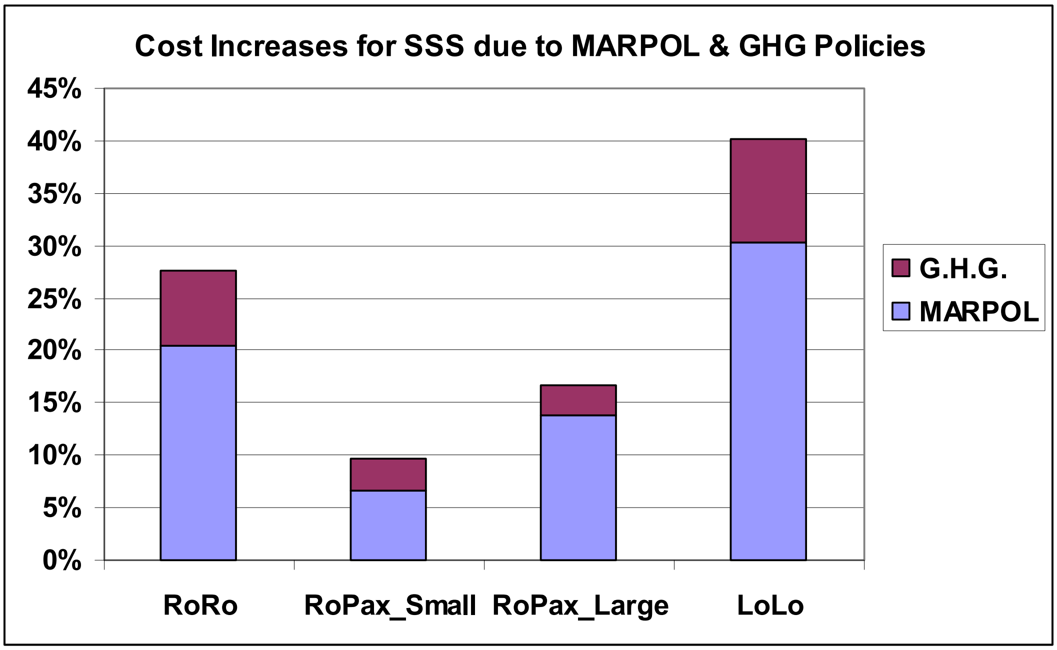
**Figure 28: Relative reduction in total emissions for all OD's for SSS, 2025.**



### 3.3 Qualitative analysis

The model assesses the relative attractiveness or competitiveness of each of the available modes on a specific route. The competitiveness is assessed based on relative cost with all other things being equal. Cost increases are driven by the policy changes discussed in the text and the two main cost increases for SSS are displayed in the following graph:

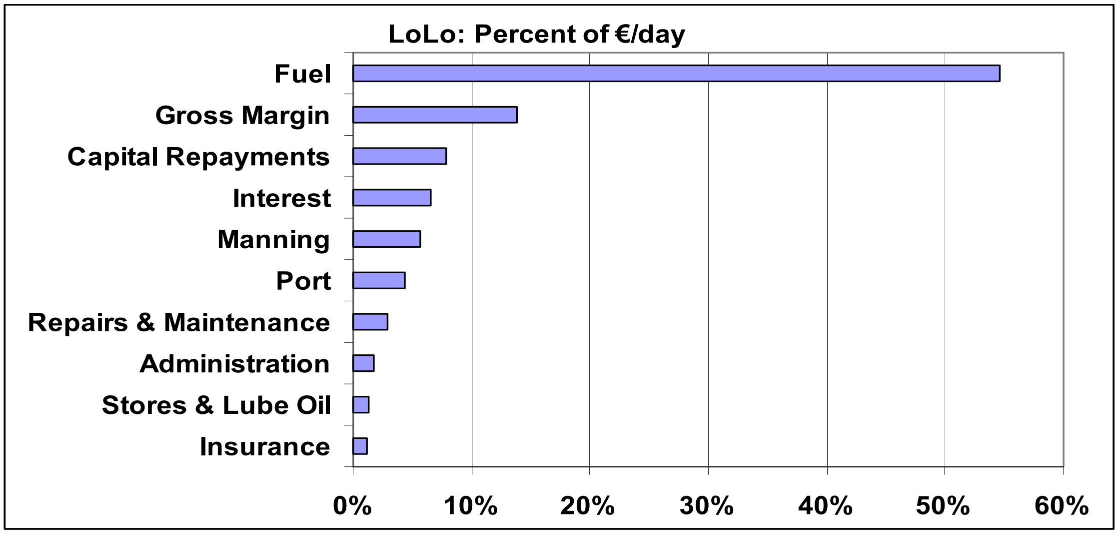
**Figure 29: Cost increases for SSS due to MARPOL and GHG policies**




Cost increases of this magnitude will necessitate a response from ship operators in order to retain customers and a minimum profit margin. Using the ship cost headings from section 2.3.1 as a guide the possible cost reduction responses for each of the vessel types shall be discussed. The impacts of these cost reduction decisions on other modal choice factors is also discussed.

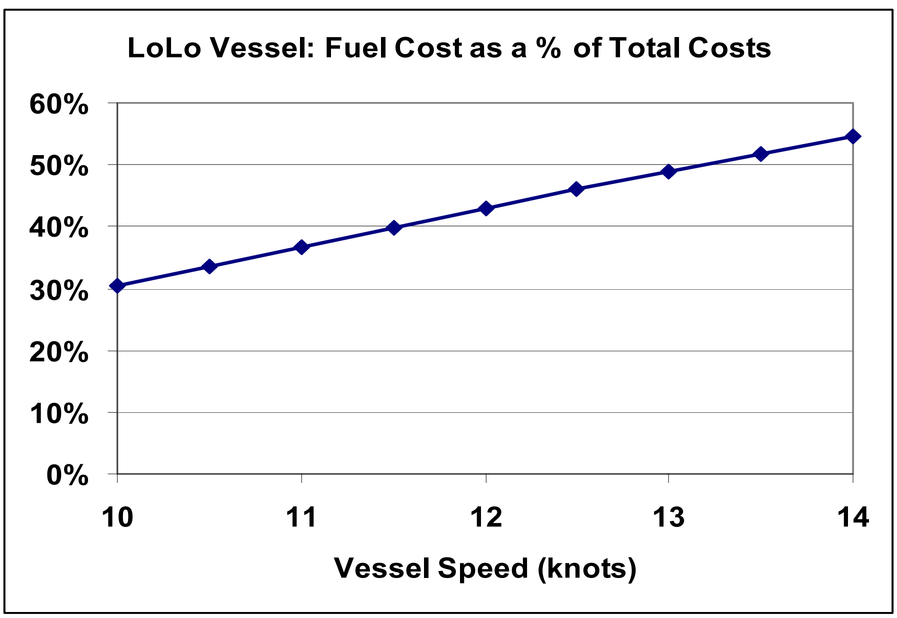
It can be seen from the previous graph that the LoLo vessel used in this study will see a 40% increase in costs due to the implementation of the 0.1% sulphur limit in 2015 and the application of a 25€/tonne of $CO_2$ GHG charge. The following graph displays the current relative cost structure for the LoLo vessel used in this study.

**Figure 30: Cost structure (%) of LoLo (€/day)**



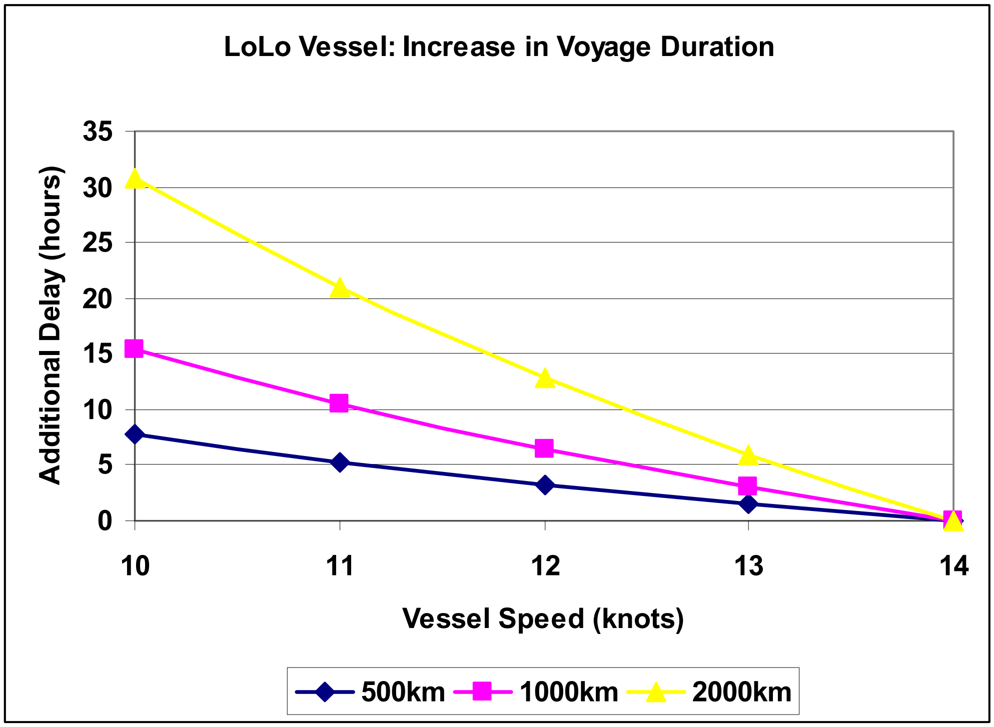

Due to the slower speed of this vessel (approximately 14knots) it is not feasible to significantly reduce its service speed. The following graph displays the relative percent cost of fuel against ship speed.

**Figure 31: Fuel cost of a LoLo Vessel as a function of speed**




A service speed of 12knots will therefore allow ship operators to reduce costs by approximately 12%. The impact of this slow down over the three chosen voyage lengths is demonstrated in the following graph.

**Figure 32: Increase in voyage duration as a function of speed of a LoLo**




Over the medium to longer range distances (>1000km), voyage times increase by between 6 and 13 hours. The impact of these transport time increases is not linear as the scheduling a ship service is multifaceted; depending on terminal operating times, peak freight traffic times, drivers resting schedules, freight transit restrictions at weekends, etc. The variety of restrictions combined with slower ship speeds could result in ships being tied up at berth for longer periods of time between sailings.

As a result of this slow down; service frequency will be reduced, transport time will be increased and the service schedule altered. It has been shown from literature and from the survey carried out during this study that these are three important modal choice factors. This implies that the proposed slow down will result in the loss of some customers. This loss of customers means that the actual realisable savings from slowing down will be less than the 12% predicted, perhaps in the region of 8% to 10%, but this will vary according to route & commodity type.

Assuming that a 10% cost saving is achieved through reducing speed, the remaining 30% cost increase must be absorbed through reduced profit margins and the remainder passed onto customers. For the purposes of this study a gross profit margin of 17% was assumed; a practical long term floor to the profit margins on capital intensive operations is assumed to be 12%. This results in the following cost increase being passed onto the customers:

$$30\% - (17\%-12\%) = 30\% - 5\% = 25\%$$

This cost increase then sets up a mini vicious cycle where cost increases lead to loss of customers which then necessitates that the ship's operating & capital costs are then spread among the remaining customers, thereby further increasing their costs and further promoting their departure. Based on this discussion it has been shown that the full cost increases may not be passed on to cargo owners. This assertion implies that the model may marginally over estimate the cost impact, due to ship owners' ability to absorb a portion of the cost increases. It has also been demonstrated, however, that the mitigation actions that could be taken by ship operators will also result in loss of cargo volume due to increased transport times, reduced service frequencies and altered service schedules. This could cause some extra cargo reductions, but keeping in mind that the model estimated maximum effects, the reduction will probably not be greater than what the model predicted.

The same logical arguments apply to RoRo & RoPax vessels with some minor variations. RoRo vessels tend to attract commodities with higher time values than LoLo vessels; therefore any slowing down of these vessels has a greater negative impact from the customers' perspective. However, due to the higher speeds of the medium to long distance RoRo vessels there is more leeway for speed reduction. The following graphs display, for all RoRo & RoPax vessels, the cost breakdowns, the relationships between ship speed and the percentage of costs attributable to fuel, and, the resultant delays due to reduced ship speeds.

**Figure 33: Cost structure (%) of RoRo (€/day)**

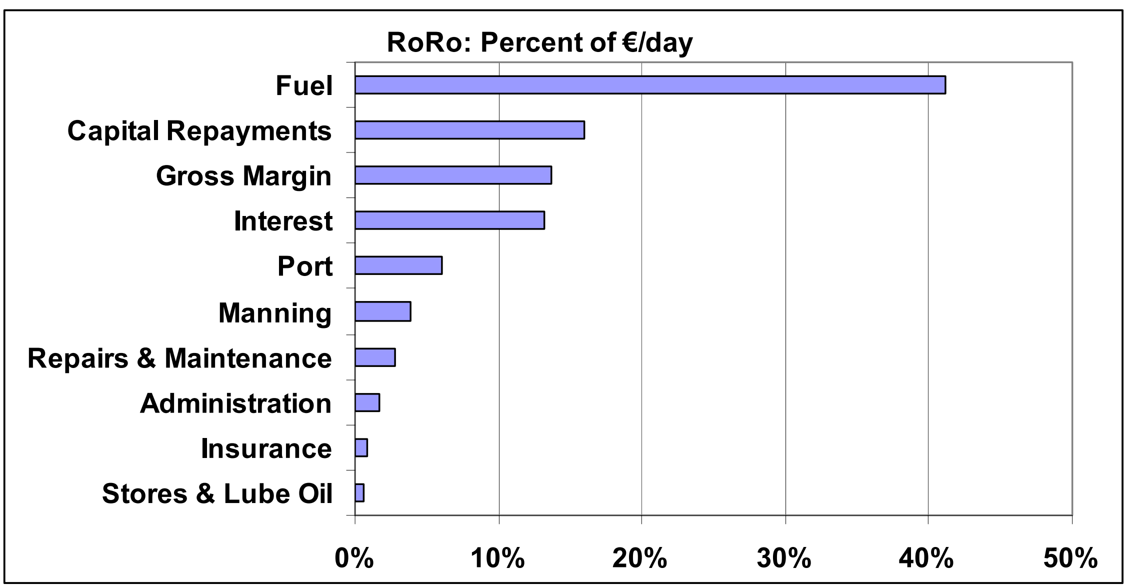


Figure 34: Fuel cost of a RoRo Vessel as a function of speed

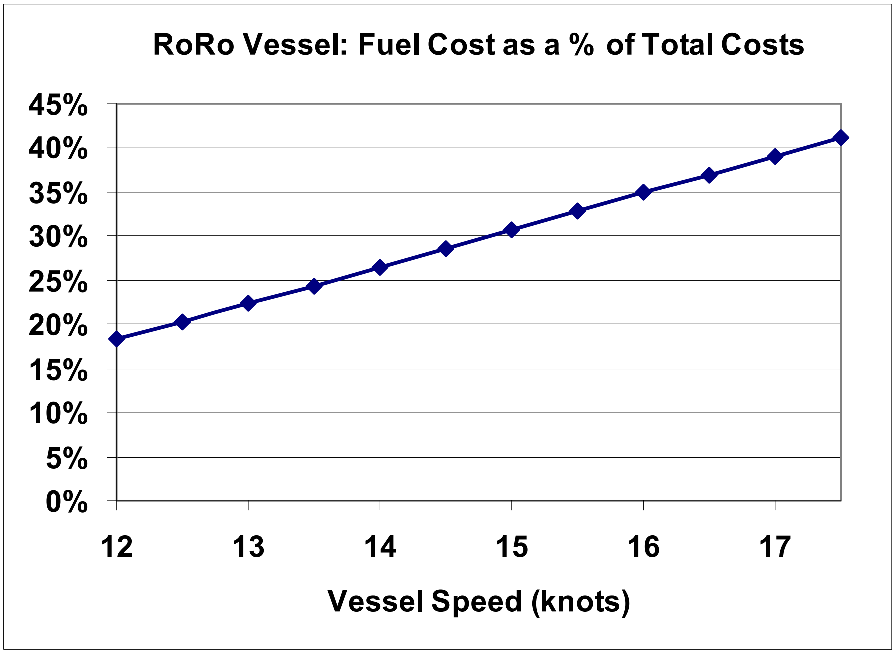



Figure 35: Increase in voyage duration as a function of speed of a RoRo

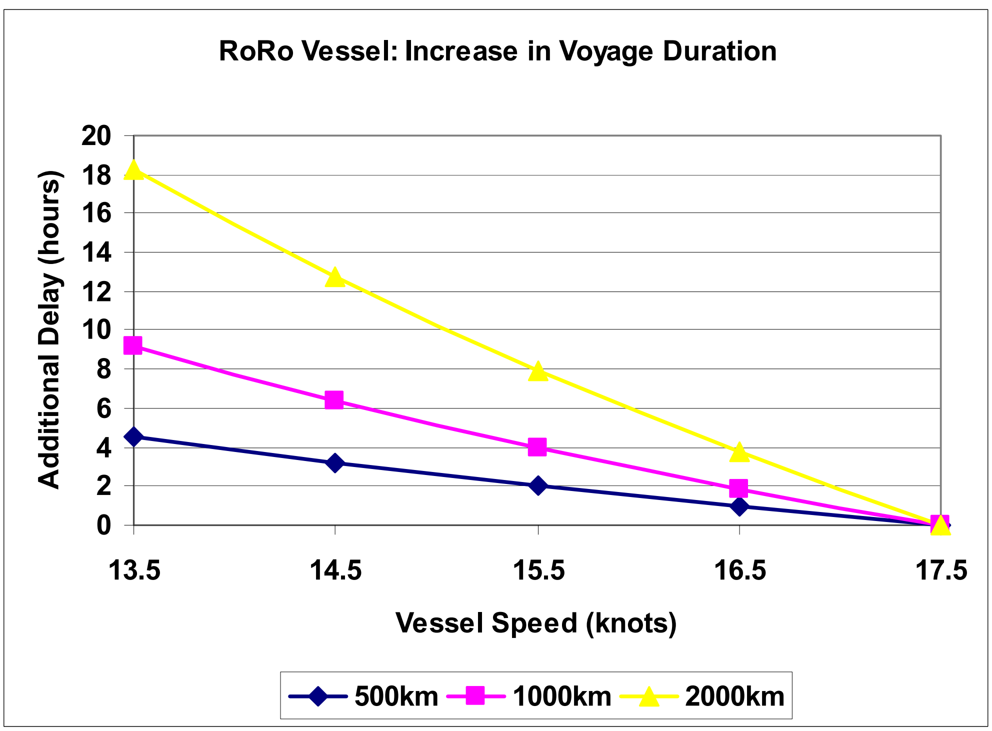


Figure 36: Cost structure (%) of RoPax Small (€/day)

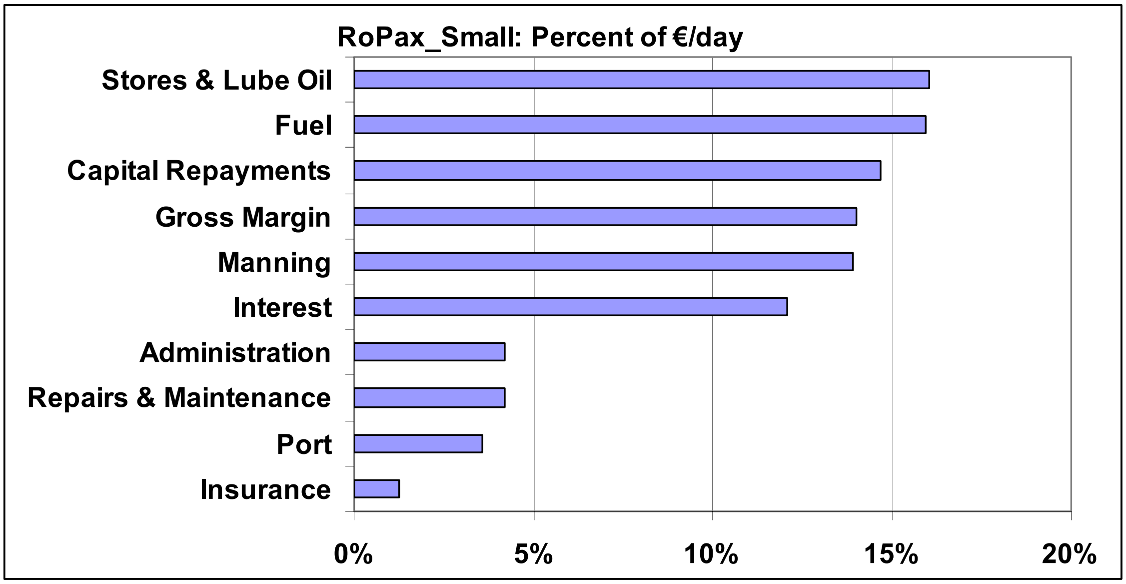



Figure 37: Fuel cost of a RoPax Small Vessel as a function of speed

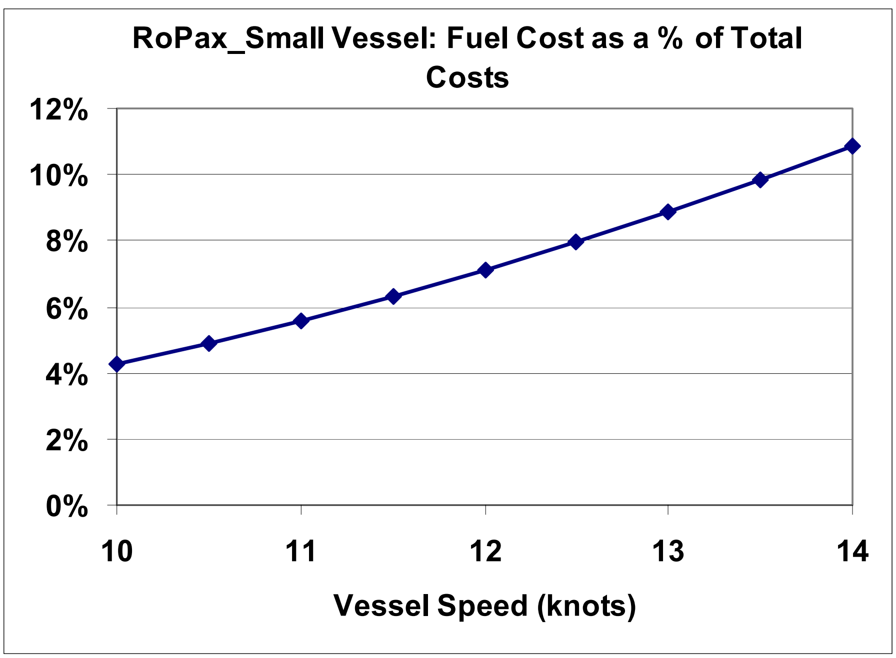


Figure 38: Increase in voyage duration as a function of speed of a RoPax Small

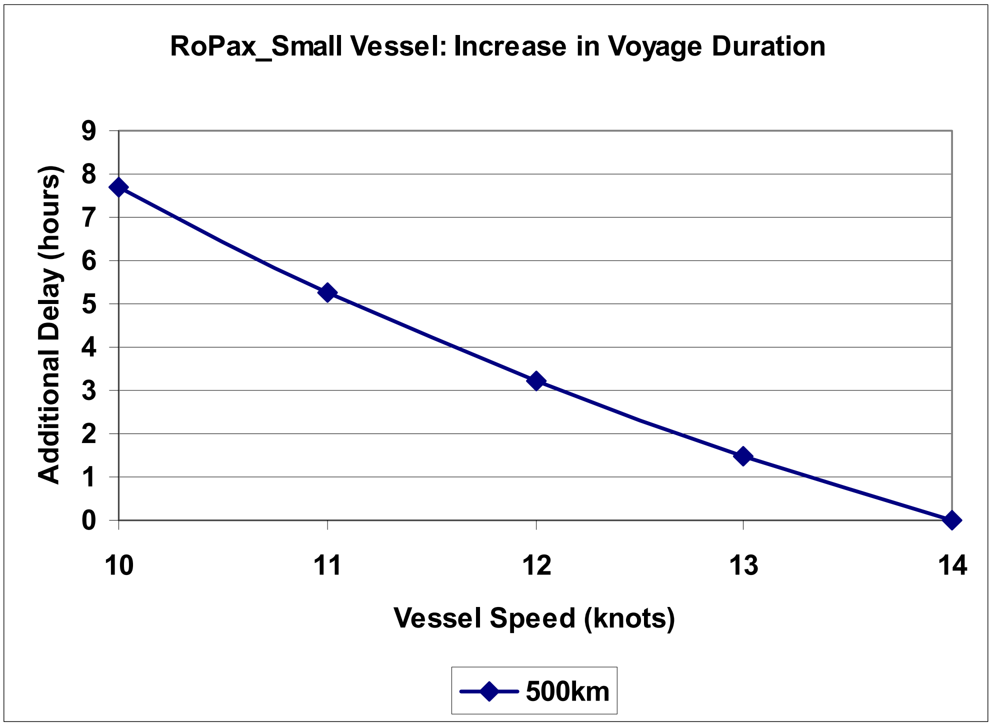



Figure 39: Cost structure (%) of RoPax Small (€/day)

