REPORT

Greenhouse Gas Emissions Trading for the Transport Sector

Kristina Holmgren, Mohammed Belhaj, Jenny Gode, Erik Särnholm, Lars Zetterberg & Markus Åhman

Project Leader: Lars Zetterberg

December 2006
B1703

This report approved
2006-12-01

Peringe Grennfelt
Scientific Director

Swedish Environmental Research Institute

Organization	Report Summary
IVL Swedish Environmental Research Institute Ltd.	**Project title** Transports and Emissions Trading
Address P.O. Box 210 60 SE-100 31 Stockholm	**Project sponsor** This project was financed by: The Swedish Environmental Protection Agency, The Swedish Energy Agency, The Swedish Maritime Administration and The Swedish Aviation Society
Telephone +46 (0)8-598 563 00	

Author

Kristina Holmgren, Mohammed Belhaj, Jenny Gode, Erik Särnholm, Lars Zetterberg & Markus Åhman

Title and subtitle of the report

Greenhouse Gas Emissions Trading for the Transport sector

Summary

See summary in report.

Keyword

Emissions trading, transport sector, road transport, aviation, maritime shipping

Bibliographic data

IVL Report B1703

The report can be ordered via

Homepage: www.ivl.se, e-mail: publicationservice@ivl.se, fax+46 (0)8-598 563 90, or via IVL, P.O. Box 21060, SE-100 31 Stockholm Sweden

Acknowledgements

We would like to thank the financers of this project; the Swedish Environmental Protection Agency, the Swedish Maritime Administration, the Swedish Energy Agency and The Swedish Aviation Society.

We would also like to thank all the participants in the reference group, i.e. Mark Storey, Larsolov Olsson, Ingvar Jundén, David Mjureke and Eva Jernbacker at the Swedish Environmental Protection Agency, Karin Sahlin, Mathias Normand and Åsa Skillius at the Swedish Energy Agency, Stefan Grudemo and Håkan Johansson at the Swedish Road Administration, Gunnar Eriksson, Stefan Lemieszewski and Reidar Grundström at the Swedish Maritime Administration and Peeter Puusepp at The Swedish Aviation Society, for their engagement in the project and their interesting discussions and helpful comments.

We would also like to thank the following persons for their participation in the interviews: Bertil Arvidsson, Sweship, Birgitta Resvik, Confederation of Swedish Enterprise, (CSE), Lars-Erik Axelsson and Staffan Thonfors, Swedish Forest Industries Federation (SFIF), Kalle Keldusild and Jenny Ryman, Swedish Civil Aviation Authority, (SCAA) and Magnus Nilsson, the Swedish Society for Nature Conservation, (SNF).

Executive summary

In this study we have analysed different options to apply emissions trading for greenhouse gas emissions to the transport sector. The main focus has been on the EU transport sector and the possibility to include it in the current EU ETS in the trading period beginning in 2013. The purpose was to study how different alternatives will affect different actors. Focus has been on three sub sectors; road transport, aviation and shipping. The railway sector has only been treated on a general level. The study includes the following three parts:

1. An economic analysis of the consequences of greenhouse gas emissions trading for the transport sector including an analysis of how the total cost for reaching an emission target will be affected by an integrated emissions trading system for the transport sector and the industry (currently included sectors) compared to separate systems for the sectors,
2. An analysis of design possibilities for the different sub-sectors. Discussion of positive and negative aspects with different choices of design parameters, such as trading entity, covered greenhouse gases[1], allocation of emission allowances and monitoring systems,
3. Examination of the acceptance among different actors for different options of using greenhouse gas emissions trading in the transport sector.

Designing emissions trading for the transport sector

When setting up an emissions trading scheme there are a number of design parameters that have to be analysed in order to find an appropriate system, with limited administrative and transaction costs and as small distortions as possible to competitiveness. Table A shows the design parameters that have been addressed in this report.

Table A. Design parameters studied.

Design parameter	Comment
Coverage of greenhouse gases[1]	CO_2 only, other greenhouse gases or emissions with direct or indirect. impact on the radiative balance.
Sectoral/ geographical scope	Entire transport sector or only part? National, European or global?
Interaction with Kyoto[2]	Mainly an issue for the aviation and shipping sectors since the inter-national bunker fuels are not included in the Kyoto commitments.
Trading entity	Who should be obliged to surrender emission allowances?
Monitoring and reporting	How should emissions be monitored and reported?
Allocation	Distribution of emissions allowances at the start of the trading scheme
Type of trading scheme	Baseline & Credit or Cap & Trade?

[1] For aviation there is also a discussion concerning the emissions of other substances with direct or indirect impact on the radiative balance

[2] By interaction with Kyoto we mean interaction with the future climate policy framework. In this study focus has been on the period following the Kyoto commitment, i.e. after 2012, and we do not know what kind of international agreement that will be in place by then. We have assumed that there will either remain similar problems for international bunker fuels as currently in the Kyoto regime or they will be included in the new regime. The latter would mean that this design parameter would be trivial.

Effectiveness of various emissions trading schemes for the transport sector and distribution of costs

Graphical analyses were made of various options of separate or integrated ETS systems for reaching emission reduction targets in the transport and industry sectors and what the consequences will be on allowance price, total costs and the distribution of these costs on the different actors. These analyses were based on abatement costs for different reduction levels, expressed as marginal abatement costs curves (MAC-curves). We assumed that the abatement costs for transportation are considerably higher than for industry. These assumptions have for small reduction levels been supported by data on abatement costs in these sectors but there is a considerable need for better data on abatement costs based on actual observations.

In our study we have chosen to start with a case (reference case) in which we assume that the transport and present ETS sectors should reduce their emissions by 10%. Within the ETS sectors reductions are assumed to be met by reducing the cap (total number of issued allowances) while reductions within the transport sector are achieved by increased taxation. Seven cases for separate or integrated ETS systems were investigated. In all of the cases except one (case 6), emissions trading replaces carbon taxation in the included sectors:

1. Reference case. The transport sector is not included in the EU ETS but the CO_2 tax is strengthened. The emission reduction is 10% in both sectors
2. Separate systems. Emissions trading is applied for both industry and the transport sector but no trade is permitted between sectors (no linkage). The emission reduction is 10% in both sectors. Allowances corresponding to 90% of historic(2008-12)[3] emissions are auctioned
3. Integrated system. The industry and transport sectors are included in a common emissions trading scheme. The total emission reduction for both sectors is 10%. Allowances corresponding to 90% of historic emissions are auctioned.
4. Integrated system. Same as case 3 but allowances corresponding to 90% of historic emissions are issued free of charge to the industry sector.
5. Integrated system for industry and part of transport sector. Only a small part of the transport sector is included in the emissions trading system
6. Hybrid system. The industry and transport sectors are included in the same emissions trading scheme but the for the transport sector there is also a CO_2 tax
7. Integrated system. Same as case 3 but the MAC-curve for the transport sector is assumed to be 50% lower than the level assumed in the other cases.

General conclusions on integration of the transport sector in an ETS (case 3 compared to the reference case)

If the transport sector is fully integrated into a common ETS with industry, as opposed to having two separate systems, and assuming that abatement costs are higher for transports than for industry, we conclude that:

- **Allowance price in the ETS will increase; the cost of carbon emissions in the transport sector will decrease.** Allowance price will increase, due to the transport sector buying allowances from industry thus increasing the demand for allowances. For

[3] Our analyses focus on the period 2013 and forward and hence the emissions for the period 2008-2012 will be historic emissions.

transportation, however, the price on allowances will be considerably lower than the tax level necessary to achieve the 10% reduction in the reference case[4].

- **Impacts on industry may be significant**. In the industry sector, regardless of allocation, the marginal operating costs, including the shadow price on allowances will increase. Price on electricity will increase in liberalised markets and for some industries this will constitute a double impact (higher price on allowances and on electricity). Production in carbon emitting industries will decrease and the EU may experience structural impacts such as closures and relocation of industry to countries outside the EU (carbon leakage). On the other hand, with a higher price on allowances, new carbon efficient technologies that previously have not been economically viable, such as certain renewable energy technologies may become profitable and may experience a market breakthrough.
- **There will be significant changes in the distribution of emissions between sectors.** In an emissions trading system reductions will take place where they have the lowest cost. Assuming that marginal abatement is cheaper in the industry sector, this sector will perform a larger amount of abatement than in the reference case and emissions in this sector will decrease. In the transport sector, emissions reductions will be smaller than in the reference case. The emissions in the transport sector may even increase above the projected emission level in 2008-12. Total CO_2 emissions will remain unchanged, since this is a prerequisite for the study.
- **Impacts on the transport sector may be significant.** In the transport sector, with a significantly lower price on carbon emissions, fuels will become cheaper and marginal operation costs will decrease considerably. Ongoing carbon reduction programmes with relatively high abatement costs, such as low carbon fuel chains and CO_2- efficient vehicles, may become unprofitable. Transportation will increase considerably compared to the reference case.
- **There will be significant changes in the distribution of costs.** Compliance costs will increase significantly within the industry sector, mainly due to the higher price on allowances. Compliance costs for the transport sector will decrease considerably, which is mainly due to the sector being able to buy allowances at a much lower price than the corresponding tax in the reference case.
- **Total costs for compliance will decrease, if structural changes in the different sectors are not accounted for**. For emissions trading systems in general, increasing the number of installations, sectors and gases will increase the number of available emission reduction options and hence decrease the total costs for achieving a given carbon emission target. We estimate with less certainty that integrating transportation in the EU ETS is likely to decrease the total costs for compliance, if structural effects are not accounted for. This is due to the differences in abatement costs between the sectors. Abatements that in the reference case were performed in the transport sector will instead be performed in the industry sector where abatement is cheaper. Structural changes, which are not accounted for in this study, may include production changes, closures and relocation in the industry sector to countries outside the EU (carbon leakage).
- **The pressure on sectors outside the ETS will be lower.** In the case of a future climate regime where nations will have quantitative emission reduction targets (like in the Kyoto Protocol) it may become easier for sectors outside the trading system to fulfil their

[4] The reference case is explained in detail in chapter 4, and corresponds to a system where the transport sector is regulated by taxation and industry by emissions trading. The same reduction targets for CO_2 emissions are set for both sectors.

emission targets since they will no longer compete with the growing transport sector for the available emission volumes in the non trading sector.

- **There exist other considerations than to lower total CO_2 emissions.** Transportation is also responsible for other environmental impacts that today are, at least partly, controlled through fuel and CO_2 taxes. But apart from that, safeguarding a certain balance between industry and transportation may be an objective in itself. If so, it may be motivated to protect the industry and to constrain the growth of transportation, even if this may lead to higher total CO_2 compliance costs. If the tax instrument is removed from the transport sector it may become more difficult to control this sector specifically.
- **The difficulty to assess dynamic and structural effects makes full integration a high risk alternative.** Compared to the reference scenario, an ETS, where transportation is fully integrated with industry, will lead to considerable changes in where abatement takes place and where costs are taken. Assessing the impact of such changes is a challenging task, and the total consequences for society are difficult to foresee. Thus a full integration carries high risks.
- **With free allocation to industry the distributional impacts on industry are reduced.** Free allocation to industry will significantly decrease the total costs for this sector compared to if auctioning is applied. If 90 % of the allowances to industry are issued at no cost (as in case 4), industry will be able to sell allowances to the transport sector and these revenues will be important. If 100% of the allowances are issued at no cost to industry, the revenues from sold allowances will be higher than the total abatement costs for industry (since abatement costs for industry are always lower than the allowance price). Free allocation is therefore a powerful means for lowering the distributional impacts on industry if transport is included in the ETS.
- **Dynamic impacts on industry will still exist with free allocation.** Free allocation will provide large revenues to industry. However, the impacts on industry due to a higher allowance price are unchanged, including higher marginal production costs, decreased output, altered investments and closures of installations. The discussion of dynamical impacts on industry and transportation (as described in case 3), remain relevant. In the transport sector we expect lower fuel prices, increased transportation, increased emissions and that several current and planned CO_2-reduction programmes become unprofitable.
- **The sizes of the sectors are important (comparing case 5 and the reference case).** Linking a minor part (10%) of the transport sector to the ETS, for instance aviation, shipping or goods transports, will have a certain impact on allowance price compared to the reference case. However, this impact will be significantly lower than if the whole transport sector is linked. Emissions from industry will decrease somewhat, while emissions from the included part of the transport sector will increase significantly, even more than in a fully integrated system. Total compliance costs will increase somewhat for industry and decrease dramatically for the part of the transport sector included in the ETS.
- **A hybrid system may moderate the impacts on allowance prices and cost distribution (comparing case 6 and the reference case).** In a hybrid system, where the transport sector is fully integrated with the EU ETS but with the tax level sustained within the transport sector the impacts on allowance price and cost distribution can be moderated as compared to if the tax is removed. Total costs for compliance, allowance price, emissions and distribution of costs will lie in between the cases with separate systems and a fully integrated system.

Uncertainties in abatement costs may have an impact on our conclusions. Our analysis is strongly dependent on the assumption that marginal abatement costs are considerably higher in the transport sector than in the industry sector. For reasonably low levels of abatement, we have been able to support this assumption through data on abatement costs and by comparing the current tax levels on industry and transportation. We have also investigated the consequences on our results if the transport sectors´ marginal abatement costs are 50% lower than assumed in our other cases, but still a factor 2.5 higher than in industry. In an integrated system this would reduce the impact on allowance price and costs for industry. However, compared to our reference case with separated systems the impacts would still be significant and our earlier conclusions would remain valid. If abatement costs at high abatement levels are higher in industry than in transportation, this may influence our conclusions. The uncertainties in abatement costs and in structural effects lead to uncertainties in fully assessing the impacts. These uncertainties in impacts may be seen as an argument per se against integrating the whole transport sector into the EU ETS.

Effectiveness and costs of alternative architectures – integrated emissions trading schemes

Based on the results from our seven cases, we have analysed the effectiveness and costs of six integrated emissions trading schemes (architectures) with different sectoral coverage of the transport and industry sectors. The results are summarised in Table B. The assessment is done in relation to the reference case (case 1) where each of the four sectors (industry, road transport, aviation and shipping) is subject to a 10% reduction target compared to emissions 2008-12 and that these reductions should be realised within the sector, i.e. no trading between sectors is allowed. We have described how these architectures meet five criteria; effectiveness, distribution of costs and emissions, impacts on carbon price/dynamic effects, level playing field/competitiveness and administration costs. The first four criteria are based on the analysis in chapter 4, while comments on practical, legal and political issues are drawn from the sector specific chapters 5-7.

We draw the following conclusions on the different architectures:

- Architecture 1 (Industry and all transport) and architecture 2 (Industry and road transport) will lead to significant impacts on carbon price and on the distribution of costs and emissions. We estimate that total compliance costs will decrease if dynamic effects are not accounted for. These dynamic effects could include production changes and closures. A hybrid system, where the transport sector also pays carbon tax, may offer a compromise. This would lead to lower impacts on carbon price and on the re-distribution of costs and emissions. But with a hybrid system we would also lose some of the gains in effectiveness.
- Architecture 3, with industry, aviation and shipping in an integrated ETS, offers increased effectiveness combined with a relatively low impact on allowance price and therefore moderate cost increases for industry, while administrative costs are kept reasonably low. We also expect moderate redistributions of costs and emissions, which may facilitate implementation. Since aviation and shipping are not paying a carbon tax today, this is a strong reason for including them, whereas we do not recommend that road transport is integrated in the EU ETS before potential dynamic effects of such a scheme are better analysed. An important note is that inclusion of shipping seems to require participation on a voluntary basis.

Table B Implications of different architectures of integrated emissions trading schemes. Reference: Separate policies - all with 10% reduction targets.

Architecture	Effectiveness	Distribution of costs and emissions between sectors	Carbon price / dynamical impacts	Level playing field / competitiveness[5]	Administrative costs
No 1. Industry +road+ shipping+ aviation	High	Large impact on distribution: Industry: large increase in costs, unless free allocation Road, SA: large decrease in costs, significant increase in emissions	Large impact: Industry: large increase in carbon price Road: large decrease in carbon price SA: large decrease in carbon price	High	Medium[6]
No 2 Industry + Road	High	Large impact on distribution: Industry: large increase in costs, unless free allocation Road: large decrease of costs, significant increase in emissions	Large impact: Industry: large increase in carbon price Road: large decrease in carbon price	Medium	Medium[6]
No 3 Industry + shipping +aviation	Medium	Medium impact on distribution: Industry: some increase in costs SA: Large decrease in costs, significant increase in emissions	Medium impact: Industry: moderate increase SA: large decrease in carbon price	Medium	Low
No 4 Industry + goods transport	Medium	Moderate impact on distribution: Industry: moderate increase on costs, unless free allocation Road, SA: significant decrease of costs and increase of emissions	Medium impact Industry: moderate increase in carbon price Road, SA: large decrease in carbon price	High	Medium/Low
No 5 Road +shipping + aviation	Low	Medium impact on distribution: Road: moderate impact on costs and emissions SA: Uncertain. Impacts can be significant Possible decrease in costs and increase in emissions depending on MAC	Medium impact: Road: Moderate impact SA: Uncertain. Possible decrease in carbon price, depending on MAC	Medium	Medium[6]
No 6 Shipping +aviation	Low	Impact depends on MAC in shipping and aviation.	Impact depends on relative MAC in shipping and aviation.	Medium	Low

Road; Road transport sector, Shipping; shipping sector, Aviation; aviation sector; Industry; industry sector.
SA: Shipping and aviation sectors.

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[5] Level playing field/competitiveness is a measure of to what extent sectors with similar products face equal carbon costs.
[6] Assuming an upstream approach on trading entity in the road sector.

- Architecture 4 (industry and goods transportation) offers increased effectiveness combined with relatively low impact on allowance price, and therefore moderate cost increases for industry. There are a number of challenges associated with this architecture: Separating goods transportation from transportation of passengers in the aviation sector would only result in a small part of the emissions[7] being separated and it would not result in any restrictions or reductions in the growth of passenger air transport. Secondly, separating goods from transportation of passengers in the road transport sector is difficult to combine with an upstream approach to trading entities, which we recommend. Third, road transportation today pays a considerably higher carbon cost than industry, aviation and shipping. Integrating road transport of goods with industry, aviation and shipping would probably require that road transportation keeps the fuel tax in order to avoid large increases in the carbon price. Such a hybrid system would increase the complexity of the system.
- Architecture 5 (road, shipping and aviation) offers low gains in effectiveness. Moreover, there is a risk for large impacts on allowance price and compliance costs in the aviation and shipping sectors.
- Architecture 6 (shipping and aviation in common scheme) offers small gains in effectiveness since the linked sectors are relatively small. Moreover, it is difficult to assess the impacts of an integration since there are great uncertainties in the estimated abatement costs for aviation relative shipping.

Design parameters for the different transport sub sectors

There are several things that are different for non-stationary entities compared to the currently covered sectors of stationary installations that need to be considered when designing ETS for them. This applies for the entire transport sector. The "installations" might be operating in several countries and the monitoring process will be different since the sources are moving. However, the different characteristics of the transport sector and the current system and the possible need of a different design of the systems do not restrict the possibility of trading the same allowances.

Road transports

In the road transport sector 97% of the direct greenhouse gas emissions are CO_2. The geographical scope for an emissions trading scheme in road transport sector could be the EU, since all emissions in this sector are included in the current regime and emissions are attributed to the country where fuel is bought and hence the geographical boundaries are easy to set.

Since a downstream approach tends to include an immense number of actors the most practical solution for the road transport sector is an upstream choice of trading entity. However, a downstream approach provides clearer incentives for emitters to reduce emissions. We investigate the possibility of choosing either of the following actors as trading entity; vehicle owners, drivers, transportation buyers, filling stations, fuel suppliers, refineries or car manufacturers. If the aim of introducing the ETS is to create a single price on CO_2 emissions and to reduce the total cost of reaching an emissions target, the best choice of trading entity for the road transport sector is fuel suppliers. This is compatible with a cap & trade system. If one would like to introduce stronger incentives of developing fuel efficient cars or cars that use alternative fuels we recommend that car manufacturers are included in a baseline & credit system. In the latter case the fuel tax should be kept. For other purposes there might be other optimal choices of trading entities.

Since the road transport sector currently pays fuel taxes and a trading scheme would either replace or complement the tax, auctioning is the best choice of allocation method.

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[7] Approximately 80% of all European air traffic is due to tourism. The remaining 20% is a mixture of business travel and freight. (European Union Committee Publications, 2006).

Aviation

The total climate impact of emissions from aviation is uncertain but is significantly higher (approximately 2 times higher) than the impact by CO_2 emissions alone. Important emissions are NO_x, SO_2, soot (particles) and water vapour.

Emissions from international aviation are not included in the Kyoto commitments. This increases the difficulties of including aviation in a system with other sectors. In this study focus is on the period following 2013. If international climate agreements include the entire aviation sector (also bunker fuels) then this sector could be included in an ETS without restrictions to trade with other sectors. If the future climate policy framework do not include the emissions from international aviation we see a gateway solution, where the aviation sector is not allowed to sell more allowances to other sectors than already bought from other sectors, as the best solution.

A cap & trade scheme is the preferred option for the aviation sector since the emissions then could be controlled and known from the beginning of the scheme. In order to include as much as possible of the emissions we recommend a geographical scope of all flights departing from and arriving at European airports. Trading entity should be aircraft operators and since costs for allowances are assumed to be passed on to costumers we suggest auctioning of allowances. Monitoring and reporting could be based on fuel consumption which already today is reported by operators.

Maritime shipping

CO_2 accounts for 99% of the direct greenhouse gas emissions from the shipping sector. There are also important indirect climate effects due to emissions of NO_x and SO_2 which result in a net negative effect on the radiative balance (i.e. tends to counteract warming). However NO_x and SO_2 contribute to acidification, eutrophication and other air quality problems and efforts have been made to reduce them for these reasons.

UNCLOS regulates the division of the sea and its resources including protection and use. The current formulation seems to prevent any other policy instrument than a voluntary trading scheme for the shipping industry. Like the international aviation, international shipping is excluded from the Kyoto commitments. This means that the same conclusions for this design parameter can be drawn as for the aviation sector. One difference is that a system for the shipping sector probably will be voluntary.. There is already a suggestion of how a voluntary trading scheme for NO_x and SO_2 in the shipping sector could be designed. A similar solution could be made for CO_2 emissions, i.e. a voluntary baseline and credit system for ship owners. Allocation would then be replaced by baseline determination and setting a limit for how many allowances/credits the shipping sector would be allowed to sell to the other trading sectors. The geographical scope of the voluntary system would depend on the interest of participants but for instance distances between EU harbours or other predetermined routes could be included. For CO_2 there is currently no system in place that could easily be used for monitoring and reporting but would have to be developed.

Other classification of the transport sector

The transport sector could also be divided into passenger transportation and goods transportation or private transports and professional transports. The idea of classifying the transport sector in either of these ways is to simplify the design of an emissions trading scheme which creates a level playing field for all industrial activities including the transportation of goods. However there might be some difficulties to distinguish between goods and passenger transportation since both can be transported at the same time with the same vehicle. For shipping and aviation it would only result in small fractions of each sector being separated. In the road sector the distinction is easier to make but does not simplify the design of the emissions trading scheme significantly.

Choice of design parameters and impact of architecture

In Table C we summarise which options for design parameters we recommend in different trading architectures. For a more detailed discussion on the design parameters, please consult chapters 5-7. Unless otherwise noted, the given options are best and independent of the choice of architecture.

Table C Choices of design parameters

Design parameter	Road	Aviation	Shipping
Coverage of greenhouse gases[8]	CO_2 only	CO_2 only. Flanking instruments for NO_x should be introduced.	CO_2 only
Geographic scope	EU	All flights departing from and arriving at European airports	Voluntary system. Depends on interest from ship owners
Interaction with Kyoto	Not an issue for this sector	Gateway[9]	Limit/Gateway[9]
Trading entity	Depends on aim of trading scheme; fuel suppliers, vehicle owners, transport buyers, or car manufacturers are all possible solutions	Aircraft operators	Ship owners
Monitoring and reporting	Depends on choice of trading entity	Fuel consumption reported by operators	Possible, but improved data availability is needed
Allocation	Auctioning[10]	Auctioning	Determination of baselines
Type of trading scheme	Cap & Trade (Baseline & credit if car manufacturers are trading entity)	Cap & Trade	Baseline & Credit if voluntary system. If mandatory system possible, Cap & Trade is better

Interviews

In order to gain a better understanding of the views of some important stakeholders, five interviews were conducted during October 2006. The interviewees were Bertil Arvidsson, Sweship, Birgitta Resvik, Confederation of Swedish Enterprise, (CSE), Lars-Erik Axelsson and Staffan Thonfors, Swedish Forest Industries Federation (SFIF), Kalle Keldusild and Jenny Ryman, Swedish Civil Aviation Authority, (SCAA) and Magnus Nilsson, the Swedish Society for Nature Conservation, (SNF).