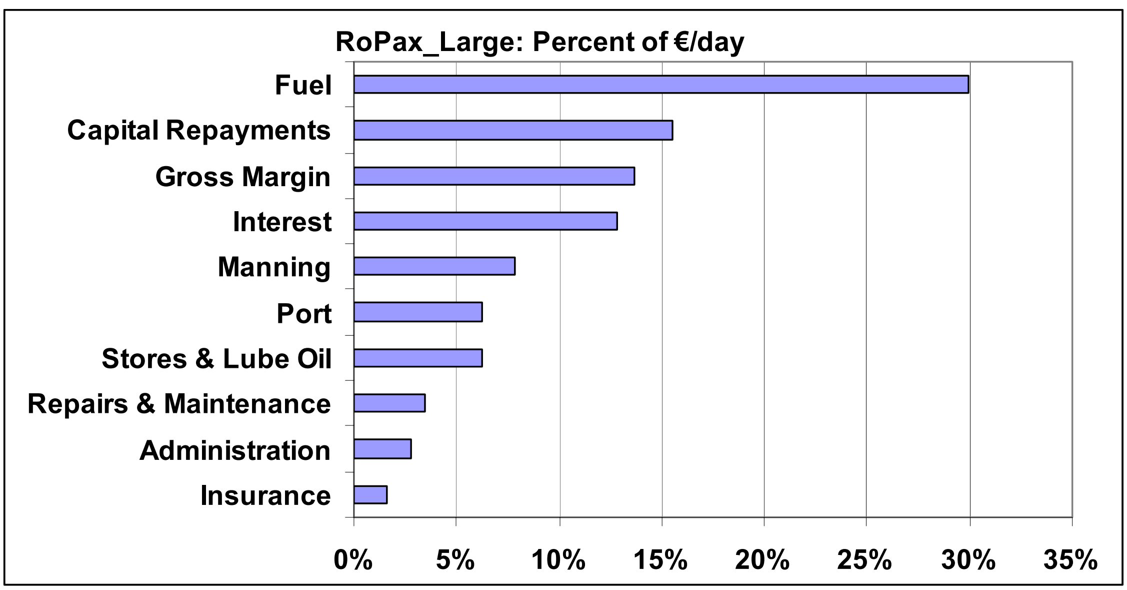


**Figure 40: Fuel cost of a RoPax Large Vessel as a function of speed**

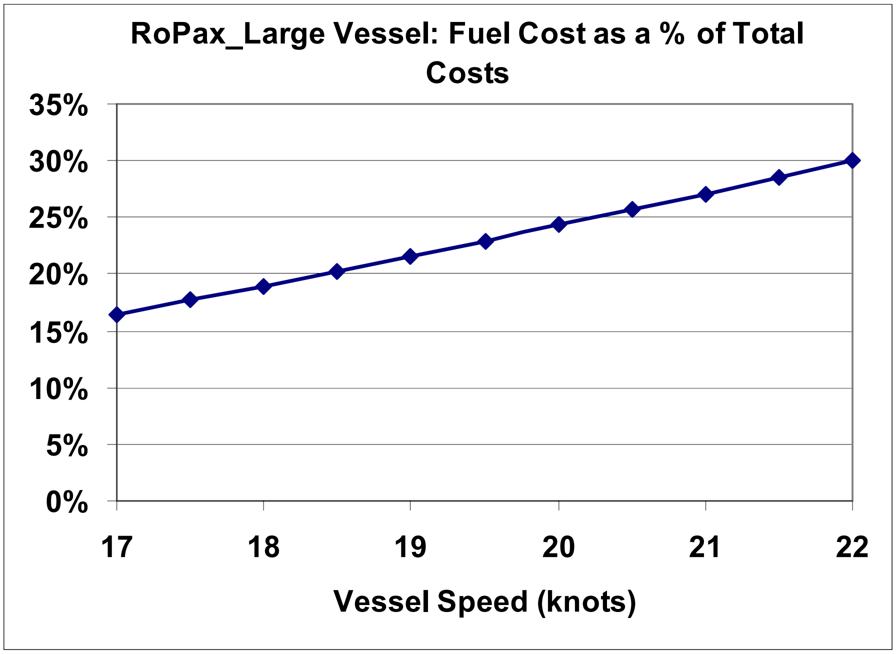
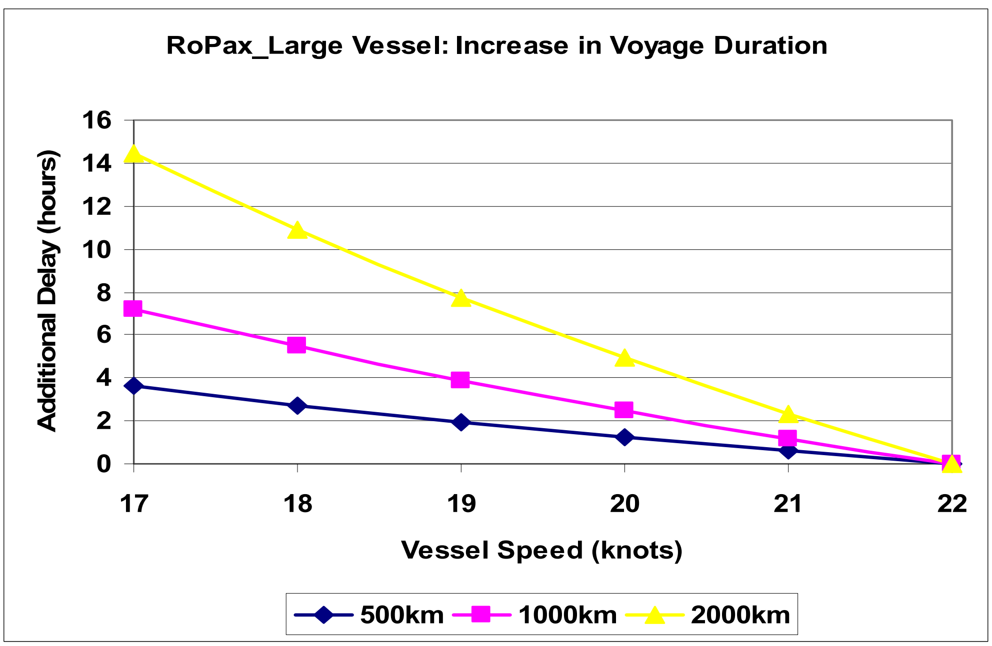



**Figure 41: Increase in voyage duration as a function of speed of a RoPax Large**



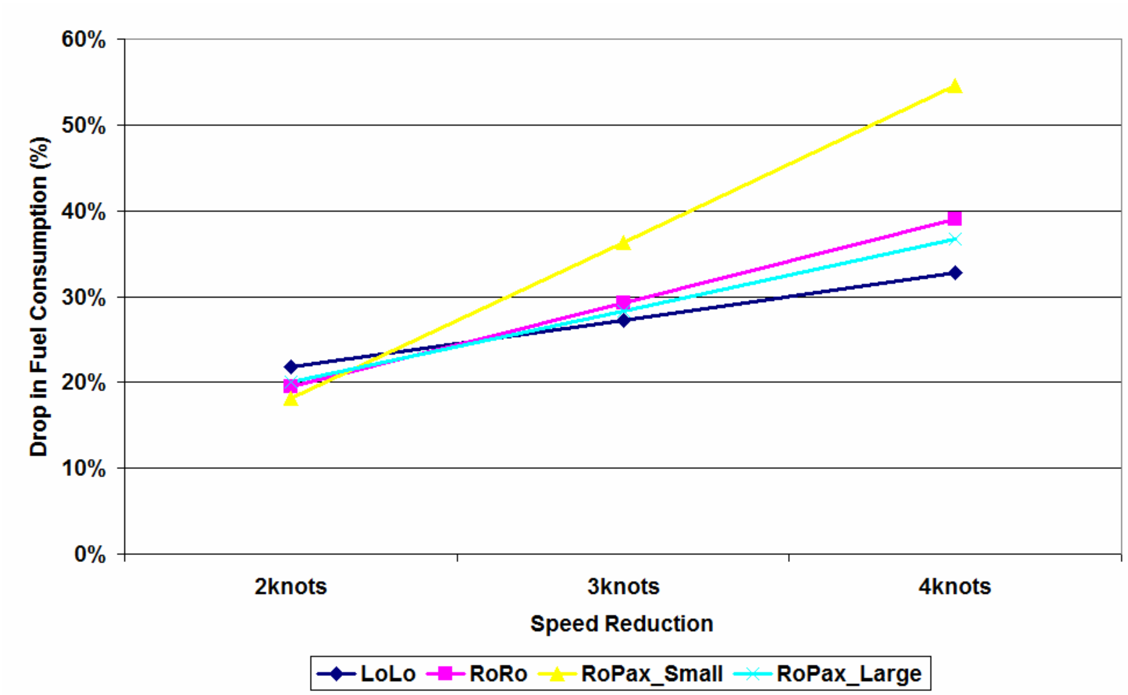

Based on these graphs and applying the same logic as described in connection with the LoLo vessel it is expected that the predicted price increase, though somewhat mitigated, combined with reduced service frequency and increased transport times will result in additional cargo losses compared to a situation where only monetary and time costs are taken into account. This is due primarily to the tendency for goods with higher time values to travel via RoRo & RoPax instead of LoLo.

A number of other potential energy saving mechanisms and actions, identified by CE Delft (2009), were also reviewed as part of this study, see following table. The CE Delft (2009) study states that an approximately 32% reduction in $CO_2$ generation, and hence fuel consumption, can be achieved through implementing all of the listed improvements. Based on figures 30, 33, 36 & 39 it can be seen that slowing down by approximately 3knots alone can provide an approximately 30% reduction in fuel consumption, see figure below. Due to the disproportional potential cost saving contribution due to slowing down it was felt that the qualitative analysis should only consider this mitigation action. The relative ease of the implementation of this mitigation factor without excessive investment

**Table 48: Measures to reduce CO2 Generation**

| Measures to Reduce $CO_2$ Generation, CE Delft (2009) |
| --- |
| Propeller/Propulsion system upgrades |
| Propeller maintenance |
| Retrofit hull improvements |
| Hull coating & maintenance |
| Air lubrication |
| Main engine retro-fit measures |
| Waste heat recovery |
| Auxiliary systems |
| Wind energy |
| Solar energy |
| Voyage & operations options |
| Speed reduction |

**Figure 42: Reduction in fuel consumption as a result of reducing speed**



# 4 Impact of new fuel standards on trade

In this chapter we analyse the potential impact of the new fuel standards on trade to and from the EU. We compare impacts on transport by deep sea vessel (DSV) to a central port, including feeding by short sea shipping & continental transport and the transport to final destination port by DSV exclusively. Competitive issues between terminal service by SSS or land are examined, but they are not the main topic of this work package.

The anticipated effects of the new fuel standards are twofold:

- Impact on physical trade flows: route choice, deep sea port choice.
- Impact on prices of imported goods.

In this chapter we first elaborate on the approach, using a simplified model, we present the results of the simulation and finally formulate conclusions for the impact on trade (both on port choice and prices of goods).

## 4.1 Methodology

In a first step in the analysis we set up a rough network to replicate the intercontinental trade to the EU, with origins, entry points and destinations. The network consists of 3 aggregated origins and 5 destinations. In between O's and D's are the ports of entry. The latter are the ports goods enter the EU market. Finally hinterland connections to the final destinations are considered. For the links in this network, we identify trade transport costs, broken down in relevant cost components. Likely cost increases due to new fuel specifications (specifically in those areas where the legislation is applicable) will influence the overall costs of transport (and consequently transported goods). Critical in determining port choice impacts are the specificities of each link (i.e. what distance is traveled in newly regulated seas).

The setup of the model consists of Origins, Entry/Exit points, Destinations and Ship Types and is as follows:

Origins:

- East (via Suez)
- East (via Cape of Good Hope)
- West (via Panama)

As starting points for these trips, Shanghai was chosen for both Eastern routes, and the Atlantic entrance of the Panama Canal in the West.

Entry/Exit points:

- Rotterdam
- Genoa
- Piraeus
- Algeciras
- Copenhagen

Note that the selected ports are in fact representations of groups of ports, close to each other and serving similar hinterland markets. For example, Rotterdam is a representation of all ports in the Le Havre-Hamburg range; Genoa could also be Marseille; Copenhagen, Malmö and Gdansk can be substituted; these ports are considered to be in competition for the Western European market.

Destinations:
- Ruhr area (Bochum)
- Northern Italy (Milan)
- South Sweden (Stockholm)
- South UK (London)
- Poland (Warsaw)

For some combinations, more sensible entry points were selected (e.g. UK: Portsmouth instead of Rotterdam, Poland: Gdansk instead of Copenhagen).

Obviously, not all combinations were relevant; for example, deliveries to Northern Italy will never pass through Copenhagen from any of the origins under study.

As an additional layer, the analysis was performed for three commodity types with corresponding ship types:
- Crude (Tankers)
- Bulk
- Container

For all -sensible- combinations, transport costs will be calculated in a scenario with high sulphur fuel (current standards) and in a scenario with low sulphur fuel (new standards); consequently, we investigate if the resulting cost changes are likely to cause changes in the preferred port of entry for each of the 56 O/D's.

## 4.2 Data used

This simplified model requires limited data inputs, on travel distances and travel costs:

### 4.2.1 Distances

We distinguish for each route the length of the journey in EU- and non-EU-seas, as the legislation cannot be applicable in non-EU seas. For the route via Suez, Port Said is taken as cut-off point; for the other two, a waypoint approximately 500 km West of Gibraltar is taken to distinguish between distance traveled in EU and non-EU seas.

For each of the combinations, following distances were reviewed:
- Distance to Europe by DSV

**Table 49: Distances to Europe by Deep Sea Vessel**

| Route | End point | Distance (km) |
|---|---|---|
| East via Suez | Port Said | 14000 |
| East via CGH | 500km West of Gibraltar | 25000 |
| West via Panama | 500km West of Gibraltar | 7500 |

Source: Google maps

- Distance within Europe by DSV

**Table 50: Distances within Europe by Deep Sea Vessel**

| Start | Destination | Distance (km) |
|---|---|---|
| Port Said | Rotterdam | 6500 |
| Port Said | Genoa | 2750 |
| Port Said | Piraeus | 1000 |
| Port Said | Algeciras | 3500 |
| Port Said | Copenhagen | 7500 |
| W of Gibraltar | Rotterdam | 2500 |
| W of Gibraltar | Genoa | 2000 |
| W of Gibraltar | Piraeus | N/A |
| W of Gibraltar | Algeciras | 500 |
| W of Gibraltar | Copenhagen | 3500 |

Source: Google maps

- Distance within Europe by Short Sea Shipping (SSS)

**Table 51: Distances within Europe by Short Sea Vessel**

| *Port* | Rotterdam | Genoa | Piraeus | Algeciras | Copenhagen |
|---|---|---|---|---|---|
| **Rotterdam** | 0 | 4250 | 5500 | 2750 | 1000 |
| **Genoa** | 4250 | 0 | 1750 | 1500 | 5250 |
| **Piraeus** | 5500 | 1750 | 0 | N/A | 6250 |
| **Algeciras** | 2750 | 1500 | N/A | 0 | 3750 |
| **Copenhagen** | 1000 | 5250 | 6250 | 3750 | 0 |

Source: Google maps

- Distance within Europe by land mode, either in a scenario with land modes doing the full terminal service from entry point to final destination (typical for high-value goods) or in a mixed scenario where the first part is done from the entry point to the port nearest the destination, followed by a part over land (typical for low-value goods).

Some EU waters are considered to be ECA-zones. This means some parts of the maritime distances in Europe are to be traveled in ECA zones (only for Rotterdam and Copenhagen ports). This is 750km and 1750km respectively. Compared to the overall distance, the distance traveled in the ECA zones is relatively low. In these zones the new fuel specifications will be applicable and will cause transport cost to increase.

### 4.2.2 Costs

The cost structures by ship type are indicated in the tables below. Fuel costs differentials are based on Purvin & Gertz (2009) and assume a relative cost increase for 0.1% to 1.5% sulfur fuel of 75% in 2010. Cost differentials are lower for later years (see Table 38). We only did the analysis for 2010 cost differentials, when they are the highest, as a "worst case" with maximum possible impact. Note that 0.1% S limit still only enters into force in 2015.

**Table 52: Cost structure container ship**

| |
|---|
| Via Panama |
| Via Suez |
| Via Cape |
| European |

The costs of deep sea shipping in the reference case, broken down by cost components and by ship type are summarized in tables below.

**Table 53: Cost structure container**

| Container Ship (€/day) | | | | |
|---|---|---|---|---|
| **Size (TEUs)** | **1000-2000** | **5000-6000** | **8000-9000** | **10000-12000** |
| | **2000** | **5500** | **8500** | **11000** |
| **Guide DWT** | **15,000 - 25,000** | **50,000 - 60,000** | **90,000 - 100,000** | **120,000 - 140,000** |
| **Manning** | €1,588 | €2,176 | €2,313 | €2,466 |
| **Insurance** | €443 | €931 | €1,168 | €1,336 |
| **Repairs & Maintenance** | €977 | €2,603 | €2,786 | €3,092 |
| **Stores & Lube Oil** | €580 | €1,557 | €1,847 | €2,122 |
| **Administration** | €550 | €931 | €962 | €1,008 |
| **Capital Repayments** | €4,378 | €11,276 | €16,848 | €20,430 |
| **Interest** | €3,599 | €9,269 | €13,850 | €16,794 |
| **Gross Margin** | €2,059 | €4,886 | €6,762 | €8,032 |
| **Port** | €2,500 | €5,200 | €6,800 | €8,300 |
| **Fuel (Ton/day)** | 45.0 | 77.0 | 91.0 | 116.0 |
| **Fuel (€/day)** | €14,341 | €24,540 | €29,002 | €36,969 |
| **Speed (knots)** | 14.0 | 18.0 | 18.0 | 18.0 |
| **Full Cargo Weight (Ton)** | 18,000 | 66,000 | 102,000 | 132,000 |
| **Total (€/day)** | **€31,015** | **€63,370** | **€82,337** | **€100,547** |

**Table 54: Cost structure dry bulk**

| Dry Bulk (€/day) | | | | |
|---|---|---|---|---|
| **Size** | **Handysize** | **Panamax** | **Post Panamax** | **Capesize** |
| **Guide DWT** | **10,000 - 40,000** | **60,000 - 80,000** | **60,000 - 110,000** | **110,000 - 200,000** |
| **Manning** | €1,389 | €1,847 | €1,847 | €2,069 |
| **Insurance** | €473 | €702 | €756 | €817 |
| **Repairs & Maintenance** | €1,107 | €1,458 | €1,656 | €1,824 |
| **Stores & Lube Oil** | €374 | €511 | €557 | €611 |
| **Administration** | €947 | €1,099 | €1,160 | €1,237 |
| **Capital Repayments** | €3,847 | €5,837 | €6,102 | €6,898 |
| **Interest** | €3,162 | €4,798 | €5,016 | €5,671 |
| **Gross Margin** | €1,921 | €2,763 | €2,906 | €3,251 |
| **Port** | €2,100 | €2,800 | €3,000 | €3,500 |
| **Fuel (Ton/day)** | 32.0 | 38.0 | 42.0 | 55.0 |
| **Fuel (€/day)** | €10,198 | €12,111 | €13,385 | €17,528 |
| **Speed (knots)** | 12.0 | 13.0 | 13.0 | 13.0 |
| **Full Cargo Weight (Ton)** | | | | |
| **Via Panama** | | 69,252 | | |
| **Via Suez** | | | 83,448 | |
| **Via Cape** | | | | 151,931 |
| **European** | 24,739 | | | |
| **Total (€/day)** | **€25,519** | **€33,927** | **€36,387** | **€43,406** |

**Table 55: Cost structure tanker**

| Tanker (€/day) | | | | |
|---|---|---|---|---|
| **Size** | **MR1** | **LR1** | **Suezmax** | **VLCC** |
| **Guide DWT** | **25,000 - 45,000** | **45,000 - 80,000** | **120,000 - 200,000** | **200,000 - 320,000** |
| **Manning** | €2,369 | €2,369 | €2,600 | €2,808 |
| **Insurance** | €554 | €592 | €1,038 | €1,377 |
| **Repairs & Maintenance** | €1,408 | €2,108 | €2,777 | €3,108 |
| **Stores & Lube Oil** | €585 | €654 | €885 | €1,131 |
| **Administration** | €1,031 | €1,292 | €1,523 | €1,723 |
| **Capital Repayments** | €5,748 | €6,684 | €9,358 | €13,368 |
| **Interest** | €4,725 | €5,495 | €7,692 | €10,989 |
| **Gross Margin** | €2,791 | €3,263 | €4,398 | €5,866 |
| **Port Charges (€/day)** | €2,500 | €3,025 | €4,445 | €6,286 |
| **Fuel (Ton/day)** | 29.0 | 35.0 | 60.0 | 92.5 |
| **Fuel (€/day)** | €9,242 | €11,154 | €19,122 | €29,480 |
| **Speed (knots)** | 12.0 | 15.0 | 15.0 | 15.0 |
| **Full Cargo Weight (Ton)** | | | | |
| **Via Panama** | | 59,404 | | |
| **Via Suez** | | | 158,078 | |
| **Via Cape** | | | | 256,626 |
| **European** | 34,763 | | | |
| **Total (€/day)** | **€30,953** | **€36,636** | **€53,838** | **€76,134** |

For land modes, costs per tonkm were derived, as in the previous chapter, from the TREMOVE model. It was assumed all terminal service transport is done by road as this will not influence the outcome of the model.

With all data compiled, we are able to first calculate total transport costs for both cases of 100% land and Short Sea + land feeding. Secondly, the fuel share for maritime transport was calculated distinguishing between the distances sailed within and outside ECAs. As a final step, the cost changes (worst case – i.e. with 2010 cost differentials) due to fuel sulphur content restrictions were applied for both a limit of 1.5% (2008) and 0.1% (2015), for fuel costs within the ECAs. A hypothetical case with ECA extended to all waters surrounding Europe (including the Mediterranean Sea and the Atlantic coast) was also calculated.

## 4.3 Results: impact on transport costs

Overall, cost changes are very limited. Moreover, the changes in costs do not lead to changes in most competitive port of entry. This mean the cheapest port of entry remains to be the cheapest, even with the regulation.
Also, little impact is expected on the feeder side; SSS feeding will still be far more competitive compared to road only feeding.

The next figures give some examples of the impact of the regulation on transport cost:

**Figure 43: Total cost of container trade from East via Suez to Ruhr in the 1.5% S scenario (blue) and 0.1% S scenario (purple) – M€/ship**

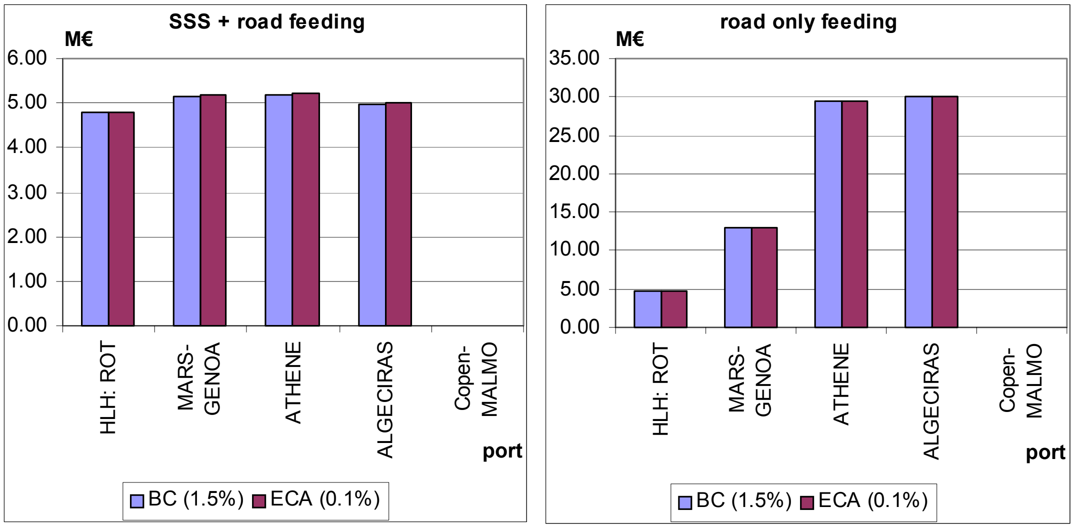



**Figure 44: Total cost of bulk trade from Panama to Ruhr in the 1.5% S scenario (blue) and 0.1% S scenario (purple) – M€/ship**

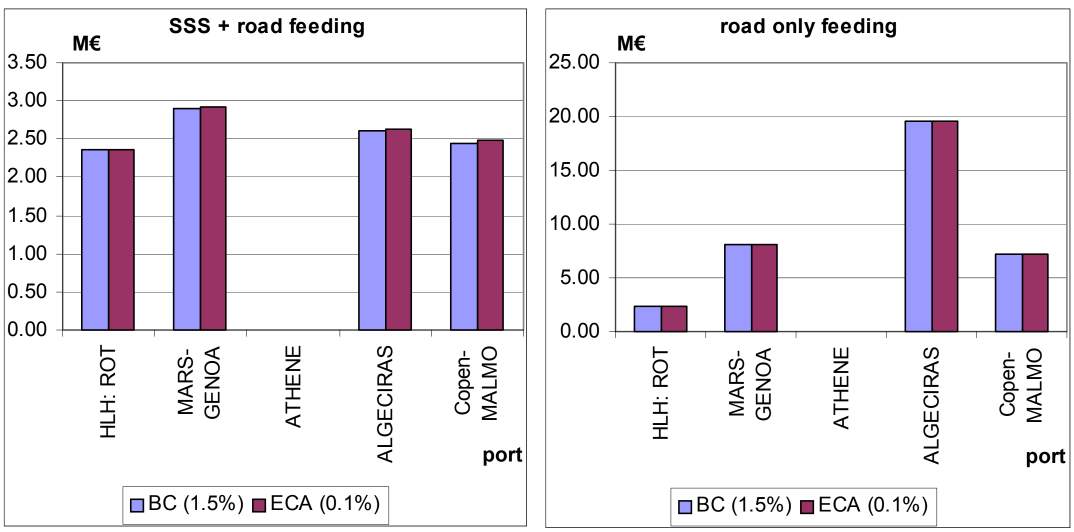


**Figure 45: Total cost of container trade from East via Cape Good Hope to North Italy in the 1.5% S scenario (blue) and 0.1% S scenario (purple) – M€/ship**

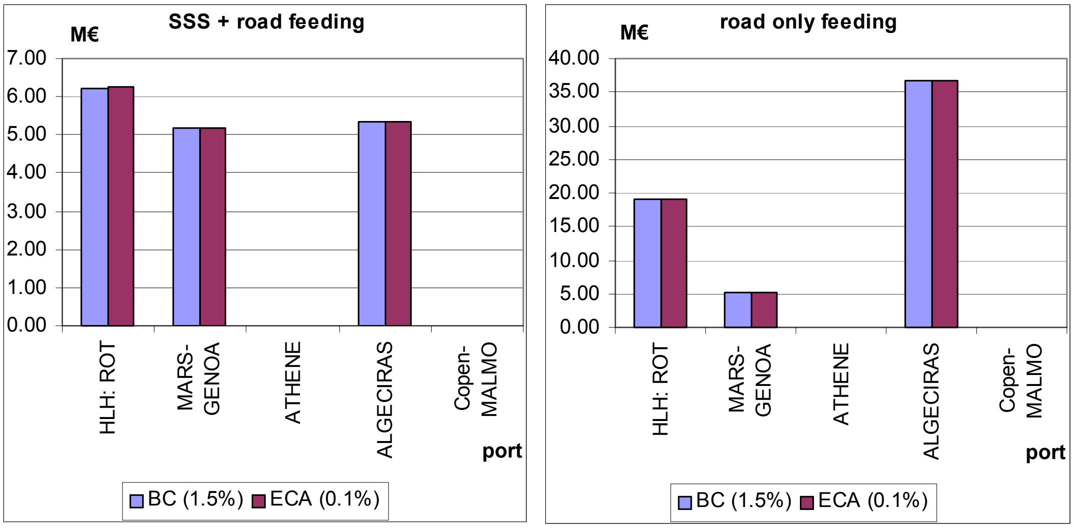
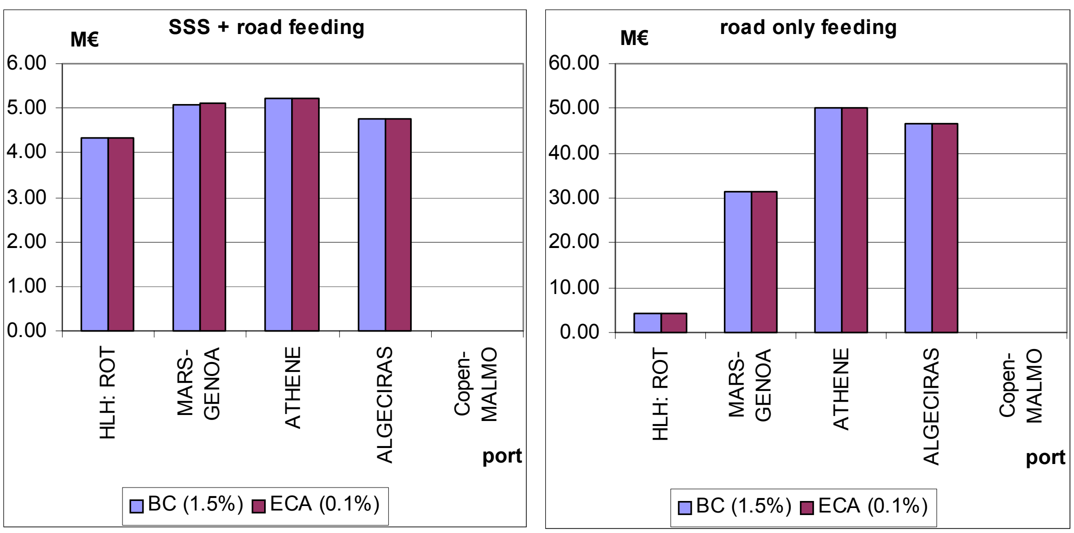



**Figure 46: Total cost of crude trade from Suez to UK and Sweden in the 1.5% S scenario (blue) and 0.1% S scenario (purple) – M€/ship**




For tankers, cost changes by 2015 are not expected to exceed 2% (for SSS+land terminal service). Assuming a 100% loading rate the cost per ton transported for tankers is between 0.30 and 0.89 €/ton/day. This means that the costs would increase maximally with 1 eurocent/ton/day. For containers and bulk, which are probably most relevant in this context, it never exceeds 2.5%. Starting from a cost of 0.87 till 1.8 €/ton/day for container transport, this means a maximum price increase of 2 to 4 eurocent/ton/day. For dry bulk the costs range between 0.29 and 1.03 €/ton/day leading to a maximum cost increase of about 1 to 2 eurocent/ton/day.

What becomes clear is that the longer the trip by DSV, the smaller the price increase. This is easily explained by the greater fuel efficiency of these larger vessels and the lower share of expensive fuel consumed in newly regulated area's, meaning they will consume less fuel than their SSS counterpart, also in ECA zones where only more expensive fuel types can be used. In this sense, although the impact is quasi negligible, the regulation is unfavorable for SSS-feeding as the new regulation favors deep sea vessels berthing at the port which is closest to the cargo's final destination. Given the limited price effects, other port choice parameters (proximity to market, economies of scale, capacity, etc.) will be detrimental rather than the change in cost due to the regulation.

If ECAs were to be extended to all waters surrounding Europe, including the Mediterranean Sea, cost increases of around 5% in 2015 (with peaks of 10%) could occur.

## 4.4 Results: Impact on commodity prices

Given the relatively moderate expected increase in transport prices, as explained in the previous chapter, only those goods for which transport cost is a major part of total costs are likely to see an effect on their competitive position. These are mainly low-value goods such as ores, grains or forest industry products (wood, paper, etc.).

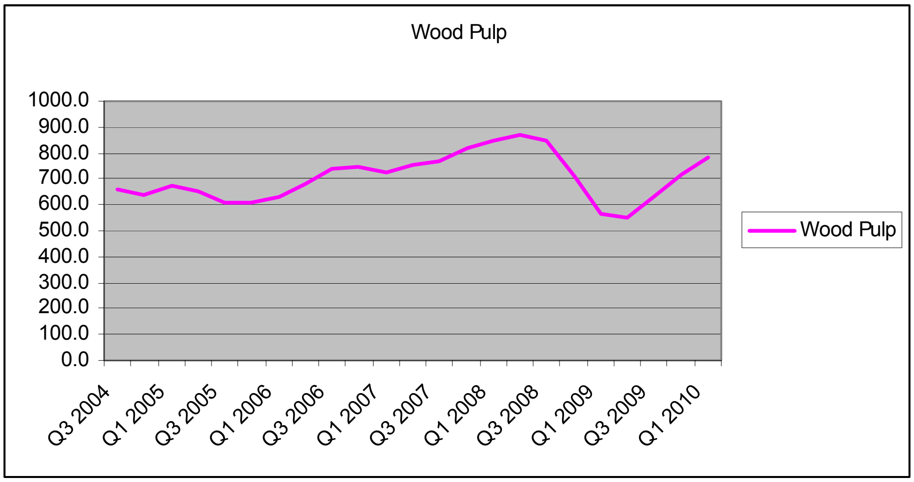
The main question from the EC's perspective is whether goods produced inside the EU will see a larger price increase than goods imported from other parts of the world. With the data available, it is impossible to formulate a decisive conclusion. The main problem is that the share of transport costs for goods from different origins is unknown. One would expect that the regulation has a larger effect on products produced within the EU as the distance traveled trough the ECA's is relatively larger than for products produced outside the EU. On the other hand, the total transport share in the cost structure of the goods is likely to be lower for products produced within the EU than outside the EU.

Still, it was attempted to gain some insight in the markets for paper/wood products and iron products, both among the main exports of the countries on the Baltic Sea (Sweden, Finland, Latvia, Estonia).

### 4.4.1 Wood and paper products

The market price for wood pulp increased substantially in the period between 2004 and the economic crisis of late 2008. At its lowest in that time span, the price was about 600$/Metric Ton (MT) at the end of 2005. The highest price was reached right before the crisis and likely would have increased beyond the level of 870$/MT, already 45% up from the price just 2.5 years before. Price level dropped back to 550$/MT by Mid 2009, but it is now (mid 2010) moving back towards its peak price level.

**Figure 47: Evolution market price wood pulp ($/MT)**

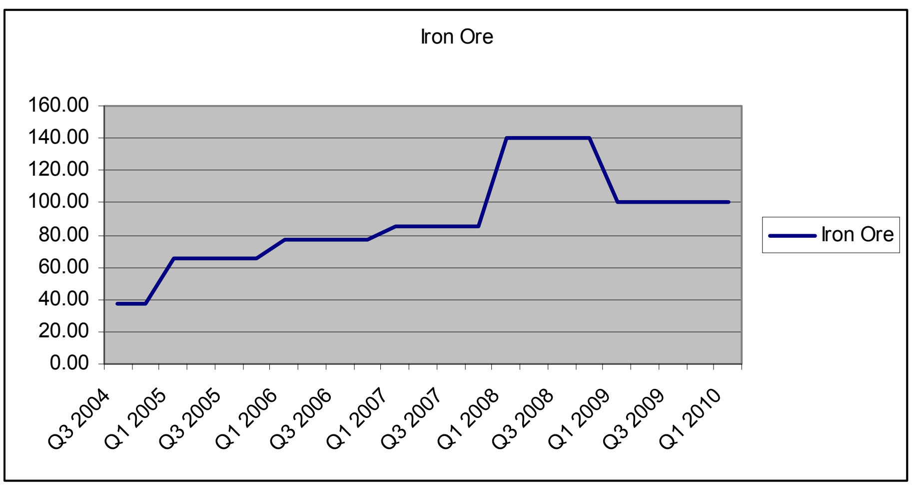



Source: World Bank Commodity prices

### 4.4.2 Iron ore

Price level measures for iron ore are not as detailed, but broadly show the same trend as wood pulp prices. Relative price changes are much larger though, as prices almost tripled from 2004 to 2008.

**Figure 48: Evolution market price iron ore ($/MT)**

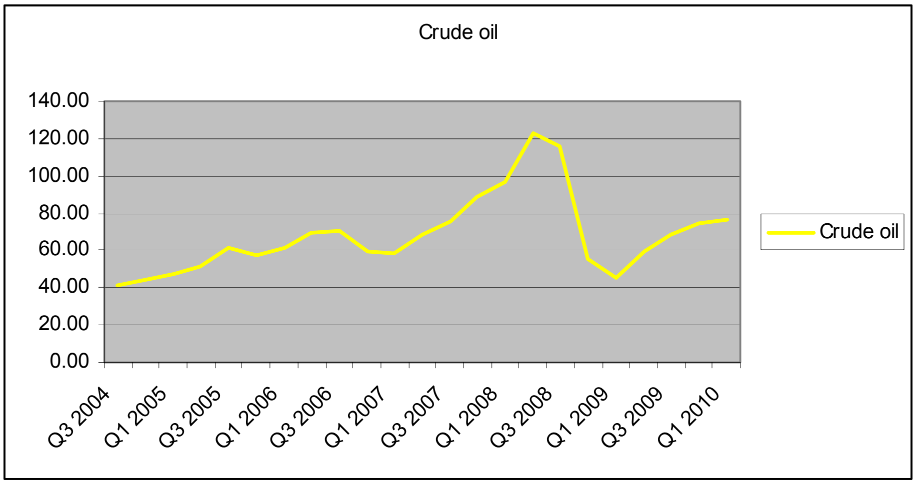



Source: World Bank Commodity prices

### 4.4.3 Crude oil

As a complement to these data, it is useful to make the comparison with crude oil prices.

**Figure 49: Evolution market price crude oil ($/bbl)**

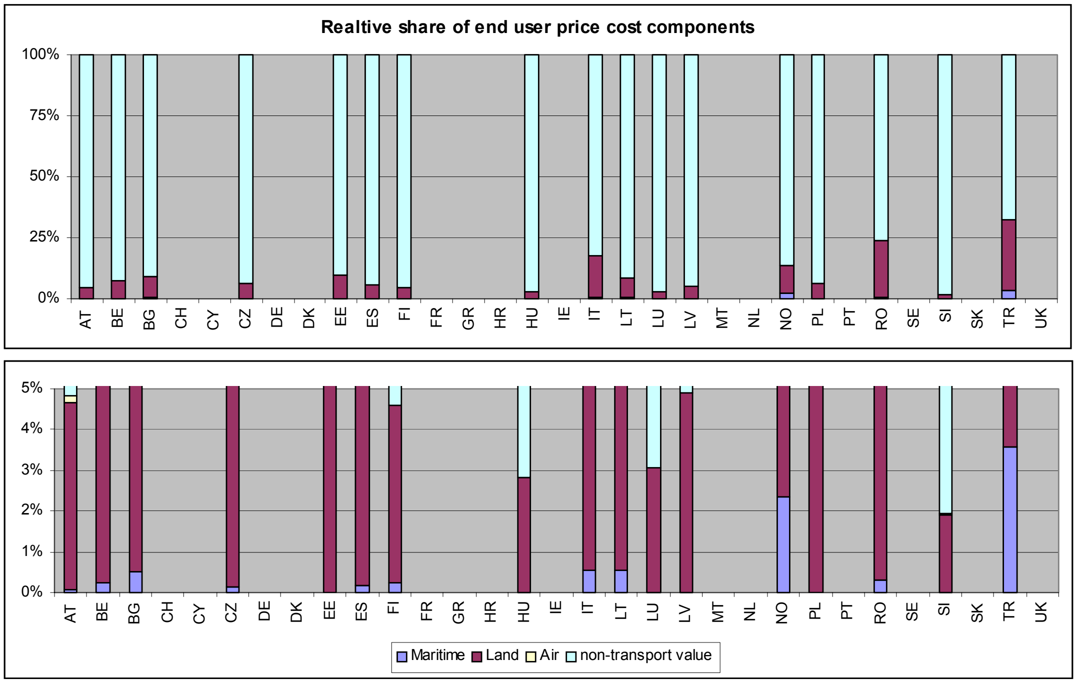



From this exercise, it appears that the price of iron ore is much more related to the price of crude oil than is the case for wood pulp. The sample it too limited however to draw decisive conclusions.

### 4.4.4 Transport costs

Apart from price evolutions, we investigated the share of transport cost, by mode, for all goods consumed in the EU. Data was derived from the social accounting matrices used in the EDIP model

**Figure 50: Share of transport cost, by mode for the EU27 countries: top: overall picture; bottom: zoom on the transport cost components.**




Note that data is not available for all countries, but the overall picture is the same for all countries. Transport costs represent, in total, little over 5% of the end user price, on average. Most of the transport share is consumed by road transport; maritime shipping accounts for less than 1% (except for NO and TR). These figures are valid for all consumption within the member states, aggregated over all commodity types. Distributional effects between commodity types are likely to occur as the share of transport cost for bulk goods is expected to be higher compared to unitized cargo, however we lacked data to deepen the analysis. Korinek & Sourdin (2009) found – for all intercontinental trade, hence not only towards Europe - that it is much more expensive to transport manufactured than agriculture goods or raw material, measured in cost per weight. However, if expressed as the share of the shipping cost in the import value, they found that 5.1% if the imported value of manufactures can be attributed to shipping and insurance, compared with 10.9% for agricultural goods and 24.1 % for industrial raw material. For crude oil, the shipping costs represent only 4% of the imported value. These shares however do not take into account all transport costs (by other modes) and only consider import values. Still, the overall picture shows that maritime shipping costs are marginally important for end user prices.

## 4.5 Conclusion

With ECAs as they are now, the sailing to and from European ports from/to other continents becomes only marginally more expensive. While this leaves Short Sea Shipping at a risk of losing activity to more fuel efficient Deep Sea Vessels making extra stops, other aspects than explicit costs (flexibility, opportunity costs, load factors) will likely temper this effect. Hence, it is not expected that changes in entry/exit points or shifts in modal balance (SSS to land) will take place.

Given the marginal cost increase of maritime transport and the marginal share of maritime transport cost in end user prices, the new legislation will cause negligible cost increase to end user prices of national consumption.

If ECAs were to be extended to, among others, the Mediterranean Sea, price increases are much higher and a shift of ports is much more likely, with Deep Sea Vessels making more calls at the expense of SSS. This assumes of course that no corresponding measures are taken for land modes or in global maritime transport, which would largely remove any of the cost advantages that DSV or other modes may possess.

# 5 Conclusions

The goal of this work was threefold:

- to gain an insight in the relative importance of different cost factors for the modes SSS, road and rail
- to analyse quantitatively and qualitatively the effect of 5 policy scenarios
- to analyse the effect of lowering the sulphur emission standard on European imports and exports.

The study first looked into the cost structure of Short Sea Shipping (SSS), road and rail transport. For SSS, we distinguish between 4 vessel types: RoRo, LoLo, RoPax Small and RoPax Large. The cost structure varies a lot between the different vessel types. Costs per tonkm also appeared to vary a lot with the distances sailed – showing a decrease in costs as distances increase. In general, rail and SSS are cheaper than road as can be seen in the table below:

**Table 56: Transportation cost (range) of road, rail and SSS (€/tonkm)**

| | SSS | Rail | Road |
|---|---|---|---|
| Cost €/tonkm | 0.006-0.09 | 0.005-0.009 | 0.10 |

Rail is much cheaper, while the cost per tonkm of certain types of vessels and certain distances is at a similar level as the road cost (0.09 €/tonkm for RoPax Small on short distances compared to 0.1 €/tonkm for road transport) . However, some costs such as storage costs, schedule delay costs, etc. which are typically higher for rail and SSS, are not included in the cost structure, nor is are costs for road caused by the driving and rest regulation. When we consider the relative importance of the fuel costs we note that

- for SSS the share of the fuel costs vary between 10% (small RoPax) and 47% (LoLo)
- for diesel rail the share of the fuel costs vary between 32% (general cargo) and 45% (dry bulk)
- for road the fuel share is about 23%.

This cost data was then used in a model that tried to quantify the effects of different policy scenarios. Apart from transport cost, other drivers like transport time and commodity type also impact the decision. Therefore we also included these elements into our model. However, certain non-cost drivers such as reliability, driving and rest times, reactions of the shipper, etc. could not be included in the cost structure nor in the model and were discussed separately.

Secondly, a model was developed to analyse quantitatively the effect of 5 policy scenarios for a selection of OD's. Only those OD's and commodities were selected that had SSS routes that could be sensitive for a change in modal shifts.

The policy scenarios analysed were:

- Policy scenario A: Sulphur regulation of 0.1% in the ECAs
- Policy scenario B: Sulphur regulation of 0.1% in the ECAs + eMaritime

- Policy scenario C: Sulphur regulation of 0.1% in the ECAs + eMaritime +GHG policy
- Policy scenario D: Sulphur regulation of 0.1% in all European seas except the Atlantic Coast + eMaritime +GHG policy
- Policy scenario E: Sulphur regulation of 0.1% in all European seas except the Atlantic Coast + eMaritime +GHG policy + NOx regulation in ECAs

The effect of these policies was assessed against a baseline scenario which includes economic growth projections, as well as likely evolutions in other transport modes.

Overall the first policy scenario – lowering the sulphur content in the ECAs - leads to the largest changes in transport volumes – from only 1% for Ropax Small to 10% for routes where LoLo is used. We assume that compliance with the MARPOL regulation is obtained by the use of low sulphur fuel. This leads to a sharp increase in fuel costs, leading to an increase in total costs – varying from an increase of 6% for Ropax-Small up to 29% for LoLos. Notable is that also road transport volumes slightly decrease. The main reason for this is the fact that total transport budget is assumed to be fixed in the model. If prices increase, this also decreases the budget for road transport as switching from SSS to road does not lead to a decrease in monetary costs. Adding the eMaritime policy somewhat milder the decrease in volumes – but the effect is rather small as eMaritime is not expected to lead to high cost decreases. It is assumed to lower port costs with about 5% - which leads to a total cost decrease varying between 0.2% (RoPax Small) and 0.4% (RoPax Large and RoRo). The effect internalising GHG emissions by SSS via a market based instrument at a price of 25 €/tonne CO2 leads to an increase in costs of about 3% (RoPax Small and Large) till 10% (LoLo) and adds an additional decrease in volumes of 0.1 to 3.5%. Extending the sulphur regulation to other European Seas- except the Atlantic – is not notable in our analysis as this only affects the limited amount of OD's between France and Italy. The NOx regulation has a cost impact of 0.6% (RoPax Large) till 2.5% (LoLo) for newly built ships. The effect of this policy decreases over time as the additional costs become less important as other policies start having their effect. Note that decreasing the loading factors would increase the volume losses.

When we translate this to the effect on modal shares between the baseline and policy scenario E, we see clearly from the table below that modal shares of the SSS option decrease for all ship types.

**Table 57: Modal share of the SSS option and change in modal share**

| | Modal share | | Change in modal share |
|---|---|---|---|
| Modal share | Baseline | Policy E | |
| LoLo | 34% | 31% | -7% |
| RoRo | 35% | 33% | -4% |
| Ropax Small | 13% | 12% | -1% |
| Ropax Large | 26% | 26% | -2% |

From this analysis it is clear that the effect on LoLo is the highest. This is mainly due to the fact that they have rather low capital costs and hence any cost increases has a relatively high impact.

When we distinguish the effect according to the commodity type it is clear that the main type of goods affected are other products (9) and metal products (5). Agriculture products (0), foodstuff (1), building material (6) and chemicals (8) are less affected.

With respect to the emissions we saw a substantial decrease in SSS emissions of SO2 (more than 90%), of NOx (more than 50%), of PM (almost 60% reduction) and of VOS (almost 30% reduction). CO2 emissions are not directly targeted and decrease with only 7%. Even when taking into account road and rail emissions the effect are clear. SO2 emissions still decrease with more than 90%, NOx with 29%, PM with 42% and VOS with 24%. Only the decrease in CO2 emissions is now much lower – only 2%. The reason is that CO2 emissions of road and rail are relatively more important when considering total emissions than for, for example, SO2 and NOx.

This quantitative assessment is complemented with a qualitative assessment which focussed on possible responses by the ship operator to minimize the effect on consumer prices. Responses such as lowering the vessel speed to decrease fuel costs or decreasing profit margins proofed to be an inadequate answer to possible costs increases as both would still lead to less volumes transported.

Finally, the assessment of the potential impact on European imports and exports (especially regarding to trade in low value goods) showed that with ECAs as they are now, the sailing to and from European ports from/to other continents becomes only marginally more expensive. While this leaves Short Sea Shipping at a risk of losing activity to more fuel efficient Deep Sea Vessels making extra stops, other aspects than explicit costs (flexibility, opportunity costs, load factors) will likely temper this effect. Hence, it is not expected that changes in entry/exit points or shifts in modal balance (SSS to land) will take place. Given the marginal cost increase of maritime transport and the marginal share of maritime transport cost in end user prices, the new legislation will cause negligible cost increase to end user prices of national consumption.