Although the representatives of the forest industries were the only ones that were absolutely negative to integrating transports in the EU ETS, nobody proposed a full integration of all transports. Several expressed worries over potential negative indirect effects of an integration of the transport sector in the EU ETS as a result of the higher electricity prices. Several interviewees expressed that these dynamic effects need to be analysed further before specific options for integration can be recommended or discarded.

[8] For aviation there is also a discussion concerning the emissions of other substances with direct or indirect impact on the radiative balance.
[9] If aviation and shipping is fully included in the climate policy framework we recommend free trade with the other sectors. What other sectors that are included in the same scheme and the abatement costs in these sectors will impact the possibility to use this solution.
[10] If car manufacturers are trading entity auctioning will be replaced by determination of baselines.

Summary (in Swedish)

I denna studie analyseras olika alternativ för att tillämpa handel med utsläppsrätter för växthusgasemissioner i transportsektorn. Främst undersöks möjligheten att inkludera EU:s transportsektor i det befintliga systemet för handel med utsläppsrätter från och med 2013. Syftet med studien är att analysera hur alternativa utformningar av system för handel med utsläppsrätter för växthusgasemissioner i transportsektorn påverkar olika aktörer. Studien omfattar dels en analys av de ekonomiska konsekvenserna av handel med utsläppsrätter för transportsektorn och dels en analys av olika så kallade designparametrar, som exempelvis var kvotplikten ska ligga, i de olika delsektorerna väg-, flyg och sjöfart. Dessutom har djupintervjuer genomförts med ett antal aktörer för att undersöka acceptansen för att tillämpa handel med utsläppsrätter för utsläpp av växthusgaser i transportsektorn.

Den ekonomiska analysen beskriver hur samhällets totala kostnader för att nå ett givet reduktionsmål påverkas av ett integrerat utsläppshandelsystem för transport- och industrisektorerna i jämförelse med att ha separata handelssystem för dem. I bägge fallen antar vi att de totala CO_2-emissionerna reduceras med 10%. Analysen görs grafiskt, genom att använda en hypotetisk marginalkostnadskurva för reduktioner i industri- och transportsektorn. Vi har antagit att kostnaderna för att reducera CO_2 är betydligt högre i transportsektorn jämfört med i industrin och detta antagande stödjs av faktiska data för åtgärdskostnader för begränsade emissionsreduktioner. Dessutom antar vi att den nuvarande beskattningen i transportsektorn ersätts med utsläppsrätter.

Vi drar slutsatsen att för industrin kommer priset för utsläpp att stiga om transportsektorn integreras i EUs utsläppshandelssystem; vidare kommer utsläppen från industrisektorn att minska samtidigt som sektorns kostnader för genomförda åtgärder stiger. Den marginella produktionskostnaden för industrin, inklusive skuggpriset för utsläpp kommer att stiga. På avreglerade elmarknader kommer priset på el att öka och för en del industrier innebär detta en dubbel kostnad, med en ökning både av priset på utsläppsrätterna och priset på el. Däremot kan ny koldioxideffektiv teknik som tidigare inte varit ekonomiskt intressant nu bli lönsam.

Under antagandet att nuvarande beskattning (koldioxidskatter och bränsleskatter) ersätts av utsläppsrätter, så kommer den totala kostnaden för koldioxidemissioner i transportsektorn att minska drastiskt. Därmed kommer emissionerna i sektorn att stiga medan transportsektorns kostnader för att uppfylla reduktionsmålet sjunker. Drivmedel kommer att bli billigare och den marginella kostnaden för transportarbete minskar. Detta innebär i sin tur att transportvolymen kommer att öka snabbare än idag. Pågående åtgärdsprogram för att reducera CO_2-emissioner med relativt sett höga åtgärdskostnader, som t.ex. införandet av alternativa bränslen och CO_2-effektiva bränslen, kommer att bli olönsamma.

Vi uppskattar att en integration av transport- och industrisektorerna i samma system för handel med utsläppsrätter kan minska samhällets totala åtgärdskostnader, om man bortser från strukturella förändringar i samhället. Dock kan strukturförändringar vara betydelsefulla och bland annat innefatta produktionsförändringar, nedläggning av industrianläggningar och förflyttning av verksamhet till länder utanför handelssystemet, s.k. läckage. Vi har inom projektet inte haft möjlighet att kvantifiera sådana strukturella förändringar och andra dynamiska effekter.

Gratis tilldelning av utsläppsrätter till industrin minskar de totala kostnaderna för denna sektor jämfört med om auktionering tillämpas. Att integrera transportsektorn i EU:s system för handel med utsläppsrätter samtidigt som man behåller transportsektorns nuvarande koldioxid- och

bränsleskatter är en kompromisslösning som minskar samhällets totala kostnader jämfört med att ha separata system. Man får en viss ökning av priset på utsläppsrätter men den blir inte lika påtaglig som om man har ett integrerat system utan koldioxid- och bränsleskatter.

Skillnaderna är stora mellan de stationära anläggningarna i EU:s handelssystem och de icke-stationära enheterna i transportsektorn. Vår analys av designparametrarna visar att man behöver ta hänsyn till dessa skillnader då man sätter upp utsläppshandelssystem för transporter. I Tabell A nedan sammanfattar vi vilka val för designparametrarna vi rekommenderar för de olika delsektorerna. I rapportens kapitel 5-7 finns en mer detaljerad diskussion kring val av designparametrar. Om inget annat anges är våra val av designparametrar oberoende av handelssystemets arkitektur.

Tabell A Val av designparametrar

Design parameter	**Väg**	**Flyg**	**Sjöfart**
Omfattning av växthusgaser[11]	Endast CO_2	Endast CO_2. Kompl-etterande styrmedel för NO_x bör införas	Endast CO_2
Geografisk omfattning	EU	Alla *flighter* som avgår från och ankommer till flygplatser inom EU	Frivilligt system. Beror på intresse från fartygsägare
Samverkan med Kyoto	Inget problem för denna sektor	*Gateway*[12]	Begränsning/*Gateway*[9]
Handlande enhet	Beror på målet med handels-systemet; bränsleleverantörer, fordonsägare, transportköpare, eller biltillverkare är möjliga val.	Flygbolag (operatörer)	Fartygsägare
Rapportering och övervakning	Beror av val av handlande enhet.	Bränslekonsumtion rapporterad av operatör	Möjligt, men förbättrad data-tillgång behövs.
Tilldelningsprincip	Auktionering[13]	Auktionering	Fastställande av *basnivå*
Typ av handels-system	*Cap & Trade*[14] (*Baseline & credit* i det fall då biltillverkare är handlande enhet.)	*Cap & Trade*	*Baseline & Credit* om systemet är frivilligt. Om det är möjligt att inför ett obligatoriskt system, så är *Cap & Trade* bättre.

Fem djupintervjuer har genomförts med representanter för industri, myndigheter och miljöorganisationer i Sverige i syfte att beskriva deras synpunkter beträffande ett eventuellt inkluderande av transportsektorn. Ingen förordade en full integration av transportsektorn i handelssystemet. En framförde synpunkten att integration av transportsektorn i EU ETS är helt oacceptabel. Flera var oroliga för höjda elpriser till följd av en integration av transportsektorn i handelssystemet och de flesta ansåg att man bör utreda de dynamiska och strukturella effekterna mer noggrant innan man inför eller förkastar ett integrerat system för industri och transporter.

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[11] För flygsektorn har man också diskuterat att ett system eventuellt även skulle omfatta andra emissioner med direkt eller indirekt påverkan på strålningsbalansen.

[12] Med *gateway* avses här en kontrollpunkt som registrerar hur många utsläppsrätter som överförs från och till en sektor. Om ett visst värde överskrids kan man stoppa handeln mellan sektorer (se kap 3 för en mer detaljerad förklaring). Om flygsektorn och sjöfarten inkluderas i internationella avtal och åtaganden så är fri handel mellan sektorer att föredra. Huruvida man kan använda sig av en reglering med en *gateway* beror på vilka sektorer som är inkluderade i samma handelssystem och hur stora åtgärdskostnaderna är i de andra sektorerna.

[13] I fallet då biltillverkare är handlande enhet handlar det snarare om att fastställa *grundnivåer* (eftersom det då blir ett *baseline & credit* system).

[14] *Cap & trade* är system med utsläppstak medan *baseline & credit* är system där man utgår från en grundnivå sk *baseline*, och där reduktioner under grundnivån kan säljas som utsläppskrediter (se kap 3.8 för en detaljerad beskrivning).

Contents

Abbreviations

AAU	Assigned amount unit
ACARE	Advisory council for Aeronautics Research in Europe
ACEA	Association des Constructeurs Européens d'Automobiles, European Automobile Manufacturers Association
CAC	Command and Control
CDM	Clean Development Mechanism
EU ETS	European Union Emissions Trading Scheme
GHG	Greenhouse gas
GWP	Global Warming Potential
IACA	International Air Carrier Association
ICAO	International Civil Aviation Organisation
IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
JAMA	Japan Automobile Manufacturers Association
JI	Joint Implementation
KAMA	Korea Automobile Manufacturers Association
LTO	Landing and Take-off
MAC	Marginal abatement cost
Mton	Mega tonnes (metric tonnes)
RF	Radiative Forcing
UNCLOS	United Nations Convention on the Law of the Seas
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value added tax

1 Introduction

The transport sector in Europe is expanding and within the EU there are ongoing discussions on what the future transport system should look like. Reducing the environmental impacts from the transport sector has been declared a priority, and decreasing the emissions of greenhouse gases is an important part. To this end, a number of different policy instruments have been implemented, like taxes and voluntary agreements, or are under discussion, like emissions trading.

In order to fulfil the commitments to the Kyoto protocol of the EU and its Member States more efficiently, minimising negative impacts on economic growth and employment, the EU has introduced an emissions trading scheme for greenhouse gases. Compared to other policy instruments, such as fixed emission caps for single installations, the emissions trading has a higher flexibility and offers potentially lower total costs to society for reaching a given emission reduction target.

1.1 Objectives and methodology

The objectives of this project are to describe and analyse different alternatives for using emissions trading in the transport sector. Special focus is directed towards analysing the possibilities to include the transport sector in the current EU ETS or to create a trading scheme for the transport sector that is linked to the EU ETS. The purpose of the project is also to study how these alternatives will affect different actors. This is done by:

1. Describing the consequences of emissions trading for the transport sector and by analysing how an emissions trading system for the transport sector will affect the total cost for society of reaching an emissions reduction target. This includes analysing effects of including the transport sector in the current EU ETS, as well as effects of introducing a separate emissions trading scheme for the transport sector.

2. Analysing positive and negative aspects with different designs of an emissions trading scheme for the transport sector. Design parameters analysed include; choice of trading entity, covered greenhouse gases, allocation of emission allowances and monitoring systems.

3. Examining the acceptance among different actors for different options for emissions trading in the transport sector.

The first objective was investigated by a graphical economic analysis base on information and assumptions of marginal abatements costs for the industry and transport sectors. The second objective was investigated based both on available literature and on the economic analysis and the third objective was investigated by making interviews with important stakeholders.

2 The transport sector and the climate

2.1 Background

Transports affect the environment in many different ways. The emissions of greenhouse gases contribute to global warming while other air pollutants, such as particles, can affect human health. Also noise is a “pollutant” associated with transports. However, in this study focus is primarily on the emissions impacting climate change.

2.2 Environmental instruments

The most common environmental policy instruments fall into three main categories: regulatory, incentive based and informational instruments.

1. The **regulatory instruments** often refer to the Command and Control Approach (CAC). CAC policies are often very specific, demanding certain technologies to be implemented or quantified environmental standards to be met by individual polluters. Polluters' compliance is based on monitoring and enforcement. Four types of standards can be mentioned in particular: ambient quality standards, emission or discharge standards, process standards and product standards. Traditionally, CAC policies are regarded as being effective, easy to manage, relatively simple to impose and broadly accepted. However, from welfare economic point of view they are often inefficient (Duarte, 1999).

2. The **incentive-based instruments** are based on the market approach. The objective of these policies is to internalise costs related to damages to the environment into the market price of a product, thereby providing “market signals” in the form of a modification of relative prices. Emission charges or taxes, user charges, product charges or taxes, administrative charges or fees, emissions trading system (ETS), deposit-refund systems and subsidies are all examples of incentive based policy instruments. In theory, these types of instruments have all the efficiency properties of competitive market pricing, which guarantee an efficient allocation of resources in the economy provided all costs are accounted for.

3. For **informational instruments** a distinction is usually made between information strategies for production and information strategies for consumption. The strategies for production may include promoting the adoption of targeted, high-profile demonstration projects, to demonstrate the techniques and cost-saving opportunities associated with cleaner production. The strategies for consumption would include encouraging educational institutions to incorporate preventative environmental management within their curricula.

In general, incentive based instruments are often used in conjunction with CAC and information instruments since effective use of incentive based instruments requires administrative and enforcement ability as well as effective information.

2.2.1 What is emissions trading?

Emissions trading is an incentive based environmental instrument in which actors within the system are motivated to reduce their emissions by the fact that they can earn money by selling emission allowances/permits corresponding to the reduction made. A prerequisite for a trading system to work is that there is a demand for emission allowances or emission reductions. This can be created either by a cap on emissions, or some other means, for instance a guaranteed price paid by the government emission reductions. Actors with abatement costs above the market price of allowances can buy the amount needed from actors who have allowances in excess.

There are two distinctly different types of emissions trading systems: cap & trade and baseline & credit. In a baseline & credit (B&C) system a pre-determined emission profile (a baseline) is allocated to every actor. The unused portion of this baseline (so called emission credits) can be banked or traded to other participants exceeding their emission baseline. The baseline & credit principle is used in the project based mechanisms of the Kyoto Protocol.

In a cap & trade system (C&T) the total amount of emissions for all actors is determined, and a number of emission allowances equalling this amount of emissions are allocated to the participants. This guarantees the desired environmental outcome in a way that B&C or other instruments, such as taxes, do not. Cap and trade retains flexibility since actors have the choice to meet emission reduction targets according to their own strategy, by reducing emissions or by buying allowances from the market. The environmental outcome is still achieved, since it is determined by the overall limits set in the system. In this way, emissions trading combines environmental effectiveness with economic efficiency. Hence, emissions trading equalises marginal control costs ensuring that controls can be achieved at lower costs than would otherwise be the case (Yamin & Lefevere, 2000).

The Kyoto Protocol includes both cap and trade - between countries that have quantified reduction targets - and baseline and credit trading in the form of the Clean Development Mechanism (CDM) and Joint Implementation (JI). The EU Emissions Trading Scheme (EU ETS) is a cap and trade system, with links to CDM and JI. It is compulsory for all-25 EU Member States and covers CO_2 emissions from more than 12 000 installations across Europe, accounting for approximately 50 % of the EU 25 CO_2 emissions. It is one of the most important European policies to reduce greenhouse gas emissions and to tackle climate change.

2.3 Greenhouse gas emissions from the transport sector

In the EU the total GHG (greenhouse gas) emissions from the transport sector have increased by 26% during the period 1990-2004. According to PRIMES[15] (Mantzos & Capros, 2006) the emissions from the transport sector in EU25 is projected to grow by 3.5% during 2005-2010. Due to this trend it is a prioritised issue to take action on the reduction of greenhouse gas emissions from transports. Action has already been taken within part of the transport sector, e.g. the road transport where a number of environmental instruments already are in place.

[15] Primes is an economic partial equilibrium model for the European Union energy system developed and maintained at the National Technical University of Athens (Blok et al. 2001).

In Table 2.1 the development of GHG emissions from the transport sector in EU25 according to EEA (2006) are given. From Table 2.2 and Table 2.1 we can derive that the transport GHG emissions from EU10[16] were (967-888) 79 Mton CO_2 equivalents in 2004.

Table 2.1 Transport sector emissions in EU25 (EEA, 2006)

GHG emissions from transport sector EU25 (EEA, 2006)	1990[17]	2003	2004
CO2 (Mton CO2 equiv.)	754	920	940
(% of total emissions)	98.2%	97.2%	97.2%
CH4 (Mton CO2 equiv.)	4.8	2.7	2.6
(% of total emissions)	0.6%	0.3%	0.3%
N2O (Mton CO2 equiv.)	9.2	23.8	24.5
(% of total emissions)	1.2%	2.5%	2.5%
TOTAL GHG (Mton CO2 equiv)	768	946	967
Increase compare to 1990	100%	123%	126%

In Table 2.2 the emissions from the transport sector according to the GHG inventory report for EU15 in 2004 (EEA, 2006) are presented (note that the numbers in Table 2.2 do not include international bunker for aviation and navigation). Over 90% of the GHG emissions from transports origin from road transports. The civil aviation and navigation sectors are responsible for 2-3% of the total GHG emissions from the transport sector respectively, whereas railway and other transportation[18] account for less than 1% each.

Table 2.2 Transport emissions according to the GHG inventory report for EU15 (EEA, 2006). International bunker not included.

GHG emissions from EU15 transport sector in 2004 (EEA, 2006)	CO_2 Mton CO_2 equiv.	% of total CO_2	CH_4 Mton CO_2 equiv.	% of total CH_4	N_2O Mton CO_2 equiv.	% of total N_2O	Total Mton CO_2 equiv.	% of total
1.A.3 Transport								
a. Civil Aviation	**23**	2.7	**0.0**	0.5	**0.3**	1.1	**24**	2.7
(% of civil aviation GHG)	98.9%		0.0%		1.1%		100.0%	
b. Road Transportation	**801**	92.7	**2.2**	95.7	**21.2**	94.7	**825**	92.8
(% of road transport GHG)	97.2%		0.3%		2.6%		100.0%	
c. Railways	**6**	0.7	**0.0**	0.3	**0.4**	1.9	**7**	0.8
(% of railways GHG)	93.6%		0.1%		6.3%		100.0%	
d. Navigation	**21**	2.4	**0.1**	2.5	**0.2**	1.1	**21**	2.4
(% of navigation GHG)	98.6%		0.3%		1.1%		100.0%	
e. Other Transportation	**8**	0.9	**0.0**	0.8	**0.1**	0.6	**8**	0.9
(% of other transportation GHG)	98.0%		0.2%		1.7%		100.0%	
Total	**864**	100.0	**2.4**	100.0	**22.3**	100.0	**888**	100.0
(% of total transportation GHG)	97.2%		0.3%		2.5%		100.0%	

[16] EU10 = new Member states in 2004.
[17] Note that 1990 emissions are the actual emissions from that year and not Kyoto baseline emissions.
[18] Other transportation mainly consists of pipeline transport and ground activities at airports and in harbours (EEA, 2006).

In Table 2.3 the EU25 GHG emissions from international aviation and navigation[19] are presented. In 2004 the international bunker fuel emissions represented 12 % (aviation) and 16% (navigation) respectively of the total transport emissions in EU25 (excluding international aviation and navigation). The national civil aviation and navigation presented in Table 2.2 represent only a small fraction of the total emissions from aviation and navigation. It can also be noted that the emissions from international aviation and navigation are growing much faster than the transport emissions in general. From 1990 to 2004 the international aviation has increased by 86% and the international navigation has increased by 45%.

Table 2.3: GHG emissions from international aviation and navigation in EU25 (EEA, 2006). The emissions are calculated based on data of fuel filled in up in EU25.

GHG Emissions from international bunker EU25 (EEA, 2006)	Aviation			Navigation		
	1990*	2003	2004	1990	2003	2004
CO2 (Mton CO2 equiv.)	64	110	118	105	144	152
(% of total emissions)	99.1%	99.0%	98.9%	98.4%	98.4%	98.4%
CH4 (Mton CO2 equiv.)	0.0	0.1	0.1	0.1	0.1	0.1
(% of total emissions)	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
N2O (Mton CO2 equiv)	0.5	1.1	1.2	1.6	2.3	2.4
(% of total emissions)	0.8%	1.0%	1.0%	1.5%	1.5%	1.5%
TOTAL GHG (Mton CO2 equiv.)	64	111	120	107	147	155
Increase compare to 1990	100%	173%	186%	100%	137%	145%

2.4 International transport and the Kyoto Protocol

Not all emissions from transports are included in the Kyoto Protocol. As shown in Table 2.4, fuels used in international air and maritime traffic, so-called bunker fuels, are not included, whereas international road and railway transports are (with emissions attributed to the country where the fuel is bought).

[19] The fuel filled in EU25 used for international transport.

Table 2.4 Overview of differences in applied environmental instruments and treatment in international climate policy framework for different transport sub sectors.

Transport sector	Treatment in Kyoto	Geographical scope	Current policy instruments
Aviation	Currently not included in Kyoto commitments.	International aviation outside EU25	No economic instruments for environmental impacts
		International aviation in EU25	
	Included in Kyoto commitments.	National aviation	In Sweden NO_x fees
Maritime shipping	Currently not included in Kyoto commitments	International shipping outside EU25	UNCLOS[20] seems to prevent any local or regional rules for shipping, which prevents the introduction of environmental instruments for this sector[21].
		International shipping in EU25	
	Included in Kyoto commitments	National shipping	
Road transport	Included in Kyoto commitments		Fuel taxes and others, individual levels in the EU25.
Diesel trains	Included in Kyoto commitments		Different in the EU25.
Electric trains	Included in Kyoto commitments		Indirectly included in EU ETS since power generation is included in EU ETS

Article 2.2 to the Kyoto Protocol encourages the states listed in Annex 1 to the protocol to stabilise or reduce greenhouse gas emissions from bunker fuels in co-operation with the International Civil Aviation Organisation (ICAO) and the International Maritime Organization (IMO) (UN 1998). However, the parties to the United Nations Framework Convention on Climate Change (UNFCCC) have had protracted discussions on how to deal with GHG emissions from international transport for many years. The main issue in these discussions, that were particularly intensive during the elaboration of the Kyoto Protocol, is the allocation of emissions from international aviation and marine bunker fuels (i.e. the fuel sold to and burned by aircraft and ships in international transport) to different countries (Oberthür, 2003). In the deliberations of the Subsidiary Body on Scientific and Technological Advice (SBSTA) of the UNFCCC, five options were selected as the basis for further work in 1996:

- no allocation
- allocation to the country where the bunker fuel is sold;
- allocation to the country of the transporting company, the country of registration of the aircraft/vessel, or the country of the operator;
- allocation to the country of departure or destination of the aircraft/vessel (including some kind of sharing of emissions between them); and
- allocation to the country of departure or destination of the passenger/cargo (including some kind of sharing of emissions between them).

No further progress on this crucial issue could be made, since countries that would have been allocated substantial amounts of emissions from bunker fuels would have found themselves disadvantaged in their GHG mitigation efforts for several reasons. Wit et al. (2004) tried to find a solution to this problem and set up three criteria which should all hold in order to make the allocation in a fair and sound manner:

- Polluter pays principle should be taken into account

[20] UNCLOS is the United Nations Convention on the Law of the Sea.

[21] This issue is described in more detail in the chapter about the maritime shipping sector, section 7.2.

- Data availability should be guaranteed
- Evasion should be minimised

The following allocation options were included in the assessment:

1. No allocation,
2. Allocation in proportion to national emissions of Parties,
3. Allocation to the country where the fuel is sold. This option means that aviation and shipping would be treated in the same way as road transport,
4. Allocation to the nationality of airlines/shipping companies,
5. Allocation to the country of destination or departure of ship. Alternatively, the emissions related to the journey of a ship could be shared by the country of departure and the country of arrival,
6. Allocation to Parties according to the country of departure or destination of passenger or cargo. Alternatively, the emissions related to the journey of passengers or cargo could be shared by the country of departure and the country of arrival,
7. Allocation to the country of origin of passengers or owner of cargo,
8. Allocation according to emissions generated within each party's national space.

Wit et al. (2004) concludes that option 5, would be feasible for the aviation sector, and option 4 would be feasible only in a global scheme. Further there is currently no feasible option for international shipping due to the lack of appropriate data sources and monitoring methodologies.

In general, there is a demand for co-ordination between the UNFCCC (United Nations Framework Convention on Climate Change) on one side and ICAO and IMO on the other. When considering action on emissions from bunker fuels, IMO and ICAO are acting in pursuit of the ultimate objective contained in Article 2 of the UNFCCC, which is to stabilise GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Parties to the UNFCCC and its Kyoto Protocol will have to decide whether any action considered by IMO and ICAO is sufficient for achieving this objective. The demand for co-ordination is even more pronounced with respect to some of the measures under consideration by ICAO and IMO, in particular, emissions trading. An 'open' emissions trading[22] system envisaged by ICAO requires compatibility with the system of emissions trading under the Kyoto Protocol, because it is intended to be linked to the latter so that emission allowances could be exchanged between them[23].

Emissions from fuels used in national aviation and shipping are considered national emissions and are therefore included in the quantified targets. This distinction between national and international aviation and shipping and the fact that not all emissions are included in the Kyoto Protocol complicates the interaction with the current EU ETS in which all sectors currently included also are covered by the Kyoto Protocol and the burden sharing agreement.