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# Annex 1: Questionnaire for RoRo Ship

| No. | Question | Specifics | Answer |
|---|---|---|---|
| Q1 | The cost of transporting freight by RoRo shipping can be apportioned under the following headings. Please assign appropriate percentage (%) values to the cost contribution per tonne-kilometre for each heading: (Space is provided to add comments) | Fuel/Energy | |
| | | Loading & Unloading | |
| | | Capital Repayment | |
| | | Maintenance | |
| | | Administration | |
| | | Labour | |
| | | Port & Canal | |
| | | Taxes & Vat | |
| | | Interest | |
| | | Insurance | |
| | | Other-1 (specify) | |
| | | Other-2 (specify) | |
| | | Other-3 (specify) | |
| | | Other-4 (specify) | |
| Q2 | Please provide average unit costs for transporting freight by RoRo shipping: | € per tonne-kilometre | |
| Q3 | Please use this space to provide further comments or information: | Open-Ended Response | |
| Q4 | Please detail expected percentage (%) cost increase/decrease for RoRo for 2025 based on 2010 costs under the following headings. Please also provide rationale for expected change: (e.g. Fuel/Energy = 15% cost increase due to lower fuel availability) | Capital Repayment | |
| | | Interest | |
| | | Fuel/Energy | |
| | | Labour | |
| | | Port & Canal | |
| | | Loading & Unloading | |
| | | Maintenance | |
| | | Insurance | |
| | | Taxes & Vat | |
| | | Administration | |
| | | Other-1 (specify) | |
| | | Other-2 (specify) | |
| | | Other-3 (specify) | |
| | | Other-4 (specify) | |
| Q5 | Please provide expected average unit costs for transporting freight by RoRo shipping in 2025: | € per tonne-kilometre | |
| Q6 | Please use this space to provide further comments or information: | Open-Ended Response | |
| Q7 | Please weight the following mode choice factors as they apply to shippers choosing RoRo: (1 = Does not impact, 512 = Essential) | Total Transport Cost | |
| | | Time in Transit | |
| | | Service Reliability | |
| | | Cargo Security | |
| | | Shipment Size | |
| | | Shipment Shelf-life | |
| | | Shipment Value | |
| | | Shipment Density | |
| | | Distance of Shipment | |
| | | Shipment Frequency | |
| | | Carrying Capacity | |
| | | Service Schedule | |

| | | | |
|---|---|---|---|
| | | Customer Service | |
| | | Proximity to Shipper | |
| | | Other-1 (specify) | |
| | | Other-2 (specify) | |
| | | Other-3 (Specify) | |
| | | Other-4 (Specify) | |
| **Q8** | Please provide further details on "Other" mode choice factors: | Other-1 | |
| | | Other-2 | |
| | | Other-3 | |
| | | Other-4 | |
| **Q9** | Please use this space to provide further comments or information: | Open-Ended Response | |

# Annex 2: Origin-Destination

| Origin | | Destination | | Commodity | Mode Stage1 | Port-1 | ship type Stage 2 | Port-2 | Mode Stage3 | TEUs | Tonnes per year | % of EU Freight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 2005 | | |
| FI | Helsinki | UK | Preston | 9 | Road | Helsinki | RoRo | Hull | Road | 1716 | 18,879 | 0.04% |
| FI | Helsinki | UK | Manchester | 9 | Road | Helsinki | RoRo | Hull | Road | 4489 | 49,375 | 0.12% |
| FI | Helsinki | UK | Manchester | 9 | Road | Helsinki | RoRo | Portsmouth | Road | 8021 | 88,233 | 0.21% |
| FI | Helsinki | UK | Manchester | 9 | Road | Helsinki | LoLo | Harwich | Road | 1274 | 14,019 | 0.03% |
| FI | Helsinki | UK | Derby | 0 | Road | Helsinki | RoRo | Hull | Road | 2175 | 39,147 | 0.06% |
| FI | Helsinki | UK | Northampton | 9 | Road | Helsinki | RoRo | Dover | Road | 1613 | 17,745 | 0.04% |
| FI | Helsinki | UK | Reading | 9 | Road | Helsinki | RoRo | Portsmouth | Road | 6441 | 70,853 | 0.17% |
| FI | Oulu | UK | Reading | 9 | Road | Oulu | LoLo | Harwich | Road | 2367 | 26,032 | 0.06% |
| FI | Oulu | UK | Reading | 9 | Road | Oulu | RoRo | Portsmouth | Road | 1154 | 12,689 | 0.03% |
| FI | Tampere | UK | Reading | 9 | Road | Pori | LoLo | Harwich | SSS | 5682 | 62,503 | 0.15% |
| FI | Tampere | UK | Reading | 9 | Road | Pori | RoRo | Portsmouth | Road | 3037 | 33,403 | 0.08% |
| FI | Helsinki | UK | Reading | 9 | Road | Helsinki | LoLo | Harwich | Road | 8862 | 97,480 | 0.23% |
| FI | Helsinki | UK | Reading | 9 | Road | Helsinki | RoRo | Portsmouth | Road | 1768 | 19,447 | 0.05% |
| FI | Helsinki | UK | Reading | 9 | Road | Helsinki | RoRo | Dover | Road | 1301 | 14,306 | 0.03% |
| FI | Helsinki | UK | Reading | 9 | Road | Helsinki | RoRo | Hull | Road | 2643 | 29,070 | 0.07% |
| FI | Helsinki | UK | Brighton | 0 | Road | Helsinki | LoLo | Harwich | Road | 3266 | 58,783 | 0.08% |
| FI | Helsinki | UK | Brighton | 0 | Road | Helsinki | RoRo | Dover | Road | 1219 | 21,951 | 0.03% |
| FI | Tampere | UK | Swansea | 9 | Road | Pori | RoRo | Hull | Road | 1062 | 11,677 | 0.03% |
| FI | Helsinki | UK | Swansea | 9 | Road | Helsinki | RoRo | Hull | Road | 1620 | 17,816 | 0.04% |
| FI | Helsinki | UK | Cardiff | 9 | Road | Helsinki | RoRo | Hull | Road | 1126 | 12,390 | 0.03% |
| FI | Tampere | UK | Belfast | 9 | Road | Pori | LoLo | Belfast | Road | 3627 | 39,898 | 0.09% |
| FI | Helsinki | UK | Belfast | 9 | Road | Helsinki | LoLo | Belfast | Road | 1573 | 17,302 | 0.04% |
| | | | | | | | | | | | | |
| SE | Malmo | DK | Copenhagen | 9 | Road | Malmo | RoPax-Small | Copenhagen | Road | 22071 | 242,786 | 0.57% |
| SE | Malmo | DK | Copenhagen | 0 | Road | Malmo | RoPax-Small | Copenhagen | Road | 1226 | 22,063 | 0.03% |
| SE | Malmo | DK | Copenhagen | 1 | Road | Malmo | RoPax-Small | Copenhagen | Road | 1648 | 28,015 | 0.04% |
| SE | Malmo | DK | Copenhagen | 6 | Road | Malmo | RoPax-Small | Copenhagen | Road | 7675 | 168,850 | 0.20% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE | Malmo | DK | Copenhagen | 5 | Road | Malmo | RoPax-Small | Copenhagen | SSS | 9786 | 210,390 | 0.25% |
| SE | Goteborg | DK | Arhus | 9 | Road | Goteborg | RoPax-Large | Fredrikshaven | Road | 2852 | 31,377 | 0.07% |
| SE | Goteborg | DK | Arhus | 0 | Road | Goteborg | RoPax-Large | Fredrikshaven | Road | 2558 | 46,047 | 0.07% |
| SE | Goteborg | DK | Arhus | 6 | Road | Goteborg | RoPax-Large | Fredrikshaven | Road | 1742 | 38,320 | 0.05% |
| SE | Goteborg | DK | Arhus | 1 | Road | Goteborg | RoPax-Large | Fredrikshaven | Road | 1232 | 20,938 | 0.03% |
| SE | Goteborg | DK | Arhus | 8 | Road | Goteborg | RoPax-Large | Fredrikshaven | Road | 1177 | 20,002 | 0.03% |
| | | | | | | | | | | | | |
| FI | Tampere | DE | Bremen | 9 | Road | Pori | RoRo | Kiel | Road | 1066 | 11,723 | 0.03% |
| FI | Helsinki | DE | Bremen | 9 | Road | Helsinki | RoPax-Large | Kiel | Road | 1161 | 12,768 | 0.03% |
| FI | Helsinki | DE | Bremen | 9 | Road | Helsinki | LoLo | Wilhelmshaven | Road | 1209 | 13,304 | 0.03% |
| FI | Tampere | DE | Hamburg | 9 | Road | Pori | RoRo | Kiel | Road | 2830 | 31,125 | 0.07% |
| FI | Tampere | DE | Hamburg | 9 | Road | Pori | LoLo | Wilhelmshaven | Road | 1883 | 20,709 | 0.05% |
| FI | Helsinki | DE | Hamburg | 9 | Road | Helsinki | RoPax-Large | Kiel | Road | 2703 | 29,738 | 0.07% |
| FI | Helsinki | DE | Hamburg | 9 | Road | Helsinki | LoLo | Wilhelmshaven | Road | 1054 | 11,591 | 0.03% |
| FI | Helsinki | DE | Lubeck | 9 | Road | Helsinki | RoPax-Large | Kiel | Road | 2145 | 23,594 | 0.06% |
| FI | Helsinki | DE | Kiel | 9 | Road | Helsinki | RoPax-Large | Kiel | Road | 13970 | 153,666 | 0.36% |
| FI | Oulu | DE | Kiel | 9 | Road | Oulu | LoLo | Kiel | SSS | 1484 | 16,319 | 0.04% |
| FI | Tampere | DE | Kiel | 9 | Road | Pori | RoRo | Kiel | Road | 1210 | 13,309 | 0.03% |
| FI | Tampere | DE | Kiel | 9 | Road | Pori | LoLo | Wilhelmshaven | Road | 4266 | 46,922 | 0.11% |
| FI | Helsinki | DE | Kiel | 9 | Road | Helsinki | RoPax-Large | Kiel | Road | 3014 | 33,159 | 0.08% |
| FI | Helsinki | DE | Kiel | 9 | Road | Helsinki | LoLo | Wilhelmshaven | Road | 12119 | 133,305 | 0.32% |
| FI | Helsinki | DE | Kiel | 0 | Road | Helsinki | RoPax-Large | Kiel | SSS | 2643 | 47,576 | 0.07% |
| | | | | | | | | | | | | |
| SE | Goteborg | UK | Durham | 9 | Road | Goteborg | RoRo | Hull | Road | 1990 | 21,893 | 0.05% |
| SE | Umea | UK | Newcastle-upon-Tyne | 0 | Road | Umea | LoLo | Tyne | Road | 5660 | 101,878 | 0.15% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE | Goteborg | UK | Newcastle-upon-Tyne | 0 | Road | Goteborg | RoRo | Tyne | Road | 2689 | 48,409 | 0.07% |
| SE | Goteborg | UK | Newcastle-upon-Tyne | 9 | Road | Goteborg | RoRo | Hull | Road | 2600 | 28,597 | 0.07% |
| SE | Goteborg | UK | Newcastle-upon-Tyne | 0 | Road | Goteborg | RoRo | Hull | Road | 1421 | 25,583 | 0.04% |
| SE | Goteborg | UK | Manchester | 9 | Road | Goteborg | RoRo | Portsmouth | Road | 2884 | 31,725 | 0.08% |
| SE | Goteborg | UK | Middlesborough | 9 | Road | Goteborg | RoRo | Hull | SSS | 1509 | 16,604 | 0.04% |
| SE | Goteborg | UK | Ipswich | 9 | Road | Goteborg | RoRo | Portsmouth | Road | 1894 | 20,837 | 0.05% |
| SE | Goteborg | UK | Ipswich | 9 | Road | Goteborg | RoRo | Hull | SSS | 4643 | 51,071 | 0.12% |
| SE | Goteborg | UK | Ipswich | 9 | Road | Goteborg | RoRo | Harwich | Road | 1169 | 12,855 | 0.03% |
| SE | Eskilstuna | UK | Reading | 9 | Road | Stockholm | LoLo | Portsmouth | SSS | 2091 | 22,999 | 0.05% |
| SE | Malmo | UK | Reading | 9 | Road | Malmo | RoRo | Portsmouth | Road | 2417 | 26,592 | 0.06% |
| SE | Umea | UK | Reading | 9 | Road | Umea | LoLo | Portsmouth | Road | 1335 | 14,685 | 0.03% |
| SE | Goteborg | UK | Reading | 9 | Road | Goteborg | RoRo | Portsmouth | Road | 2896 | 31,857 | 0.08% |
| SE | Goteborg | UK | Reading | 9 | Road | Goteborg | LoLo | Harwich | Road | 5953 | 65,481 | 0.15% |
| SE | Goteborg | UK | Reading | 9 | Road | Goteborg | RoRo | Hull | Road | 10106 | 111,169 | 0.26% |
| SE | Goteborg | UK | Reading | 9 | Road | Goteborg | RoPax-Large | Dover | Road | 3049 | 33,538 | 0.08% |
| SE | Goteborg | UK | Reading | 0 | Road | Goteborg | RoPax-Large | Dover | Road | 1336 | 24,047 | 0.03% |
| SE | Goteborg | UK | Reading | 0 | Road | Goteborg | RoRo | Hull | Road | 1101 | 19,823 | 0.03% |
| SE | Goteborg | UK | Reading | 8 | Road | Goteborg | RoRo | Portsmouth | Road | 1173 | 19,946 | 0.03% |
| SE | Goteborg | UK | Reading | 0 | Road | Goteborg | LoLo | Harwich | Road | 1104 | 19,871 | 0.03% |
| SE | Goteborg | UK | Reading | 0 | Road | Goteborg | RoRo | Portsmouth | Road | 1050 | 18,904 | 0.03% |
| SE | Goteborg | UK | Brighton | 9 | Road | Goteborg | RoPax-Large | Dover | SSS | 7388 | 81,270 | 0.19% |
| SE | Goteborg | UK | Dover | 0 | Road | Goteborg | RoRo | Hull | Road | 1073 | 19,319 | 0.03% |
| SE | Goteborg | UK | Bournemouth | 9 | Road | Goteborg | RoRo | Hull | Road | 4950 | 54,450 | 0.13% |
| SE | Goteborg | UK | Edinburgh | 9 | Road | Goteborg | RoRo | Rosyth | Road | 1013 | 11,148 | 0.03% |
| SE | Goteborg | UK | Belfast | 9 | Road | Goteborg | LoLo | Belfast | Road | 1350 | 14,849 | 0.04% |
| | | | | | | | | | | | | |
| RU | St. Peterburg | SE | Uppsala | 0 | Rail | St. Peterburg | RoPax-Large | Stockholm | Road | 3446 | 62,036 | 0.09% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RU | St. Peterburg | SE | Malmo | 0 | Rail | St. Peterburg | RoRo | Malmo | Road | 6469 | 116,433 | 0.17% |
| RU | St. Peterburg | SE | Gavle | 0 | Rail | St. Peterburg | RoPax-Large | Soderhamn | Road | 4022 | 72,394 | 0.10% |
| RU | St. Peterburg | SE | Umea | 0 | Rail | St. Peterburg | LoLo | Umea | Road | 3235 | 58,229 | 0.08% |
| RU | St. Peterburg | SE | Kalmar | 0 | Rail | St. Peterburg | LoLo | Kalmar | Road | 4343 | 78,180 | 0.11% |
| RU | St. Peterburg | SE | Goteborg | 0 | Rail | St. Peterburg | LoLo | Goteborg | Road | 1589 | 28,593 | 0.04% |
| | | | | | | | | | | | | |
| DK | Copenhagen | SE | Malmo | 9 | SSS | Copenhagen | RoPax-Small | Malmo | Road | 8071 | 88,781 | 0.21% |
| DK | Copenhagen | SE | Malmo | 0 | SSS | Copenhagen | RoPax-Small | Malmo | SSS | 11850 | 213,305 | 0.31% |
| DK | Copenhagen | SE | Malmo | 1 | SSS | Copenhagen | RoPax-Small | Malmo | Road | 1287 | 21,885 | 0.03% |
| DK | Copenhagen | SE | Malmo | 6 | SSS | Copenhagen | RoPax-Small | Malmo | Road | 1892 | 41,615 | 0.05% |
| DK | Copenhagen | SE | Malmo | 5 | SSS | Copenhagen | RoPax-Small | Malmo | Road | 2491 | 53,551 | 0.06% |
| DK | Copenhagen | SE | Kalmar | 6 | SSS | Copenhagen | RoRo | Kalmar | Road | 1004 | 22,090 | 0.03% |
| DK | Arhus | SE | Goteborg | 9 | SSS | Fredrikshaven | RoPax-Small | Goteborg | Road | 1191 | 13,106 | 0.03% |
| DK | Arhus | SE | Goteborg | 0 | SSS | Fredrikshaven | RoPax-Small | Goteborg | Road | 1838 | 33,082 | 0.05% |
| DK | Arhus | SE | Goteborg | 8 | SSS | Fredrikshaven | RoPax-Small | Goteborg | Road | 20428 | 347,275 | 0.53% |
| DK | Arhus | SE | Goteborg | 1 | SSS | Fredrikshaven | RoPax-Small | Goteborg | Road | 2753 | 46,806 | 0.07% |
| | | | | | | | | | | | | |
| FI | Oulu | BE | Antwerp | 9 | Road | Oulu | LoLo | Antwerp | Road | 1550 | 17,045 | 0.04% |
| FI | Tampere | BE | Antwerp | 9 | Road | Pori | LoLo | Antwerp | Road | 1497 | 16,472 | 0.04% |
| FI | Helsinki | BE | Antwerp | 9 | Road | Helsinki | LoLo | Antwerp | Road | 1572 | 17,295 | 0.04% |
| FI | Helsinki | BE | Liege | 9 | Road | Helsinki | LoLo | Antwerp | Road | 1415 | 15,562 | 0.04% |
| FI | Oulu | BE | Brugge | 9 | Road | Oulu | LoLo | Antwerp | Road | 2383 | 26,209 | 0.06% |
| FI | Helsinki | BE | Brugge | 9 | Road | Helsinki | LoLo | Antwerp | SSS | 3954 | 43,493 | 0.10% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FI | Helsinki | BE | Brugge | 9 | Road | Helsinki | LoLo | Zeebrugge | Road | 1900 | 20,899 | 0.05% |
| FI | Oulu | BE | Brussels | 9 | Road | Oulu | LoLo | Antwerp | SSS | 3543 | 38,971 | 0.09% |
| FI | Helsinki | BE | Brussels | 9 | Road | Helsinki | LoLo | Antwerp | Road | 1135 | 12,481 | 0.03% |
| FI | Helsinki | BE | Kortrijk | 9 | Road | Helsinki | LoLo | Zeebrugge | Road | 4661 | 51,268 | 0.12% |
| FI | Helsinki | BE | Kortrijk | 9 | Road | Helsinki | LoLo | Antwerp | Road | 2501 | 27,510 | 0.07% |
| | | | | | | | | | | | | |
| BE | Antwerp | UK | Middlesborough | 9 | Road | Antwerp | LoLo | Hull | Road | 3049 | 33,539 | 0.08% |
| BE | Kortrijk | UK | Middlesborough | 9 | Road | Zeebrugge | LoLo | Hull | Road | 1288 | 14,165 | 0.03% |
| BE | Kortrijk | UK | Middlesborough | 9 | Road | Zeebrugge | RoRo | Portsmouth | Road | 1188 | 13,064 | 0.03% |
| BE | Antwerp | UK | Cambridge | 8 | Road | Antwerp | RoPax-Large | Dover | SSS | 1531 | 26,022 | 0.04% |
| BE | Kortrijk | UK | Cambridge | 9 | Road | Zeebrugge | RoRo | Portsmouth | Road | 1974 | 21,716 | 0.05% |
| BE | Antwerp | UK | Reading | 9 | Road | Antwerp | RoPax-Large | Dover | Road | 3373 | 37,103 | 0.09% |
| BE | Antwerp | UK | Reading | 9 | Road | Antwerp | RoRo | Southampton | Road | 1318 | 14,498 | 0.03% |
| BE | Antwerp | UK | Reading | 9 | Road | Antwerp | RoPax-Large | Harwich | SSS | 1382 | 15,205 | 0.04% |
| BE | Antwerp | UK | Reading | 0 | Road | Antwerp | RoPax-Large | Dover | Road | 2069 | 37,242 | 0.05% |
| BE | Brugge | UK | Reading | 9 | Road | Zeebrugge | RoRo | Southampton | Road | 3114 | 34,258 | 0.08% |
| BE | Brugge | UK | Reading | 9 | Road | Zeebrugge | RoPax-Small | Harwich | Road | 1105 | 12,153 | 0.03% |
| BE | Kortrijk | UK | Reading | 9 | Road | Zeebrugge | RoRo | Portsmouth | Road | 2139 | 23,534 | 0.06% |
| BE | Kortrijk | UK | Reading | 9 | Road | Zeebrugge | LoLo | Southampton | Road | 1283 | 14,110 | 0.03% |
| BE | Kortrijk | UK | Reading | 0 | Road | Zeebrugge | RoRo | Portsmouth | Road | 1449 | 26,089 | 0.04% |
| BE | Kortrijk | UK | Reading | 9 | Road | Zeebrugge | RoPax-Small | Harwich | Road | 1020 | 11,223 | 0.03% |
| BE | Antwerp | UK | Brighton | 9 | Road | Antwerp | RoPax-Large | Dover | Road | 2622 | 28,843 | 0.07% |
| BE | Antwerp | UK | Brighton | 8 | Road | Antwerp | RoPax-Large | Dover | Road | 1856 | 31,557 | 0.05% |
| BE | Kortrijk | UK | Brighton | 9 | Road | Zeebrugge | RoRo | Portsmouth | SSS | 2390 | 26,287 | 0.06% |
| | | | | | | | | | | | | |
| UK | Newcastle - upon-Tyne | BE | Antwerp | 8 | Road | Hull | LoLo | Antwerp | Road | 10600 | 180,192 | 0.28% |
| UK | Liverpool | BE | Antwerp | 8 | Road | Dover | RoPax-Large | Antwerp | Road | 9313 | 158,326 | 0.24% |
| UK | Hull | BE | Antwerp | 9 | Road | Hull | LoLo | Antwerp | Road | 2365 | 26,019 | 0.06% |
| UK | Middlesborough | BE | Antwerp | 9 | Road | Hull | LoLo | Antwerp | Road | 4564 | 50,200 | 0.12% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UK | London | BE | Antwerp | 6 | Road | Dartmouth | LoLo | Antwerp | Road | 1360 | 29,916 | 0.04% |
| UK | Reading | BE | Antwerp | 9 | Road | Dover | RoPax-Large | Antwerp | Road | 2488 | 27,372 | 0.06% |
| UK | Reading | BE | Antwerp | 9 | Road | Harwich | RoRo | Antwerp | Road | 6386 | 70,246 | 0.17% |
| UK | Brighton | BE | Antwerp | 9 | Road | Dover | RoPax-Large | Antwerp | Road | 1086 | 11,949 | 0.03% |
| UK | Bristol | BE | Antwerp | 9 | Road | Dover | RoPax-Large | Antwerp | Road | 1802 | 19,826 | 0.05% |
| UK | Plymouth | BE | Antwerp | 6 | Road | Hull | LoLo | Antwerp | Road | 22706 | 499,526 | 0.59% |
| UK | London | BE | Kortrijk | 6 | Road | Dartmouth | LoLo | Zeebrugge | Road | 1454 | 31,983 | 0.04% |
| UK | Crawley | BE | Kortrijk | 6 | Road | Dartmouth | LoLo | Zeebrugge | Road | 3291 | 72,403 | 0.09% |
| UK | Reading | BE | Kortrijk | 9 | Road | Dover | RoPax-Small | Zeebrugge | Road | 3025 | 33,272 | 0.08% |
| UK | Reading | BE | Kortrijk | 9 | Road | Portsmouth | RoRo | Zeebrugge | Road | 3482 | 38,297 | 0.09% |
| UK | Brighton | BE | Kortrijk | 9 | Road | Dover | RoPax-Small | Zeebrugge | Road | 2773 | 30,508 | 0.07% |
| UK | Brighton | BE | Kortrijk | 9 | Road | Portsmouth | RoRo | Zeebrugge | Road | 1266 | 13,921 | 0.03% |
| UK | Plymouth | BE | Kortrijk | 6 | Road | Hull | RoRo | Zeebrugge | SSS | 2340 | 51,490 | 0.06% |
| | | | | | | | | | | | | |
| FI | Helsinki | ES | Santiago de Compostela | 0 | Road | Helsinki | LoLo | Gijon | SSS | 2868 | 51,627 | 0.07% |
| FI | Oulu | ES | Santander | 9 | Road | Oulu | LoLo | Santander | Road | 3513 | 38,643 | 0.09% |
| FI | Tampere | ES | Santander | 9 | Road | Pori | LoLo | Santander | Road | 1893 | 20,820 | 0.05% |
| FI | Helsinki | ES | Santander | 9 | Road | Helsinki | LoLo | Santander | Road | 1405 | 15,458 | 0.04% |
| FI | Helsinki | ES | Madrid | 9 | Road | Helsinki | LoLo | Santander | Road | 1051 | 11,563 | 0.03% |
| FI | Helsinki | ES | Barcelona | 9 | Road | Helsinki | LoLo | Barcelona | Road | 1035 | 11,380 | 0.03% |
| FI | Helsinki | ES | Barcelona | 9 | Road | Helsinki | LoLo | Santander | Road | 1882 | 20,697 | 0.05% |
| FI | Helsinki | ES | Valencia | 9 | Road | Helsinki | LoLo | Valencia | Rail | 1358 | 14,934 | 0.04% |
| FI | Helsinki | ES | Las Palmas | 9 | Road | Helsinki | LoLo | Las Palmas | Road | 16601 | 182,616 | 0.43% |
| | | | | | | | | | | | | |
| NO | Oslo | DK | Arhus | 9 | Road | Oslo | RoPax-Large | Frederikshaven | SSS | 2842 | 31,264 | 0.07% |
| NO | Fredrikstad | DK | Arhus | 9 | Road | Tonsberg | RoPax-Large | Frederikshaven | SSS | 1027 | 11,302 | 0.03% |
| NO | Fredrikstad | DK | Arhus | 8 | Road | Tonsberg | RoPax-Large | Frederikshaven | Road | 6829 | 116,095 | 0.18% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NO | Fredrikstad | DK | Arhus | 6 | Road | Tonsberg | RoPax-Large | Frederikshaven | Road | 6627 | 145,789 | 0.17% |
| NO | Stavanger | DK | Arhus | 9 | Road | Kristiansand | RoPax-Large | Frederikshaven | Rail | 1286 | 14,148 | 0.03% |
| NO | Stavanger | DK | Arhus | 6 | Road | Kristiansand | RoPax-Large | Frederikshaven | Road | 1085 | 23,859 | 0.03% |
| NO | Bergen | DK | Arhus | 1 | Road | Bergen | RoRo | Frederikshaven | Road | 19375 | 329,367 | 0.50% |
| NO | Bergen | DK | Arhus | 6 | Road | Bergen | RoRo | Frederikshaven | Road | 4537 | 99,819 | 0.12% |
| NO | Bergen | DK | Arhus | 0 | Road | Bergen | RoRo | Frederikshaven | Road | 1600 | 28,807 | 0.04% |
| | | | | | | | | | | | | |
| FI | Helsinki | DK | Copenhagen | 9 | Road | Helsinki | RoRo | Copenhagen | Road | 11426 | 125,685 | 0.30% |
| FI | Oulu | DK | Copenhagen | 9 | Road | Oulu | LoLo | Copenhagen | Road | 1003 | 11,035 | 0.03% |
| FI | Oulu | DK | Copenhagen | 0 | Road | Oulu | LoLo | Copenhagen | Road | 11175 | 201,150 | 0.29% |
| FI | Tampere | DK | Copenhagen | 9 | Road | Pori | LoLo | Copenhagen | Road | 2359 | 25,953 | 0.06% |
| FI | Tampere | DK | Copenhagen | 0 | SSS | Pori | LoLo | Copenhagen | Road | 1381 | 24,856 | 0.04% |
| FI | Helsinki | DK | Copenhagen | 9 | Road | Helsinki | RoRo | Copenhagen | SSS | 2479 | 27,264 | 0.06% |
| FI | Helsinki | DK | Copenhagen | 0 | Road | Helsinki | RoRo | Copenhagen | Road | 1888 | 33,978 | 0.05% |
| | | | | | | | | | | | | |
| FI | Helsinki | SE | Stockholm | 9 | Road | Helsinki | RoPax-Large | Stockholm | Road | 2327 | 25,596 | 0.06% |
| FI | Tampere | SE | Stockholm | 9 | Road | Pori | RoRo | Stockholm | Road | 2207 | 24,278 | 0.06% |
| FI | Helsinki | SE | Stockholm | 9 | Road | Helsinki | RoPax-Large | Stockholm | Road | 1404 | 15,443 | 0.04% |
| FI | Helsinki | SE | Stockholm | 5 | Road | Helsinki | RoPax-Large | Stockholm | Road | 10560 | 227,050 | 0.27% |
| FI | Helsinki | SE | Stockholm | 0 | Road | Helsinki | RoPax-Small | Stockholm | Road | 1426 | 25,672 | 0.04% |
| FI | Helsinki | SE | Uppsala | 9 | Road | Helsinki | RoPax-Large | Stockholm | Road | 2048 | 22,526 | 0.05% |
| FI | Helsinki | SE | Gavle | 9 | Road | Helsinki | RoRo | Sundsvall | Road | 2478 | 27,259 | 0.06% |
| | | | | | | | | | | | | |
| NO | Fredrikstad | DE | Bremen | 9 | Road | Tonsberg | LoLo | Wilhelmshaven | Road | 1089 | 11,976 | 0.03% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NO | Fredrikstad | DE | Hamburg | 9 | Road | Tonsberg | LoLo | Wilhelmshaven | Road | 1331 | 14,640 | 0.03% |
| NO | Fredrikstad | DE | Hamburg | 9 | Road | Tonsberg | LoLo | Hamburg | Road | 1808 | 19,885 | 0.05% |
| NO | Stavanger | DE | Hamburg | 6 | Road | Kristiansand | RoRo | Hamburg | Road | 2210 | 48,622 | 0.06% |
| NO | Stavanger | DE | Hamburg | 6 | Road | Kristiansand | RoRo | Wilhelmshaven | Road | 2833 | 62,315 | 0.07% |
| NO | Bergen | DE | Hamburg | 6 | Road | Bergen | LoLo | Hamburg | Road | 4107 | 90,357 | 0.11% |
| NO | Stavanger | DE | Lubeck | 6 | Road | Kristiansand | RoPax-Large | Wilhelmshaven | Road | 1875 | 41,242 | 0.05% |
| NO | Stavanger | DE | Oldenburg | 6 | Road | Kristiansand | RoPax-Large | Wilhelmshaven | Road | 1041 | 22,895 | 0.03% |
| NO | Bergen | DE | Oldenburg | 6 | Road | Bergen | LoLo | Wilhelmshaven | Road | 2485 | 54,679 | 0.06% |
| NO | Fredrikstad | DE | Kiel | 9 | Road | Tonsberg | RoPax-Large | Wilhelmshaven | Road | 1096 | 12,054 | 0.03% |
| NO | Stavanger | DE | Kiel | 6 | Road | Kristiansand | RoPax-Large | Wilhelmshaven | Road | 3730 | 82,049 | 0.10% |
| | | | | | | | | | | | | |
| FI | Oulu | FR | Paris | 9 | Road | Oulu | LoLo | Antwerp | Road | 1753 | 19,281 | 0.05% |
| FI | Tampere | FR | Paris | 9 | Road | Pori | LoLo | Antwerp | Road | 1750 | 19,254 | 0.05% |
| FI | Helsinki | FR | Paris | 9 | Road | Helsinki | RoRo | Antwerp | Road | 1722 | 18,943 | 0.04% |
| FI | Helsinki | FR | Beauvais | 9 | Road | Helsinki | RoRo | Antwerp | Road | 1585 | 17,435 | 0.04% |
| FI | Helsinki | FR | Orleans | 9 | Road | Helsinki | RoRo | Antwerp | SSS | 3659 | 40,245 | 0.10% |
| FI | Oulu | FR | Lille | 9 | Road | Oulu | LoLo | Antwerp | Road | 5671 | 62,379 | 0.15% |
| FI | Helsinki | FR | Lille | 9 | Road | Helsinki | RoRo | Antwerp | Road | 1608 | 17,685 | 0.04% |
| FI | Oulu | FR | Strasbourg | 9 | Road | Oulu | LoLo | Antwerp | SSS | 2878 | 31,662 | 0.07% |
| FI | Helsinki | FR | Strasbourg | 9 | Road | Helsinki | RoRo | Antwerp | SSS | 1591 | 17,506 | 0.04% |
| FI | Helsinki | FR | Poitiers | 0 | Road | Helsinki | LoLo | Le Havre | Road | 12774 | 229,938 | 0.33% |
| FI | Oulu | FR | Lyon | 9 | Road | Oulu | LoLo | Antwerp | Road | 1538 | 16,923 | 0.04% |
| FI | Helsinki | FR | Lyon | 9 | Road | Helsinki | RoRo | Antwerp | Road | 1074 | 11,818 | 0.03% |
| | | | | | | | | | | | | |
| SE | Stockholm | FI | Helsinki | 9 | Road | Stockholm | RoPax-Large | Helsinki | Road | 1178 | 12,961 | 0.03% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE | Umea | FI | Oulu | 6 | Road | Umea | RoPax-Large | Oulu | Road | 5108 | 112,379 | 0.13% |
| SE | Stockholm | FI | Tampere | 9 | Road | Stockholm | RoPax-Large | Pori | Road | 3671 | 40,378 | 0.10% |
| SE | Stockholm | FI | Helsinki | 9 | Road | Stockholm | RoPax-Large | Helsinki | Road | 1164 | 12,808 | 0.03% |
| SE | Stockholm | FI | Helsinki | 0 | Road | Stockholm | RoPax-Large | Helsinki | Road | 1678 | 30,199 | 0.04% |
| SE | Stockholm | FI | Helsinki | 1 | Road | Stockholm | RoPax-Large | Helsinki | Road | 1207 | 20,514 | 0.03% |
| | | | | | | | | | | | | |
| FR | Rouen | IT | L'Aquila | 0 | Road | Marseilles | RoPax-Large | Genoa | Road | 2538 | 45,684 | 0.07% |
| FR | Rouen | IT | Bari | 0 | Road | Marseilles | RoPax-Large | Genoa | Road | 1044 | 18,800 | 0.03% |
| FR | Rouen | IT | Potenza | 0 | Road | Marseilles | RoPax-Large | Genoa | Road | 4384 | 78,908 | 0.11% |
| FR | Rouen | IT | Naples | 0 | Road | Marseilles | RoPax-Large | Livorno | Road | 2057 | 37,029 | 0.05% |
| FR | Rouen | IT | Firenze | 0 | Road | Marseilles | RoPax-Large | Livorno | Road | 1103 | 19,857 | 0.03% |
| FR | Marseilles | IT | Firenze | 0 | Rail | Marseilles | RoPax-Large | Livorno | SSS | 1121 | 20,171 | 0.03% |
| FR | Marseilles | IT | Firenze | 0 | Road | Marseilles | RoPax-Large | Livorno | Road | 2403 | 43,263 | 0.06% |
| FR | Rouen | IT | Trieste | 0 | Road | Marseilles | RoPax-Large | Livorno | SSS | 2192 | 39,462 | 0.06% |
| FR | Rouen | IT | Genoa | 0 | Road | Marseilles | RoRo | Naples | Road | 18370 | 330,667 | 0.48% |
| FR | Rouen | IT | Catanzaro | 0 | Road | Marseilles | RoRo | Messina | Road | 10598 | 190,769 | 0.28% |
| FR | Rouen | IT | Cagliari | 0 | Road | Marseilles | RoRo | Cagliari | Road | 1593 | 28,679 | 0.04% |
| | | | | | | | | | | | | |
| SE | Stockholm | BE | Antwerp | 8 | SSS | Stockholm | LoLo | Antwerp | Road | 2428 | 41,274 | 0.06% |
| SE | Goteborg | BE | Antwerp | 9 | Road | Goteborg | RoRo | Antwerp | Road | 3255 | 35,800 | 0.08% |
| SE | Goteborg | BE | Antwerp | 9 | Road | Goteborg | RoRo | Antwerp | Road | 2362 | 25,978 | 0.06% |
| SE | Goteborg | BE | Brugge | 9 | Road | Goteborg | LoLo | Zeebrugge | Road | 1049 | 11,541 | 0.03% |
| SE | Goteborg | BE | Kortrijk | 9 | Road | Goteborg | LoLo | Zeebrugge | Road | 1073 | 11,805 | 0.03% |
| | | | | | | | | | | | | |
| SE | Malmo | DE | Lubeck | 9 | Road | Malmo | RoRo | Wilhelmshaven | Road | 1718 | 18,900 | 0.04% |
| SE | Malmo | DE | Lubeck | 9 | Road | Malmo | RoPax-Large | Kiel | Road | 1314 | 14,449 | 0.03% |
| SE | Goteborg | DE | Lubeck | 9 | Road | Goteborg | RoRo | Wilhelmshaven | Road | 1641 | 18,051 | 0.04% |
| SE | Goteborg | DE | Lubeck | 9 | Road | Goteborg | RoPax-Large | Kiel | Road | 1102 | 12,118 | 0.03% |
| SE | Malmo | DE | Kiel | 9 | Road | Malmo | RoPax-Large | Kiel | Road | 1106 | 12,169 | 0.03% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE | Malmo | DE | Kiel | 9 | Road | Malmo | RoRo | Wilhelmshaven | Road | 1086 | 11,950 | 0.03% |
| SE | Goteborg | DE | Kiel | 9 | Road | Goteborg | RoPax-Large | Kiel | Road | 3608 | 39,690 | 0.09% |
| SE | Goteborg | DE | Kiel | 9 | Road | Goteborg | RoRo | Wilhelmshaven | Road | 2709 | 29,802 | 0.07% |
| | | | | | | | | | | | | |
| RU | St. Peterburg | BE | Antwerp | 9 | Rail | St. Peterburg | LoLo | Antwerp | Road | 2718 | 29,896 | 0.07% |
| RU | St. Peterburg | BE | Antwerp | 9 | Rail | St. Peterburg | LoLo | Antwerp | Road | 1152 | 12,670 | 0.03% |
| RU | St. Peterburg | BE | Liege | 9 | Rail | St. Peterburg | LoLo | Antwerp | Road | 2353 | 25,879 | 0.06% |
| RU | St. Peterburg | BE | Brugge | 9 | Rail | St. Peterburg | LoLo | Antwerp | Road | 1185 | 13,034 | 0.03% |
| RU | St. Peterburg | BE | Brussels | 9 | Rail | St. Peterburg | LoLo | Antwerp | Road | 6989 | 76,883 | 0.18% |
| RU | St. Peterburg | BE | Kortrijk | 9 | Rail | St. Peterburg | LoLo | Antwerp | Road | 1303 | 14,336 | 0.03% |
| | | | | | | | | | | | | |
| RU | St. Peterburg | IT | Potenza | 9 | Rail | St. Peterburg | LoLo | Genoa | Road | 2606 | 28,671 | 0.07% |
| RU | St. Peterburg | IT | Potenza | 5 | Rail | St. Peterburg | LoLo | Genoa | Road | 1342 | 28,851 | 0.03% |
| RU | St. Peterburg | IT | Venice | 5 | Rail | St. Peterburg | LoLo | Venice | SSS | 1022 | 21,983 | 0.03% |
| RU | St. Peterburg | IT | Venice | 0 | Rail | St. Peterburg | LoLo | Venice | SSS | 28107 | 505,927 | 0.73% |
| RU | St. Peterburg | IT | Venice | 9 | Rail | St. Peterburg | LoLo | Venice | Road | 1008 | 11,092 | 0.03% |
| RU | St. Peterburg | IT | Naples | 5 | Rail | St. Peterburg | LoLo | Livorno | SSS | 13989 | 300,761 | 0.36% |
| RU | St. Peterburg | IT | Firenze | 5 | Rail | St. Peterburg | LoLo | Livorno | Road | 2147 | 46,169 | 0.06% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RU | St. Peterburg | IT | Trieste | 5 | Rail | St. Peterburg | LoLo | Civitavecchia | Road | 1340 | 28,810 | 0.03% |
| | | | | | | | | | | | | |
| DK | Arhus | NO | Oslo | 9 | SSS | Fredrikshaven | RoPax-Large | Oslo | Road | 1033 | 11,363 | 0.03% |
| DK | Arhus | NO | Fredrikstad | 9 | SSS | Fredrikshaven | RoRo | Tonsberg | Road | 1070 | 11,772 | 0.03% |
| DK | Arhus | NO | Fredrikstad | 0 | SSS | Fredrikshaven | RoRo | Tonsberg | Road | 1119 | 20,144 | 0.03% |
| DK | Arhus | NO | Stavanger | 9 | SSS | Fredrikshaven | RoRo | Kristiansand | Road | 1088 | 11,969 | 0.03% |
| DK | Arhus | NO | Bergen | 9 | SSS | Fredrikshaven | RoRo | Bergen | Road | 5953 | 65,482 | 0.15% |
| DK | Arhus | NO | Bergen | 1 | SSS | Fredrikshaven | RoRo | Bergen | Road | 1964 | 33,387 | 0.05% |
| DK | Arhus | NO | Trondheim | 0 | SSS | Fredrikshaven | RoRo | Trondheim | Road | 13338 | 240,085 | 0.35% |
| | | | | | | | | | | | | |
| NO | Fredrikstad | BE | Antwerp | 9 | Road | Tonsberg | LoLo | Antwerp | Road | 2962 | 32,582 | 0.08% |
| NO | Stavanger | BE | Antwerp | 9 | Road | Kristiansand | RoRo | Antwerp | Road | 1021 | 11,232 | 0.03% |
| NO | Fredrikstad | BE | Brugge | 9 | Road | Tonsberg | LoLo | Antwerp | Road | 3489 | 38,379 | 0.09% |
| NO | Fredrikstad | BE | Brussels | 9 | Road | Tonsberg | LoLo | Antwerp | Road | 1297 | 14,262 | 0.03% |
| | | | | | | | | | | | | |
| NO | Fredrikstad | UK | Reading | 9 | Road | Tonsberg | LoLo | Harwich | Road | 14661 | 161,270 | 0.38% |
| NO | Oslo | UK | Edinburgh | 9 | Road | Oslo | LoLo | Rosyth | Road | 1457 | 16,030 | 0.04% |
| NO | Fredrikstad | UK | Edinburgh | 9 | Road | Tonsberg | LoLo | Rosyth | Road | 3750 | 41,250 | 0.10% |
| NO | Stavanger | UK | Edinburgh | 9 | Road | Kristiansand | RoRo | Rosyth | Road | 1214 | 13,349 | 0.03% |
| NO | Trondheim | UK | Edinburgh | 9 | Road | Trondheim | LoLo | Rosyth | Road | 1647 | 18,120 | 0.04% |
| NO | Fredrikstad | UK | Belfast | 9 | Road | Tonsberg | LoLo | Belfast | Road | 2113 | 23,241 | 0.05% |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | **22.57%** |

# Annex 3: Average, maximum and minimal change in the different policy scenarios

This annex presents the total effect on tonkm, the maximum effect and the minimum effect. A distinction is made according to ship type and according to commodity type.

## Policy scenario A

**Table 58: Total effect of Policy A on tonkm, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| | | 2015 | 2020 | 2025 | 2015 | 2020 | 2025 |
| Policy Scenario A | LoLo | -8.69% | -8.85% | -8.29% | -0.75% | -0.76% | -0.70% |
| | RoRo | -4.34% | -4.43% | -4.13% | -0.39% | -0.39% | -0.36% |
| | Ropax Small | -0.97% | -0.99% | -0.92% | -0.04% | -0.04% | -0.04% |
| | Ropax Large | -2.55% | -2.61% | -2.43% | -0.30% | -0.31% | -0.29% |

**Table 59: Maximal change in tonkm for an OD of Policy A, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| | | 2015 | 2020 | 2025 | 2015 | 2020 | 2025 |
| Policy Scenario A | LoLo | -19.52% | -19.92% | -18.76% | -10.57% | -10.78% | -10.10% |
| | RoRo | -15.13% | -15.48% | -14.52% | -8.10% | -8.27% | -7.74% |
| | Ropax Small | -3.19% | -3.28% | -3.06% | -0.35% | -0.35% | -0.33% |
| | Ropax Large | -7.39% | -7.57% | -7.07% | -1.79% | -1.80% | -1.67% |

**Table 60: Minimal change in tonkm for an OD of Policy A, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| | | 2015 | 2020 | 2025 | 2015 | 2020 | 2025 |
| Policy Scenario A | LoLo | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | RoRo | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | Ropax Small | -0.19% | -0.19% | -0.19% | -0.01% | -0.01% | -0.01% |
| | Ropax Large | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

**Table 61: Total effect of Policy A on tonkm, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| | | 2015 | 2020 | 2025 | 2015 | 2020 | 2025 |
| Policy Scenario A | 0 | -3.73% | -3.79% | -3.54% | -0.33% | -0.33% | -0.31% |
| | 1 | -3.81% | -3.85% | -3.57% | -0.48% | -0.48% | -0.45% |
| | 5 | -8.90% | -9.13% | -8.55% | -1.03% | -1.04% | -0.97% |
| | 6 | -2.77% | -2.81% | -2.61% | -0.23% | -0.23% | -0.22% |
| | 8 | -3.03% | -3.07% | -2.85% | -0.06% | -0.06% | -0.06% |
| | 9 | -7.63% | -7.79% | -7.28% | -0.82% | -0.83% | -0.77% |

**Table 62: Maximal change in tonkm for an OD of Policy A, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| | | 2015 | 2020 | 2025 | 2015 | 2020 | 2025 |
| Policy Scenario A | 0 | -15.13% | -15.13% | -15.13% | -8.10% | -8.10% | -8.10% |
| | 1 | -12.12% | -12.12% | -12.12% | -1.50% | -1.50% | -1.50% |
| | 5 | -9.35% | -9.35% | -9.35% | -1.07% | -1.07% | -1.07% |
| | 6 | -12.36% | -12.36% | -12.36% | -4.39% | -4.39% | -4.39% |
| | 8 | -5.63% | -5.63% | -5.63% | -2.86% | -2.86% | -2.86% |
| | 9 | -19.52% | -19.52% | -19.52% | -10.57% | -10.57% | -10.57% |

**Table 63: Minimal change in tonkm for an OD of Policy A, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| | | 2015 | 2020 | 2025 | 2015 | 2020 | 2025 |
| Policy Scenario A | 0 | -0.18% | -0.18% | -0.18% | -0.02% | -0.02% | -0.02% |
| | 1 | -0.24% | -0.24% | -0.24% | -0.01% | -0.01% | -0.01% |
| | 5 | -3.11% | -3.11% | -3.11% | -0.05% | -0.05% | -0.05% |
| | 6 | -0.29% | -0.29% | -0.29% | -0.01% | -0.01% | -0.01% |
| | 8 | -0.24% | -0.24% | -0.24% | -0.01% | -0.01% | -0.01% |
| | 9 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

## Policy scenario B

**Table 64: Total effect of Policy B on tonkm, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario B | LoLo | -8.61% | -8.77% | -8.21% | -0.75% | -0.75% | -0.70% |
| | RoRo | -4.26% | -4.35% | -4.05% | -0.38% | -0.39% | -0.36% |
| | Ropax Small | -0.94% | -0.97% | -0.90% | -0.04% | -0.04% | -0.04% |
| | Ropax Large | -2.51% | -2.57% | -2.39% | -0.30% | -0.30% | -0.28% |

**Table 65: Maximal change in tonkm for an OD of policy B, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario B | LoLo | -19.35% | -19.76% | -18.59% | -10.48% | -10.68% | -10.01% |
| | RoRo | -14.88% | -15.23% | -14.27% | -7.96% | -8.14% | -7.60% |
| | Ropax Small | -3.10% | -3.19% | -2.97% | -0.34% | -0.34% | -0.32% |
| | Ropax Large | -7.20% | -7.38% | -6.88% | -1.74% | -1.76% | -1.62% |

**Table 66: Minimal change in tonkm for an OD of Policy B, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario B | LoLo | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | RoRo | 0.03% | 0.03% | 0.03% | 0.01% | 0.01% | 0.01% |
| | Ropax Small | -0.18% | -0.18% | -0.17% | -0.01% | -0.01% | -0.01% |
| | Ropax Large | 0.08% | 0.08% | 0.08% | 0.02% | 0.02% | 0.02% |

**Table 67: Total effect of Policy B on tonkm, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario B | 0 | -3.66% | -3.73% | -3.47% | -0.33% | -0.33% | -0.30% |
| | 1 | -3.77% | -3.81% | -3.53% | -0.47% | -0.48% | -0.44% |
| | 5 | -8.75% | -8.97% | -8.40% | -1.01% | -1.03% | -0.95% |
| | 6 | -2.71% | -2.76% | -2.56% | -0.23% | -0.23% | -0.21% |
| | 8 | -2.97% | -3.01% | -2.80% | -0.06% | -0.06% | -0.06% |
| | 9 | -7.52% | -7.68% | -7.17% | -0.81% | -0.82% | -0.76% |

**Table 68: Maximal change in tonkm for an OD of Policy B, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario B | 0 | -14.88% | -15.23% | -14.27% | -7.96% | -8.14% | -7.60% |
| | 1 | -12.02% | -12.32% | -11.58% | -1.48% | -1.49% | -1.38% |
| | 5 | -9.20% | -9.44% | -8.83% | -1.05% | -1.07% | -0.99% |
| | 6 | -12.25% | -12.56% | -11.81% | -4.35% | -4.40% | -4.09% |
| | 8 | -5.58% | -5.63% | -5.22% | -2.83% | -2.85% | -2.64% |
| | 9 | -19.35% | -19.76% | -18.59% | -10.48% | -10.68% | -10.01% |

**Table 69: Minimal change in tonkm for an OD of Policy B, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario B | 0 | -0.18% | -0.18% | -0.16% | -0.02% | -0.02% | -0.01% |
| | 1 | -0.23% | -0.24% | -0.22% | -0.01% | -0.01% | -0.01% |
| | 5 | -3.03% | -3.12% | -2.90% | -0.05% | -0.05% | -0.05% |
| | 6 | -0.28% | -0.28% | -0.26% | -0.01% | -0.01% | -0.01% |
| | 8 | -0.23% | -0.23% | -0.21% | -0.01% | -0.01% | -0.01% |
| | 9 | 0.19% | 0.19% | 0.19% | 0.01% | 0.01% | 0.01% |

## Policy scenario C

**Table 70: Total effect of Policy C on tonkm, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario C | LoLo | -8.61% | -11.84% | -11.28% | -0.75% | -1.05% | -0.99% |
| | RoRo | -4.26% | -5.98% | -5.69% | -0.38% | -0.55% | -0.52% |
| | Ropax Small | -0.94% | -1.41% | -1.34% | -0.04% | -0.06% | -0.06% |
| | Ropax Large | -2.51% | -3.58% | -3.40% | -0.30% | -0.43% | -0.40% |

**Table 71: Maximal change in tonkm for an OD of Policy C, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario C | LoLo | -19.35% | -25.94% | -24.85% | -10.48% | -14.35% | -13.68% |
| | RoRo | -14.88% | -20.17% | -19.26% | -7.96% | -10.96% | -10.43% |
| | Ropax Small | -3.10% | -4.63% | -4.40% | -0.34% | -0.51% | -0.48% |
| | Ropax Large | -7.20% | -10.05% | -9.56% | -1.74% | -2.45% | -2.31% |