[22] By open emissions trading means that it will be open for linkage and trade with other trading schemes.
[23] The difficulties with linking trading schemes between sectors included in the Kyoto commitments and sectors not included in the Kyoto commitments (international bunker) is discussed in section 3.3 and in chapters 6 and 7.

2.5 Description of transport sub sectors

2.5.1 International transport

Emissions from fuels used in international air and maritime traffic, so-called bunker fuels, are not included in the quantified emission reduction targets set in the Kyoto Protocol, since no agreement has been reached on the question of the accountability of such emissions. The simplest way would be to treat these sub sectors in the same way as road transport and distribute the emissions to the country where the fuel is bought. However, this is considered to be an unfair way of distributing the emissions. Article 2.2 to the Kyoto Protocol encourages the states listed in Annex 1 to the protocol to stabilise or reduce greenhouse gas emissions from bunker fuels in co-operation with the International Civil Aviation Organisation (ICAO) and the International Maritime Organization (IMO) (UN 1998).

The parties to the United Nations Framework Convention on Climate Change (UNFCCC) have had protracted discussions on how to deal with GHG emissions from international transport for many years. The main issue in these discussions, that were particularly intensive during the elaboration of the Kyoto Protocol, is the allocation of emissions from international aviation and marine bunker fuels (i.e. the fuel sold to and burned by aircraft and ships in international transport) to different countries (Oberthür, 2003). In the deliberations of the Subsidiary Body on Scientific and Technological Advice (SBSTA) of the UNFCCC, five options were selected as the basis for further work in 1996:

- no allocation
- allocation to the country where the bunker fuel is sold;
- allocation to the country of the transporting company, the country of registration of the aircraft/vessel, or the country of the operator;
- allocation to the country of departure or destination of the aircraft/vessel (including some kind of sharing of emissions between them); and
- allocation to the country of departure or destination of the passenger/cargo (including some kind of sharing of emissions between them).

No further progress on this crucial issue could be made, since countries that would have been allocated substantial amounts of emissions from bunker fuels would have found themselves disadvantaged in their GHG mitigation efforts for several reasons. Wit et al. (2004) tried to find a solution to this problem and set up three criteria which should all hold in order to make the allocation in a fair and sound manner:

- Polluter pays principle should be taken into account
- Data availability should be guaranteed
- Evasion should be minimised

The following allocation options were included in the assessment:

9. No allocation,
10. Allocation in proportion to national emissions of Parties,

11. Allocation to the country where the fuel is sold. This option means that aviation and shipping would be treated in the same way as road transport,
12. Allocation to the nationality of airlines/shipping companies,
13. Allocation to the country of destination or departure of ship. Alternatively, the emissions related to the journey of a ship could be shared by the country of departure and the country of arrival,
14. Allocation to Parties according to the country of departure or destination of passenger or cargo. Alternatively, the emissions related to the journey of passengers or cargo could be shared by the country of departure and the country of arrival,
15. Allocation to the country of origin of passengers or owner of cargo,
16. Allocation according to emissions generated within each party's national space.

Wit et al. (2004) concludes that option 5, would be feasible for the aviation sector, and option 4 would be feasible only in a global scheme. Further there is currently no feasible option for international shipping due to the lack of appropriate data sources and monitoring methodologies.

In general, there is a demand for co-ordination between the UNFCCC (United Nations Framework Convention on Climate Change) on one side and ICAO and IMO on the other. When considering action on emissions from bunker fuels, IMO and ICAO are acting in pursuit of the ultimate objective contained in Article 2 of the UNFCCC, which is to stabilise GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Parties to the UNFCCC and its Kyoto Protocol will have to decide whether any action considered by IMO and ICAO is sufficient for achieving this objective. The demand for co-ordination is even more pronounced with respect to some of the measures under consideration by ICAO and IMO, in particular, emissions trading. An 'open' emissions trading[24] system envisaged by ICAO requires compatibility with the system of emissions trading under the Kyoto Protocol, because it is intended to be linked to the latter so that emission allowances could be exchanged between them[25].

Emissions from fuels used in national aviation and shipping are considered national emissions and are therefore included in the quantified targets. This distinction between national and international aviation and shipping and the fact that not all emissions are included in the Kyoto Protocol complicates the interaction with the current EU ETS in which all sectors currently included also are covered by the Kyoto Protocol and the burden sharing agreement.

2.5.2 Road transport

Emissions and trends

In Table 2.5 the CO_2 emissions from the energy sector in EU25 are presented. Emissions from road transports have by 24 % during the period 1990-2002. In 2002, 26% of the CO_2 emissions from EU originated from energy consumption within the transport sector and the road transport sector alone accounted for 84.5% of those emissions.

[24] By open emissions trading means that it will be open for linkage and trade with other trading schemes.
[25] The difficulties with linking trading schemes between sectors included in the Kyoto commitments and sectors not included in the Kyoto commitments (international bunker) is discussed in section 3.3 and in chapters 6 and 7.

Table 2.5. CO_2 emissions from energy sector (EU25, million tonnes CO_2).

Year	Total	Heat & Power generation	Industry	Transport	Of which road transport	House-holds	Services & others
1990	3775	1487	723	793	675	500	273
1995	3655	1417	640	857	726	486	255
2000	3692	1428	598	971	811	464	233
2002	3750	1472	593	986	835	454	248
2002/ 1990 %	-1	-1	-18	+24	+24	-8	-9
Share [%]	-	39	16	26	(84.5)	12	7

Source: Adapted from European Union (2004).

Environmental policy instruments: some examples

The road transport sector in the EU Member States is subject to a number of different environmental instruments. It has proved easier to introduce measures in this sector compared to for instance the aviation and shipping sectors. One reason for this is that fuel taxes for road transports have a comparably low impact on where fuel is bought, since it is difficult to bunker fuels or move the demand of transportation geographically.

Governments have used taxes and other policy instruments in the road transport sector for many reasons. Undoubtedly, an important one is simply in order to raise tax revenues for the government. In this context, it could be seen as a way of internalising costs of infrastructural investments. In addition, taxes are used as a measure to internalise environmental costs. Many of these policies have directly or indirectly affected the emissions of CO_2:

- Sales and vehicle registration tax is a tax only applied when buying a new car and is therefore only paid once per car. In some European countries this tax has been related to factors that indirectly influence fuel consumption as cylinder capacity, power rating and vehicle weight (Kågeson, 2005).

- Annual circulation taxes have traditionally mainly been used to cover maintenance costs of roads etc. The damage a car makes to the roads is partly dependent on the size and weight of the car and the vehicle use tax has then been differentiated to size or in some cases engine size (Kågeson, 2005). However, the EU is encouraging member states to change the vehicle tax to be differentiated in relation to fuel efficiency. Germany and Sweden have adopted this way of differentiating the vehicle use tax. In these countries higher emissions per km give higher taxes independent of vehicle size. The purpose of this design of the tax is to give incentives for buying fuel efficient cars.

- Fuel tax is applied directly to the fuel. The fuel tax can be called energy tax, CO_2 tax and usually there is also VAT. Whatever the tax is called the effect is the same: it results in an increased fuel price, which decreases the demand of fuel (and indirect decreases demand for road transport). In addition it increases the demand for fuel efficient vehicles and it can also be designed to increase demand for bio-fuels or renewable fuels by giving tax exemptions for these fuels.

- Road tax/fee has most frequently been used to finance highways, (e. g. in France and Norway) but also in the form of congestion charges to reduce traffic or change the distribution of traffic volumes over time of day (e. g. in Stockholm and London). The results of a road tax depend on the purpose of its introduction and on alternative transportation. If a road tax is introduced to finance e. g. a highway the purpose is to get as many as possible to pay the fee and therefore the alternatives to travel on the highway are minimised. The tax/fee will still of course affect the travel behaviour and the use of the road will be lower than it would have been without a tax. In the case of Stockholm the purpose has been to decrease the amount of people travelling by private cars in and out from Stockholm during rush hours. Therefore extra resources have been allocated to public transportation e.g. buses, trains and subways to encourage people to use these alternatives instead.

- Voluntary commitments with ACEA[26], JAMA[27] and KAMA[28] are ways of increasing the fuel efficiency of vehicles. The goal has been to reduce the average emissions for new cars to 140 grams CO_2 per km until 2008[29] and if the industry fails to meet the 2008 target, the EU Commission is expected to adopt formal regulations to reduce CO_2 emissions from new passenger vehicles (WRI, 2005). For ACEA there has been a reduction in specific fuel use since the introduction of the agreement from 185 g CO_2/km in 1995 to 164 g CO_2/km in 2003 (Kågeson, 2005). JAMA and KAMA have also decreased their specific emissions. Kågeson (2005) conclude that the voluntary agreement will not be reached unless the individual member states introduce strong economic incentives to promote fuel efficient cars. According to the EU Commissions annual communication on the effectiveness of the community strategy to reduce CO_2 emissions from cars for 2006 (EU COM 2006 463) a substantial reduction has been achieved but still significant efforts need to be undertaken in order to reach the goal in 2008. The Commission states that it will *review available options, including legislative ones, to further reduce CO_2 emissions from passenger cars and light commercial vehicles*.

- In the USA there are standards to stimulate fuel efficiency. These standards have not been very hard to accomplish and the effect this far has been relatively small, but are at least a trial of stimulating fuel efficiency.

- Building new roads, land use and city planning affect the GHG emissions from road transports. However, the main focus with city planning is in most cases to decrease transport times and make the transportation faster. In the long term land use and city planning have great potential to decrease GHG emissions.

Policy instruments for creating incentives to reduce emissions in the road transport sector already exist as described above In general these policies are aimed at providing incentives for decreased transports and increased transport efficiency. However, to date there have been few, if any, examples of policy instruments that provide incentives for technology development at the manufacturer level. The agreement between ACEA, JAMA, KAMA and EU described above is only a voluntary agreement, and according to Kågeson (2005) and SRU (2005) the goals will not be reached.

2.5.3 Aviation

Emissions and trends

According to the Intergovernmental Panel on Climate Change (IPCC) special report "Aviation and the Global Atmosphere", published in 1999 aviation was (globally) responsible for 13% of CO_2

[26] European Automobile Manufacturers Association.
[27] Japan Automobile Manufacturers Association
[28] Korea Automobile Manufacturers Association
[29] All new cars with no more than eight seats in addition to the driver's seat sold in EU are included. The specific emissions should be measured according to the test procedure in Directive 93/116/EC

emissions from the transport sector in 1992. About half of the CO_2 emissions from international aviation reported by developed countries originate from Europe (EU COM 2005 (459)). According to EEA (2006) CO_2 emissions from international aviation originating from EU25 has increased by 87 percent during 1990-2004. IPCC (1999) also states that growth in demand for aviation, measured in revenue passenger –km, averaged 5% per year for the period 1980–95 and this growth rate is expected to continue until at least 2015. Although emissions are expected to increase in absolute terms; the growth rate is projected to be lower than the growth of traffic mainly due to increased aircraft efficiency.

The emissions from aviation are growing faster than in any other part of the transport sector in Europe. Growth in national aviation during 1990-2005 was approximately 36% (EEA 2006, Mantzos & Capros, 2006). However, national aviation in the EU25 accounts for less than 3 percent of the total CO_2 emissions. Forecasts for the sector suggests continuing growth of demand and if the current trend continues the EU international aviation emissions will have increased by 150%[30] from 1990 by 2012. This would offset more than a quarter of the reductions required by the Community's target under the Kyoto Protocol (EU COM 2005 (459)).

Environmental policy instruments in the aviation sector

The process of introducing emissions trading for greenhouse gases has progressed further in the aviation sector than in the other transport sub sectors.

On January 24th 2001 the European Parliament and the Council decided to identify and undertake policy actions to reduce greenhouse gas emissions from aviation if no such action was agreed within ICAO by 2002 (EU COM 2001). In 2005, the EU Commission adopted a communication on how to reduce the climate impact from aviation (EU COM 2005 (459)), concluding that emissions trading is the best policy option for internalizing the climate impact of aviation emissions. It was suggested that aviation fuel should not be treated differently than other vehicle fuels by generally being exempted from energy taxes. It was also pointed out that there are currently no legal barriers for Member States to introduce taxes on domestic flights. However, currently there are legally binding exemptions made in a number of bilateral air service agreements (ASA:s) which make it difficult (in the short and medium term) to introduce taxes without distorting competition between carriers of different nationality. Further it was concluded that emissions trading, compared to for example airline ticket or departure taxes, introduces additional incentives for operators to improve environmental performance.

Furthermore, the EU Environment ministers have agreed that including aviation in the EU ETS is the best way forward to reduce the sector's impact on climate change (Council of European Union 2005/12/2). To prepare for the necessary decisions to be taken, the Commission set up an Aviation Working Group which was assigned the task of considering ways of including aviation in the EU ETS. This Working Group presented its final report on April 2006 (ECCP II, 2006). The Commission is currently preparing a legislation proposal (to be tabled by the end of 2006) on how to include the aviation sector in EU ETS. In addition to this the European Parliament has expressed its opinion of being in favour of including the aviation sector in an emissions trading scheme (EUP 2006). Furthermore, ICAO endorses an open emissions trading scheme for CO_2 emissions from the aviation sector (ICAO 2004). The European airline industry favour emissions trading to other policy options such as taxes or other charges.

[30] The reported emissions from international aviation and navigation are based on the amount of fuel sold in each country.

The European Parliament has adopted a resolution (EUP 2006) on reducing the climate change impact of aviation. The Parliament supports the Commissions proposal of a more consistent treatment of fuel tax also for aviation fuel and is of the opinion that taxes immediately should be required on all domestic and intra-EU flights (with the possibility to except all carriers on routes on which non-EU carriers operate). The Parliament also recommends that the ultimate goal should be a world wide introduction. It is pointed out that the tax exemptions on air transport and other imbalances lead to very unfair competition between aviation and other transport sectors. Particularly it is a burden for the railway sector, since the railway sector is not only covered by taxes but also by the EU ETS which significantly raises the cost for this transport system.

EUP (2006) specifically addresses the issues connected to the inclusion of aviation into the EU ETS. The Parliament proposes that there should be a separate system introduced for aviation emissions. Due to the lack of binding commitments for international aviation emissions under UNFCCC and the Kyoto Protocol, the aviation sector should be unable to sell emission allowances into the EU ETS. However, there could be a gateway to the EU ETS enabling the aviation sector to buy from the EU ETS. The Parliament proposes that a separate scheme for the aviation sector is tested in a pilot phase covering the period 2008-2012. Should aviation eventually be incorporated into a wider ETS, it should be done in such a way so as to ensure it does not distort the market to the disadvantage of less protected sectors. This may include a cap on the number of emission allowances actors in the aviation sector are permitted to buy from the market, and a requirement to make a proportion of the necessary emissions reductions without trading before being allowed to buy permits.

The European airlines, which prefer emissions trading to other regulation, recommend that a trading scheme, at least initially, should be limited to CO_2 and intra-EU flights and that allocation should be defined at EU, not national, level. Of course they would prefer a global scheme to a European one (AEA, ASD, EBAA, EEA, ERA & IACA, 2005).

2.5.4 Shipping

Emissions and trends

Ships have relatively low greenhouse gas emissions per tonne kilometre and sea transport is a comparably efficient transport mode – up to six times more fuel efficient than alternative transport modes per tonne kilometre (Swedish Commission against oil dependency, 2006). The share of CO_2 emissions from maritime transport is about 2 % globally and 4 % for EU25 (Wit et al., 2004). Fuel consumption from international navigation is projected to increase by at least 1 to 2% per year if no measures are taken, leading to increased CO_2 emissions (EC, 2001). A shift towards high speed ships is also projected to increase the fuel consumption and thereby the CO_2 emissions.

Environmental policy instruments in the navigation sector

Currently international navigation is exempted from fuel taxes, just as international aviation. The United Nations Convention on the Law of the Sea (UNCLOS) regulates the division of the sea and its resources including protection and use. The current formulation seems to prevent implementation of local and regional rules for navigation. There are however currently local fees for navigation, for instance the fairway fees in Sweden. These can be applied since they are serviced based, maintaining fairways in good conditions. Unless it could be associated with some service any emissions trading scheme including navigation would therefore have to be voluntary, unless the writing of the convention is changed, which is very unlikely at least in the short and medium term

(Grundström & Lemieszewski, personal communication). Furthermore, the parties of the UNFCCC have not yet agreed on a method for how emissions from international navigation should be accounted for. This is one of the reasons why international maritime bunker fuels are not included in the Kyoto Protocol.

The International Maritime Organisation (IMO) has the purposes "to provide machinery for cooperation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting navigation engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation and prevention and control of marine pollution from ships" (IMO, 2006). In 2000, IMO carried out a study on greenhouse gas emissions from ships and proposed three strategy options that could be feasible for reducing greenhouse gas emissions (IMO, 2000):

1. Explore the interests for entering into voluntary agreements on GHG emission limitations between the IMO and the ship owners, or to use environmental indexing,
2. Start working on how to design emission standards for new and possibly also for existing vessels,
3. Pursue the possibilities of credit trading from additional abatement measures implemented on new and possibly also on existing vessels,

CO_2 indexing – one example of environmental indexing – means description of CO_2 efficiencies of ships including CO_2 emissions per tonne cargo or passenger per nautical mile etc. According to The Swedish Maritime Administration, this option seems promising, provided that a fair methodology for determining these indexes is established (Grundström & Lemieszewski, personal communication). However, IMO has not yet agreed on strategies for implementation of policies to reduce greenhouse gas emissions.

Kågeson (2001) suggests that CO_2 emissions from ships are better regulated by other means than national caps. Instead, he argues that CO_2 taxation or environmental charges related to specific fuel consumption and distance are better alternatives. Kågeson also states that use of efficiency standards probably not is a realistic alternative. His argument is that efficiency standards might rule out high speed ships as these ships have high fuel consumption and thereby also high CO_2 emissions. This is, in a way, contrary to the suggestions made by IMO (2000) about CO_2 indexing.

The Swedish Shipowners' Association has proposed an emissions trading system for NO_x and SO_2 emissions from seagoing ships. This would be a voluntary system and emission allowances or reduction units are to be created by the shipping industry and to be sold to the land-based emitters who have restrictions on total emissions (emissions capped) according to the Integrated Pollution Prevention and Control (IPPC) Directive (this proposed system is further described in chapter 7).

2.5.5 Railway

Emissions and trends

In general railway is considered to be an environmentally friendly transport mode. The reason is that most of the traffic is operated by electrified locomotives and hence greenhouse gas emissions per travelled km are relatively low. However, there is still a significant amount of railway operated with diesel locomotives.

Environmental policy instruments in the railway sector

CER (Community of European Railways and Infrastructure Companies) have written a position paper that concerns the current EU ETS (CER, 2005), which points out the fact that there is an important impact on railways from the current trading system due to the impact on electricity prices. The corresponding impact is not present for other transport modes, therefore they urge that at least airlines be included before 2013. In Kågeson (2001) it is concluded that operators might increase the use of diesel locomotive due to high electricity prices and hence the emissions from this sector might increase due to the current EU ETS.

The railway sector will not be analysed in detail in this study. However, we believe that if road transports are included in a trading scheme, there are strong arguments for including diesel fuelled railway as well. It will most likely be simpler to include the diesel fuelled railway than to include road transport. The electrified railway is already indirectly included in the EU ETS since power plants are included.

2.5.6 Other classification options for the transport sector

There have been suggestions that the transport sector better be classified based on other criteria than transportation mode when applying emissions trading to the sector. One such classification is passenger transportation vs. transportation of goods; another is private vs. professional transportation.

Passenger transportation vs. transportation of goods

The different modes of transport for freight (e. g. maritime shipping, aviation, road and railroad) compete with each other more than modes of passenger transport do. This is a strong argument to include all freight transports in the same emissions trading scheme. Another argument for including freight transport in the EU ETS is that a majority of these transports are ordered by companies that are already included in the EU ETS. If all emissions that originate from the industries' decisions are included in the same emissions trading system, the economical effectiveness in emission reduction will increase. It is, however, complicated to separate freight transport and passenger transport from each other since both categories can be transported with the same vehicle at the same time. The problem is most obvious in the shipping sector, but exists for the other transport modes to.

Private vs. professional transportation

A solution to the problem of separating between freight transport and passenger transport would be to include professional operators, but to exclude private ones. If such a limitation is applied most cars, small airplanes and boats would be excluded. In the road transport sector more than 50% of the emissions would be excluded. For the other transport modes the amount of excluded emissions would be smaller. Including professional transport actors do not fully correspond to the ambition to include freight transports. However, the major difference between the two options is that some passenger transports would also be included if choosing the professional vs. private option. It can be argued that at least some of the passenger transports depend on industry decisions since a lot of travelling could be categorised as business travelling.

3 Designing emissions trading for the transport sector

When setting up an emissions trading scheme there is a number of design parameters that have to be considered. Table 3.1 lists the design parameters discussed in this study. In this chapter the design parameters are discussed on a general level whereas the specific considerations for each of the sub sectors will be explained and discussed in chapters 5 -7.

Table 3.1 Overview of design parameters considered in this study.

Design parameter	**Options**	**Comment**
Coverage of greenhouse gases[31]	- CO_2 - Kyoto GHG´s - Contrails - NO_x/SO_2	CO_2 is the main focus in this study but some specifics for the sub sectors are discussed in chapters 5 - 7
Sectoral & Geographical scope	- Transport sector & existing trading scheme in common system. - Transport sector and existing trading scheme in separate systems - Existing trading scheme & transport in common system (excl. private transport)	See chapter 4 for the exact description of the different options.
Interaction with Kyoto	This issue will be discussed assuming either a change compared to the current situation or that the same type of regime remains	This issue concerns mainly international transport in the aviation and shipping sectors
Trading entity	- Upstream - Mid-stream - Downstream - Other options	The specific choices for the different sub sectors are discussed in chapter 5 -7.
Monitoring & reporting	Related to the trading entity.	The specific choices for the different sub sectors are discussed in chapter 5 -7.
Allocation	- Auctioning - Benchmarking - Grandfathering - No allocation	The specific choices for the different sub sectors are discussed in chapter 5 -7.
Policy options	- Current situation - Emissions trading only - Emissions trading and current CO_2 tax for road transports.	See chapter 4 for the exact description of the different options.
Type of trading scheme	- Cap & trade - Baseline & credit	Cap & trade or baseline & credit for different selections of trading entity
Climate goal	Size of European emission caps?. How large domestic reductions should be done in Europe 2013-2017?	10% reductions during 2013-2017, compared to the emission level in 2008-2012. (10% domestic reductions).
Time perspective	- 2008 - 2008 – 2012 - 2013 – 2017	2013-2017 is the chosen time perspective in this study since there is little room for large changes until 2008-2012

[31] For aviation there is also a discussion concerning the emissions of other substances with direct or indirect impact on the radiative balance.

3.1 Coverage of greenhouse gases

According to economic theory it would be optimal to include as many of the greenhouse gases as possible in the trading scheme, since efficiency increases if a larger share of the economy is covered. EU ETS provides a wide spatial and sectoral coverage. Other greenhouse gases than CO_2 are to be phased in later depending on two issues: monitoring difficulties and transaction costs. However, currently either measuring uncertainty is too large, or transaction costs are too high, to include other gases. We have made the assumption that only CO_2 will be included during the time frame selected in this project (2013-2017). Further discussion on this subject is given in the chapters describing each sub sector (chapters 5-7.)

3.2 Sectoral / Geographical scope

The EU ETS is a cap & trade system for stationary installations where common rules for all EU25 Member States combine 25 national caps into one system. Drawing an analogy for the transport sector is complicated by the fact that emission sources are not stationary and that they include both national and international elements. However, there are a number of potential options for the introduction of emissions trading for the transport sector that will be further analysed in this study (see Table 3.1 and chapter 4).

The sectoral scope of the emissions trading scheme concerns the questions whether or not the transport sector should be included in the same system as the industry. It is also a question of whether any differentiation between different sub sectors of the transport sector should be made. If the transport sector and the current EU ETS sectors are included in a common system, there is a concern that high willingness to pay within the transport sector would result in relatively high prices for allowances which would be detrimental to other participating sectors. If the allowance price is low, (5 – 30 €/ton), it can be assumed that the transport sector will cope with additional CO_2 costs without tapping the potential of relatively cheap abatement options (Bergmann et al. 2005). However, the price of allowances in a separate scheme for the transport sector will most probably be higher than if the transport sector is included together with other sectors (Bergmann et al. 2005). Having a separate system for the transport sector might be an attractive solution if reducing emissions within the transport sector is an objective in itself. The system should then be closed, not allowing for trade with other emissions trading schemes nor using other flexible mechanisms.