**Table 72: Minimal change in tonkm for an OD of Policy C, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario C | LoLo | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | RoRo | 0.03% | 0.00% | 0.00% | 0.01% | 0.00% | 0.00% |
| | Ropax Small | -0.18% | -0.27% | -0.25% | -0.01% | -0.01% | -0.01% |
| | Ropax Large | 0.08% | 0.00% | 0.00% | 0.02% | 0.00% | 0.00% |

**Table 73: Total effect of Policy C on tonkm, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario C | 0 | -3.66% | -5.09% | -4.83% | -0.33% | -0.46% | -0.43% |
| | 1 | -3.77% | -5.30% | -5.01% | -0.47% | -0.67% | -0.63% |
| | 5 | -8.75% | -12.03% | -11.47% | -1.01% | -1.43% | -1.35% |
| | 6 | -2.71% | -3.80% | -3.60% | -0.23% | -0.32% | -0.30% |
| | 8 | -2.97% | -4.17% | -3.95% | -0.06% | -0.08% | -0.08% |
| | 9 | -7.52% | -10.38% | -9.87% | -0.81% | -1.14% | -1.08% |

**Table 74: Maximal change in tonkm for an OD of Policy C, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario C | 0 | -14.88% | -20.17% | -19.26% | -7.96% | -10.96% | -10.43% |
| | 1 | -12.02% | -16.34% | -15.63% | -1.48% | -2.09% | -1.98% |
| | 5 | -9.20% | -12.63% | -12.04% | -1.05% | -1.49% | -1.40% |
| | 6 | -12.25% | -16.63% | -15.91% | -4.35% | -6.10% | -5.77% |
| | 8 | -5.58% | -7.83% | -7.40% | -2.83% | -3.99% | -3.77% |
| | 9 | -19.35% | -25.94% | -24.85% | -10.48% | -14.35% | -13.68% |

**Table 75: Minimal change in tonkm for an OD of Policy C, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario C | 0 | -0.18% | -0.25% | -0.23% | -0.02% | -0.02% | -0.02% |
| | 1 | -0.23% | -0.35% | -0.33% | -0.01% | -0.02% | -0.01% |
| | 5 | -3.03% | -4.51% | -4.30% | -0.05% | -0.07% | -0.07% |
| | 6 | -0.28% | -0.40% | -0.38% | -0.01% | -0.01% | -0.01% |
| | 8 | -0.23% | -0.34% | -0.32% | -0.01% | -0.02% | -0.02% |
| | 9 | 0.19% | -0.21% | -0.20% | 0.01% | 0.00% | 0.00% |

## Policy scenario D

**Table 76: Total effect of Policy D on tonkm, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario D | LoLo | -8.61% | -11.84% | -11.28% | -0.75% | -1.05% | -0.99% |
| | RoRo | -4.58% | -6.21% | -5.83% | -0.43% | -0.58% | -0.54% |
| | Ropax Small | -0.94% | -1.41% | -1.34% | -0.04% | -0.06% | -0.06% |
| | Ropax Large | -2.65% | -3.72% | -3.48% | -0.31% | -0.44% | -0.41% |

**Table 77: Maximal change in tonkm for an OD of Policy D, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario D | LoLo | -19.35% | -25.94% | -24.85% | -10.48% | -14.35% | -13.68% |
| | RoRo | -14.88% | -20.17% | -19.26% | -7.96% | -10.96% | -10.43% |
| | Ropax Small | -3.10% | -4.63% | -4.40% | -0.34% | -0.51% | -0.48% |
| | Ropax Large | -7.20% | -10.05% | -9.56% | -1.74% | -2.45% | -2.31% |

**Table 78: Minimal change in tonkm for an OD of Policy D, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario D | LoLo | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | RoRo | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | Ropax Small | -0.18% | -0.27% | -0.25% | -0.01% | -0.01% | -0.01% |
| | Ropax Large | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

**Table 79: Total effect of Policy D on tonkm, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario D | 0 | -3.66% | -5.09% | -4.83% | -0.33% | -0.46% | -0.43% |
| | 1 | -3.77% | -5.30% | -5.01% | -0.47% | -0.67% | -0.63% |
| | 5 | -8.75% | -12.03% | -11.47% | -1.01% | -1.43% | -1.35% |
| | 6 | -2.71% | -3.80% | -3.60% | -0.23% | -0.32% | -0.30% |
| | 8 | -2.97% | -4.17% | -3.95% | -0.06% | -0.08% | -0.08% |
| | 9 | -7.56% | -10.41% | -9.89% | -0.82% | -1.15% | -1.08% |

**Table 80: Maximal change in tonkm for an OD of Policy D, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario D | 0 | -14.88% | -20.17% | -19.26% | -7.96% | -10.96% | -10.43% |
| | 1 | -12.02% | -16.34% | -15.63% | -1.48% | -2.09% | -1.98% |
| | 5 | -9.20% | -12.63% | -12.04% | -1.05% | -1.49% | -1.40% |
| | 6 | -12.25% | -16.63% | -15.91% | -4.35% | -6.10% | -5.77% |
| | 8 | -5.58% | -7.83% | -7.40% | -2.83% | -3.99% | -3.77% |
| | 9 | -19.35% | -25.94% | -24.85% | -10.48% | -14.35% | -13.68% |

**Table 81: Minimal change in tonkm for an OD of Policy D, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario D | 0 | -0.18% | -0.25% | -0.23% | -0.02% | -0.02% | -0.02% |
| | 1 | -0.23% | -0.35% | -0.33% | -0.01% | -0.02% | -0.01% |
| | 5 | -3.03% | -4.51% | -4.30% | -0.05% | -0.07% | -0.07% |
| | 6 | -0.28% | -0.40% | -0.38% | -0.01% | -0.01% | -0.01% |
| | 8 | -0.23% | -0.34% | -0.32% | -0.01% | -0.02% | -0.02% |
| | 9 | -0.14% | 0.07% | 0.06% | 0.00% | 0.00% | 0.00% |

## Policy scenario E

**Table 82: Total effect of Policy E on tonkm, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario E | LoLo | -8.61% | -11.98% | -11.56% | -0.75% | -1.06% | -1.02% |
| | RoRo | -4.60% | -6.26% | -5.94% | -0.43% | -0.59% | -0.55% |
| | Ropax Small | -0.94% | -1.45% | -1.43% | -0.04% | -0.06% | -0.06% |
| | Ropax Large | -2.62% | -3.74% | -3.51% | -0.31% | -0.45% | -0.42% |

**Table 83: Maximal change in tonkm for an OD of Policy E, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario E | LoLo | -19.35% | -26.22% | -25.40% | -10.48% | -14.52% | -14.02% |
| | RoRo | -14.88% | -20.33% | -19.58% | -7.96% | -11.05% | -10.61% |
| | Ropax Small | -3.10% | -4.77% | -4.69% | -0.34% | -0.52% | -0.51% |
| | Ropax Large | -7.20% | -10.10% | -9.65% | -1.74% | -2.46% | -2.33% |

**Table 84: Minimal change in tonkm for an OD of Policy E, distinction according to ship type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario E | LoLo | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | RoRo | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | Ropax Small | -0.18% | -0.28% | -0.27% | -0.01% | -0.01% | -0.01% |
| | Ropax Large | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

**Table 85: Total effect of Policy E on tonkm, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario E | 0 | -3.76% | -5.14% | -4.92% | -0.34% | -0.46% | -0.44% |
| | 1 | -3.77% | -5.37% | -5.15% | -0.47% | -0.68% | -0.65% |
| | 5 | -8.75% | -12.14% | -11.68% | -1.01% | -1.45% | -1.38% |
| | 6 | -2.71% | -3.84% | -3.67% | -0.23% | -0.32% | -0.31% |
| | 8 | -2.97% | -4.21% | -4.02% | -0.06% | -0.09% | -0.08% |
| | 9 | -7.52% | -10.52% | -10.10% | -0.81% | -1.16% | -1.10% |

**Table 86: Maximal change in tonkm for an OD of Policy E, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario E | 0 | -14.88% | -20.33% | -19.58% | -7.96% | -11.05% | -10.61% |
| | 1 | -12.02% | -16.52% | -16.00% | -1.48% | -2.12% | -2.03% |
| | 5 | -9.20% | -12.73% | -12.24% | -1.05% | -1.51% | -1.43% |
| | 6 | -12.25% | -16.81% | -16.28% | -4.35% | -6.18% | -5.93% |
| | 8 | -5.58% | -7.93% | -7.60% | -2.83% | -4.05% | -3.87% |
| | 9 | -19.35% | -26.22% | -25.40% | -10.48% | -14.52% | -14.02% |

**Table 87: Minimal change in tonkm for an OD of Policy E, distinction according to commodity type**

| | | SSS route | | | road route | | |
|---|---|---|---|---|---|---|---|
| Policy Scenario E | 0 | -0.15% | -0.25% | -0.24% | -0.01% | -0.01% | -0.01% |
| | 1 | -0.23% | -0.36% | -0.35% | -0.01% | -0.01% | -0.01% |
| | 5 | -3.03% | -4.65% | -4.58% | -0.05% | -0.05% | -0.05% |
| | 6 | -0.28% | -0.40% | -0.38% | -0.01% | -0.01% | -0.01% |
| | 8 | -0.23% | -0.35% | -0.35% | -0.01% | -0.01% | -0.01% |
| | 9 | 0.19% | 0.05% | 0.04% | 0.01% | 0.01% | 0.01% |

Full overview of effects on O-D level

On the following pages, a detailed list of effects of all five scenarios is given for each of the 252 O-D pairs

| 2025 | | | | | | Baseline | | Policy A | | Policy B | | Policy C | | Policy D | | Policy E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road |
| | Origin | | Destination | Com | ship type | tonkm | tonkm | % | % | % | % | % | % | % | % | % | % |
| FI | Helsinki | UK | Preston | 9 | RoRo | 61450064 | 10600723 | -6.39% | -2.47% | -6.27% | -2.42% | -8.74% | -3.41% | -8.74% | -3.41% | -8.90% | -3.47% |
| FI | Helsinki | UK | Manchester | 9 | RoRo | 157832177 | 27563900 | -6.65% | -2.49% | -6.53% | -2.45% | -9.08% | -3.44% | -9.08% | -3.44% | -9.25% | -3.51% |
| FI | Helsinki | UK | Manchester | 9 | RoRo | 353727270 | 49256251 | -13.06% | -6.91% | -12.83% | -6.79% | -17.41% | -9.36% | -17.41% | -9.36% | -17.70% | -9.53% |
| FI | Helsinki | UK | Manchester | 9 | LoLo | 51390957 | 7826044.2 | -9.04% | -4.06% | -8.95% | -4.02% | -12.45% | -5.67% | -12.45% | -5.67% | -12.78% | -5.82% |
| FI | Helsinki | UK | Derby | 0 | RoRo | 124971731 | 19337784 | -9.98% | -4.08% | -9.80% | -4.00% | -13.44% | -5.58% | -13.44% | -5.58% | -13.68% | -5.68% |
| FI | Helsinki | UK | Northampton | 9 | RoRo | 62421478 | 9265905.7 | -5.62% | -2.24% | -5.52% | -2.20% | -7.71% | -3.10% | -7.71% | -3.10% | -7.86% | -3.16% |
| FI | Helsinki | UK | Reading | 9 | RoRo | 254686788 | 36598684 | -14.38% | -7.61% | -14.13% | -7.47% | -19.08% | -10.26% | -19.08% | -10.26% | -19.39% | -10.44% |
| FI | Oulu | UK | Reading | 9 | LoLo | 105871008 | 15042306 | -11.97% | -5.21% | -11.86% | -5.16% | -16.28% | -7.21% | -16.28% | -7.21% | -16.68% | -7.40% |
| FI | Oulu | UK | Reading | 9 | RoRo | 54793209 | 7331907.7 | -7.63% | -2.89% | -7.49% | -2.83% | -10.38% | -3.98% | -10.38% | -3.98% | -10.56% | -4.05% |
| FI | Tampere | UK | Reading | 9 | LoLo | 221346388 | 31923105 | -13.67% | -6.58% | -13.54% | -6.51% | -18.47% | -9.05% | -18.47% | -9.05% | -18.92% | -9.28% |
| FI | Tampere | UK | Reading | 9 | RoRo | 126689615 | 17060460 | -13.91% | -7.41% | -13.67% | -7.27% | -18.49% | -10.00% | -18.49% | -10.00% | -18.79% | -10.18% |
| FI | Helsinki | UK | Reading | 9 | LoLo | 325896434 | 50352876 | -18.76% | -10.10% | -18.59% | -10.01% | -24.85% | -13.68% | -24.85% | -13.68% | -25.40% | -14.02% |
| FI | Helsinki | UK | Reading | 9 | RoRo | 69905247 | 10045437 | -7.30% | -2.75% | -7.17% | -2.70% | -9.94% | -3.79% | -9.94% | -3.79% | -10.12% | -3.86% |
| FI | Helsinki | UK | Reading | 9 | RoRo | 49170910 | 7389848.3 | -8.37% | -3.52% | -8.21% | -3.46% | -11.35% | -4.84% | -11.35% | -4.84% | -11.55% | -4.93% |
| FI | Helsinki | UK | Reading | 9 | RoRo | 102061889 | 15016163 | -4.55% | -1.91% | -4.47% | -1.87% | -6.27% | -2.64% | -6.27% | -2.64% | -6.39% | -2.70% |
| FI | Helsinki | UK | Brighton | 0 | LoLo | 195871398 | 26920629 | -9.86% | -3.86% | -9.76% | -3.82% | -13.51% | -5.38% | -13.51% | -5.38% | -13.86% | -5.52% |
| FI | Helsinki | UK | Brighton | 0 | RoRo | 74834282 | 10052601 | -14.52% | -7.74% | -14.27% | -7.60% | -19.26% | -10.43% | -19.26% | -10.43% | -19.58% | -10.61% |
| FI | Tampere | UK | Swansea | 9 | RoRo | 44689544 | 6175576.7 | -3.70% | -1.62% | -3.63% | -1.59% | -5.12% | -2.26% | -5.12% | -2.26% | -5.22% | -2.30% |
| FI | Helsinki | UK | Swansea | 9 | RoRo | 64657218 | 9816854.9 | -8.82% | -4.18% | -8.65% | -4.10% | -11.95% | -5.72% | -11.95% | -5.72% | -12.16% | -5.83% |
| FI | Helsinki | UK | Cardiff | 9 | RoRo | 43981641 | 6698753.3 | -9.17% | -4.33% | -9.00% | -4.25% | -12.41% | -5.93% | -12.41% | -5.93% | -12.63% | -6.04% |
| FI | Tampere | UK | Belfast | 9 | LoLo | 159884843 | 24841714 | -16.26% | -7.66% | -16.11% | -7.59% | -21.73% | -10.47% | -21.73% | -10.47% | -22.23% | -10.73% |
| FI | Helsinki | UK | Belfast | 9 | LoLo | 65905408 | 11158443 | -11.79% | -4.12% | -11.68% | -4.08% | -16.00% | -5.72% | -16.00% | -5.72% | -16.40% | -5.87% |
| | | | | | | | | | | | | | | | | | |
| SE | Malmo | DK | Copenhagen | 9 | RoPax-Small | 12505881 | 73473830 | -5.71% | -0.06% | -5.60% | -0.06% | -7.76% | -0.08% | -7.76% | -0.08% | -7.90% | -0.08% |
| SE | Malmo | DK | Copenhagen | 0 | RoPax-Small | 1136452 | 6285174.4 | -2.92% | -0.02% | -2.83% | -0.02% | -4.20% | -0.03% | -4.20% | -0.03% | -4.48% | -0.03% |
| SE | Malmo | DK | Copenhagen | 1 | RoPax-Small | 1443060 | 10519996 | -3.00% | -0.03% | -2.91% | -0.03% | -4.32% | -0.05% | -4.32% | -0.05% | -4.61% | -0.05% |
| SE | Malmo | DK | Copenhagen | 6 | RoPax-Small | 8697421 | 126907262 | -3.05% | -0.01% | -2.96% | -0.01% | -4.38% | -0.02% | -4.38% | -0.02% | -4.67% | -0.02% |
| SE | Malmo | DK | Copenhagen | 5 | RoPax-Small | 10837146 | 25350223 | -2.98% | -0.05% | -2.90% | -0.05% | -4.30% | -0.07% | -4.30% | -0.07% | -4.58% | -0.07% |
| SE | Goteborg | DK | Arhus | 9 | RoPax-Large | 11981952 | 128883337 | -0.13% | -0.01% | -0.13% | -0.01% | -0.20% | -0.01% | -0.20% | -0.01% | -0.21% | -0.01% |
| SE | Goteborg | DK | Arhus | 0 | RoPax-Large | 17584297 | 178049988 | -0.51% | -0.03% | -0.50% | -0.03% | -0.71% | -0.04% | -0.71% | -0.04% | -0.72% | -0.04% |
| SE | Goteborg | DK | Arhus | 6 | RoPax-Large | 14633397 | 390923683 | -0.27% | -0.01% | -0.26% | -0.01% | -0.38% | -0.01% | -0.38% | -0.01% | -0.38% | -0.01% |
| SE | Goteborg | DK | Arhus | 1 | RoPax-Large | 7995656 | 106717592 | -0.27% | -0.01% | -0.27% | -0.01% | -0.38% | -0.01% | -0.38% | -0.01% | -0.39% | -0.01% |
| SE | Goteborg | DK | Arhus | 8 | RoPax-Large | 7638074 | 66768617 | -2.20% | -0.17% | -2.13% | -0.16% | -3.04% | -0.24% | -3.04% | -0.24% | -3.07% | -0.24% |

| 2025 | | | | | | Baseline | | Policy A | | Policy B | | Policy C | | Policy D | | Policy E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road |
| Origin | | Destination | | Com | ship type | tonkm | tonkm | % | % | % | % | % | % | % | % | % | % |
| FI | Tampere | DE | Bremen | 9 | RoRo | 24916313 | 48632709 | -2.58% | -0.58% | -2.51% | -0.56% | -3.57% | -0.80% | -3.57% | -0.80% | -3.61% | -0.81% |
| FI | Helsinki | DE | Bremen | 9 | RoPax-Large | 24442163 | 53055049 | -5.48% | -1.17% | -5.38% | -1.14% | -7.49% | -1.62% | -7.49% | -1.62% | -7.63% | -1.66% |
| FI | Helsinki | DE | Bremen | 9 | LoLo | 36836391 | 55283524 | -7.19% | -1.53% | -7.06% | -1.50% | -9.75% | -2.13% | -9.75% | -2.13% | -9.93% | -2.17% |
| FI | Tampere | DE | Hamburg | 9 | RoRo | 61323667 | 120802304 | -3.76% | -0.84% | -3.66% | -0.81% | -5.17% | -1.17% | -5.17% | -1.17% | -5.22% | -1.18% |
| FI | Tampere | DE | Hamburg | 9 | LoLo | 64814424 | 80376701 | -4.29% | -0.92% | -4.25% | -0.91% | -6.01% | -1.30% | -6.01% | -1.30% | -6.18% | -1.34% |
| FI | Helsinki | DE | Hamburg | 9 | RoPax-Large | 52315537 | 115626617 | -4.08% | -0.49% | -4.00% | -0.48% | -5.61% | -0.68% | -5.61% | -0.68% | -5.71% | -0.69% |
| FI | Helsinki | DE | Hamburg | 9 | LoLo | 33978805 | 45066209 | -4.91% | -0.89% | -4.86% | -0.88% | -6.86% | -1.27% | -6.86% | -1.27% | -7.04% | -1.31% |
| FI | Helsinki | DE | Lubeck | 9 | RoPax-Large | 41208614 | 88392734 | -4.75% | -0.88% | -4.62% | -0.85% | -6.50% | -1.22% | -6.50% | -1.22% | -6.56% | -1.23% |
| FI | Helsinki | DE | Kiel | 9 | RoPax-Large | 249728869 | 576401068 | -11.15% | -1.43% | -11.05% | -1.42% | -15.03% | -2.02% | -15.03% | -2.02% | -15.40% | -2.08% |
| FI | Oulu | DE | Kiel | 9 | LoLo | 38203657 | 79493889 | -5.09% | -0.64% | -4.95% | -0.62% | -6.94% | -0.89% | -6.94% | -0.89% | -7.01% | -0.90% |
| FI | Tampere | DE | Kiel | 9 | RoRo | 24437850 | 49829919 | -3.83% | -0.65% | -3.72% | -0.63% | -5.25% | -0.91% | -5.25% | -0.91% | -5.30% | -0.92% |
| FI | Tampere | DE | Kiel | 9 | LoLo | 152527567 | 175675210 | -3.70% | -0.88% | -3.67% | -0.87% | -5.21% | -1.26% | -5.21% | -1.26% | -5.36% | -1.29% |
| FI | Helsinki | DE | Kiel | 9 | RoPax-Large | 53887187 | 124377418 | -6.53% | -0.49% | -6.41% | -0.48% | -8.85% | -0.69% | -8.85% | -0.69% | -9.01% | -0.70% |
| FI | Helsinki | DE | Kiel | 9 | LoLo | 406919352 | 500025639 | -4.23% | -0.89% | -4.19% | -0.88% | -5.93% | -1.26% | -5.93% | -1.26% | -6.09% | -1.30% |
| FI | Helsinki | DE | Kiel | 0 | RoPax-Large | 77317089 | 189007888 | -6.37% | -0.65% | -6.20% | -0.63% | -8.62% | -0.91% | -8.62% | -0.91% | -8.70% | -0.92% |
| | | | | | | | | | | | | | | | | | |
| DK | Copenhagen | SE | Malmo | 9 | RoPax-Small | 4573114 | 27055760 | -2.70% | -0.02% | -2.63% | -0.02% | -3.72% | -0.03% | -3.72% | -0.03% | -3.76% | -0.03% |
| DK | Copenhagen | SE | Malmo | 0 | RoPax-Small | 10987326 | 34920513 | -10.92% | -0.07% | -10.82% | -0.07% | -14.67% | -0.10% | -14.67% | -0.10% | -15.01% | -0.10% |
| DK | Copenhagen | SE | Malmo | 1 | RoPax-Small | 1127306 | 4615153 | -11.69% | -0.16% | -11.58% | -0.16% | -15.63% | -0.22% | -15.63% | -0.22% | -16.00% | -0.23% |
| DK | Copenhagen | SE | Malmo | 6 | RoPax-Small | 2143594 | 32910409 | -11.92% | -0.03% | -11.81% | -0.03% | -15.91% | -0.04% | -15.91% | -0.04% | -16.28% | -0.04% |
| DK | Copenhagen | SE | Malmo | 5 | RoPax-Small | 2758418 | 20446032 | -8.41% | -0.06% | -8.26% | -0.06% | -11.26% | -0.08% | -11.26% | -0.08% | -11.45% | -0.08% |
| DK | Copenhagen | SE | Kalmar | 6 | RoRo | 11264533 | 122654906 | -3.08% | -0.04% | -2.99% | -0.04% | -4.43% | -0.06% | -4.43% | -0.06% | -4.72% | -0.06% |
| DK | Arhus | SE | Goteborg | 9 | RoPax-Small | 5004660 | 51665247 | -0.28% | -0.02% | -0.28% | -0.01% | -0.42% | -0.02% | -0.42% | -0.02% | -0.45% | -0.02% |
| DK | Arhus | SE | Goteborg | 0 | RoPax-Small | 12633256 | 70061604 | -0.23% | -0.02% | -0.22% | -0.02% | -0.34% | -0.03% | -0.34% | -0.03% | -0.36% | -0.03% |
| DK | Arhus | SE | Goteborg | 8 | RoPax-Small | 132615301 | 1.259E+09 | -0.22% | -0.01% | -0.21% | -0.01% | -0.32% | -0.02% | -0.32% | -0.02% | -0.35% | -0.02% |
| DK | Arhus | SE | Goteborg | 1 | RoPax-Small | 17873909 | 127684986 | -0.23% | -0.02% | -0.22% | -0.02% | -0.33% | -0.02% | -0.33% | -0.02% | -0.35% | -0.02% |
| | | | | | | | | | | | | | | | | | |
| FI | Oulu | BE | Antwerp | 9 | LoLo | 67383799 | 102521224 | -5.53% | -0.49% | -5.43% | -0.48% | -7.54% | -0.69% | -7.54% | -0.69% | -7.68% | -0.70% |
| FI | Tampere | BE | Antwerp | 9 | LoLo | 56461583 | 82450056 | -2.40% | -0.43% | -2.33% | -0.42% | -3.48% | -0.63% | -3.48% | -0.63% | -3.71% | -0.68% |
| FI | Helsinki | BE | Antwerp | 9 | LoLo | 55858137 | 86426871 | -2.51% | -0.33% | -2.43% | -0.32% | -3.63% | -0.48% | -3.63% | -0.48% | -3.87% | -0.51% |
| FI | Helsinki | BE | Liege | 9 | LoLo | 53354289 | 77665719 | -1.96% | -0.32% | -1.91% | -0.31% | -2.85% | -0.46% | -2.85% | -0.46% | -3.04% | -0.50% |
| FI | Oulu | BE | Brugge | 9 | LoLo | 107512386 | 164795247 | -3.93% | -1.38% | -3.82% | -1.34% | -5.66% | -2.01% | -5.66% | -2.01% | -6.03% | -2.15% |
| FI | Helsinki | BE | Brugge | 9 | LoLo | 146938379 | 234454957 | -6.76% | -1.16% | -6.63% | -1.14% | -9.17% | -1.61% | -9.17% | -1.61% | -9.34% | -1.64% |
| FI | Helsinki | BE | Brugge | 9 | LoLo | 65143933 | 112659848 | -13.60% | -3.68% | -13.47% | -3.65% | -18.22% | -5.12% | -18.22% | -5.12% | -18.65% | -5.26% |
| FI | Oulu | BE | Brussels | 9 | LoLo | 156991880 | 239680428 | -6.95% | -0.70% | -6.88% | -0.69% | -9.58% | -0.99% | -9.58% | -0.99% | -9.83% | -1.02% |
| FI | Helsinki | BE | Brussels | 9 | LoLo | 41248165 | 63295594 | -6.74% | -0.72% | -6.67% | -0.71% | -9.30% | -1.01% | -9.30% | -1.01% | -9.54% | -1.04% |
| FI | Helsinki | BE | Kortrijk | 9 | LoLo | 163498460 | 269750065 | -8.92% | -1.29% | -8.83% | -1.27% | -12.17% | -1.81% | -12.17% | -1.81% | -12.48% | -1.87% |
| FI | Helsinki | BE | Kortrijk | 9 | LoLo | 92638421 | 144745445 | -8.53% | -1.30% | -8.45% | -1.29% | -11.68% | -1.83% | -11.68% | -1.83% | -11.98% | -1.89% |

| 2025 | | | | | | Baseline | | Policy A | | Policy B | | Policy C | | Policy D | | Policy E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road |
| Origin | | Destination | | Com | ship type | tonkm | tonkm | % | % | % | % | % | % | % | % | % | % |
| SE | Goteborg | UK | Durham | 9 | RoRo | 33911534 | 276820362 | -6.21% | -0.26% | -6.15% | -0.26% | -8.58% | -0.37% | -8.58% | -0.37% | -8.81% | -0.38% |
| SE | Umea | UK | Newcastle-upon-Tyne | 0 | LoLo | 333724206 | 2.068E+09 | -5.35% | -0.07% | -5.21% | -0.07% | -7.27% | -0.10% | -7.27% | -0.10% | -7.34% | -0.10% |
| SE | Goteborg | UK | Newcastle-upon-Tyne | 0 | RoRo | 60952253 | 658439396 | -7.00% | -0.06% | -6.87% | -0.06% | -9.44% | -0.08% | -9.44% | -0.08% | -9.61% | -0.09% |
| SE | Goteborg | UK | Newcastle-upon-Tyne | 9 | RoRo | 45926781 | 369572855 | -2.00% | -0.07% | -1.96% | -0.06% | -2.78% | -0.09% | -2.78% | -0.09% | -2.83% | -0.09% |
| SE | Goteborg | UK | Newcastle-upon-Tyne | 0 | RoRo | 41086506 | 347972698 | -5.27% | -0.19% | -5.22% | -0.19% | -7.32% | -0.26% | -7.32% | -0.26% | -7.52% | -0.27% |
| SE | Goteborg | UK | Manchester | 9 | RoRo | 73549314 | 391469203 | -7.27% | -0.98% | -7.14% | -0.96% | -9.84% | -1.36% | -9.84% | -1.36% | -10.02% | -1.38% |
| SE | Goteborg | UK | Middlesborough | 9 | RoRo | 28420772 | 209084048 | -1.65% | -0.07% | -1.61% | -0.06% | -2.29% | -0.09% | -2.29% | -0.09% | -2.34% | -0.09% |
| SE | Goteborg | UK | Ipswich | 9 | RoRo | 44075843 | 221406797 | -3.70% | -0.21% | -3.63% | -0.21% | -5.10% | -0.29% | -5.10% | -0.29% | -5.19% | -0.30% |
| SE | Goteborg | UK | Ipswich | 9 | RoRo | 88057260 | 542666646 | -1.62% | -0.08% | -1.59% | -0.08% | -2.26% | -0.11% | -2.26% | -0.11% | -2.30% | -0.11% |
| SE | Goteborg | UK | Ipswich | 9 | RoRo | 18181439 | 136598240 | -5.73% | -0.16% | -5.62% | -0.16% | -7.79% | -0.22% | -7.79% | -0.22% | -7.93% | -0.22% |
| SE | Eskilstuna | UK | Reading | 9 | LoLo | 75090760 | 284240955 | -4.06% | -0.16% | -3.98% | -0.16% | -5.58% | -0.22% | -5.58% | -0.22% | -5.68% | -0.23% |
| SE | Malmo | UK | Reading | 9 | RoRo | 58399272 | 255287647 | -5.27% | -0.25% | -5.17% | -0.25% | -7.19% | -0.35% | -7.19% | -0.35% | -7.32% | -0.36% |
| SE | Umea | UK | Reading | 9 | LoLo | 57553344 | 256319569 | -5.68% | -0.26% | -5.58% | -0.26% | -7.73% | -0.36% | -7.73% | -0.36% | -7.87% | -0.37% |
| SE | Goteborg | UK | Reading | 9 | RoRo | 60608732 | 361459251 | -7.06% | -0.27% | -6.99% | -0.27% | -9.70% | -0.38% | -9.70% | -0.38% | -9.95% | -0.39% |
| SE | Goteborg | UK | Reading | 9 | LoLo | 108117507 | 742961164 | -4.11% | -0.21% | -4.03% | -0.20% | -5.64% | -0.29% | -5.64% | -0.29% | -5.75% | -0.29% |
| SE | Goteborg | UK | Reading | 9 | RoRo | 202190380 | 1.261E+09 | -2.04% | -0.11% | -2.02% | -0.10% | -2.89% | -0.15% | -2.89% | -0.15% | -2.98% | -0.15% |
| SE | Goteborg | UK | Reading | 9 | RoPax-Large | 58520532 | 380523011 | -7.98% | -0.92% | -7.84% | -0.90% | -10.76% | -1.27% | -10.76% | -1.27% | -10.95% | -1.29% |
| SE | Goteborg | UK | Reading | 0 | RoPax-Large | 41959820 | 287156185 | -4.08% | -0.12% | -4.04% | -0.12% | -5.71% | -0.17% | -5.71% | -0.17% | -5.87% | -0.17% |
| SE | Goteborg | UK | Reading | 0 | RoRo | 36054243 | 236722884 | -3.28% | -0.19% | -3.22% | -0.19% | -4.53% | -0.26% | -4.53% | -0.26% | -4.62% | -0.27% |
| SE | Goteborg | UK | Reading | 8 | RoRo | 37947990 | 205634701 | -4.44% | -0.20% | -4.32% | -0.20% | -6.06% | -0.28% | -6.06% | -0.28% | -6.12% | -0.28% |
| SE | Goteborg | UK | Reading | 0 | LoLo | 32808804 | 237286149 | -1.61% | -0.05% | -1.57% | -0.05% | -2.24% | -0.07% | -2.24% | -0.07% | -2.26% | -0.07% |
| SE | Goteborg | UK | Reading | 0 | RoRo | 35965892 | 225749545 | -6.50% | -0.26% | -6.38% | -0.25% | -8.80% | -0.36% | -8.80% | -0.36% | -8.96% | -0.37% |
| SE | Goteborg | UK | Brighton | 9 | RoPax-Large | 139550225 | 911556667 | -8.10% | -0.93% | -7.95% | -0.91% | -10.91% | -1.28% | -10.91% | -1.28% | -11.10% | -1.31% |
| SE | Goteborg | UK | Dover | 0 | RoRo | 36237741 | 206147882 | -2.04% | -0.11% | -2.01% | -0.11% | -2.88% | -0.16% | -2.88% | -0.16% | -2.97% | -0.16% |
| SE | Goteborg | UK | Bournemouth | 9 | RoRo | 105089817 | 651729723 | -1.20% | -0.07% | -1.17% | -0.07% | -1.67% | -0.09% | -1.67% | -0.09% | -1.70% | -0.10% |
| SE | Goteborg | UK | Edinburgh | 9 | RoRo | 15015727 | 169971401 | -5.14% | -0.11% | -5.00% | -0.10% | -6.98% | -0.15% | -6.98% | -0.15% | -7.05% | -0.15% |
| SE | Goteborg | UK | Belfast | 9 | LoLo | 31436345 | 237781208 | -7.22% | -0.26% | -7.09% | -0.26% | -9.74% | -0.37% | -9.74% | -0.37% | -9.91% | -0.37% |

| 2025 | | | | | | Baseline | | Policy A | | Policy B | | Policy C | | Policy D | | Policy E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road |
| Origin | | Destination | | Com | ship type | tonkm | tonkm | % | % | % | % | % | % | % | % | % | % |
| UK | Newcastle - upon-Tyne | BE | Antwerp | 8 | LoLo | 180792735 | 3629058.6 | -4.07% | -2.01% | -3.99% | -1.97% | -5.62% | -2.79% | -5.62% | -2.79% | -5.73% | -2.84% |
| UK | Liverpool | BE | Antwerp | 8 | RoPax-Large | 159787208 | 2867457 | -0.95% | -0.47% | -0.94% | -0.47% | -1.36% | -0.67% | -1.36% | -0.67% | -1.40% | -0.69% |
| UK | Hull | BE | Antwerp | 9 | LoLo | 17892254 | 1545587.8 | -14.13% | -6.84% | -13.88% | -6.72% | -18.76% | -9.22% | -18.76% | -9.22% | -19.07% | -9.38% |
| UK | Middlesborou gh | BE | Antwerp | 9 | LoLo | 55673461 | 3380185.9 | -0.53% | -0.25% | -0.51% | -0.24% | -0.77% | -0.36% | -0.77% | -0.36% | -0.82% | -0.39% |
| UK | London | BE | Antwerp | 6 | LoLo | 41684795 | 1320.1241 | -2.88% | -1.45% | -2.80% | -1.41% | -3.99% | -2.01% | -3.99% | -2.01% | -4.03% | -2.03% |
| UK | Reading | BE | Antwerp | 9 | RoPax-Large | 16813992 | 1063847.6 | -1.77% | -0.85% | -1.72% | -0.82% | -2.47% | -1.18% | -2.47% | -1.18% | -2.49% | -1.19% |
| UK | Reading | BE | Antwerp | 9 | RoRo | 46874305 | 2730244.8 | -2.43% | -1.17% | -2.38% | -1.14% | -3.38% | -1.63% | -3.38% | -1.63% | -3.45% | -1.66% |
| UK | Brighton | BE | Antwerp | 9 | RoPax-Large | 7007691 | 443353.03 | -2.85% | -1.36% | -2.80% | -1.33% | -3.96% | -1.89% | -3.96% | -1.89% | -4.04% | -1.93% |
| UK | Bristol | BE | Antwerp | 9 | RoPax-Large | 15928638 | 1011714 | -2.45% | -1.18% | -2.42% | -1.17% | -3.47% | -1.68% | -3.47% | -1.68% | -3.58% | -1.72% |
| UK | Plymouth | BE | Antwerp | 6 | LoLo | 723485890 | 41741.113 | -0.73% | -0.37% | -0.71% | -0.35% | -1.02% | -0.51% | -1.02% | -0.51% | -1.03% | -0.52% |
| UK | London | BE | Kortrijk | 6 | LoLo | 41785091 | 1223.647 | -3.61% | -1.82% | -3.57% | -1.80% | -5.09% | -2.58% | -5.09% | -2.58% | -5.24% | -2.65% |
| UK | Crawley | BE | Kortrijk | 6 | LoLo | 92882699 | 2855.1034 | -1.99% | -1.00% | -1.97% | -0.99% | -2.82% | -1.42% | -2.82% | -1.42% | -2.91% | -1.46% |
| UK | Reading | BE | Kortrijk | 9 | RoPax-Small | 17547190 | 1146569.4 | -1.97% | -0.96% | -1.95% | -0.94% | -2.80% | -1.36% | -2.80% | -1.36% | -2.89% | -1.40% |
| UK | Reading | BE | Kortrijk | 9 | RoRo | 26231943 | 1319724.1 | -1.21% | -0.58% | -1.18% | -0.56% | -1.69% | -0.80% | -1.69% | -0.80% | -1.70% | -0.81% |
| UK | Brighton | BE | Kortrijk | 9 | RoPax-Small | 15240912 | 997541.19 | -1.13% | -0.55% | -1.11% | -0.54% | -1.58% | -0.76% | -1.58% | -0.76% | -1.61% | -0.78% |
| UK | Brighton | BE | Kortrijk | 9 | RoRo | 9028391 | 455196.46 | -1.38% | -0.65% | -1.34% | -0.64% | -1.92% | -0.91% | -1.92% | -0.91% | -1.94% | -0.92% |
| UK | Plymouth | BE | Kortrijk | 6 | RoRo | 71559121 | 4000.4225 | -0.51% | -0.26% | -0.50% | -0.25% | -0.71% | -0.36% | -0.71% | -0.36% | -0.72% | -0.36% |
| | | | | | | | | | | | | | | | | | |
| BE | Antwerp | UK | Middlesborough | 9 | LoLo | 37195253 | 127529.29 | -2.51% | -1.26% | -2.48% | -1.24% | -3.55% | -1.79% | -3.55% | -1.79% | -3.66% | -1.84% |
| BE | Kortrijk | UK | Middlesborough | 9 | LoLo | 14879768 | 50337.21 | -4.14% | -2.08% | -4.09% | -2.06% | -5.82% | -2.95% | -5.82% | -2.95% | -5.99% | -3.03% |
| BE | Kortrijk | UK | Middlesborough | 9 | RoRo | 16197241 | 46424.532 | -2.47% | -1.24% | -2.45% | -1.23% | -3.51% | -1.77% | -3.51% | -1.77% | -3.61% | -1.82% |
| BE | Antwerp | UK | Cambridge | 8 | RoPax-Large | 16057554 | 16484.786 | -5.28% | -2.67% | -5.22% | -2.64% | -7.40% | -3.77% | -7.40% | -3.77% | -7.60% | -3.87% |
| BE | Kortrijk | UK | Cambridge | 9 | RoRo | 18982125 | 43233.479 | -3.20% | -1.61% | -3.17% | -1.59% | -4.53% | -2.29% | -4.53% | -2.29% | -4.66% | -2.35% |
| BE | Antwerp | UK | Reading | 9 | RoPax-Large | 22791806 | 81436.178 | -9.85% | -5.04% | -9.76% | -4.99% | -13.55% | -7.01% | -13.55% | -7.01% | -13.90% | -7.19% |
| BE | Antwerp | UK | Reading | 9 | RoRo | 11144477 | 31820.69 | -11.84% | -6.08% | -8.20% | -4.17% | -12.63% | -6.51% | -12.63% | -6.51% | -13.04% | -6.72% |
| BE | Antwerp | UK | Reading | 9 | RoPax-Large | 10146075 | 33372.972 | -2.02% | -1.01% | -2.00% | -1.00% | -2.87% | -1.44% | -2.87% | -1.44% | -2.96% | -1.49% |
| BE | Antwerp | UK | Reading | 0 | RoPax-Large | 22877192 | 65362.522 | -2.31% | -1.16% | -2.29% | -1.15% | -3.28% | -1.65% | -3.28% | -1.65% | -3.38% | -1.70% |
| BE | Brugge | UK | Reading | 9 | RoRo | 20889440 | 60017.601 | -5.45% | -2.75% | -5.35% | -2.70% | -7.49% | -3.81% | -7.49% | -3.81% | -7.64% | -3.88% |
| BE | Brugge | UK | Reading | 9 | RoPax-Small | 6584628 | 21290.395 | -1.28% | -0.64% | -1.24% | -0.62% | -1.78% | -0.89% | -1.78% | -0.89% | -1.79% | -0.90% |
| BE | Kortrijk | UK | Reading | 9 | RoRo | 16119798 | 45797.562 | -3.45% | -1.74% | -3.39% | -1.70% | -4.79% | -2.42% | -4.79% | -2.42% | -4.88% | -2.46% |
| BE | Kortrijk | UK | Reading | 9 | LoLo | 9620253 | 27458.524 | -1.55% | -0.78% | -1.51% | -0.76% | -2.16% | -1.08% | -2.16% | -1.08% | -2.18% | -1.09% |
| BE | Kortrijk | UK | Reading | 0 | RoRo | 17869916 | 40596.886 | -4.51% | -2.28% | -4.42% | -2.23% | -6.22% | -3.15% | -6.22% | -3.15% | -6.34% | -3.22% |
| BE | Kortrijk | UK | Reading | 9 | RoPax-Small | 6889448 | 21840.382 | -0.43% | -0.22% | -0.42% | -0.21% | -0.61% | -0.30% | -0.61% | -0.30% | -0.61% | -0.31% |
| BE | Antwerp | UK | Brighton | 9 | RoPax-Large | 16915410 | 60434.837 | -2.03% | -1.02% | -1.98% | -0.99% | -2.83% | -1.42% | -2.83% | -1.42% | -2.85% | -1.43% |
| BE | Antwerp | UK | Brighton | 8 | RoPax-Large | 18507517 | 18702.784 | -3.16% | -1.59% | -3.09% | -1.56% | -4.38% | -2.21% | -4.38% | -2.21% | -4.46% | -2.25% |
| BE | Kortrijk | UK | Brighton | 9 | RoRo | 17047756 | 48538.436 | -0.71% | -0.36% | -0.69% | -0.35% | -1.04% | -0.52% | -1.04% | -0.52% | -1.12% | -0.56% |

| | 2025 | | | | | Baseline | | Policy A | | Policy B | | Policy C | | Policy D | | Policy E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road |
| | Origin | | Destination | Com | ship type | tonkm | tonkm | % | % | % | % | % | % | % | % | % | % |
| FI | Helsinki | ES | Santiago de Compostela | 0 | LoLo | 266963188 | 776971657 | -12.00% | -2.34% | -11.88% | -2.32% | -16.15% | -3.28% | -16.15% | -3.28% | -16.54% | -3.37% |
| FI | Oulu | ES | Santander | 9 | LoLo | 211989802 | 164172163 | -11.70% | -2.54% | -11.59% | -2.51% | -15.81% | -3.54% | -15.81% | -3.54% | -16.19% | -3.63% |
| FI | Tampere | ES | Santander | 9 | LoLo | 103272009 | 81346916 | -9.46% | -1.94% | -9.37% | -1.92% | -12.92% | -2.71% | -12.92% | -2.71% | -13.24% | -2.79% |
| FI | Helsinki | ES | Santander | 9 | LoLo | 73612778 | 61513612 | -1.93% | -0.24% | -1.87% | -0.23% | -2.80% | -0.34% | -2.80% | -0.34% | -2.99% | -0.37% |
| FI | Helsinki | ES | Madrid | 9 | LoLo | 62379221 | 48530107 | -4.88% | -1.16% | -4.79% | -1.14% | -6.70% | -1.62% | -6.70% | -1.62% | -6.82% | -1.65% |
| FI | Helsinki | ES | Barcelona | 9 | LoLo | 87252398 | 43247987 | -3.11% | -0.80% | -3.02% | -0.78% | -4.49% | -1.17% | -4.49% | -1.17% | -4.79% | -1.25% |
| FI | Helsinki | ES | Barcelona | 9 | LoLo | 118940495 | 78657693 | -5.02% | -1.49% | -4.92% | -1.46% | -6.89% | -2.06% | -6.89% | -2.06% | -7.02% | -2.10% |
| FI | Helsinki | ES | Valencia | 9 | LoLo | 109575864 | 62927583 | -8.68% | -2.14% | -8.52% | -2.10% | -11.70% | -2.95% | -11.70% | -2.95% | -11.91% | -3.00% |
| FI | Helsinki | ES | Las Palmas | 9 | LoLo | ######### | 1.117E+09 | -7.51% | -1.29% | -7.37% | -1.26% | -10.16% | -1.78% | -10.16% | -1.78% | -10.34% | -1.81% |
| | | | | | | | | | | | | | | | | | |
| NO | Oslo | DK | Arhus | 9 | RoPax-Large | 20473832 | 28374.085 | -2.46% | -1.23% | -2.43% | -1.22% | -3.49% | -1.76% | -3.49% | -1.76% | -3.59% | -1.81% |
| NO | Fredrikstad | DK | Arhus | 9 | RoPax-Large | 7253978 | 9303.296 | -1.41% | -0.71% | -1.39% | -0.70% | -2.01% | -1.01% | -2.01% | -1.01% | -2.07% | -1.04% |
| NO | Fredrikstad | DK | Arhus | 8 | RoPax-Large | 74512855 | 14262.956 | -3.53% | -1.78% | -3.50% | -1.76% | -4.99% | -2.53% | -4.99% | -2.53% | -5.13% | -2.60% |
| NO | Fredrikstad | DK | Arhus | 6 | RoPax-Large | 93571128 | 264248.41 | -3.56% | -1.79% | -3.52% | -1.77% | -5.02% | -2.54% | -5.02% | -2.54% | -5.16% | -2.61% |
| NO | Stavanger | DK | Arhus | 9 | RoPax-Large | 12444799 | 18001.599 | -1.79% | -0.90% | -1.77% | -0.89% | -2.54% | -1.28% | -2.54% | -1.28% | -2.62% | -1.32% |
| NO | Stavanger | DK | Arhus | 6 | RoPax-Large | 20987606 | 66849.17 | -5.32% | -2.69% | -5.26% | -2.66% | -7.45% | -3.79% | -7.45% | -3.79% | -7.66% | -3.90% |
| NO | Bergen | DK | Arhus | 1 | RoRo | 362447653 | 140963126 | -3.42% | -0.99% | -3.39% | -0.98% | -4.82% | -1.41% | -4.82% | -1.41% | -4.96% | -1.45% |
| NO | Bergen | DK | Arhus | 6 | RoRo | 109844353 | 313251.44 | -8.12% | -4.13% | -8.04% | -4.09% | -11.25% | -5.77% | -11.25% | -5.77% | -11.55% | -5.93% |
| NO | Bergen | DK | Arhus | 0 | RoRo | 31699839 | 8148551 | -6.32% | -2.28% | -6.25% | -2.26% | -8.79% | -3.21% | -8.79% | -3.21% | -9.03% | -3.30% |
| | | | | | | | | | | | | | | | | | |
| FI | Helsinki | DK | Copenhagen | 9 | RoRo | 179654581 | 424998524 | -9.74% | -2.63% | -9.56% | -2.58% | -13.06% | -3.63% | -13.06% | -3.63% | -13.29% | -3.70% |
| FI | Oulu | DK | Copenhagen | 9 | LoLo | 23674784 | 50426465 | -4.82% | -0.56% | -4.69% | -0.54% | -6.58% | -0.78% | -6.58% | -0.78% | -6.64% | -0.79% |
| FI | Oulu | DK | Copenhagen | 0 | LoLo | 431545324 | 2.439E+09 | -6.15% | -0.46% | -5.99% | -0.45% | -8.33% | -0.64% | -8.33% | -0.64% | -8.41% | -0.65% |
| FI | Tampere | DK | Copenhagen | 9 | LoLo | 42238989 | 87109457 | -2.07% | -0.30% | -2.01% | -0.30% | -2.87% | -0.42% | -2.87% | -0.42% | -2.90% | -0.43% |
| FI | Tampere | DK | Copenhagen | 0 | LoLo | 36616705 | 221336539 | -6.06% | -0.42% | -5.90% | -0.41% | -8.21% | -0.59% | -8.21% | -0.59% | -8.29% | -0.60% |
| FI | Helsinki | DK | Copenhagen | 9 | RoRo | 38971391 | 92192382 | -3.98% | -0.31% | -3.87% | -0.30% | -5.45% | -0.43% | -5.45% | -0.43% | -5.50% | -0.43% |
| FI | Helsinki | DK | Copenhagen | 0 | RoRo | 48567608 | 304818537 | -5.82% | -0.21% | -5.66% | -0.20% | -7.88% | -0.29% | -7.88% | -0.29% | -7.96% | -0.29% |
| | | | | | | | | | | | | | | | | | |
| FI | Helsinki | SE | Stockholm | 9 | RoPax-Large | 15623751 | 44831434 | -6.27% | -0.62% | -6.16% | -0.61% | -8.52% | -0.87% | -8.52% | -0.87% | -8.67% | -0.89% |
| FI | Tampere | SE | Stockholm | 9 | RoRo | 11942950 | 41916990 | -3.82% | -1.35% | -3.75% | -1.33% | -5.27% | -1.89% | -5.27% | -1.89% | -5.37% | -1.93% |
| FI | Helsinki | SE | Stockholm | 9 | RoPax-Large | 11810453 | 27048957 | -8.39% | -1.68% | -8.24% | -1.64% | -11.30% | -2.33% | -11.30% | -2.33% | -11.50% | -2.37% |
| FI | Helsinki | SE | Stockholm | 5 | RoPax-Large | 138589629 | 1.028E+09 | -8.99% | -1.01% | -8.83% | -0.99% | -12.04% | -1.40% | -12.04% | -1.40% | -12.24% | -1.43% |
| FI | Helsinki | SE | Stockholm | 0 | RoPax-Small | 15670206 | 119293717 | -8.92% | -1.29% | -8.76% | -1.27% | -11.96% | -1.80% | -11.96% | -1.80% | -12.17% | -1.84% |
| FI | Helsinki | SE | Uppsala | 9 | RoPax-Large | 13749667 | 39622544 | -6.35% | -1.71% | -6.29% | -1.69% | -8.81% | -2.42% | -8.81% | -2.42% | -9.05% | -2.49% |
| FI | Helsinki | SE | Gavle | 9 | RoRo | 27650668 | 54956530 | -4.54% | -1.06% | -4.50% | -1.05% | -6.36% | -1.51% | -6.36% | -1.51% | -6.53% | -1.55% |