The geographical scope of the system relates to the extent of including international transports. For the road transport and for the railway a straight forward solution would be to apply the same geographical limitations for international transport as is done in the Kyoto Protocol. That is, emissions are attributed to the country where the fuel is sold. For aviation and navigation the issue is more complicated and is discussed in more detail in the chapters describing those sectors i.e. chapters 6-7.

As shown in Table 3.1 there are different possible options for the integration of an emissions trading system for the transport sector with the current EU ETS.

1. Current EU-ETS and the transport system in the same trading scheme,
   This option means that the whole transport sector is included in the current EU ETS. The emissions trading scheme would then cover > 75 % of EU25 CO_2 emissions. The argument

for this option is mainly that the scheme will be large, which implies higher effectiveness than smaller systems.

2. Existing trading scheme and the transport system in different trading schemes with no trading connections
   The same amount of emissions would be covered as in the first option, but they would be in separate trading schemes. The most important argument for this option is that this guarantees emission reductions in the transport sector itself (if the size of the cap in the transport sector is lower than the emissions would have been otherwise).
3. Existing trading scheme and the transport system in the same trading scheme but excluding private transport;
   This option will make a downstream approach easier (where end-users are trading entity, see separate section on trading entity) than for instance in option 1. Excluding private vehicles in the transport sector would limit the number of actors participating in a downstream trading scheme. Furthermore, professional actors are easier to monitor than private actors.

In chapter 4 the three abovementioned options (and a few variations of them) will be analysed in more detail.

One could also suggest purely national systems which would only include for instance the Swedish transport sector. Theoretically such an option could be possible even if no action is taken on EU level, given the opening for opt-in of sectors in the EU ETS. However, in the final report from the Flexmex 2 (SOU 2005:10) it was stated that a harmonised solution for the transport sector is preferable (i.e. harmonised solution within the EU, Sweden should not alone include its transport sector).

3.3 Interaction with Kyoto

Although the time frame chosen in this study is post-Kyoto (after 2012) and thereby interaction with Kyoto would not be a problem, the discussion on interaction with Kyoto concerns the difficulties with the current climate regime which does not cover all parts of the transport sector. It should also be remembered that there are still no decisions taken upon the climate regimes post-Kyoto so we do not know what a future regime will look like.

The problems with interaction with Kyoto mainly concern the international shipping and aviation sectors, since these sectors are not included in the national obligations under the Kyoto Protocol (see also separate discussion above). The emissions from international aviation and shipping are reported as memo items in the national inventories (under International Bunkers). If international aviation and shipping are to be included in the EU ETS it is necessary to set up a system that handles the problems of calculating and presenting the emission allowances at the end of the Kyoto period.

During the Kyoto commitment period (2008-2012) the emission allowances issued within the EU ETS will be covered by AAU's (Assigned Amount Units), which are national emission allowances. Each country will have a certain amount of AAU's corresponding to its commitment target. Since emissions from international aviation and shipping are not included in this target, these emissions will not be covered by AAU's. Including any of these sectors in the EU ETS will not cause any problem in the coverage of AAU's if the sectors are net buyers of emission allowances. However, the target for the sectors included in the EU ETS will be stricter than the original obligation according to the Kyoto Protocol since the aviation and shipping sector would use part of the AAU's. On the other hand if the shipping and aviation sectors would be net sellers to the market there is a risk of under compliance of the countries since they will not hold enough AAU's at the end of the trading period.

There have been several suggestions on how to solve this issue. In the long run the best solution of course would be to include the international aviation and shipping sectors into the Kyoto regime (or the regime that will follow the Kyoto regime). Nevertheless, this is not possible for the commitment period 2008-2012.

Suggestions on how to cope with interaction with Kyoto for the aviation sector

Wit et al. (2005) analyse the following six suggestions for how the interaction with the Kyoto Protocol could be solved for the aviation sector. These solutions could in theory also be used for the shipping industry:

1. Extending the scope of the Kyoto Protocol to also include international aviation,
2. Borrowing of AAU's from sectors not covered by the EU ETS. This requires a tracking mechanism that tracks which AAU's that are borrowed and which are not,
3. No allocation to the aviation sector. The aviation sector will have to buy all required allowances (corresponding to their total emissions) at the market, something that will tighten the requirements for the other sectors to reach the Kyoto commitments
4. Obligation to buy allowances above a certain baseline. The aviation sector will only have to surrender allowances above a certain baseline, they will not be allocated these allowances but will have to buy them at the market. Compared to option 3 it will not tighten the Kyoto commitments as much, since the number of allowances bought by the aviation sector will be smaller,
5. Semi-open trading for aviation. The aviation sector can only buy allowances from non-aviation operators but are not allowed to sell any units to them,
6. Trading for aviation with a gateway mechanism. The aviation sector will only be able to sell as many allowances as the sector as a whole already have bought from the non-aviation sector.

Both Wit et al. (2005) and ECCP II (2006) consider option 1, to include both international aviation and navigation in scope of the Kyoto Protocol or any regime following it, to be the simplest solution, with the disadvantage that it is not very likely that it can be changed before 2013. Since there is a wish to include international aviation as soon as possible it might be necessary to chose one of the other options. ECCP II (2006) considered option 3 and 4 to be quite simple solutions, although option 4 would be somewhat more complex since baselines will have to be defined. It was also pointed out that option 3, where the aviation sector will have to buy a large quantity of emissions allowances might impact the price in the EU ETS market significantly. There was also a concern that option 5 would decrease the effectiveness of the system. In ECCP II (2006) Member States stated that option 6 was their preferred option. There was some concern of the effects on the market in the case of a closed gateway and a risk of creating two types of emission allowances. However this is considered to be a small risk if the system could work as in the current UK system where operators are informed of the status of the gateway. For option 2 it was considered a risk that not all of the borrowed allowances could be surrendered (i.e. if the aviation sector would be a net seller to the other sectors). However, EU Member States consider this risk to be to large for choosing this option (ECCP II 2006).

Most of these conclusions will also hold true if applied to international shipping. However, the legal basis for regulating international shipping seems to reduce the possibility of including the sector in an emissions trading scheme other than on voluntary basis (this is further discussed in chapter 7).

3.4 Trading entity

The trading entity is the actor that will be obliged to surrender emission allowances corresponding to the amount of emissions emitted. In the current EU ETS the trading entity is the owner of the emitting installation included in the system, but it is not obvious that this would be the optimal solution for a scheme covering the transport sector. Trading entities can be categorised into different levels depending on how close the actor is to the actual emissions (within parenthesis corresponding actors relevant for the transport sector are given):

- upstream (e.g. fuel depots or refineries)
- mid-stream (filling stations)
- downstream (vehicle owners or drivers)

There are also other possible trading entities such as vehicle manufacturers or the consumer of transports which can not easily be put into any of the mentioned categories. In fact, the user or consumer of transports, e.g. industry, has been suggested by Eckerhall (2005) to be an advantageous choice of trading entity for the transport sector. This is since they can impact the demand of transports by planning sales and deliveries more efficiently. However, the acceptance for this approach might be low, since it would mean that industry, which is already included in the trading scheme, also would be held responsible for emissions in the transport sector. On the other hand it could create a single price on the CO_2 emissions resulting from decisions and investments in industry.

Important factors influencing the choice of trading entity, besides political and legal viability, are:

- Possibility to monitor emissions. (Can the emissions of the chosen actor be monitored easily?),
- Number of actors within the chosen category. (The total number of actors included will impact the administrative costs and the transaction costs of the system),
- Incentives raised to change emission levels. (A car owner can chose to buy a new bio-fuelled car and filling stations can reduce the sold amount of fossil fuel by increasing the sold amount of alternatives),
- Amount of emissions included. (Different choices can have different coverage of the total emissions from the sector),

Further discussion on the choice of trading entity is to be found in chapters 5 -7.

3.5 Monitoring and reporting

This design parameter is strongly linked to the selection of trading entity and will be analysed in chapters 5 -7. In order to make implementation as simple and inexpensive as possible a design solution is sought where emission data for the chosen trading entity is already available and where at least a simple monitoring system already exists.

3.6 Allocation

The consequences of auctioning, grandfathering, benchmarking or not allocation at all will be analysed in the chapters 5-7. A general description of these options, however, will be given in this section. The option of choosing the design of a baseline & credit trading scheme as well as allocation by baseline will be discussed in the chapters 5 -7 (a more general discussion on baseline & credit systems is given in 3.8).

Auctioning

Auctioning means that the actors will not be allocated allowances for free but will have to buy them. One lesson that emerges from the literature is the potential importance of revenue-recycling. A majority of the economics literature suggests that a system of tradable allowances set in motion by an auction of the permits to sources carries significant efficiency advantages preferred to the alternative in which the permits are distributed to the sources free of charge. The most important reasons are that the former alternative provides more efficient incentives and generates revenues that can be used to reduce other distorting taxes, while the latter does not (inter alia Parry & Oates, 1998).

Benchmarking

The benchmarking solution of allocation means that actors are allocated allowances based on some kind of benchmark, e.g. emissions per produced unit. One advantage of this allocation method is that early action is rewarded. Hence actors who have low specific emissions will have a larger part of their actual emissions covered. This allocation method requires that a suitable benchmark can be constructed and implemented.

Grandfathering

Grandfathering means that allocation is based on historic emission levels. The basic principle is thus very simple, although it does require extensive data. A major disadvantage of grandfathering is that it does not reward actions taken before the base year on which the allocation is based and, if updated, provides perverse incentives for actors to increase emissions. There is also evidence that grandfathering can result in higher transaction costs than auctioning (Bergmann et al., 2005).

No allocation

The difference to auctioning is that there are no designated allowances created for the sector. Instead the actors would have to by allowances at the open market. Naturally, this allocation option could not be applied for the entire trading scheme, but is only an option for a limited number of sectors in a larger system.

3.7 Policy options

In general, transaction costs, market structure and political feasibility are critical factors affecting the choice of policy instrument (Stavins, 1995).

Transaction costs in the permit market are important for performance. Higher transaction costs tend to reduce trade and raise permit prices; hence increasing total abatement costs.

Tradable emission permit (TEP) regulations are sensitive to strategic behaviour and can create barriers to entry. The success of a TEP thus critically depends on the market structure (Carlsson & Hammar 2002). There are a number of design issues for decreasing the possibility of strategic behaviour, such as auctioning of permits instead of grandfathering.

Ironically, these design issues are also important for the political feasibility. Grandfathered permits are much more likely to be accepted by many of the actors than auctioned permits or emission charges. Finally, the importance of a functioning market with small possibilities of strategic behaviour also directs the attention to the benefits of allowing trading of permits across sectors and countries if a TEP scheme is chosen. Effectiveness of the regulation increases with the number and size of the permit market.

The consequences of combining emissions trading with a tax are analysed in the chapter 4.

3.8 Type of trading scheme

There are two distinct types of emissions trading systems, cap & trade (C&T) and baseline & credit (B&C). The current EU ETS is a cap & trade system. In a cap & trade system a cap (limit) is set for the emissions and the emission allowances (which equals the amount of emissions set in the cap) can be traded. The major advantage with a cap & trade system is that the emission level within the trading sectors will be known. Especially if the environmental goal is set as an emission level this is very important.

In a baseline and credit (B&C) system a pre-determined emission profile (a baseline) is allocated to every participant. The unused portion of this baseline (so called emission credits) can be banked or traded to other participants exceeding their emission baseline. If the emissions are greater than the baseline, some B&C systems require the emitter to buy credits from other participants while some do not. In a way the baseline and credit system therefore results in trading of emission savings rather than emission allowances as is the case with a cap and trade (C&T) system such as the EU ETS. It is therefore not trivial to link a B&C system to a C&T system. The baselines can be set e.g. by considering historical emissions or predicting future emissions (absolute baseline) or by determining a performance standard, such as emissions per production unit (relative baseline). To ensure overall reductions in a system with absolute baseline, the baselines must be designed to result in declining emissions. For that reason, the baselines are normally below the business as usual scenario. The principle of such a B&C system is shown in Figure.3.1. If participants exceeding their baselines are not obliged to compensate for the higher emissions, the overall emissions will not be fixed even if baselines are given in absolute terms.

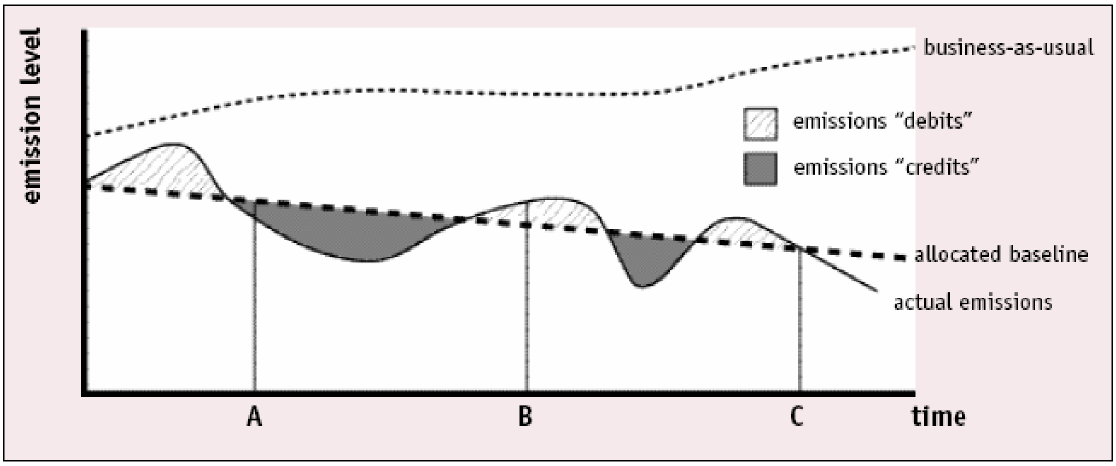

Figure.3.1. Illustration of a baseline and credit system (Australian Greenhouse Gas Office 1999)

In the case of setting a relative baseline according to a performance standard, the total emissions cannot be known from the beginning, since the output (amount of production units) is unknown. In that case the y axis in Figure.3.1 should be relative emission level or level of emission performance instead of emission level.

The baseline & credit principle is used in two of the flexible mechanisms in the Kyoto protocol: the Clean Development Mechanism (CDM) and Joint Implementation (JI). An advantage with this kind of system is that a reduction of a future increase in emissions can be financed through generation of tradable permits, and that it allows for no-lose targets (that is, actors can get the possibility to earn permits, without risking punishment for non compliance with a set cap).

A baseline & credit system could also be a solution in cases where it is hard to set an absolute cap or quantify the reductions. For example, baseline & credit could be a possibility if car manufacturers would be the trading entity in the road transport sector (see further discussion in chapter 5).

Most of the discussion and analysis made in this study concerns cap & trade systems, since it deals with the question of how to link an ETS for the transport sector to the current EU ETS. However, a review of the literature, and as demonstrated by Boemare et al. (2003), it is not without problems to define cap & trade and baseline & credit unambiguously. Indeed, according to UNCTAD (1998), the specificity of a 'baseline & credit system (Boemare & Quirion 2002) is 'to be project-based'. This can be compared to the way Boom & Nentjes (2002) define credit trading, 'there is no need for abatement projects to create credits' but credits are expressed in unit of pollutant per unit of output. For Tietenberg (1999), a 'credit' system 'is typically denominated in terms of a pollutant flow such as tons/year'. For Rosenzweig et al. (2002), the key distinction is that in a 'baseline-and credit' system, the seller does not necessarily have an emission cap.

Cap & trade for the transport sector

In general there is a focus on cap & trade emissions trading schemes for the transport sector. One reason might be the sector's increasing emissions and the need for an actual limit. If for example a trading scheme (which would be a baseline & credit system) with an efficiency target for the car making industry were to be used, it would be more difficult to foresee how large the actual emissions from the sector would be. There is also the argument that linking (or including) the emissions trading scheme for the transport sector to the current EU ETS will increase the effectiveness of both schemes and this will be easier if both are cap & trade schemes.

Baseline and credit for the transport sector

Among others, Klooster et al. states that a B&C system for the transport sector is the best option for regulating relative performance related emissions (e.g. g/km). As a result, the system is preferably designed with the vehicle manufacturers as trading entity. End consumers could be an alternative for some transport sub sectors (such as maritime shipping), while for others the number of trading entities would be very high and the system hard to verify, monitor and implement. A B&C system for the road transport sector with car manufacturers as the trading entity would stimulate technological development towards low-emitting vehicles, and would be relatively easy to implement, since monitoring and verification procedures are already available and the number of parties are limited. Therefore, the system also ought to have limited administrative and transaction costs. However, such a system has only limited influence on the total emissions as it would not significantly influence vehicle use. Furthermore, it would not stimulate other mitigation measures such as driving less or applying eco-driving. There would also be a significant time lag in the system since it would only affect new vehicles and thus, it will take time before an effect on the whole vehicle fleet can be seen. In contrast, a C&T system directly stimulates eco-driving, leaving the car at home, more fuel efficient vehicles etc.

In a B&C system the environmental outcome is uncertain (no matter how high the price for credits is people could still drive as much as, or more than, before), but the maximum costs for the consumers are known. This is exactly the opposite compared to C&T, where the environmental outcome is known, but the costs are unknown since they are depending on the price of emission allowances.

A European B&C system with vehicle manufacturers as the trading entity would be a viable option for passenger cars and perhaps also for light commercial vehicles. For heavy duty vehicles it could be possible, if standardised CO_2 emission tests were developed. The same is true for marine shipping, but the system would also need to be widened to include ship builders outside the EU, since there otherwise would be a great risk for distortion in competition between ship builders in the EU and non-EU ship builders and a risk for evasion (EU ship builders moving to non-EU countries) number of ship builders in EU is too small to result in an efficient B&C system. When it comes to the aviation sector, the total number of manufacturers is too low to be an efficient option even for a global system, but B&C with aircraft operators as the trading entity could be possible. One question to address though is how to compensate for different load. In addition, there is a risk of stimulating odd solutions to lower the emissions per passenger-km, such as letting people join flights for free. Klooster et al. concludes that, for the aviation sector a C&T system would be less costly and more efficient in reducing emissions.

National vs. European system

A baseline and credit system with vehicle manufacturers as the trading entity is not suitable for national schemes for two reasons. Firstly, it would be prohibited according to the EU rule regarding free movement of goods (Klooster et al.). Secondly, the vehicle manufacturing market in a single country is probably too small for efficient adaptation to new production lines and therefore the influence on the manufacturers would be limited (Klooster et al.). All in all, since B&C is mostly suitable with vehicle manufacturers as the trading entity, it could only be used separately in every sub sector in the transport sector, and is not suitable for national schemes. The only way of introducing such a system would be a common system for the whole EU applied separately to those sub sectors possible today (passenger cars and maybe light duty vehicles).

Fitting into the Kyoto Protocol

If it was possible to apply a B&C system with an absolute baseline, and this was to fit into the Kyoto Protocol (or other commitments), the total sum of baselines allocated to the participants would have to be consistent with the target set by the Kyoto Protocol (or other commitment). However, some observers claim that for countries with commitments under the Kyoto Protocol, it could be inconsistent with the frameworks set by the Kyoto Protocol, to adopt a B&C system. The reason for this would be that article 17 of the Kyoto Protocol states that "Parties may participate in emissions trading for the purposes of fulfilling their (emission) commitments." This means that each party with an emissions commitment can be trading with other parties. It is further required that any such national or regional emissions trading system should be integrated as seamlessly as possible into the international trading system. One could therefore claim that to be able to fulfil these requirements any such national/regional system has to be C&T. Otherwise, there might be inconsistencies between the national/regional frameworks and those set by the international climate policy framework (such as the Kyoto Protocol) that could result in impediments to open trading.

A summary of the advantages and draw-backs of a baseline and credit systems applied to the transport are given below:

Advantages of baseline & credit

- A baseline & credit system can be easier to implement than C&T, at least for manufacturers of passenger cars and possibly light duty vehicles as well, since monitoring and verification procedures are already available. This does not apply to other sub sectors.
- B&C systems can offer low administration and transaction costs. Of course this depends on the number of parties, but with vehicle manufacturers as the trading entity the number of parties would be limited which would give low administration and transaction costs.
- Baseline and credit systems with vehicle manufacturers as the trading entity stimulate technological development and shift towards fuel efficient vehicles.
- If vehicle manufacturers are chosen as the trading entity, baseline and credit systems are in principal the only option, because at that level no information on total emissions could be known and therefore it is difficult to use a C&T system.
- An ambitious B&C system can be more efficient than a C&T with a low ambition, but still, the outcome will not be known from the beginning (at least not with vehicle manufacturers as the trading entity).
- B&C systems offer a way to set targets for sectors (such as the transport sector) that are not included in a trading system or for sectors hard to include in a cap and trade system.
- B&C systems could possibly be used in a transitional period before entering another trading system.

Drawbacks of baseline & credit

- Final emissions are not known from the beginning.
- Only emissions above the baseline require credits (compare C&T: ALL emissions have to be covered by allowances, and all emissions above the allocation require purchase of allowances).
- Competitiveness to car manufacturers outside the system might be negatively affected.

- The system would probably be difficult to apply to the whole transport sector (if that is desired).
- A B&C system with car manufacturers as trading entity does not stimulate use of alternative fuels, eco-driving or taking the bus/train/subway instead. It only stimulates development of fuel efficient vehicles.
- The system may be evaded either by importing old cars or by postponing the shift to new fuel efficient cars.
- It takes some time before a B&C system with vehicle manufacturers as trading entity shows effect, as it is only influencing new vehicles and it will take some years before the whole fleet is affected.
- In principle, a B&C system for the transport sector could only be used effectively with vehicle manufacturers as trading entity.
- A B&C system can be difficult to link to the EU ETS.
- Methodologies and institutions for setting baselines do not exist. Setting up and implementing those will increase administrative and transaction costs.
- The system is not suitable for national schemes. Since this study has a European scope this disadvantage is of minor importance, but is still an interesting conclusion.

3.9 Climate goal

The climate goal should not be regarded as a design parameter but rather as the overall objective of the environmental instrument according to which the other parameters should be chosen. This since the choices of many of the other parameters are dependent on the climate goal. As it is stressed in the EU climate strategy (EU COM 2005, 35) it is obvious that we face much larger emission reductions in the future than what is outlined by the Kyoto Protocol. It is also stated that the longer we wait with reductions the larger the risk of irreversible climate changes.

Emission target for the EU

The EU Resolution on Winning the Battle against Global Climate Change EU 2005/2049 (INI), states that the EU strategy on Climate Change mitigation should include undertaking emission reductions of 30% by 2020. In a press release from the 17th of November 2005 this goal was specified as “undertaking strong emissions reductions at home, starting with 20-30% domestic reductions by 2020” (compared to 1990). “Domestic reductions” imply that these reductions exclude the use of CDM and JI credits to reach the target. This goal can also be achieved by using a combination of market incentives and regulation to stimulate investments in efficiency and/or carbon-free and low-carbon technologies. 30% reductions by 2020 will require changes in most sectors, if not all. It is also probable that even further reductions will be required after 2020 and most sectors should be targeted at developing methods of less greenhouse gas intensive technology and other solutions. For this reason it might be appropriate not to set specific targets for the different sectors but to let costs and technological development decide in which sectors the largest reductions can be achieved. This would point towards an open (integrated) ETS for as many sectors as possible. However, the political goal is of great importance when choosing what instrument should be used (Bergmann et al. 2005); if the goal is cost effectiveness, an expanded

ETS might be the best alternative, but if it is a certain reduction target for the transport sector itself other instruments might be more suitable.

The climate target, which can be translated into an emission target, depends on the chosen time frame. The focus of this project will be the third trading period of the EU ETS, i.e. 2013-2017. Reductions by 2015 (in the middle between 2013 and 2017) will, assuming linearity, be 7-12% from 2010 years level. In this study 10 % domestic reduction between 2010 and 2015 is assumed (15.5% reduction compared to 1990 levels).

Emission target for trading sectors

The section above specifies a reduction target for the domestic emissions in EU. However, it does not specify the emission reductions for different sectors, sub sectors or different climate gases. This means that different sectors can still have different reduction targets. As discussed in chapter 4 there might be reasons to for instance limit the reductions in the industry sector whereas the transport sector should take on larger reductions. Up until now the sectors included in the EU ETS has taken on a larger reduction burden than other sectors, such as the transport sector, that are not included in the trading scheme.

Another question which is not included in the definition "domestic reductions" is the reduction target for the international bunker fuels (international aviation and maritime shipping). In this study the emission reductions for these sources are set to 10% between 2010 and 2015 (just as for the rest of the transport sector) with whatever definition of the transport sector is used.

3.10 Time perspective

Since there is little time left for adjustments in the EU ETS before the second trading period 2008-2012 we find it unlikely that the transport sector could be included before 2013. However, the inclusion of the aviation sector has been investigated in detail and it is still likely that it could be included at least during the second trading period 2008-2012 although no formal decision has been taken yet (2006-11-21). Since the other sub sectors of the transport sector have not been investigated in such detail it is not probable that these sectors will be included before the trading period 2013-2017. These are the main reasons for us to choose the period 2013-2017 as the time frame in this study.