| | 2025 | | | | | Baseline | | Policy A | | Policy B | | Policy C | | Policy D | | Policy E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Origin | | Destination | Com | ship type | SSS tonkm | Road tonkm | SSS % | Road % | SSS % | Road % | SSS % | Road % | SSS % | Road % | SSS % | Road % |
| NO | Fredrikstad | DE | Bremen | 9 | LoLo | 11752084 | 2273824.6 | -3.82% | -1.41% | -3.78% | -1.39% | -5.38% | -1.99% | -5.38% | -1.99% | -5.53% | -2.05% |
| NO | Fredrikstad | DE | Hamburg | 9 | LoLo | 17835408 | 2500363.3 | -6.33% | -2.74% | -6.26% | -2.71% | -8.82% | -3.85% | -8.82% | -3.85% | -9.06% | -3.96% |
| NO | Fredrikstad | DE | Hamburg | 9 | LoLo | 29354213 | 3395985.5 | -8.08% | -3.36% | -7.93% | -3.30% | -10.98% | -4.62% | -10.98% | -4.62% | -11.18% | -4.71% |
| NO | Stavanger | DE | Hamburg | 6 | RoRo | 45323705 | 154558100 | -2.62% | -0.22% | -2.56% | -0.22% | -3.62% | -0.31% | -3.62% | -0.31% | -3.69% | -0.32% |
| NO | Stavanger | DE | Hamburg | 6 | RoRo | 66326511 | 198083318 | -1.46% | -0.18% | -1.43% | -0.18% | -2.04% | -0.25% | -2.04% | -0.25% | -2.08% | -0.26% |
| NO | Bergen | DE | Hamburg | 6 | LoLo | 170002785 | 327309203 | -6.32% | -0.37% | -6.16% | -0.36% | -8.55% | -0.52% | -8.55% | -0.52% | -8.63% | -0.52% |
| NO | Stavanger | DE | Lubeck | 6 | RoPax-Large | 30591058 | 146284695 | -0.67% | -0.06% | -0.65% | -0.05% | -0.93% | -0.08% | -0.93% | -0.08% | -0.95% | -0.08% |
| NO | Stavanger | DE | Oldenburg | 6 | RoPax-Large | 33220713 | 82986904 | -0.77% | -0.09% | -0.74% | -0.08% | -1.07% | -0.12% | -1.07% | -0.12% | -1.08% | -0.12% |
| NO | Bergen | DE | Oldenburg | 6 | LoLo | 85320219 | 223419512 | -4.17% | -0.26% | -4.06% | -0.25% | -5.71% | -0.36% | -5.71% | -0.36% | -5.76% | -0.36% |
| NO | Fredrikstad | DE | Kiel | 9 | RoPax-Large | 12870456 | 2006338.2 | -1.00% | -0.42% | -0.97% | -0.41% | -1.46% | -0.61% | -1.46% | -0.61% | -1.57% | -0.66% |
| NO | Stavanger | DE | Kiel | 6 | RoPax-Large | 103579122 | 266819089 | -0.87% | -0.13% | -0.85% | -0.12% | -1.21% | -0.17% | -1.21% | -0.17% | -1.23% | -0.18% |
| | | | | | | | | | | | | | | | | | |
| FI | Oulu | FR | Paris | 9 | LoLo | 76224655 | 141922530 | -4.50% | -0.68% | -4.42% | -0.67% | -6.18% | -0.95% | -6.18% | -0.95% | -6.30% | -0.96% |
| FI | Tampere | FR | Paris | 9 | LoLo | 72157790 | 122094205 | -4.43% | -0.88% | -4.35% | -0.86% | -6.09% | -1.23% | -6.09% | -1.23% | -6.21% | -1.25% |
| FI | Helsinki | FR | Paris | 9 | RoRo | 73088499 | 119105712 | -3.90% | -0.56% | -3.86% | -0.56% | -5.47% | -0.80% | -5.47% | -0.80% | -5.62% | -0.83% |
| FI | Helsinki | FR | Beauvais | 9 | RoRo | 64575610 | 110841822 | -6.41% | -1.07% | -6.34% | -1.06% | -8.87% | -1.51% | -8.87% | -1.51% | -9.11% | -1.56% |
| FI | Helsinki | FR | Orleans | 9 | RoRo | 147720542 | 271673776 | -5.39% | -0.95% | -5.33% | -0.94% | -7.50% | -1.35% | -7.50% | -1.35% | -7.71% | -1.39% |
| FI | Oulu | FR | Lille | 9 | LoLo | 287465078 | 434067328 | -5.86% | -0.84% | -5.75% | -0.83% | -7.99% | -1.17% | -7.99% | -1.17% | -8.14% | -1.19% |
| FI | Helsinki | FR | Lille | 9 | RoRo | 60192057 | 103503000 | -5.77% | -0.79% | -5.66% | -0.77% | -7.86% | -1.09% | -7.86% | -1.09% | -8.01% | -1.12% |
| FI | Oulu | FR | Strasbourg | 9 | LoLo | 130674545 | 222171227 | -5.66% | -0.99% | -5.60% | -0.98% | -7.87% | -1.40% | -7.87% | -1.40% | -8.08% | -1.44% |
| FI | Helsinki | FR | Strasbourg | 9 | RoRo | 68103969 | 103847750 | -2.55% | -0.50% | -2.48% | -0.48% | -3.52% | -0.69% | -3.52% | -0.69% | -3.56% | -0.70% |
| FI | Helsinki | FR | Poitiers | 0 | LoLo | 950177749 | 5.788E+09 | -1.77% | -0.12% | -1.72% | -0.11% | -2.45% | -0.16% | -2.45% | -0.16% | -2.48% | -0.17% |
| FI | Oulu | FR | Lyon | 9 | LoLo | 77210119 | 141542383 | -2.65% | -0.44% | -2.62% | -0.43% | -3.74% | -0.62% | -3.74% | -0.62% | -3.84% | -0.64% |
| FI | Helsinki | FR | Lyon | 9 | RoRo | 50788619 | 84831739 | -1.11% | -0.21% | -1.07% | -0.20% | -1.54% | -0.29% | -1.54% | -0.29% | -1.56% | -0.29% |
| | | | | | | | | | | | | | | | | | |
| SE | Stockholm | FI | Helsinki | 9 | RoPax-Large | 7911522 | 9519895.3 | -4.59% | -0.75% | -4.46% | -0.73% | -6.27% | -1.04% | -6.27% | -1.04% | -6.33% | -1.05% |
| SE | Umea | FI | Oulu | 6 | RoPax-Large | 54123447 | 86303220 | -9.78% | -1.82% | -9.61% | -1.79% | -13.08% | -2.52% | -13.08% | -2.52% | -13.31% | -2.57% |
| SE | Stockholm | FI | Tampere | 9 | RoPax-Large | 19862468 | 29233883 | -2.91% | -1.18% | -2.88% | -1.17% | -4.11% | -1.68% | -4.11% | -1.68% | -4.23% | -1.73% |
| SE | Stockholm | FI | Helsinki | 9 | RoPax-Large | 9794683 | 9406957.5 | -9.58% | -1.79% | -9.48% | -1.77% | -13.04% | -2.52% | -13.04% | -2.52% | -13.37% | -2.59% |
| SE | Stockholm | FI | Helsinki | 0 | RoPax-Large | 18433290 | 22694366 | -9.04% | -1.14% | -8.88% | -1.12% | -12.11% | -1.58% | -12.11% | -1.58% | -12.32% | -1.62% |
| SE | Stockholm | FI | Helsinki | 1 | RoPax-Large | 12521861 | 17718199 | -8.96% | -1.07% | -8.80% | -1.05% | -12.01% | -1.48% | -12.01% | -1.48% | -12.21% | -1.51% |
| | | | | | | | | | | | | | | | | | |
| FR | Rouen | IT | L'Aquila | 0 | RoPax-Large | 23649224 | 177451025 | -0.17% | -0.01% | -0.16% | -0.01% | -0.23% | -0.02% | -0.23% | -0.02% | -0.24% | -0.02% |
| FR | Rouen | IT | Bari | 0 | RoPax-Large | 48974551 | 85725265 | -0.62% | -0.15% | -0.61% | -0.15% | -0.89% | -0.22% | -0.89% | -0.22% | -0.91% | -0.23% |
| FR | Rouen | IT | Potenza | 0 | RoPax-Large | 242320202 | 365412878 | -0.43% | -0.11% | -0.42% | -0.11% | -0.61% | -0.16% | -0.61% | -0.16% | -0.62% | -0.16% |
| FR | Rouen | IT | Naples | 0 | RoPax-Large | 112035038 | 159059967 | -0.35% | -0.09% | -0.34% | -0.09% | -0.50% | -0.13% | -0.50% | -0.13% | -0.51% | -0.14% |
| FR | Rouen | IT | Firenze | 0 | RoPax-Large | 53287435 | 62989745 | -0.35% | -0.10% | -0.34% | -0.09% | -0.49% | -0.13% | -0.49% | -0.13% | -0.50% | -0.14% |
| FR | Marseilles | IT | Firenze | 0 | RoPax-Large | 40916590 | 31004557 | -3.18% | -0.68% | -3.15% | -0.67% | -4.48% | -0.97% | -4.48% | -0.97% | -4.61% | -0.99% |
| FR | Marseilles | IT | Firenze | 0 | RoPax-Large | 33190016 | 66498858 | -2.82% | -0.31% | -2.79% | -0.31% | -3.98% | -0.44% | -3.98% | -0.44% | -4.09% | -0.45% |
| FR | Rouen | IT | Trieste | 0 | RoPax-Large | 30274266 | 133194093 | -0.42% | -0.06% | -0.41% | -0.05% | -0.59% | -0.08% | -0.59% | -0.08% | -0.60% | -0.08% |
| FR | Rouen | IT | Genoa | 0 | RoRo | ######### | 844952955 | -1.08% | -0.34% | -1.06% | -0.34% | -1.51% | -0.48% | -1.51% | -0.48% | -1.54% | -0.49% |
| FR | Rouen | IT | Catanzaro | 0 | RoRo | 711070077 | 1.001E+09 | -0.49% | -0.11% | -0.48% | -0.10% | -0.68% | -0.15% | -0.68% | -0.15% | -0.69% | -0.15% |

| 2025 | | | | | | Baseline | | Policy A | | Policy B | | Policy C | | Policy D | | Policy E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road | SSS | Road |
| Origin | | Destination | | Com | ship type | tonkm | tonkm | % | % | % | % | % | % | % | % | % | % |
| SE | Stockholm | BE | Antwerp | 8 | LoLo | 119695624 | 556492134 | -5.23% | -0.08% | -5.09% | -0.08% | -7.10% | -0.11% | -7.10% | -0.11% | -7.17% | -0.11% |
| SE | Goteborg | BE | Antwerp | 9 | RoRo | 55044543 | 319462433 | -3.75% | -0.06% | -3.65% | -0.06% | -5.14% | -0.08% | -5.14% | -0.08% | -5.19% | -0.08% |
| SE | Goteborg | BE | Antwerp | 9 | RoRo | 39943613 | 231821051 | -4.92% | -0.14% | -4.78% | -0.14% | -6.69% | -0.20% | -6.69% | -0.20% | -6.76% | -0.20% |
| SE | Goteborg | BE | Brugge | 9 | LoLo | 16169684 | 110794980 | -3.00% | -0.05% | -2.91% | -0.05% | -4.12% | -0.07% | -4.12% | -0.07% | -4.17% | -0.07% |
| SE | Goteborg | BE | Kortrijk | 9 | LoLo | 16822215 | 112931993 | -2.19% | -0.05% | -3.15% | -0.07% | -4.07% | -0.09% | 0.06% | 0.00% | 0.04% | 0.00% |
| | | | | | | | | | | | | | | | | | |
| SE | Malmo | DE | Lubeck | 9 | RoRo | 23218453 | 187802947 | 0.00% | 0.00% | 0.05% | 0.00% | -0.61% | -0.02% | -1.67% | -0.06% | -1.69% | -0.07% |
| SE | Malmo | DE | Lubeck | 9 | RoPax-Large | 11577401 | 143577843 | 0.00% | 0.00% | 0.05% | 0.00% | -0.64% | -0.02% | -1.75% | -0.04% | -1.78% | -0.04% |
| SE | Goteborg | DE | Lubeck | 9 | RoRo | 19067176 | 93738576 | 0.00% | 0.00% | 0.04% | 0.00% | -0.52% | -0.03% | -1.42% | -0.09% | -1.44% | -0.09% |
| SE | Goteborg | DE | Lubeck | 9 | RoPax-Large | 12050288 | 62929005 | 0.00% | 0.00% | 0.04% | 0.00% | -0.49% | -0.02% | -1.34% | -0.05% | -1.36% | -0.05% |
| SE | Malmo | DE | Kiel | 9 | RoPax-Large | 6523408 | 34974509 | 0.00% | 0.00% | 0.19% | 0.01% | -2.20% | -0.13% | -5.78% | -0.35% | -5.86% | -0.36% |
| SE | Malmo | DE | Kiel | 9 | RoRo | 14681289 | 34345888 | 0.00% | 0.00% | 0.05% | 0.01% | -0.65% | -0.06% | -1.77% | -0.17% | -1.80% | -0.17% |
| SE | Goteborg | DE | Kiel | 9 | RoPax-Large | 39468655 | 189592653 | 0.00% | 0.00% | 0.12% | 0.00% | -1.47% | -0.02% | -3.92% | -0.06% | -3.97% | -0.06% |
| SE | Goteborg | DE | Kiel | 9 | RoRo | 27862388 | 142360558 | 0.00% | 0.00% | 0.05% | 0.00% | -0.59% | -0.04% | -1.61% | -0.10% | -1.63% | -0.10% |
| | | | | | | | | | | | | | | | | | |
| DK | Arhus | NO | Oslo | 9 | RoPax-Large | 4565462 | 7871639.7 | -1.38% | -0.23% | -1.34% | -0.22% | -1.92% | -0.32% | -1.92% | -0.32% | -1.94% | -0.33% |
| DK | Arhus | NO | Fredrikstad | 9 | RoRo | 6435852 | 7396296.6 | -1.16% | -0.28% | -1.14% | -0.27% | -1.62% | -0.39% | -1.62% | -0.39% | -1.66% | -0.40% |
| DK | Arhus | NO | Fredrikstad | 0 | RoRo | 12928972 | 31000646 | -0.37% | -0.05% | -0.54% | -0.08% | -0.70% | -0.10% | -0.70% | -0.10% | -0.71% | -0.10% |
| DK | Arhus | NO | Stavanger | 9 | RoRo | 7805632 | 11624828 | -0.76% | -0.18% | -0.74% | -0.17% | -1.06% | -0.25% | -1.06% | -0.25% | -1.08% | -0.25% |
| DK | Arhus | NO | Bergen | 9 | RoRo | 93185291 | 71232072 | -3.25% | -0.76% | -3.19% | -0.75% | -4.50% | -1.06% | -4.50% | -1.06% | -4.59% | -1.08% |
| DK | Arhus | NO | Bergen | 1 | RoRo | 36740450 | 21206037 | -5.33% | -1.40% | -5.28% | -1.38% | -7.44% | -1.98% | -7.44% | -1.98% | -7.65% | -2.03% |
| DK | Arhus | NO | Trondheim | 0 | RoRo | 447226585 | 632039079 | -4.11% | -0.42% | -4.06% | -0.41% | -5.75% | -0.59% | -5.75% | -0.59% | -5.91% | -0.61% |
| | | | | | | | | | | | | | | | | | |
| NO | Fredrikstad | BE | Antwerp | 9 | LoLo | 51607015 | 0 | -9.03% | 0.00% | -8.94% | 0.00% | -12.46% | 0.00% | -12.46% | 0.00% | -12.79% | 0.00% |
| NO | Stavanger | BE | Antwerp | 9 | RoRo | 15966906 | 0 | -4.70% | 0.00% | -4.65% | 0.00% | -6.61% | 0.00% | -6.61% | 0.00% | -6.79% | 0.00% |
| NO | Fredrikstad | BE | Brugge | 9 | LoLo | 73172513 | 0 | -5.98% | 0.00% | -5.92% | 0.00% | -8.36% | 0.00% | -8.36% | 0.00% | -8.59% | 0.00% |
| NO | Fredrikstad | BE | Brussels | 9 | LoLo | 26069649 | 0 | -12.06% | 0.00% | -11.94% | 0.00% | -16.43% | 0.00% | -16.43% | 0.00% | -16.84% | 0.00% |
| | | | | | | | | | | | | | | | | | |
| NO | Fredrikstad | UK | Reading | 9 | LoLo | 232596418 | 7909024.2 | -7.80% | -3.80% | -7.73% | -3.77% | -9.91% | -4.86% | -9.91% | -4.86% | -10.20% | -5.01% |
| NO | Oslo | UK | Edinburgh | 9 | LoLo | 29024744 | 1074207.1 | -15.54% | -7.36% | -15.40% | -7.29% | -20.85% | -10.06% | -20.85% | -10.06% | -21.34% | -10.31% |
| NO | Fredrikstad | UK | Edinburgh | 9 | LoLo | 53969450 | 2641717 | -17.24% | -8.61% | -17.08% | -8.53% | -22.97% | -11.69% | -22.97% | -11.69% | -23.50% | -11.98% |
| NO | Stavanger | UK | Edinburgh | 9 | RoRo | 14918786 | 1023142.1 | -6.33% | -2.94% | -6.27% | -2.91% | -8.83% | -4.13% | -8.83% | -4.13% | -9.07% | -4.25% |
| NO | Trondheim | UK | Edinburgh | 9 | LoLo | 44114433 | 1423655.5 | -11.83% | -5.35% | -11.72% | -5.29% | -16.11% | -7.39% | -16.11% | -7.39% | -16.52% | -7.59% |
| NO | Fredrikstad | UK | Belfast | 9 | LoLo | 48243777 | 1606107.4 | -8.89% | -4.13% | -8.80% | -4.08% | -12.26% | -5.75% | -12.26% | -5.75% | -12.58% | -5.91% |

# Annex 4: effect on emissions

**Table 88: Total emissions (tons) for the SSS alternative**

| | | SSS alternative | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SSS | | | | | | Road | | | | | |
| Ton emissions | | **baseline** | policy A | policy B | policy C | policy D | policy E | **baseline** | policy A | policy B | policy C | policy D | policy E |
| VOS | 2010 | 277 | 277 | 277 | 277 | 277 | 277 | 39 | 39 | 39 | 39 | 39 | 39 |
| | 2015 | 285 | 216 | 216 | 216 | 216 | 216 | 27 | 26 | 26 | 26 | 26 | 26 |
| | 2020 | 286 | 210 | 210 | 206 | 206 | 206 | 8 | 8 | 8 | 8 | 8 | 8 |
| | 2025 | 292 | 209 | 209 | 205 | 205 | 205 | 5 | 5 | 5 | 5 | 5 | 5 |
| CO2 | 2010 | 274777 | 274777 | 274777 | 274777 | 274777 | 274777 | 187951 | 187951 | 187951 | 187951 | 187951 | 187951 |
| | 2015 | 323802 | 303767 | 304091 | 304091 | 303994 | 304001 | 203919 | 198267 | 198352 | 198352 | 198328 | 198352 |
| | 2020 | 352094 | 329861 | 330210 | 322127 | 322028 | 321727 | 202637 | 196942 | 197025 | 194944 | 194921 | 194839 |
| | 2025 | 377798 | 355562 | 355940 | 347267 | 347212 | 346567 | 208756 | 203296 | 203382 | 201253 | 201241 | 201074 |
| Nox | 2010 | 6574 | 6574 | 6574 | 6574 | 6574 | 6574 | 1638 | 1638 | 1638 | 1638 | 1638 | 1638 |
| | 2015 | 7101 | 5689 | 5694 | 5694 | 5694 | 5330 | 1441 | 1401 | 1401 | 1401 | 1401 | 1401 |
| | 2020 | 7269 | 5817 | 5823 | 5696 | 5695 | 4309 | 1034 | 1005 | 1005 | 994 | 994 | 994 |
| | 2025 | 7474 | 6002 | 6008 | 5877 | 5877 | 3560 | 633 | 616 | 616 | 610 | 610 | 609 |
| SO2 | 2010 | 2442 | 2442 | 2442 | 2442 | 2442 | 2442 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2015 | 2815 | 195 | 195 | 195 | 195 | 195 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2020 | 3031 | 211 | 212 | 206 | 206 | 206 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2025 | 3227 | 228 | 228 | 222 | 222 | 222 | 1 | 1 | 1 | 1 | 1 | 1 |
| PM | 2010 | 426 | 426 | 426 | 426 | 426 | 426 | 38 | 38 | 38 | 38 | 38 | 38 |
| | 2015 | 485 | 218 | 219 | 219 | 219 | 219 | 32 | 31 | 31 | 31 | 31 | 31 |
| | 2020 | 516 | 231 | 231 | 226 | 226 | 226 | 21 | 20 | 20 | 20 | 20 | 20 |
| | 2025 | 547 | 245 | 245 | 240 | 240 | 240 | 21 | 20 | 20 | 20 | 20 | 20 |

**Table 89: Total emissions (tons) for the road alternative**

| | | Road alternative | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SSS | | | | | | Road | | | | | | Rail | | | | | |
| Ton emissions | | **baseline** | policy A | policy B | policy C | policy D | policy E | **baseline** | policy A | policy B | policy C | policy D | policy E | **baseline** | policy A | policy B | policy C | policy D | policy E |
| VOS | 2010 | 36 | 36 | 36 | 36 | 36 | 36 | 374 | 374 | 374 | 374 | 374 | 374 | 2 | 2 | 2 | 2 | 2 | 2 |
| | 2015 | 37 | 30 | 30 | 30 | 30 | 30 | 258 | 256 | 257 | 257 | 256 | 257 | 3 | 3 | 3 | 3 | 3 | 3 |
| | 2020 | 38 | 30 | 30 | 30 | 30 | 30 | 82 | 81 | 81 | 81 | 81 | 81 | 3 | 3 | 3 | 3 | 3 | 3 |
| | 2025 | 39 | 31 | 31 | 31 | 31 | 31 | 52 | 51 | 51 | 51 | 51 | 51 | 3 | 3 | 3 | 3 | 3 | 3 |
| CO2 | 2010 | 35235 | 35235 | 35235 | 35235 | 35235 | 35235 | 1812596 | 1812596 | 1812596 | 1812596 | 1812596 | 1812596 | 1676 | 1676 | 1676 | 1676 | 1676 | 1676 |
| | 2015 | 41521 | 41182 | 41190 | 41190 | 41190 | 41190 | 1966590 | 1956249 | 1956421 | 1956421 | 1956380 | 1956421 | 1962 | 1954 | 1954 | 1954 | 1954 | 1954 |
| | 2020 | 45149 | 44776 | 44784 | 44599 | 44599 | 44592 | 1954223 | 1943847 | 1944014 | 1940001 | 1939965 | 1939813 | 2091 | 2082 | 2082 | 2079 | 2079 | 2079 |
| | 2025 | 48445 | 48082 | 48091 | 47896 | 47896 | 47881 | 2013239 | 2003333 | 2003506 | 1999425 | 1999406 | 1999097 | 2258 | 2250 | 2250 | 2246 | 2246 | 2246 |
| Nox | 2010 | 844 | 844 | 844 | 844 | 844 | 844 | 15799 | 15799 | 15799 | 15799 | 15799 | 15799 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2015 | 925 | 735 | 735 | 735 | 735 | 744 | 13893 | 13820 | 13821 | 13821 | 13821 | 13821 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2020 | 959 | 740 | 740 | 738 | 738 | 613 | 9968 | 9915 | 9916 | 9896 | 9895 | 9895 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2025 | 1002 | 752 | 753 | 751 | 751 | 522 | 6101 | 6071 | 6072 | 6059 | 6059 | 6058 | 1 | 1 | 1 | 1 | 1 | 1 |
| SO2 | 2010 | 589 | 313 | 313 | 313 | 313 | 313 | 12 | 12 | 12 | 12 | 12 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2015 | 694 | 26 | 26 | 26 | 26 | 26 | 13 | 12 | 12 | 12 | 12 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2020 | 755 | 29 | 29 | 29 | 29 | 29 | 12 | 12 | 12 | 12 | 12 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2025 | 810 | 31 | 31 | 31 | 31 | 31 | 13 | 13 | 13 | 13 | 13 | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| PM | 2010 | 55 | 55 | 55 | 55 | 55 | 55 | 366 | 366 | 366 | 366 | 366 | 366 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2015 | 64 | 29 | 29 | 29 | 29 | 29 | 309 | 307 | 307 | 307 | 307 | 307 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2020 | 69 | 30 | 30 | 30 | 30 | 30 | 203 | 202 | 202 | 202 | 202 | 201 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 2025 | 74 | 31 | 31 | 31 | 31 | 31 | 200 | 199 | 199 | 198 | 198 | 198 | 1 | 1 | 1 | 1 | 1 | 1 |