4 Effectiveness of various ET-schemes for the transport sector and distribution of costs

In this section we perform a graphical analysis of various options for including the transport sector in an ETS and what the consequences will be on allowance price, total costs and the distribution of these costs on the different actors. In all cases except one (case 6), emissions trading replaces carbon taxation in the included sectors:

Seven cases are studied:

1 **Reference case:** the transport sector is not included in the EU ETS. The CO_2 tax from 2008-12 is increased so that a 10% reduction in the transport sector is achieved compared to emissions in 2008-12. In the EU ETS the cap is reduced by 10% compared to emissions 2008-12.

2. **Separate systems.** In the transport sector, the CO_2 tax is removed and replaced by a transport specific emissions trading system, with no linkage to the EU ETS. The industry is in a separate ETS as in the reference case. In both the transport ETS and the industry ETS the caps are set at 90% of emissions 2008-12.

3. **Integrated systems**. The transport and industry sectors are in the same ETS. The cap is set at 90% of emissions 2008-12. The CO_2 tax in the transport sector is removed. All allowances are auctioned.

4. **The role of free allocation versus auction.** This case is analogous to case 3, but with the difference that allowances corresponding to 90 % of the emissions in 2008-12 are issued to industry at no cost. For transports allowances are auctioned as in case 3.

5. **The role of size of the transport sector**. In the other cases, the transport sector is assumed to be the same size as the industry sector. In this case we assume that the size of the transport sector is 10% of the size of industry. This is motivated if a part of the transport sector would be linked to the EU ETS, for instance aviation, shipping or goods only.

6. **Hybrid system**. Transports and industry are in the same ETS. The cap is set at 90% of emissions 2008-12. However, in addition to emission allowances we assume that a CO_2 tax of 100€/ton is applied to the transport sector.

7. **The role of the marginal abatement costs for the transport sector.** This case is analogous to case 3, but with the difference that the MAC-curve for transportation is 50% lower than in the other cases.

These scenarios are analysed with respect to:

- Price of allowances,
- Distribution of emissions/abatement,
- Distribution of costs for industry, transport sector and for the state,
- Total social costs for reaching the climate target
- Consequences for marginal abatement costs and operating costs.

Marginal abatement cost curves used and other assumptions

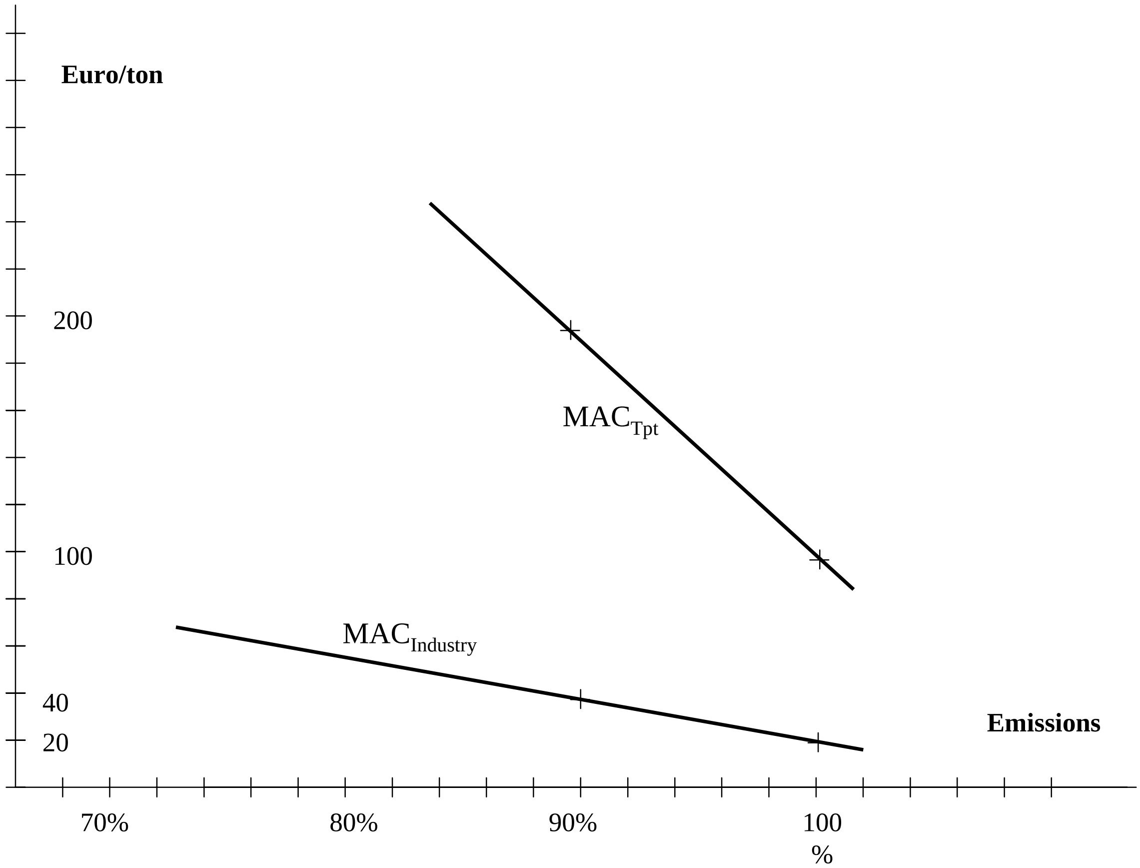

Figure 4.1 MAC-curves for industry and transport, used in graphical analysis.

For the graphical analysis, we assume the following MAC-curves for transport and industry:

- Industry MAC: At 100% of 2008-2012 emissions the abatement costs are 20 €/ton. At 90% of current emissions the abatement costs are 40 €/ton.
- Transport sector MAC: At 100% of 2008-2012 emissions the abatement costs are 100 €/ton. At 90% of current emissions the abatement costs are 200 €/ton.

We assume that allowances are auctioned both to industry and transports. In case 4 we investigate the effect of allowances being issued free of charge to the industry. Further we assume that the industry and transport sectors are equal in size. This is a simplification, but makes the analyses easier. In case 5 we investigate the consequences if the transport sector is much smaller than the industry.

Underpinning of the marginal abatement cost curves

For the analysis, we assume that for a given reduction, the marginal abatement costs for the transport sector are always higher than for industry, at least down to 25% reduction volumes. Even if this assumption appears likely, at least for low abatement levels, it is important to underpin this assumption with observations since it is crucial for the results.

Table 4.1 Percentage emissions reductions and costs in the transport and industry sectors.

	Transport	Mineral	Refineries	Energy
Cost (SEK)	Reduction (%)	Reduction (%)	Reduction (%)	Reduction (%)
<100	0.324	1.25	10	15
<300	0.336	1.96	22.5	50
<400	0.396	3.55	-	51
<800	0.475	4.46	-	67

Adapted from Bates et al. (2001), Stripple et al. (2005), Holmgren & Sternhufvud (forthcoming) and Särnholm (2005). 1 SEK = 0.11 €.

Table 4.1 brings together the percentage of emission reductions and their costs in the transport and in three different industry sectors. The figures for the transport sector are based on simulations using technical measures to reduce emissions from petrol cars in EU15 (Bates et al., 2001). For the industry sector the figures are based on calculations to reduce emissions in the Swedish mineral-, refinery and co-generation sectors. Note, however that including non technical measures may reduce the abatement costs in both sectors. These costs are not included in the table.

As shown in Table 4.1, the sensitivity of emission reduction to cost variation is higher in the transport sector compared to different industry sectors. In the transport sector a shift in costs from 100 SEK to 300 SEK leads to a 0.012 percent emission reduction. In the industry sector the same shift in costs from 100 SEK to 300 SEK leads to an emission reduction of 0.71% in the mineral sector, 12.5% in the refinery sector and 35% in the energy sector. Hence this supports the assumption that abatement costs in the transport sector are significantly higher than in the industry sector.

Our assumption that marginal abatement costs for transportation are higher than for industry can also be supported by studying tax levels for transport and industry. Tax levels create incentives for abatement as long as the marginal abatement costs are lower than the tax levels. Under perfect market conditions, including for instance perfect information and no capital constraints, we would expect that levels of marginal abatement reflect tax levels. Even if we are not assuming perfect market conditions, we suggest that tax levels at least roughly indicate the marginal cost of abatement.

For industry, the most important EU wide CO_2 tax is the cost for emission allowances. These have ranged from 8-33 €/ton CO_2 during the period 1 Jan 2005 to 31 Oct 2006 (Ellerman & Buchner, forthcoming). For the transport sector, fuel taxes in the 15 EU member states ranged in November 2000 from 150 to 323 €/m^3 for gasoline and from 246 to 751 €/m^3 for diesel (Kågeson, 2001). These taxes were not exclusively CO_2 taxes, but would correspond to 150-323 €/ton emitted CO_2 for gasoline and 94-288 €/ton emitted CO_2 for diesel. This information shows that tax levels in transportation are an order of magnitude higher than for industry throughout the EU, which supports the assumption that marginal abatement costs are higher in transportation than in industry.

However, for higher abatement levels, the uncertainty increases. In industry, for high abatement levels, say at 30-50 %, it may well be the case that abatement costs will increase significantly, since an important part of the industrial emissions are associated with chemical processes such as cement production, steel production and mineral oil refining. We have not been able to assess abatement costs at these high reduction levels and compare them to abatement costs in the transport sector.

4.1 Case 1. Reference case. Transport sector outside the EU ETS and with a strengthened CO2 tax

In this case the industry cap is 90% of current emissions and allowances are auctioned. The transport sector is not regulated through an ETS, but through a strengthened CO_2 tax. This tax is set at a level so that 10% emissions reduction is obtained.

In order to simultaneously compare the results, the MAC-curves for industry and transport are shown in the same diagram (figure 4.2). The industry MAC curve is positioned so emissions increase to the **right**. The transport MAC curve is flipped so emissions increase to the **left**. The two curves are aligned so the 90% emissions levels coincide. Since both sectors are assumed to be the same size (in terms of emissions), any point on the x-axis corresponds to total emissions (for both sectors) that are 90% of total emissions 2008-12. The coloured fields in the graph illustrate the different cost components, where the size of the fields is proportional to the costs. We use the unit (€/ton)*(percentage of total emissions) to quantify the costs.

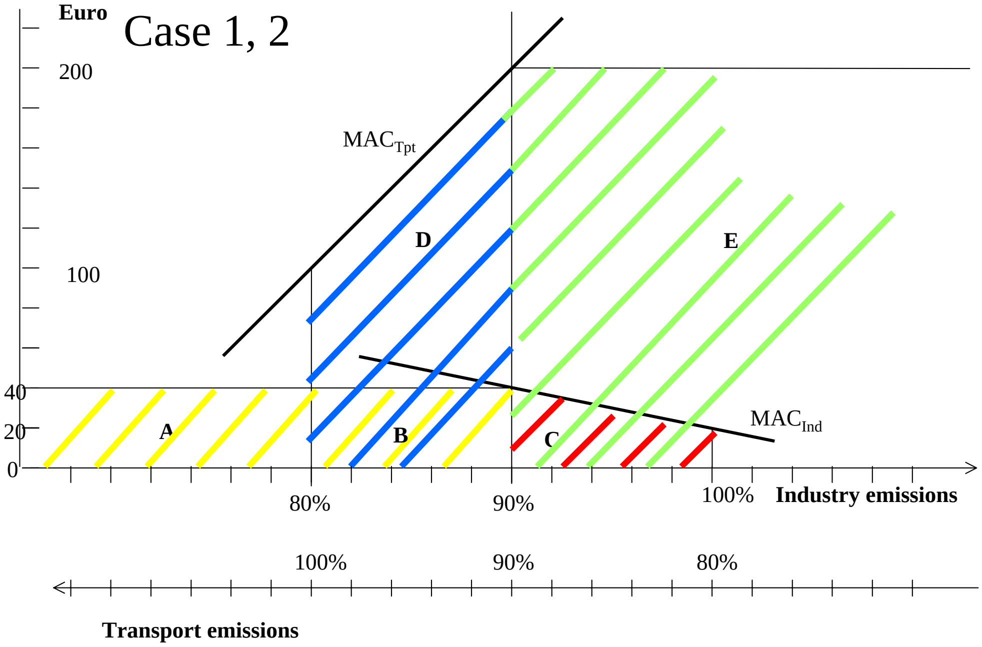

Figure 4.2 Graphical illustration of estimated costs for abatement and allowances/taxes for industry and transport assuming different marginal abatement costs. Case 1 and case 2: industry and transportation are in separate systems. Field C (red) illustrates abatement costs for industry, field AB (yellow) allowance costs for industry, field B (blue) abatement costs for transportation and field (CE) costs for allowances/taxes for transportation. Please refer to text for further explanations of conditions and methodology.

Results

For the industry, allowance price is 40 €/ton, emissions are 90%, abatement costs are 300 units (area C (red) in the figure), costs for acquired allowances 3600 units (area AB (yellow)) and total costs AB+C= 3900 units. For the transport sector, the tax level is 200 €/ton, emissions are 90%, abatement costs are 1500 units (area BD (blue)), costs for CO_2 tax 18000 units and total costs BD (blue)+CE (green)=19500 units. The state revenues, through auctioned allowances and CO_2 tax are AB (yellow) + CE (green)=21600 units. Total social costs are BD (blue)+C (red)=1800 units.

4.2 Case 2. Transport sector in a separate ETS

In this case, transport and industry have separate caps. Allowances can be traded within caps but not between caps. The industry cap is 90% of current emissions and allowances are auctioned. The transport cap is 90% of current emissions and these allowances are auctioned.

Results

The results are in fact identical to the reference case. The price of allowances/taxes, the distribution of emissions reductions, the industry costs, the transport costs, the state revenues and the total costs are identical as in the reference case. The only difference is that instead of a CO_2 tax, the transport sector will pay for allowances but at the same rate as the previous tax.

4.3 Case 3. Transport and industry sectors in a common ETS, auctioning of allowances

In this case, transport and industry lie in a common ETS and trading of allowances is possible. The total cap is 90% of current emissions. Allowances to industry and transport are issued by auction, corresponding to 90% of emissions 2008-12. There is no CO_2 tax on transportation.

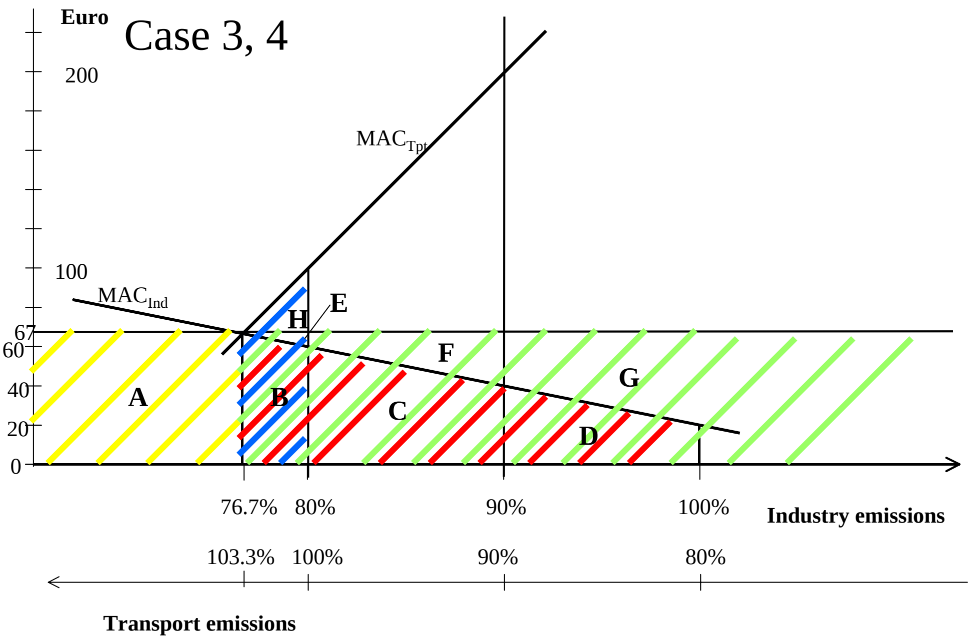

Figure 4.3 Graphical illustration of estimated costs for abatement and allowances for industry and transport. Case 3: industry and transportation are integrated in the same emissions trading system. Please refer to the text for an explanation of the different components in the graph.

Results

For both the industry and the transport sector the allowance price is 67 €/ton as compared to 40 €/ton for industry and 200 €/ton for transportation in the reference case.

Industry emissions are 76.7 %, as compared to 90% in the reference case. Abatement costs are 1011 units (BCD (red)) and costs for acquired allowances are 5111 units (A (yellow)). Total compliance costs (abatement +allowances) in industry are BCD+A= 6122, as compared to 3900 units in the reference case.

For the transport sector, emissions are 103.3%, as compared to 90% in the reference case. Abatement costs are negative at -278 units (BEH (blue)), and costs for allowances 6889 units (BCDEFG (green)). Total costs for transportation are BCDEFG-BEH= 6611 units, as compared to 19500 units in the reference case. The state revenues, through auctioned allowances, are ABCDEFG =12000 units, as compared to 21600 units in the reference case. Total social costs are BCD-BEH= 733 units as compared to 1800 units in the reference case.

4.4 Case 4. The role of free allocation versus auction

This case is analogous to the previous case, but with the difference that industry receives allowances at no cost, and can trade these or use them.

Results

The analysis can be done in the same graph as in case 3, where the freely allocated allowances are represented by the field ABCEF in the graph. In spite of the free allocation, the level of abatement in industry is unchanged. This means that the industry sector will abate down to 76.7 % of emissions, as in case 3 and sell the surplus of allowances to the transport sector. As in case 3, the allowance price in both the industry and the transport sector is 67 €/ton. Revenues from acquired allowances will be ABCEF = 6000 units so total compliance costs are 6122-6000= 122 units as compared to 6122 units in case 3 with auction. The state revenues, through auctioned allowances to transportation, are DG =6000 units as compared to 12000 units in the case with auction. Total social costs are BCD-BEH= 733 units which is the same as in a fully integrated system.

In conclusion, if allowances to industry are issued freely, the revenues from sold allowances to the transport sector will be important. If we compare this case with the previous case (3) where allowances were auctioned to industry, we can see that free allocation to industry will significantly decrease the total costs for this sector. However, the price on allowances is unchanged and so is the sectoral emissions and distribution of carbon reductions.

4.5 Case 5. The role of size of the transport sector

In this case, industry and a small part of transport lie in a common ETS. The transport sector is assumed to be 10% of the industrial sector. Allowances to industry and transport are issued allowances through auction, corresponding to 90% of emissions 2008-12. There is no CO_2 tax on transportation. This scenario reflects a case were parts of the transport sector is included, for instance commercial road transportation, aviation or shipping. An issue here is what MAC-curve to use for this case. We have not been able to investigate what MAC-curves to use for these potential sub-sectors. For simplicity, we here assumed that MAC-curve for transportation has the same characteristics as in earlier cases.

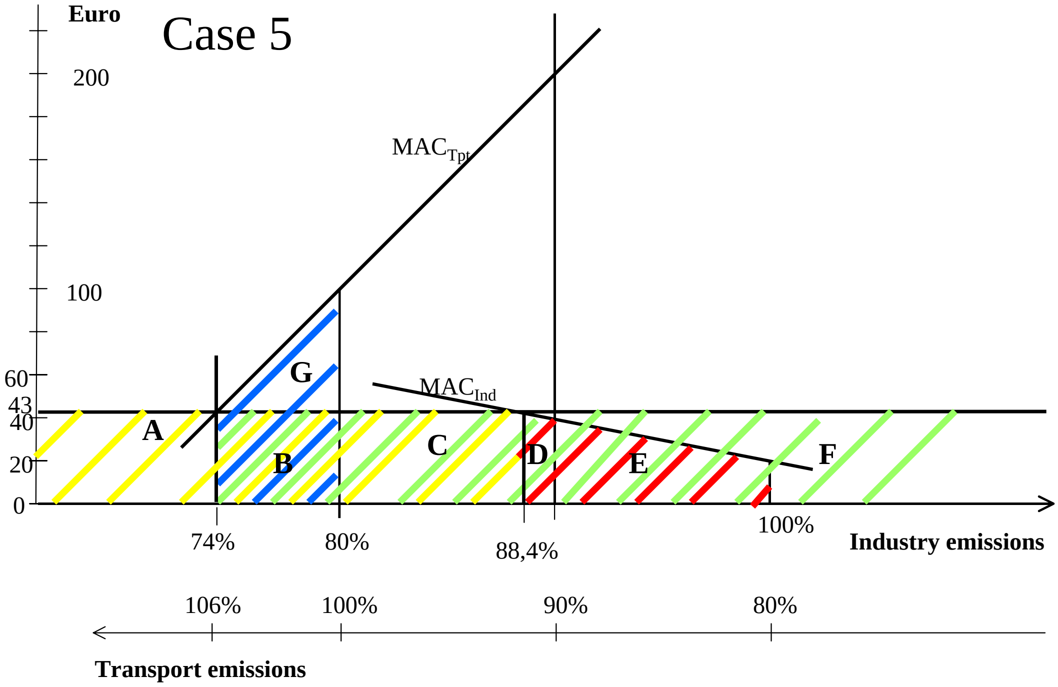

Figure 4.4 Graphical illustration of estimated costs for abatement and allowances for industry and transport. Case 5: The role of size of the transportation sector. We here assume that the size of the transport sector is 1/10 of the industry sector. Please refer to the text for an explanation of the different components in the graph.

Results

The result is illustrated in Figure 4.4. Industry will abate down to ca 88.4 % of current emissions. This will provide the necessary 10% reductions for industry, and additional 1.6 % reductions that will be sold to transportation. Since the transport sector is only 10% of the size of industry, this 1.6% emission reduction in industry allows transportation to increase emissions 16% above the emission target of 90% corresponding to 106% of current emissions. Allowance price will be 43 €/ton as compared to 40 €/ton in the reference case or 67 €/ton in a fully integrated system (case 3).

For industry, emissions are 88.4 % as compared to 90% in the reference case or 76.7% in an integrated system. Abatement costs are 365 units (DE (red)) and costs for acquired allowances are 3814 units (ABC (yellow)). Total compliance costs (abatement +allowances) in industry are DE+ABC= 4180 units, as compared to 3900 units in the reference case or 6122 units in a fully integrated system.

For the transport sector, emissions are 106%, as compared to 90% in the reference case or 103.3% in a fully integrated system. Abatement costs are negative at -41 units (BG (blue)), and costs for allowances 456 units (BCDEF (green)). Total costs for transportation are BCDEF-BG= 415 units. If we scale this figure by a factor 10 so the size of the sector is equal to the size of the transport sector in the other cases, the total costs correspond to 4152 units, as compared to 19500 units in the reference case or 6611 units in a fully integrated system.

The state revenues, through auctioned allowances, are ABCDEF =4270 units. Total social costs are BE–BG = 324 units.

In conclusion, we see that linking a minor part (10%) of the transport sector to the EU ETS, will lead to a significantly lower impact than if the whole transport sector is linked. Emissions for industry will decrease somewhat, while emissions from the transport sector will increase significantly, even more than in a fully integrated system. Total compliance costs will increase somewhat for industry and decrease dramatically for the part of the transport sector included in the ETS. It should be noted that the results should be seen in the light that we have not been able to determine MAC-curves for the sub-sectors aviation, shipping or goods.

4.6 Case 6. Hybrid system with a sustained tax in the transport sector

We have also investigated a case were we keep a CO_2 tax of 100 € in the transport sector and include transportation in the EU ETS. The detailed analysis is presented in appendix 1 with conclusions re-iterated here.

Results

With a hybrid system, allowance price will be 50 €, as opposed to 40 € in a separate ETS and 67 € in an integrated ETS.

For industry, emissions are 85%, as compared to 90% in the reference case or 76.7% in a fully integrated system. With auction, total costs for industry are 4775 units, compared to 3900 units in a separate system and 6122 units in an integrated system. With free allocation, total costs for industry are 275 units in a hybrid system, as compared to 300 units in a separate system and 122 in an integrated system.

For the transport sector emissions are 95%, as compared to 90% in the reference case or 103.3% in a fully integrated system. Total costs for transports in a hybrid system will be 14875 units, as compared to 19500 units in a separate system and 6611 units in an integrated system. State revenues in a hybrid system, assuming auctioned allowances will be 18500 units, as compared to 21600 units in the reference case or 12000 in an integrated system. Total costs on society with a hybrid system will be 1150 units, as compared to 1800 units in the reference case and 733 units in an integrated system.

In conclusion, with a hybrid system as described above, where the transport sector is fully integrated with the EU ETS but with the tax level sustained, the impacts on allowance price and cost distribution can be moderated. Allowance price, emissions and costs will lie in between the cases with separate systems (case 2) and a fully integrated system (case 3).

4.7 Case 7. The role of marginal abatement costs in the transport sector

In this case, we investigate the importance of the marginal abatement cost curve for the transport sector. There are a number of alternative cost curves that could be studied. In this report, we have studied one option, where we assume a MAC-curve for the transport sector with 50% lower abatement costs than in the previous cases. We assume that at 100% of emissions, the marginal abatement costs are 50 €/ton as compared to 100 €/ton in the previous cases. Further, we assume that at 90% of emissions the marginal abatement cost is 100 €/ton as compared to 200 €/ton in the previous cases. Still, we assume that for a given reduction, the transport abatement costs are always higher than the industrial abatement costs, at least down to 80% emission levels.

Apart from the changed transport MAC-curve this case is analogous to case 3. We assume that transport and industry is integrated in a common ETS, allowances to industry and transport are issued through auction, corresponding to 90% of emissions 2008-12 and that there is no CO_2 tax on transportation.

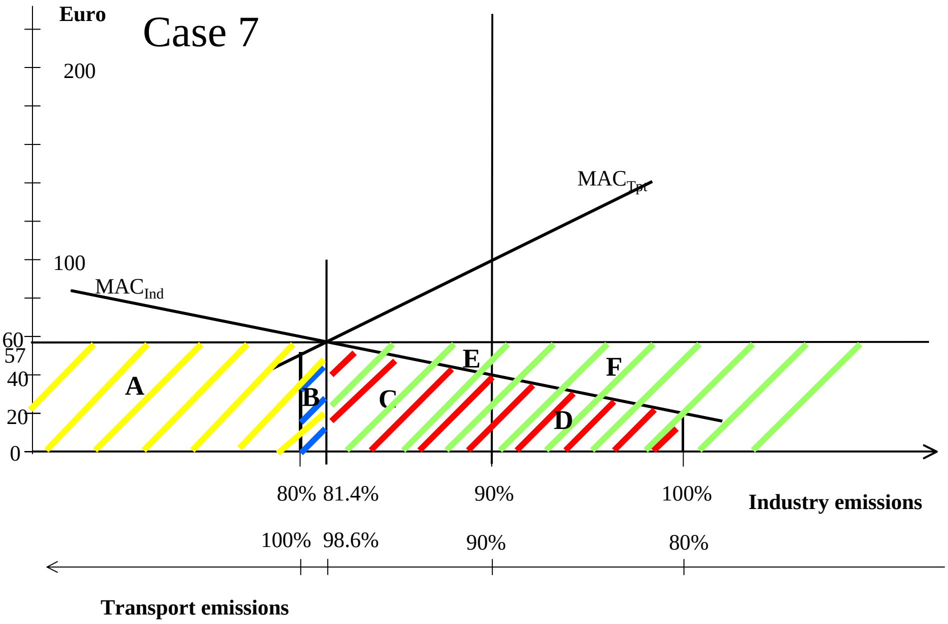

Figure 4.5 Graphical illustration of estimated costs for abatement and allowances for industry and transport. Case 7: The role of the marginal abatement costs for the transport sector. We here assume that the marginal abatement costs for the transport sector are 50% of the previous cases. Please refer to the text for an explanation of the different components in the graph.

Results

With a moderate MAC-curve for transportation, allowance price will be 57 €, as opposed to 40 € in a separate ETS (industry) and 67 € in an integrated ETS.

For industry, emissions are 81.4 %, as compared to 90% in the reference case or 76.7% in a fully integrated system. Abatement costs are 716 units (CD (red)) and costs for acquired allowances are 4653 units (AB (yellow)). Total compliance costs in industry are 5369 units, as compared to 3900 units in a separate system and 6122 units in an integrated system.

For the transport sector, emissions will be 98.6%, as compared to 90% in the reference case or 103.3% in a fully integrated system with our previous MAC-curve. Abatement costs are 77 units (B (blue)) and costs for allowances are 5633 (CDEF (green)). Total costs for transports will be 5709 units, as compared to 6611 units in an integrated system with our previous MAC-curve. State revenues, assuming auctioned allowances will be 10286 units, as compared to 12000 units in an integrated system with our previous MAC-curve. Total costs on society will be 793 units, as compared to 733 units in an integrated system with our previous MAC-curve.

In conclusion, in an integrated system, a MAC-curve for the transport sector that is closer to the MAC-curve of industry would reduce the impact on allowance price and costs for industry. However, compared to our reference case with separated systems the impacts would still be significant on industry. In a hypothetical case where the transport MAC-curve is very similar to the industrial MAC-curve, we expect there would be little difference between having an integrated trading system or separate systems.

4.8 Summary of results in cases 1 through 7

The graph below summarises the costs for the different cases

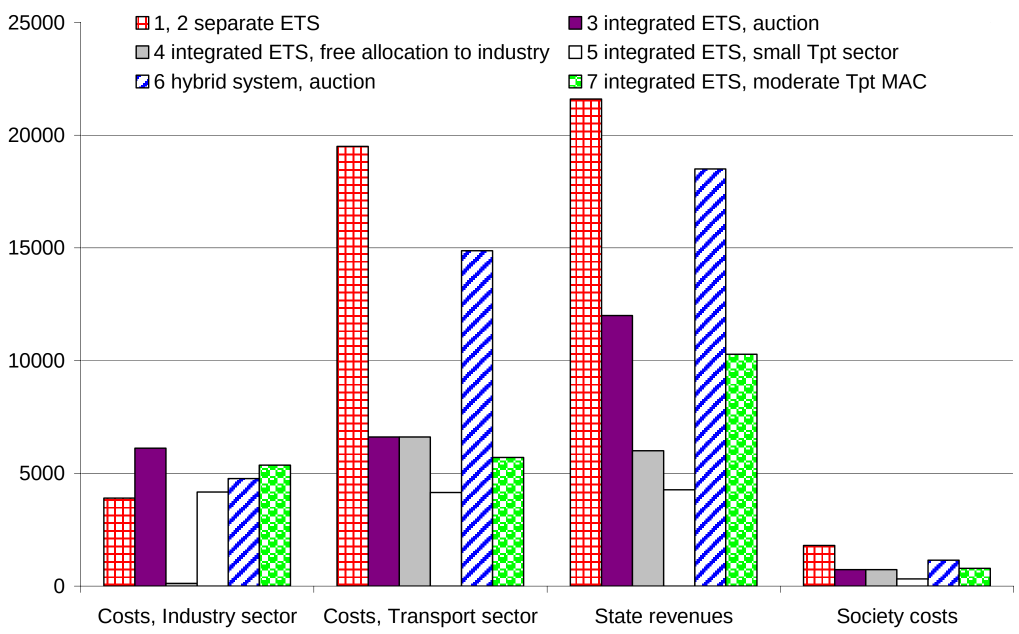

Figure 4.6 Summary of cost distribution for cases 1-6. For case 5 we have scaled up the transport costs by a factor 10 in order to make this value comparable with the other cases.

If the transport sector is fully integrated into a common ETS with industry, as opposed to having two separate systems, and assuming that abatement costs are higher for transports than for industry, we conclude that:

Allowance price in the ETS will increase; the cost of carbon emissions in the transport sector will decrease. Allowance price will increase, due to the transport sector buying allowances from industry thus increasing the demand for allowances. For transportation, however, the price on allowances will be considerably lower than the tax level necessary to achieve the 10% reduction in the reference case.

There will be significant changes in the distribution of emissions between sectors. In an emissions trading scheme reductions will take place where they have the lowest cost. Assuming that marginal abatement is cheaper in the industry sector, this sector will perform a larger amount of abatement than in the reference case and emissions in this sector will decrease. In the transport sector, emission reductions will be smaller than in the reference case and may even increase above the projected emission levels in 2008-12. Abatement will move from transportation to industry. Total emissions will remain unchanged, since this is a prerequisite for the study.

There will be significant changes in the distribution of costs. Compliance costs will increase significantly in the industry sector, mainly due to the higher price on allowances. Compliance costs for the transport sector will decrease considerably, which is mainly due to the sector being able to buy allowances at a much lower price than the tax in the reference case.

Impacts on industry may be significant. In the industry sector, regardless of allocation, the marginal operating costs, including the shadow price on allowances will increase. Price on electricity will increase in liberalised markets and for some industries this will constitute a double impact (higher price on allowances and on electricity). Production in carbon emitting industries will decrease and the EU may experience structural impacts such as closures and relocation of industry to countries outside the EU (carbon leakage). On the other hand, with a higher price on allowances, new carbon efficient technologies that previously have not been economically viable, such as certain renewable energy technologies may become profitable and may experience a market breakthrough.

Impacts on the transport sector may be significant. In the transport sector, with a significantly lower price on carbon emissions, fuels will become cheaper and marginal operation costs will decrease considerably. Ongoing carbon reduction programmes with relatively high abatement costs, such as low carbon fuel chains and CO_2- efficient vehicles, will become unprofitable. Transportation will increase at a considerably faster rate than in the reference case.

Total costs for compliance will decrease, if structural changes in the different sectors are not accounted for. For emissions trading systems in general, increasing the number of installations, sectors and gases will increase the number of available emission reduction options and hence decrease the total costs for achieving a given carbon emission target. We estimate with less certainty that integrating transportation in the ETS is likely to decrease the total costs for compliance, if structural effects are not accounted for. This is due to the differences in abatement costs between the sectors. Abatements that in the reference case were performed in the transport sector will instead be performed in the industry sector where abatement is cheaper. Structural changes, which are not accounted for in this study may include production changes, closures and relocation in the industry sector to countries outside the EU (carbon leakage).

Pressure on sectors outside the ETS will be lower. In the case of a future climate policy framework where nations have quantitative targets (like in the Kyoto Protocol) it may become easier for sectors outside the trading system to fulfil their emission targets since they will no longer compete with the growing transport sector for the available emission volumes in the non trading sector.

There exist other considerations than to lower total CO_2 emissions. The issue of how to control the transport sector clearly involves other considerations than to only minimise costs for reaching a climate target. Transportation is also responsible for other environmental impacts that today are, at least partly, controlled through fuel and CO_2 taxes. But apart from that, safeguarding a certain balance between industry and transportation may be an objective in itself. If so, it may be motivated to protect the industry and to constrain the growth of transportation, even if this may lead to higher total CO_2 compliance costs. If the tax instrument is removed from the transport sector it may become more difficult to control this sector specifically.

With free allocation to industry the distributional impacts on industry are reduced. Free allocation to industry will significantly decrease the total costs for this sector compared to if auctioning is applied. If 90 % of the allowances to industry are issued at no cost, industry will be able to sell allowances to the transport sector and these revenues will be important. If 100% of the allowances are issued at no cost to industry, the revenues from sold allowances will be higher than the total abatement costs for industry (since abatement costs for industry are always lower than the allowance price). Free allocation is therefore a powerful means for lowering the distributional impacts on industry if transport is included in the ETS.

Dynamic impacts on industry will still exist with free allocation. Free allocation will provide significant revenues to industry. However, the impacts on industry due to a higher allowance price are unchanged, including higher marginal production costs, decreased output, altered investments and closures of installations. The discussion of dynamical impacts on industry and transportation (as described in case 3) remain relevant. In the transport sector we expect lower fuel prices, increased transportation, increased emissions and that several current and planned CO_2-reduction programmes become unprofitable.

The sizes of the sectors are important. Linking a minor part (10%) of the transport sector to the ETS, for instance aviation, shipping or goods transports, will have a certain impact on allowance price compared to the reference case. However, this impact will be significantly lower than if the whole transport sector is linked. Emissions from industry will decrease somewhat, while emissions from the included part of the transport sector will increase significantly, even more than in a fully integrated system. Total compliance costs will increase somewhat for industry and decrease dramatically for the part of the transport sector included in the ETS.

A hybrid system may moderate the impacts on allowance price and cost distribution. In a hybrid system, where the transport sector is fully integrated with the EU ETS but with the tax level sustained within the transport sector the impacts on allowance price and cost distribution can be moderated as compared to if the tax is removed. Total costs for compliance, allowance price, emissions and distribution of costs will lie in between the cases with separate systems (case 2) and a fully integrated system (case 3).

Uncertainties in abatement costs may have an impact on our conclusions. Our analysis is strongly dependent on the assumption that marginal abatement costs are considerably higher in the transport sector than in the industry sector. For reasonably low levels of abatement, we have been able to support this assumption through data on abatement costs and by comparing the current tax levels on industry and transportation. We have also investigated the consequences on our results if the transport marginal abatement costs are 50% lower than assumed in our other cases, but still a factor 2.5 higher than for industry. In an integrated system this would reduce the impact on allowance price and costs for industry. However, compared to our reference case with separated systems the impacts would still be significant and our earlier conclusions would remain valid.

For large reduction levels the uncertainty in abatement costs increase. In the industry sector, for large abatement levels, say 30-50%, it may well be the case that abatement costs will increase significantly, since an important part of the industrial emissions are associated with chemical processes such as cement production, steel production and mineral oil refining. We have not been able to assess abatement costs at these high levels and compare them to abatement costs in the transport sector. If abatement costs at high abatement levels are higher in industry than in transportation, this may influence our conclusions. These uncertainties in impacts may be seen as an argument per se against integrating the whole transport sector into the EU ETS.

5 Road transport

5.1 Introduction

The total GHG emissions from the road transport sector account for approximately 18.3 % of the total GHG emissions in EU25, which is an increase from 13.6 % in 1990 (EEA, 2006). This increase has occurred even though the sector is subject to different policy instruments such as fuel taxes, vehicle taxes etc. The road transport sector is responsible for almost 93% of the carbon dioxide emissions in the transport sector (excluding bunker fuels[32]) (see Table 2.2). Including the bunker fuels the road transport sector account for about 72 % of the total transport CO_2 emissions[33].

The road transport sector can be divided into sub sectors according to Table 5.1. Passenger cars is the largest sub sector, however the emissions from lorries have a higher growth rate. Other road transports such as public road transport and motor cycles have only small proportions of the total road transport emissions and the share is predicted to decrease slightly until 2010.

Table 5.1: CO_2 emissions from the road transport sector for EU25 based on PRIMES34 (Mantzos & Capros, 2006). The numbers for 1990 differs slightly from the numbers in EEA (2006) due to adjusted definitions for calculating emissions.

CO_2 emissions from transport sector according to Mantzos & Capros (2006)	1990* Mton CO_2	1990* % of total	2005 Mton CO_2	2005 % of total	2010 Mton CO_2	2010 % of total
Passenger transport activity (road transport)						
Public road transport	23	3.4%	21	2.4%	20	2.2%
Private cars	402	59.7%	488	56.4%	478	53.6%
Motorcycles	5	0.7%	7	0.8%	7	0.8%
Freight transport activity (road transport)						
Lorries	243	36.1%	350	40.4%	386	43.3%
Total	**673**	**100%**	**866**	**100%**	**891**	**100%**
Change from 1990	0%		29%		32%	

[32] The bunker fuels are not included in the Kyoto-protocol.
[33] Assuming the same proportion of road transport in EU25 as in EU15.
[34] PRIMES is an economic partial equilibrium model for the European Union energy system developed and maintained at the National Technical University of Athens.

5.2 Design parameters

A general description of design parameters is given in chapter 3. In this chapter we focus on the possibilities to design an emissions trading scheme for the road transport sector only. The following design parameters are discussed:

- Coverage of greenhouse gases
- Geographic scope / interaction with Kyoto
- Trading entity and Monitoring and reporting
- Allocation

5.3 Coverage of greenhouse gases

Carbon dioxide accounts for more than 97% of the direct GHG emissions from the road transport sector according to EEA (2006) (see also Table 2.2). Since the amount of emissions of other greenhouse gases from the road transport are so small, focus should be on reduction of CO_2. Furthermore, many of the measures that reduce CO_2 emissions from this sector simultaneously also reduce other emissions such as CH_4 and NO_x.

5.4 Geographical scope / interaction with Kyoto

All emissions from road transports are attributed to the country where the fuel is bought. This means that for the road transport sector no division between national and international emissions are made and there are no problems with the interaction with the Kyoto Protocol. For most countries the accounted emissions correspond approximately to the amount emitted in the country. However, for small countries with fuel taxes different from the neighbouring countries, as Luxemburg, accounted emissions can be much higher than the amount emitted in the country[35] (Luxembourg's NAP, 2006).

5.5 Trading entity, monitoring and reporting

The emissions from the road transport sector are affected by actors in the fuel supply chain, by vehicle producers, and by the actors that affect the travelled mileage (Winkelman et al., 2000). All these actors can theoretically be chosen as trading entities. The options for trading entities included in this study are listed below:

A. vehicle owner
B. vehicle driver (who purchases the fuel). In many cases this is the same actor as the vehicle owner

[35] Approximately 75% of the fuel bought in Luxemburg is used abroad. The reason for this large bunkering of fuel by foreign drivers in Luxemburg is the lower fuel taxes.

C. transport buyer, the one that benefit from the transport or someone buying transportation services
D. filling station
E. fuel supplier
F. refinery
G. vehicle manufacturer.

The options of different trading entities have advantages and disadvantages that have been evaluated according to the following parameters:

- possibility to reduce emissions
- number of trading entities
- coverage of emissions
- monitoring and reporting
- transaction cost / administrative cost.

5.5.1 The vehicle owner (category A)

Possibility to reduce emissions

The vehicle owner can reduce emissions by considering fuel efficiency and possibility to use bio-fuels when buying a new vehicle and can improve the maintenance of the vehicle as mentioned for category B (vehicle driver). The vehicle owner has in many cases the opportunity to influence the vehicle driver (category B) to drive more fuel efficient, e.g. by educate her / him in eco-driving. The vehicle owner also in some cases has the possibility to convert the vehicle to a bio-fuelled vehicle.

Number of trading entities

According to SIKA (2006) there were 4.15 million passenger cars in use in Sweden in the end of 2005. 376 000 of these were owned by physical proprietors of non financial corporations[36] and 449 000 were owned by other corporations. The actual number of passenger car owners is less than 4.15 millions since some people (and especially many corporations) own more than one passenger car. We approximate the number of passenger car owners (or in this case trading entities) to 3 millions. The number of passenger cars in the whole EU25 is around 200 million (Gibbs & Retallack, 2006) and the total number of car owners in EU25 is approximated to 150 million (based on the assumption that the ratio between the number of cars and car owners is the same in EU25 as in Sweden).

In the end of 2005 there were about 460 000 lorries (including road tractors) in use in Sweden (SIKA, 2006). No statistics on how many lorries that exist in EU25 has been found but the number can be approximated to 20 millions by assuming the same ratio as between Sweden and EU25 for passenger cars (see the paragraph above). It is difficult to estimate how many vehicle owners (trading entities) there would be for lorries. Lorries are to a larger extent owned by companies and the companies often have more than one lorry. The Swedish transporting association statistics (2006) only include a small part of all lorries in Sweden but gives an indication of the number of companies that own lorries. The 37 000 lorries in Table 5.3 are owned by approximately 11 000

[36] In Swedish: Egna företag.

companies. Applying that ratio (11 000 / 37 000) on the assumed number of lorries in EU25 (20 million) give that the lorries in EU25 are owned by about 7 million companies.

In Sweden there were 13 500 buses in use in the end of 2005 (SIKA, 2006). With the same assumption of the ratio between the number of vehicles and owners as for lorries, the estimate is that there are 4 000 bus owners. The corresponding numbers for EU would with the same up-scaling as for passenger cars be almost 1 million buses and somewhat less than 200 000 bus owners.

The approximated numbers of vehicle owners in Sweden and EU25 are presented in Table 5.2.

Table 5.2: Approximated number of vehicle owners in Sweden and EU25.

1000 of owners	Passenger car owners	Lorry owners	Bus owners	Total owners
Sweden	3 000	140	4	3 144
EU25	150 000	7 000	200	156 300

Table 5.3: Distribution of lorries among transporting companies (Swedish transporting association statistics, 2006)

Number of vehicles / transporting company	Number of vehicles	
1	5 726	15.5%
2-5	11 345	30.8%
6-10	6 388	17.3%
11-15	3 209	8.7%
16-	10 193	27.7%
Total	36 861	100.0%

Coverage of emissions

The coverage of emissions is dependent on which of the vehicle owners that would be included in the emissions trading. According to Table 5.1 the passenger cars cause approximately 56% (~ 490 Mton CO_2) of the total CO_2 emissions from the road transport sector in EU25, lorries cause approximately 40% (~ 350 Mton CO_2) and public transport cause 2.4% (~ 20 Mton CO_2).

Monitoring and reporting

The annual distance driven by cars in Sweden is monitored by the Swedish Motor Vehicle Inspection Company. The distance driven per year together with the specific emission factors (g CO_2/km) according to the EU standard cycle for the different cars could be used for estimating the annual CO_2 emissions. However, old vehicles are not tested by the EU standard cycle and this will still only be an estimate of the emissions emitted from the car[37]. The emissions from the car estimated according to this method will only depend on the annual mileage and the specific emission factor and do not take into account how the car is driven and maintained, which are factors that also effect the emissions. In many other EU25 countries it would probably also be difficult to find data for mileage for each single car which will make this method even more difficult to implement.

[37] An average passenger car in Sweden was during 2005 driven 14 240 km (SIKA, 2006-09-20) and with an assumed petrol consumption of 8 litres per 100 km, the average CO_2 emissions per passenger car would be 2.8 ton CO_2.

The annual fuel consumption of the car would provide better information on the emission level. However, the amount of fuel used per year by a specific car is currently not reported anywhere. To build up a reporting and monitoring system for fuel consumption (and corresponding emissions) on vehicle level can be assumed to be very expensive. A new system for about 3 million passenger car owners in Sweden or about 150 million in EU25 (see above) would be needed.

For lorries and buses there is no EU standard cycle that provides the specific emission for the vehicle. The approach of using specific emission factors and annual mileage would therefore be impossible to use for the lorries and buses. On the other hand all companies need book-keeping for their incomes and expenditures. In the book-keeping or in other official documents that has to be provided by companies it would probably be possible to include the amount of fuel used for each company. For all vehicles owned by companies this could be an option for reporting and monitoring the fuel used and the corresponding emissions. All data for calculating the emissions from the companies' vehicles does not exist in the official documents from companies today. However, the cost of introducing this would not be as large as building a completely new reporting and monitoring system as for the private passenger cars. This method of monitoring and reporting could include lorries, buses and passenger cars (about 10-20% of the total number of passenger cars as stated above) owned by companies.

Transaction and administrative costs

The administrative cost to build up a reporting and monitoring system for fuel consumption and the corresponding emissions in the passenger car sub sector would be high since there is no existing reporting system today. A system with mileage from accredited organisations like the Swedish Motor Vehicle Inspection Company and specific emission factors would be much cheaper, but would also eliminate some of the most important incentives for emission reduction. The only remaining reduction possibilities would be to buy a more fuel efficient car or to reduce mileage. In addition it might not be possible to implement this for a European system at the same low cost since the mileage is not monitored in all member states. The administrative cost to build up a reporting and monitoring system for vehicles that are owned by a company would be lower. From the companies' official documents the use of fuel for road transport could be assumed to be monitored without any large initial administrative costs.

The transaction costs are particularly dependent on the number of trading entities. With the large number of passenger car owners the transaction cost would be huge if these would be the trading entity. If only company owned vehicles would be included in the scheme the transaction cost would decrease. The main reason is that the companies that own vehicles on average have much larger emissions than the average passenger car owner since the vehicles are used more; the companies own more vehicles and the average vehicle use more fuel (heavier vehicles). Still the number of trading entities included the EU ETS would rise from about 700 in Sweden today (SEPA, 2006) to at least 100 000 (how many hundreds of thousands depend on how many of the passenger cars owned by companies that would be included). For EU25 the number of trading entities would rise from approximately 12 000 to at least 5 million.

5.5.2 The vehicle driver (category B)

Possibility to reduce emissions

The vehicle driver has the possibility to reduce the emissions from the vehicle by a number of measures: to drive more fuel efficiently, to drive less, to maintain the vehicle better (use right tire pressure, use low-viscosity engine oil, etc.) and to chose bio-fuels (if the vehicle is a flexi-fuel vehicle).

Number of trading entities

With this choice of trading entity all vehicle drivers would be included - corresponding to all people with a driving licence. In Sweden it corresponds to at least 6 million people, in EU25 to more than 300 million.

Coverage of emissions

All emissions in the road transport sector will be included if all vehicle drivers are included.

Monitoring and reporting

Monitoring the emissions from vehicle drivers would be difficult. It is possible to monitor the professional vehicle drivers by a similar approach as proposed for category A (vehicle owner). However, there is no existing administrative system that could be used for private drivers. An option could be that allowances for the emissions corresponding to the amount of filled up fuel must be handed over from the car driver to the filling station at the same time as the payment. However, then it is the filling station that would be the entity that is monitored by officials and not the car driver. This option is very similar to the case with the filling station as trading entity that is discussed below (category D).

Transaction /administrative cost

The administrative cost for building up a system that can monitor the vehicle drivers would be high. The approach to include only the professional drivers would reduce administrative cost since the monitoring system could be linked to official document procedures that already exist. Administration cost for the approach where the filling station is the entity monitored by the officials is discussed below (category D). The transaction costs within a system where the vehicle driver is the chosen trading entity will be very large due to the large number of trading entities and the small amount of emissions included for each entity. Total transaction costs would decrease if only professional drivers were included since their average emissions probably are higher and since it would decrease the number of trading entities significantly.

5.5.3 The buyer of transport (category C)

Possibility to reduce emissions

The buyer of transport can reduce the emissions by buying less transport services and by considering fuel efficiency and use of bio-fuels when buying transport services. Consumer demand can change the mode of transport, e. g. from road transport to railroad transport. A possible option for choosing these actors as trading entities would be to apply a baseline & credit system. If companies that use a lot of transport services can reduce their emissions below a baseline they can earn credits that could be sold. This would give incentives to companies that use transport services to increase the demand for environmental performance of transports.

The number of trading entities is difficult to estimate because it is very difficult to determine where the transaction of transport services is take place. There is no physical marketplace for transport services. For example fuel is usually traded at the filling stations and the fuel suppliers have control over all fuel that is sold. There is nothing similar to that for transport services and it would therefore be difficult to monitor all transactions of transport services bought by transport buyers. However, with only some large companies (mayor transport buyers) included through a baseline & credit system, both the transaction and administration cost would probably be relatively low.

5.5.4 The filling station (category D)

Possibility to reduce emissions

The filling station can reduce the emissions caused by the fuel they sell by introducing the possibility to buy bio-fuels at the station and adjust the price of the fuels (bio-fuels vs. fossil fuels). The filling stations also have the possibility to promote bio-fuels with information and advertisement.

Number of trading entities

In Sweden there are about 4000 filling stations (SPI, 2006-06-15). No data for EU25 has been found but applying the assumption that the proportion between the number of cars and number of filling stations is the same in Sweden and EU25 the total number of filling stations in EU25 can be approximated to 200 000.

Coverage of emissions

All emissions from passenger cars and most emissions from lorries would be included if filling stations were chosen to be trading entities. However, some large transporting companies have their own supply of fuel and these emissions would not be covered if filling stations were selected to be trading entities.

Monitoring and reporting

To build up a monitoring and reporting system for the filling stations would not be difficult. The amount of fuel sold every year is well documented and it is therefore easy to also report and monitor the emissions.

Transaction/administrative costs

The administrative cost for this trading entity would be limited. The volumes of fuel sold every year are relatively well documented and to build up reporting and monitoring procedures would be relatively simple. The total transaction cost is lower than for the categories already mentioned (A, B & C), mainly due to the lower number of actors.

5.5.5 The fuel supplier (category E)

Possibility to reduce emissions

The fuel supplier can reduce the emissions by similar measures as the filling stations (category D). An additional measure is that they can mix bio-fuels into the fossil fuels. The major possibility to reduce the emissions is probably to increase the price of the fossil fuels. This will affect the end consumers to decrease their use of fossil fuels. However, this will also decrease the turnover of the fuel suppliers and is therefore probably not a preferred solution for them.

Number of trading entities

There are less than 10 fuel suppliers in Sweden (SPI, 2006-06-15). In UK the 20 biggest fuel suppliers account for over 99% of the total amount of fuel to the road transport sector (Gibbs and Retallack, 2006). The total number of fuel suppliers in the EU has not been found. However, the numbers from Sweden and United Kingdom implies that the total number of fuel suppliers in EU is relatively low (especially since many fuel suppliers operate in more than one of the EU countries).

Coverage of emissions

Selecting fuel suppliers as trading entity would include all emissions in the road transport sector.

Monitoring and reporting

The fuel suppliers are responsible for collecting and paying the fuel taxes. The amount of fuel sold is therefore very well documented and it would be very simple to report and monitor the emissions. The fuel suppliers also know for which purpose the fuel is used since there are different taxes for different use.

Transaction cost/administrative cost

The administrative and transaction costs can be assumed to be very low since the fuel suppliers already deal with the fuel tax and the number of fuel suppliers is very low.

5.5.6 The refineries (category F)

Possibility to reduce emissions

The refineries can to some extent affect how much bio-fuel that is blended into the fuel[38]. They can also promote the use of bio-fuels by information campaigns and by pricing.

Coverage of emissions

Selecting refineries as trading entity would include a major part of emissions in the road transport sector. However, there is an import of fuel refined outside of the EU and refineries within the EU export fuels to countries outside. If the risk of evasion is to be avoided, a system where refineries are trading entities would have to take trade of fuels into consideration.

Monitoring and reporting

At refinery level it is not decided where the fuel is going to be used. The fuel could be used in the country where it is produced, but can also be exported to other countries (both EU and non-EU countries). Only the fuel used in countries included in EU ETS needs allowances. Due to the difficulty to track the final utilisation of the fuel delivered from the refineries and thereby decide which fuel that needs to be covered by emission allowances it is difficult to construct a monitoring and reporting system with refineries as trading entity.

[38] The maximum amount of bio-fuel that can be blended into the fuel also depend on decisions by the authorities and by the construction of the vehicles.

Transaction /administrative cost

The administrative cost depends on the difficulty to build a monitoring and reporting system where refineries are trading entities. This cost is assumed to be lower than the costs for a similar system where vehicle owners are trading entities due to the number of trading entities involved. However, the administrative cost could be assumed to be higher than for fuel suppliers since there is a need for developing a system which tracks the final utilisation of the fuel delivered from the refineries. The transaction cost would be low due to the low number of trading entities.

5.5.7 Car manufactures (category G)

Possibility to reduce emissions

Car manufactures can by technical research improve the fuel efficiency of cars and also develop cars that can use bio-fuels and renewable energy sources. They can also choose to produce more fuel-efficient and bio-fuelled cars. With car manufacturers as trading entity there would be no incentive to reduce mileage, to apply eco-driving or for drivers to maintain the car appropriate in order to decrease fuel consumption (Kågeson, 2001). The emission reduction possibilities for car producers and car dealers are in some ways similar; the largest difference is that car producers have the extra potential to affect the technical research. Due to the many similarities between car manufactures and car dealers and this clear advantage of choosing car manufacturer as trading entity we have not investigated further the possibility to chose car dealers.

Number of trading entities

The total number of car manufactures in EU25 is relatively low. If only considering car manufacturers that produce cars on an industrial scale, there are for instance only two car manufacturers in Sweden. There are ten major car manufacturers in EU25 (ACEA, 2006). In order to avoid disadvantages for European car manufacturers all car manufacturers selling cars at the EU market should be included. This will increase the number of trading entities, but the number will probably still be less than 100. The legal possibility to include car manufacturers outside Europe is unclear and need further investigation.

Monitoring and reporting

The car manufactures can reduce the emissions from the road transport sector in the longer perspective by developing more fuel efficient vehicles. However, data on the number of cars produced in one year can not be used for estimating the amount of emissions within the road transport sector during that year. Therefore it is very difficult to include car manufactures in a cap and trade emissions trading system. Winkelman et al. (2000) and SRU (2005) has evaluated different options to approximate the total emissions from the new cars by using the specific emissions (g/km). The procedure is to assume an average mileage per car and multiply that with the specific emissions. However, the specific emissions according to the European test cycle do not correspond to actual conditions (Smokers et al., 2006) and the assumption of total mileage is a very crude approximation. An emissions trading scheme where car manufacturers are the trading entities is therefore preferably a baseline and credit system (SRU, 2005). In a baseline & credit system car manufacturers that produce cars with higher specific emissions than the set baseline have to buy emission credits from car manufacturers that produce cars with lower emissions than the baseline. Specific emissions according to the EU standard cycle are mandatory for all new cars sold in Europe. Monitoring and reporting of the specific emissions would therefore be possible.

Coverage of emissions

The passenger car sub sector which would be the sector included if car manufacturers were chosen as trading entity for the road transport sector are responsible for 56% of the CO_2 emissions in the sector (Table 5.1). However, the car manufacturers can only affect the emissions from new cars. Since the introduction time of new cars is so long it will take up to 20 years before the majority of utilised cars have been affected by emissions trading.

Transaction costs/ administrative costs

Since the number of trading entities would be relatively low if car manufacturers are selected to be trading entities the administrative costs would be relatively low. Transaction costs will also be relatively low since the total number of actors would be few.

5.5.8 Discussion on trading entities

Both with a downstream approach (e. g. vehicle owners) or an upstream approach (e. g. the fuel suppliers) it will be a substantial change for the EU ETS if the road transport sector is included. Either there will be more than 200 million new actors (with a downstream approach) or there will be a change from only downstream approach to a mix of upstream and downstream trading entities (Gibbs and Retallack, 2006).

The selections of trading entities that will cover the largest part of the emissions in the road transport sector are the fuel suppliers or the refineries. Choosing filling stations would also mean high coverage. Both fuel suppliers and refineries have the possibility to include other modes of transportation. Other choices of trading entities only cover parts of the road transport emissions.

The end users (e. g. the vehicle owners) have most possibilities to reduce the emissions in the road transport sector. Incentives for the end users to reduce emissions can be created by selecting vehicle owners as the trading entity. However, the incentives could also be created by an increased fuel price. Increases in fuel price will probably occur if filling stations, the fuel suppliers or the refineries are chosen as trading entities. The costs for the allowances will be the same for the end user when the end user is the trading entity as when e. g. the fuel supplier is the trading entity (with the assumption that the fuel supplier can pass on the cost for the emission allowances to the end user). However, the end user may have an increased incentive compared to e. g. the fuel supplier if he/she is the trading entity due to a psychological effect. This psychological effect originates from that the end user may feel more responsible for reducing the emissions if he/she is the trading entity. However, this effect is difficult to verify. Selecting the car manufactures as trading entity would increase the incentive for them to produce cars with less specific CO_2 emissions per km.

Selecting the fuel suppliers as trading entities would probably mean the lowest administrative and transaction cost since they already administrate the fuel taxes and since these options would result in relatively few trading entities. A way of limiting the administrative costs in a downstream approach is to limit the included vehicles to vehicles owned by companies. According to Gibbs and Retallack the current urge for simplification of the EU ETS can be interpreted as the interest to include many new small actors, such as car owners, is low.

Bergmann et al. (2005), Gibbs & Retallack (2006) and Klooster et al. (2006) all conclude that fuel suppliers are the best choice of trading entities. The argument is that this entity provides the best emission coverage and that the administrative and transaction costs are the lowest. However, SRU (2005) conclude that it would be better to have the car manufactures as trading entities. The main reason is that a system where the fuel suppliers are the trading entities is very similar to a tax (and fuel taxes are already present) and it is better to introduce a new incentive to improve fuel efficiency.

In conclusion, the choice of trading entity should be guided by the aim of the introduction of emissions trading:

- If the aim is to improve the incentives for vehicle drivers to reduce emissions and a downstream approach is preferred, the best options is to use companies that own vehicles as trading entity,
- If large emission coverage and low administrative and transaction cost are the most important issues, the best selection of trading entity is fuel suppliers,
- If the aim is to introduce a policy instrument that encourages the production of fuel efficient vehicles, the car manufactures should be the trading entity.
- A forth option could be to use transport buyers as trading entity in a voluntary baseline and credit system where they can sell their emission credits at the EU ETS market.

5.6 Allocation

The possibility for the trading entities in the road transport sector to pass on the cost for the emissions trading system is in most cases good. This would suggest that auctioning of allowances not only is the most efficient allocation methodology, but that it would also meet less resistance than for instance in the industry sectors. With other allocation methods there is a risk that the trading entities will get windfall profits from the trading scheme.

The quality of historical data of sold fuel from fuel suppliers and filling stations is good, which also implies that historical emissions could be determined relatively easily. However, the historical fuel consumption and emission data for individual car owners, and probably also for company owned vehicles, are poor. The specific fuel consumption for new cars sold in EU has been monitored for about 10 years which provide good historical data. The lack of historic data implies that auction is the only option if car owners or companies owning vehicles are chosen to be trading entities. The availability of data for other trading entities indicates that other allocation methods are possible.

In a baseline and credit system there could be a common baseline or there could be differentiated baselines depending on historical emissions for the different car manufacturers. The data availability opens up for both options.

5.7 Conclusions for the road transport sector

In this chapter the five most important design parameters for including road transport sector into the emissions trading have been described. The following conclusions concerning the design parameters for the road transport sector are drawn:

Coverage of greenhouse gases

According to EEA (2006) CO_2 emissions is responsible for 97% of the greenhouse gas emissions from the road transport sector. Therefore only CO_2 emissions are judged to be of importance to regulate in the road transport sector.

Geographic scope and interaction with Kyoto

The emissions in the road transport sector are attributed to the country where the fuel is bought, even for international transport, and is already included in the Kyoto regime.

Trading entity and monitoring and reporting

The trading entity is the most complex design parameter to determine for the road transport sector. The objective of using emissions trading in the road transport sector affects the selection of trading entity. If the purpose is to link the road transport sector to the existing EU ETS, the best choice of trading entity for the road transport sector is fuel suppliers. The reason is the low administration and transaction costs and the large coverage of emissions in the road transport sector. The selection of fuel suppliers as trading entity also provides the opportunity to include e. g. oil used in the household sector since fuel suppliers also sell this fuel.

Applying a downstream approach and choosing vehicle owning companies as trading entities could be an option. However, the administrative and transaction costs will be much larger, and the coverage of emissions would be smaller, than in a case where fuel suppliers are trading entities. An argument for a downstream approach is the psychological effect of making the incentives to reduce emissions very visible to the end user. However, the effect of this is difficult to verify. Our conclusion is that this option of trading entity would be possible but not a preferred option. If fuel taxes will not be accepted for actors included in the EU ETS it will be a problem to exclude the fuel tax for companies that own vehicles (mainly freight transport). It will be difficult to implement a system that use fuel taxes for passenger cars but exclude fuel taxes for freight transport.

Fuel suppliers or vehicle owners provide similar incentives for emission reductions as a fuel tax but other trading entities can be used as complement to the fuel tax. The two main options for trading entities would then be car manufacturers or transport buyers. For both options a baseline and credit system would be preferred. With the selection of car manufacturers it would probably be beneficial to include all car manufacturers that sell cars in Europe. However, the legal possibility for that need to be further investigated. With the choice of transport buyers as trading entity it would probably not be feasible to include all transport buyers; but at least buyers of large quantities should be included.

The main reason for selecting car manufactures as trading entity is that it would introduce a policy instrument for car manufacturers that does not exist today. There would be incentives for car manufacturers to develop more fuel efficient vehicles and to develop vehicles powered by alternative fuels. The current fuel taxes which today result in incentives for drivers to save fuel is functioning well and could be used also in the future. There would be no conflict in having both emissions trading for car manufacturers and a fuel tax at the same time.

Allocation

Auctioning would be the preferred allocation method for most choices of trading entity. In the cases when car manufacturers or transport buyers are the chosen trading entities, and a baseline & credit system is a better solution, allocation will be replaced by determining baselines.

Economical effects

According to chapter 4 the fuel price would be reduced and the emissions would increase in the road transport sector if the road transport sector was included in the same emissions trading scheme as the industry. However, the total emissions will not increase since the industry will have to implement emission abatement.

6 Aviation

The issue of including aviation (both national and international) in the current EU ETS is high on the EU agenda. Many studies (Wit et al. 2005, Cames & Deuber 2004, Defra & DfT 2006, Klooster et al 2006, Hanses 2006) on the subject have already been performed and the EU Commission will most likely present a legislation proposal on the inclusion of the aviation sector in the EU ETS by the end of 2006.

6.1 Design of emissions trading for the aviation sector

For the aviation sector there are many intricate issues of the design of the trading scheme that has to be resolved. The seven key design elements for the aviation sector can be seen in Table 6.1 together with the suggestions put forward by some of the studies made on the subject (Wit et al. 2005, Cames & Deuber 2004, Defra & DfT 2006, Klooster et al. 2006, Hanses 2006). Table 6.1 presents three design examples of models for the aviation sectors inclusion in the EU ETS by Wit et al. (2005), the preferences of the European Parliament and the suggestion by Hanses (2006), which is very much in line with what European Airlines suggest (IACA, 2006).

Table 6.1 Options for design elements in an emissions trading scheme for aviation.

Design element	**Wit et al. (2005) Option 1**	**Wit et al. (2005) Option 2**	**Wit et al. (2005) Option 3**	**EUP (2006)**	**Hanses (2006)**
Coverage of greenhouse gases	CO_2 and multiplier for other climate impacts	Only CO_2 combined with other policy options	Only CO_2 combined with other policy options	Full impact covered by regulation, not all necessarily by ETS	Only CO_2 combined with other policy options
Geographic scope	Within EU	Departures from EU airports	EU airspace	All flights to and from EU airports if possible all flights within EU airspace	Within EU
Interaction with the Kyoto Protocol	Aviation buys allowances from other sectors above a historic baseline	Unrestricted trading based on AAU's borrowed from other sectors	Trading with other sectors based on a gateway mechanism	Separate system, aviation sector unable to sell into the current EU ETS. If gate-way carefully regulated.	Aviation sector able to trade with other sectors based on a system with gateway.
Trading entity	Aircraft operators	Aircraft operators	Aircraft operators	Depending on result of impact assessment	Aircraft operators
Monitoring & reporting	Amount of fuel used, reported by operators	Amount of fuel used, reported by operators	Data from Eurocontrol	Not mentioned	Fuel consumption as reported by aircraft operators.
Allocation methodology	Baseline (Grandfathering)	Benchmark	Auctioning	Full auctioning	Benchmark
Allocation decision	Common rules set by the EU	Common rules set by the EU	Common rules set by the EU	Common rules set by the EU	Common rules set by the EU

Note that there are other options than the ones mentioned in the table; a wider scope of possibilities is discussed in Wit et al. (2005). Wit et al. (2005), EUP (2006) and Hanses (2006) only look at cap & trade solutions. In Klooster et al. (2006) also the possibilities of a baseline & credit system is discussed. The conclusion for the aviation sector is that a baseline & credit system probably would lead to less emission reductions and thereby have lower environmental impact and higher administrative and transaction costs than a cap & trade system. In the conclusions section of this chapter our own suggestions for the aviation sector are given

6.2 Coverage of greenhouse gases and other emissions impacting the radiative balance

The climate impact of aviation

Aircraft emit gases and particles directly into the upper troposphere and lower stratosphere implying negative impacts on atmospheric composition. The climate impact from aviation was assessed in IPCC (1999). The alteration of the atmospheric composition by aviation emissions impacts the radiative balance by different mechanisms:

- emissions of greenhouse gases (e.g., CO_2 or H_2O) increases in greenhouse gas concentrations;
- emissions of chemical species that produce or reacts with greenhouse gases (such as NO_x, which increases ozone (O_3) and decreases methane (CH_4) concentrations, or SO_2, which both has a direct impact on the radiative balance and oxidizes to sulphate aerosols with impacts on the formation and properties of clouds, or soot particles which absorbs heat; and
- emissions of substances (e.g., H_2O, soot) that trigger the generation of additional clouds (e.g., contrails and cirrus)[39].

Most of these impacts have a positive radiative forcing[40], with the exception of reduced methane concentrations due to reactions with NO_x emissions and the reflection of radiation by sulphate particles, which have negative radiative forcing and therefore tends to decrease the temperature of the atmosphere. The effect of cirrus cloud formation is still poorly known and there is no best estimate of the impact on the radiative balance of this effect. There are difficulties in comparing the impacts on the radiative balance of the different emissions from aircraft since there is no good comparative measure for quantification. Radiative forcing, RF, and GWP (Global Warming Potentials) are good measures when dealing with greenhouse gases that stay in the atmosphere for more than 2 years and therefore also are well mixed (Cames & Deuber 2004). These criteria hold mainly for CO_2, but not for the other emissions from aircraft impacting the radiative balance. Both NO_x and ozone have much shorter retention times than two years and also the effects on contrails and cirrus formation are on a shorter time scale. This also implies that the effects of these substances are more regional. Emissions are concentrated to the areas in which air traffic is denser, i.e. in the mid-latitudes of the northern hemisphere. In addition the emissions are also dependent on different ambient conditions such as moisture content, geographical location, time of the year etc.

Figure 6.1, which is based on Sausen et al. (2005), illustrates the impact on the radiative balance from the different emissions from aircraft in 1992 and 2000, respectively. The impacts on the radiative balance are based on the estimates made in IPCC (1999) but updated according to improved knowledge of actual emissions and the impacts of the different emissions. Since CO_2 has

[39] Contrails are formed in cold air masses when moist and warm air is exhausted form the aircraft. This causes formation of ice crystals which are visible as white traces. When the ambient air of the exhausts is dry the ice crystals will evaporate quickly and the climate impact will be small. If the air is saturated the contrails will be persistent and spread out. When the contrails loose their linear shape it is no longer possible to differentiate them from cirrus clouds.

[40] A positive radiative forcing tends to warm the temperature of the Earths surface.

a much longer retention time than the other emissions, the effect shown is from the accumulated emissions from aviation since 1950. Figure 6.1 also shows that the impact of CO_2 has risen during the period 1992-2000 (due to more air traffic and hence more combustion of fuel), the impact of O_3 remained unaltered (due to a combination of more air traffic and improved knowledge of the impact on the radiative balance of the gas), CH_4 has decreased somewhat, whereas the estimate for contrails has been reduced substantially due to better scientific knowledge. The scientific knowledge of the impact on the radiative balance due to increased cirrus formation has been improved but there is still no best estimate (Sausen et al., 2005).

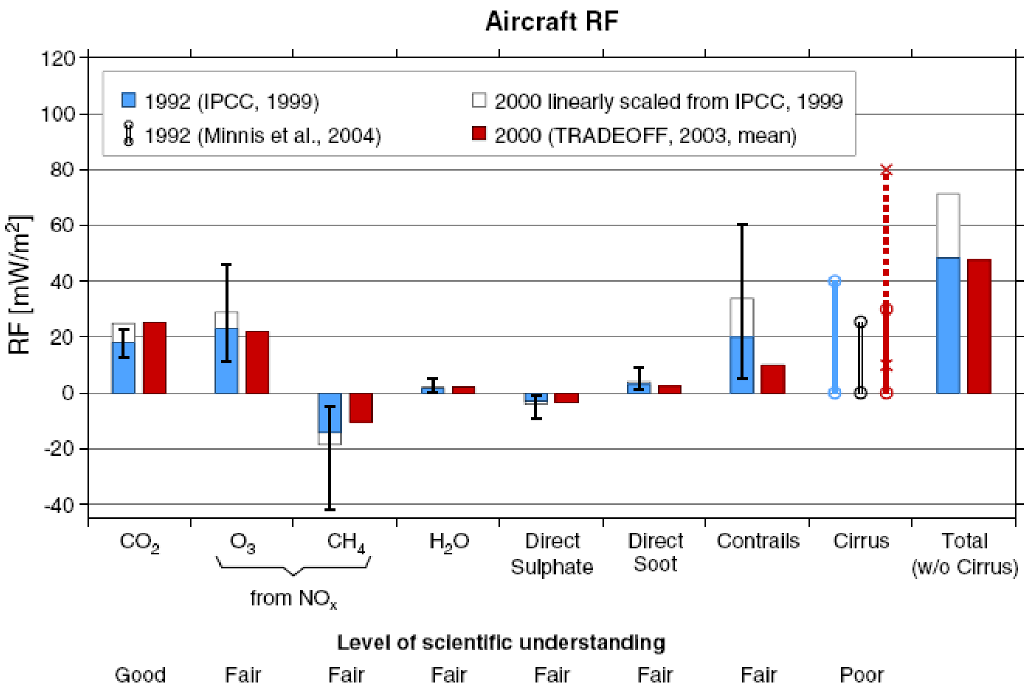

Figure 6.1. Radiative forcing (RF) from aviation for 1992 and 2000, based on IPCC (1999) and TRADEOFF[41] results. The best estimates for 1992 by IPCC (1999) and two estimates for 2000 are given; one is derived from IPCC (1999) by linear interpolation, the second is based on the mean values resulting from the TRADEOFF project. As in IPCC (1999), the TRADEOFF radiative forcings for CO_2, O_3 and CH_4 are both a result of aircraft NO_x emissions. Source: Sausen et al. 2005 with permission of Meteorologische Zeitschrift (http://www.borntraeger-cramer.de).

As can be seen in Figure 6.1 the total impact on the radiative balance[42] of aircraft is significantly higher than the effect from the CO_2 emissions alone. This is unique for the aviation sector compared to the other sub sectors of the transport sector, in which the impact on the radiative balance is dominated by the CO_2 emissions from fuel combustion. This raises the question of whether and how also the other emissions should be subject to environmental instruments.

The updated values by the TRADEOFF project as presented by Sausen et al. (2005) (in Figure 6.1) suggests that the impact on the radiative balance of contrails is lower than what was expected by IPCC (1999) whereas the range of the impact on the radiative balance caused by contrail formation

[41] TRADEOFF is an EU Framework Programme 5 research programme which was performed during 2000-2003. Aircraft emissions: Contribution of different Climate Components to changes in Radiative Forcing.
[42] Note that the totals in Figure 6.1 exclude the impact of cirrus formation.

is significantly higher. Sausen et al. conclude that if the impact on the radiative balance of contrails would turn out to be in the higher end of the estimates it will be important to try to find ways (restricting routes and cruising altitudes) that minimises the potential for cirrus formation. Furthermore, Cames & Deuber (2004) states that there is a trade-off between CO_2 emissions and contrail formation which actually might lead to increased impact on the radiative balance from aviation if there is a trading system considering only CO_2 emissions. The reason is that studies indicate that flying at lower altitudes reduces contrail and cirrus formation whereas it increases fuel consumption and thereby CO_2 emissions.

Coverage of emissions impacting the radiative balance from the aviation sector in ETS

According to the study by Wit et al. (2005) on the climate impacts of aviation there are basically three options on how to consider the climate impacts of emissions from aviation in an emissions trading scheme:

- Incorporating aviation CO_2 with a multiplier that takes into account the impacts of other emissions,
- Utilising an GWP-compatible metric on an individual flight-to-flight basis,
- Only including CO_2 in the trading scheme and using flanking instruments for the other emissions.

A fixed multiplier (with fixed value) applied on the CO_2 emissions might result in incentives that increase the impact on the radiative balance from aviation due to the trade-off between both CO_2 and NO_x and between CO_2 and contrail and cirrus formation. To argue for this solution based on the precautionary principle as Wit et al. (2005) do is therefore risky.

There is an extensive work being undertaken in order to find metrics that could be used for the purpose of comparing traditional greenhouse gas emissions to other emissions also having an impact on the climate (QUANTIFY, 2005). Although there is still no final solution to this question it will probably be a feasible solution in the future. Wit et al. (2005) dismisses the option of a GWP compatible metric since there currently is no appropriate metric for comparing the impact on the radiative balance of the different emissions.

The third option addresses a larger part of the climate impact but does not require comparability between the different emissions. We think it is worthwhile to try to introduce the flanking instruments at the same time as the CO_2 is included in the trading scheme in order to avoid problems of introduction of "false" reduction measures like the ones mentioned for the CO_2 multiplier. This also means that it would be good to both have some kind of instrument for NO_x (such as the current Swedish system, see section 6.9) and to try to regulate the flight altitudes in a way that decreases the risk for increased contrail and cirrus formation. The latter might have to wait until there are appropriate knowledge and suitable metrics that could compare the effect of contrails and cirrus formation to greenhouse gas emissions. Wit et al. (2005) concluded that regulation on flight altitudes in order to reduce the formation of contrails is not yet feasible since there is a lack of knowledge in the processes. To introduce NO_x landing fees was considered to be feasible as well as NO_x en rout charges by both Wit et al. (2005) and EUP II (2006).

The main discussion in the ECCP II (2006) was that there is a trade-off between CO_2 and NO_x emissions at least when designing new engines. However since engine manufacturers are working towards the goals of reduction of both NO_x and CO_2 set by ACARE (Advisory council for Aeronautics Research in Europe) this is probably not a real risk. However it should be remembered that there are also operational measures to be taken that might in fact have trade-offs between CO_2 emissions and NO_x. One example is the cruise altitude. Higher altitudes would mean less CO_2 emissions whereas the NO_x emissions emitted at higher altitudes would have a potentially stronger impact on the climate. Regulating both CO_2 and NO_x would reduce the possible trade-off effects. There is a similar trade-off between CO_2 and contrail and cirrus formation, where higher altitudes might increase the risk for contrail and cirrus formation whereas CO_2 emissions will be reduced. However the scientific understanding of cirrus formation is still considered to be rather low and research within this area should be prioritized since the current knowledge might be insufficient in order to design efficient policies.

Opinions on the coverage of emissions

The European Parliament stressed that it is important to address the full climate impact of aviation but not all of the different emissions need to be covered by ETS, other instruments might be used for part of the emissions (EUP, 2006). In ECCP II (2006) it is stated that there are concerning disadvantages with the approach of a CO_2 multiplier and that an effect-by-effect approach based on specific emissions would be better. Furthermore, participants also generally considered the current scientific knowledge of non-CO_2 effects to be insufficient and an effect-by effect approach not being feasible at the time being. It is also stated both in ECCP II (2006) and in Wit et al. (2006) that NO_x charges could be a flanking instrument which also reduces the risk of trade-off between CO_2 and NO_x as described by engine manufacturers. However, Hanses (2006) suggests that only CO_2 should be included based on the criteria to keep the system simple so that an inclusion in the EU ETS can occur as soon as possible.

6.3 Geographic scope

Wit et al. (2005) suggest six different options for the geographical scope, i.e. emissions from:

1 Intra-EU flights

2a Intra-EU flights+ 50% of routes to and from the EU

2b All flights departing from the EU (entire flight)

3 Emissions in EU airspace

4 All flights departing from the EU and EU airspace

5 Intra-EU and routes to and from countries that have ratified the Kyoto Protocol.

Additional options, such as all flights arriving in and departing from the EU as mentioned in ECCP II (2006) and EUP (2006) could also be possible. Table 6.2 shows the estimated scope in kton CO_2 of the different options. The largest scope is achieved by option 4 whereas the first option would have the smallest scope. Further, there is no estimate made of the additional option of flights arriving in and departing form the EU, but it will at least be larger than option 2b.

Table 6.2 Coverage of emissions of different geographical scopes.

Geographical scenario	CO_2 emissions [kton]	% of largest scope
1 Intra-EU	51, 875	32%
2a Intra-EU + 50% routes to/from EU	130,287	80%
2b Departing from EU	130,403	81%
3 Emissions in EU airspace	114,337	71%
4 Departing from EU + EU airspace	161,998	100%
5 Intra-EU and routes to/from other KP states	72,449	45%

Source: Wit et al. (2005)

As shown in Table 6.1 Wit et al. (2005) include options 1, 2b and 3 in their proposed systems.

The first option of only including intra EU flights is not only the suggestion with the smallest coverage but it might also suffer from problems with re-routing[43]. In addition the intra EU only option might cause distortions in competition and lack of incentives to reduction measures (indicated by manufacturers in ECCP II (2006)). Due to these reasons we think it is wise to widen the scope somewhat.

Option 2b as presented by Wit et al. (2005) is to include all departures from EU airports. This option has the largest coverage of the three suggested models. Note that this option includes emissions from EU flights to 3rd countries. However, we believe that if all departing flights could be included also arriving flights should be included resulting in an increase of the scope of the system. Of course this requires some kind of mechanism which takes into consideration that some flights both depart and arrive within EU so that routes are not double-charged. This could be solved by charging all flights departing from EU airports and all flights arriving to EU airports from non EU airports. According to Wit et al. (2005) it is legally feasible to implement an emissions trading scheme according to any of the suggestions put forward in Table 6.1 provided that it is applied without distinction as to nationality. We see no problem of charging operators arriving at EU airports from non EU airports since it would not make any distinction between nationalities of the operators but to flight routes.

Option 3, to include all flights within EU airspace, has a greater coverage than intra-EU flights but smaller than option 2b. For option 3 there might be a risk of re-routing of flights in order to minimise the distance within EU airspace[44]. This might even have a negative effect on emissions and the environment.

The Commissions communication stated that the preferred environmental option is to cover all flights departing from EU airports, as limiting the scope to intra-EU flights would address less than 40% of the emissions from all flights departing from the EU. The option to include all flights departing from EU airports would also be easy to broaden to global coverage.

The European Parliament suggests that a scheme for aviation should as a first step cover all flights to and from any EU airport (if possible also intercontinental flights transiting through EU air space). It also stresses that a world wide emissions trading scheme needs to be introduced as soon as possible. Hanses (2006) suggests that the starting point should be flights within the EU since this

[43] Note that flights not included in this scenario include domestic routes within Ultra Peripheral Regions (UPR), Overseas countries and Territories (OSTC) and countries outside the EU but within the EFTA. Furthermore, flights from the EU to UPRs, OSTCs or EFTA countries are not included.

[44] The EU airspace was defined based on the Flight information Regions (FIRs) of the EU Member States as employed by EUROCONTORL and officially agreed on with ICAO. For the flights within EU it was assumed that the full rout length is considered even if part of the route is outside EU airspace.

option most probably is the easiest and fastest to implement. In ECCP II (2006) there was a focus on the following three options:

- intra EU-flights only,
- all flights departing from the EU,
- all flights arriving or departing from the EU.

None of these options was pointed out as the preferred one, although pros and cons were discussed. There was, however a general agreement that the long term objective should be to expand the scheme to cover countries outside the EU.

Based on the above discussion, we conclude that the geographical coverage of the scheme should include at least all flights departing from EU (as the suggestion by the Commission) but if there is no legal hindrance it should be widened further to also include all flights arriving at EU airports from non-EU airports as suggested by the European Parliament (EUP, 2006). This scope can also easily be scaled up and will during the phase of up scaling to the ultimate goal of a global system have the widest possible scope. In Wit et al. (2005) there is a description of the Chicago convention (and bilateral agreements) which does not contain any legal hindrance to include the full climate impact of aviation into the EU ETS.

6.4 Interactions with the Kyoto Protocol

As mentioned in section 2.4 international aviation is not included in the national obligations under the Kyoto Protocol. Further, military and private aviation are not included in either of these categories (national or international). Private aviation is very small and military aviation is reported separately (in category 1 A 5 other). The international aviation is reported as memo items in the national inventories (under International Bunkers, Aviation). Since domestic aviation is included in the Kyoto Protocol, domestic flights are not difficult to include in the EU ETS. If international aviation is to be included in the EU ETS it is necessary to set up a system that handles the problems of calculating and presenting the emission allowances at the end of the Kyoto period. The suggested options as well as the pros and cons for these options are discussed in section 3.3.

The European Parliament has made statements in favour for a system where the aviation sector is separated from the other sectors and where the aviation sector is not allowed to sell into the current EU ETS (EUP, 2006). According to the same table Hanses (2006) suggested trading between current EU ETS and international aviation by a gateway mechanism, which also turned out to be the preferred option by Member States (ECCP II 2006) due to the reasons described in section 3.3.

Based on the analysis in chapter 4 we conclude that trade between the aviation sector and the other sectors should be allowed in order to maintain economic effectivenss. Further, as few restrictions as possible should be set for the trade in order to avoid two classes of allowances. If the assumption that the abatement costs are higher in the aviation sector than in the current EU ETS sectors holds true, the gateway solution is the best short-term solution, since the gateway then most likely would be open most of the time. In such a case also the described option where AAU's are borrowed from other sectors not included in emissions trading (see section 3.3) would be a possible solution. If the assumption that the aviation sector will be a net buyer is wrong, the consequences will be smaller if the gateway solution is chosen compared to the other options.

6.5 Trading entity

For the aviation sub sector there are several possible trading entities; aircraft operators[45], airports, fuel suppliers, providers of air traffic management (ATM) or aircraft manufacturers. According to Wit et al. (2005) aircraft operators are the most appropriate trading entity since they have the best opportunities to control fuel consumption. They also have direct control over the type of aircraft in operation as well as the monitoring data. We agree with this conclusion (just as the other parties referred to in Table 6.1.

At present EUROCONTOROL[46] charges about 3,300 aircraft operators with route charges. However, the number of trading partners from the aviation sector could be reduced by introducing a threshold rule such as in the other sectors of the current EU ETS (e.g. 20 MW of rated thermal input for combustion installations). Wit et al. (2005) estimate that depending on the geographical scope of a trading system with aircraft operators as trading entity, this would include 770-930 additional actors. Most studies also conclude that to have aircraft operators as the trading entity is only feasible if all operators (both EU-based and operators of other nationality) could be treated equally. This option would cause severe distortions in competition if operators could not be treated equally.

As can be noted from Table 6.1 all included options suggest aircraft operators to be the trading entity. To have the aircraft operators as trading entity was also the starting point given by the Commission to the ECCP II (2006). For a non-global system, aircraft operators seem to be the optimal solution. Nevertheless, in a global system only including CO_2 emissions, fuel suppliers would be a more simple solution. In a non-global system there would probably be great risk of evasion is fuel suppliers were chosen trading entity. Since strategic bunkering (making additional stops just outside the boarders of the system) might even cause increases in emissions we do not recommend this.

6.6 Monitoring & reporting

There is a number of possible sources of the information of CO_2 emissions from aircraft, including:

- Data reported by airlines: under current legislation, trip fuel must be recorded in the mass and balance documentation that must be prepared before and after each flight. Many airlines store trip fuel data electronically in fuel management systems,
- Data from ATM (air traffic management) authorities, who keep track of all flights undertaken in their airspace. For example, EUROCONTROL currently keeps track of distances, aircraft types, environmental data an origin-destination pairs for every flight handled. Based on this information fuel consumption could be modelled,

[45] Note that there is a difference between the terms “aircraft operator” “and airline/air carriers”. All airlines are aircraft operators but not all aircraft operators are airlines. Using the term airline would exempt large companies that own and operate airlines but which do not provide commercial services.
[46] EUROCONTROL is the European Organisation for the safety of Air Navigation.

- Data from current operations of bunker fuel suppliers: these suppliers are currently under no obligation to report to authorities, using them as data source would require some kind of reporting system.

Concerning the other emissions from aircraft, data available at the EUROCONTROL could also be used for determining the NO_x emissions. In the future it might also be possible to use the data available in order to estimate the formation of contrails. However, as mentioned earlier the scientific knowledge of contrails is still considered to be too uncertain in order to be appropriately included in an ETS.

Wit et al. (2005) suggests that the emissions should be determined either based on data of used fuel from operators or from data available at EUROCONTROL. The approach of using the EUROCONTROL data will result in predetermined estimates of fuel consumption and not actual fuel consumption. This might reduce the incentives of implementing measures during the flight that reduce the fuel consumption. Further, Hanses (2006) suggests that the fuel consumption as reported from the aircraft operators should be used. In ECCP II (2006) there was a general agreement that reporting of actual fuel use by airlines would be the most accurate method and that it would provide the broadest possible range of incentives to implement reduction measures. We suggest that data on used fuels from operators is used for reporting and data from EUROCONTROL could be used for comparison in the verification process.

6.7 Allocation

Allocation decision

Since aviation has been regulated on an international basis for years it might be more feasible with an international allocation decision. National decisions would require precise assignments of emissions and climate impact from the aviation sector for each member state. This is a complex issue which is still unsolved. Further there is no burden sharing agreement for the aviation sector being one of the reasons for national decisions in the other sectors.

All suggested designs in Table 6.1 implies that the allocation decision is taken on EU level and not on national level as is the case for the current EU ETS sectors. Wit et al. (2005) suggests a central allocation decision in order to lower the administrative/transaction costs for operators operating in several or all of the 25 member states. In ECCP II (2006) an additional argument (to the ones mentioned above) is that there seems to be a greater degree of mobility in the aviation sector, enabling differences in general fiscal or regulatory policies between countries to be exploited. However most of the participants were in favour of a harmonised approach, although several Member States stated that it is important to take into account differing national circumstances[47].

In the current EU ETS each member state has to provide a national allocation plan on how the national allowances are going to be allocated. In order to change this there probably need to be made changes to the Directive 2003/87/EC on emissions trading. However, other amendments and adjustments need also to be done in order to include any of the transport sub sectors to the current system. Some countries might also argue that the national aviation is included in the

[47] Especially mentioned was the UPR (ultra peripheral regions) and regions with the availability of alternatives to air transports (which are more limited for example Mediterranean Islands).

national commitment according to the burden sharing agreement, so logically the cap for these emissions should be decided upon nationally.

Allocation method

We have considered the following five options for allocation method:

1. Grandfathering,
2. Benchmarking,
3. Auctioning,
4. Baseline,
5. No allocation.

Using **grandfathering** (allocation based on historic emission levels) as an allocation method would lead to risks of mistreating operators that have made early actions to reduce emissions especially if not an early base period is used. Lack of data is the main reason for not being able to choose an early base year. Wit et al. (2005) states that this option is in strong violation to the polluter pays principle. IVL notes that this was the most commonly used allocation method for industry within the first period of the EU ETS (2005-2007).

Also **benchmarking** requires good data and a comparative benchmark that can be used. The advantage is that early action is better rewarded and there will be incentives for introducing new and more emission efficient technologies. This allocation option was also used to some extent, especially for new entrants in the first period of the EU ETS.

If allocation is made by **auctioning** there is no emission data requirement. Early action is rewarded since lower emissions mean lower demand for allowances. Allocation will bring larger costs for the operators since they will have to buy all allowances. On the other hand, for the aviation sector where it is likely that costs will be passed through to the consumers this will limit the problems with windfall profits which will be the case in all the free allocation options if operators are able to pass through costs to consumers.

The option of a **baseline** allocation would rather be the case in a baseline & credit system (without the credit) than in a cap & trade system. In this case operators only have to surrender allowances for emissions above a certain baseline. An important disadvantage with this option is that there is no incentive for the operators to reduce the emissions below the baseline since they have no possibility to sell allowances. This allocation resembles grandfathering in the sense that the baseline will be based on historic emissions.

In the **no allocation** option aircraft operators have to buy all allowances in order to cover their emissions. The disadvantage with this option is that it has higher mitigation costs both for the aviation and for the current EU ETS sectors due to more stringent mitigation target. On the other hand, it means that the pressure to reduce emissions will be smaller for the non trading sectors.

The availability of data argues for no allocation or auctioning. Data availability is also better for benchmarking than for grandfathering. Wit et al. (2005) includes baseline, benchmark and auctioning in their design suggestions. They also express that auctioning appears to be the most appealing option of initial allocation and that the second best choice is a baseline approach with auctioning. In ECCP II (2006) it is stated that many Member States had not yet reached a final position on this issue. However the discussion focused on grandfathering, benchmarking and auctioning and many of the parties were in favour for benchmarking. As presented in Table 6.1 the European Parliament is in favour for auctioning since they otherwise see a risk for windfall profits. The European Parliament (EUP 2006) also emphasizes that the initial allocation should not allow for emission growth above the 1990 level. Hanses (2006) suggests a benchmark based on the reason that auctioning is not applied to 100% in any of the other sectors currently included in the EU ETS and new sectors should be treated in a similar way. The European airlines emphasizes that it is important that the initial allocation to airlines is free of charge (IACA, 2006).

Textbook theory strongly suggests that auctioning is the allocation method to be preferred in a cap and trade system. It provides efficient incentives and eliminates the risks of distortion in competition between the participating actors. However, in a real and geographically limited system there are reasons to why free allocation could be justified which include competition from actors not included in the system or sunk costs (for a further explanation on this issue see Åhman & Holmgren (2006)). Competition from other actors not included in the system should be limited in the case of the aviation sector since all operators within the EU will be included, irrespective of nationality. Hence excluded operators can not be competing on the same route as included operators.

In addition, the definition of a new entrant tends to be far more complicated in the transport sector than in the currently covered sectors in the EU ETS. This issue is discussed in Wit et al. (2005) and the conclusion is that the easiest way to deal with this problem is to avoid free allocation for all operators.

There is no given solution on which distribution method that should be applied. The European Parliament is in favour of auctioning, a solution that might be appropriate also for other sectors in the trading scheme. One important difference between current EU ETS sectors and the aviation sector is the competition with participants outside the scheme. For industry producing similar products as competitors outside the scheme there are substantial risk for distortions between European actors and non-EU actors. In the suggested scheme for the aviation sector all operators operating within the geographical scope will have the same rules to follow. It is however argued that operators with only part of their business within the EU (geographical scope) might more easily absorb the extra costs whereas operators only operating within the scheme. However, there are already today differences in charges between countries and airports that could cause similar distortions that are not considered to be problematic.

6.8 Economic effects

According to our analysis in chapter 4 it will be cheaper for the aviation sector to be included in the EU ETS compared to introducing a fuel tax, even if the aviation sector is allocated allowances by auctioning. From the analysis in chapter 4 we can also conclude that creating separate caps for the aviation sector and the industry will cause the aviation sector the same costs as if a fuel tax were introduced. All these conclusions assume that abatement costs are higher in the aviation sector than in the industry sector.

Wit et al. (2005) conclude that aviation is less vulnerable to economic distortions than other sectors in the EU ETS. One reason is that unlike the other sectors non-EU based operators will also be included since the proposed options are to include operators based on flight route, irrespectively of nationality or type of operation.

According to Nertun 2005 (personal communication) fuel costs currently represent 24% of the expenses for airlines (in this case referring to SAS). For low-fare airlines the corresponding figure could probably be as much as 40% according to Nertun. The Commission estimated that including aviation in the EU ETS should not add more than 9 € to the price of a return flight (EurActiv 20050801).

According to Defra & DfT (2006) including the aviation sector in the EU ETS will have a limited effect on average annual prices of carbon instruments. Addition of the aviation sector will produce a small increase in demand for EUA:s (emission allowances in the current EU ETS) and could place some upward pressure on prices in the short term. Defra & DfT conclude that even a small increase in short term prices for EUA:s will encourage an increase in either the quantity of ERU:s (CDM credits) that are supplied to the market or induce additional abatement by the power sector, adjusting the market to the increased demand. A key assumption made by Defra & DfT (2006) is that the base year for aviation is 2008 meaning that during the period of 2008-2012 only small increases of emissions in the aviation sector can be expected. They declare that if another year is selected for base year the growth in emissions might be sufficiently high to result in an increase in the price of EUA:s.

The International Air Carrier Association (IACA) has expressed its concern to the Commission that the financial impact of including aviation in the EU ETS might be underestimated. IACA also states that emissions trading should be one element of a broader strategy to reduce the climate change impact of aviation. Also in ECCP II (2006) it is stated by airline operators that they disagree with the analysis in Wit et al. (2005) especially on the impact on airline costs, the ability to pass on costs in ticket prices and the competitiveness of airlines. According to IACA it is a critical requirement of including aviation in the EU ETS that operators are allocated allowances for free. IACA, just as the European Parliament thinks it is important to strive for a global system. Meanwhile it is important that airlines operating on the same route should be subject to the same rules.

6.9 Conclusions for the aviation sector

The studies performed within the EU on the subject of including aviation and other sectors of the transport sector into an ETS has put forward some possible solutions of which a few are presented in Table 6.1.

Coverage of greenhouse gases and other emissions impacting the radiative balance

We conclude that it is most reasonable to, at least at this initial stage, include only the CO_2 emissions from aircraft in the EU ETS. However, the possibility of also introducing a system of NO_x charges should be considered and investigated further. The Swedish system of LTO NO_x charges (mentioned in the ECCP II (2006)) could be a starting point but the possibility to also include NO_x cruise emissions should be investigated. In addition the possibility of setting restrictions on cruising altitudes in order to reduce contrail and cirrus formation should be investigated further. However, we believe that there need to be better measures for comparing the impacts from cirrus and contrails with greenhouse gases and better knowledge of the actual effects before any regulation is introduced for these emissions.

Geographical scope of the scheme

We conclude that if there is no legal hindrance to both charge all departing flights and flights arriving to EU airports from non EU airports this is the best solution when starting at regional level (such as the EU). Scaling it to a global system would only reduce the number of flights arriving from airports not included in the system. This is also what is suggested by the European Parliament (EUP, 2006).

Interaction with the Kyoto Protocol

According to our analysis in chapter 4 the most economically efficient system for all parties is a system with open trade between aviation and the current EU ETS. If there also in the period after Kyoto is a similar international climate policy framework where emissions from international aviation is not included a gateway option appears to be the second best solution (after free trade). The gateway solution is a low-risk solution with low impact on the trade (as long as the aviation sector in general has higher abatement costs than other included sectors) between aviation and the rest of the EU ETS. However, it should be noted that the European Parliament stresses that actual emission reductions within the aviation sector are important, which might not be realised if there is a linkage to other trading sectors. Most parties agree upon the long term goal of a global system of emissions trading for the aviation sector. It is clear that this should be prioritized in the work with future climate regimes. Meanwhile we consider the best solution to be the gate-way option as suggested by the Wit et al. (2005) (model 3), Hanses (2006) and ECCP II (2006).

Allocation

The advantage of auctioning is that it prevents large wind-fall profits which could result from any free allocation option. Wind-fall profits may distort competition with other transport modes (e.g. rail). Auctioning also reduces the administrative burden as no baseline, benchmark or historic emissions data will be needed. It also reduces the difficulties on how to treat new entrants. Due to these reasons we conclude that auctioning is the best choice of allocation method for the aviation sector. We find it likely that aircraft operators will be able to pass on costs to consumers.

Monitoring and verification

Due to the reasons put forward by ECCP II (2006), the most reasonable solution is to use the reported fuel consumption by operators. Further it seems wise to also use data available at EUROCONTROL as reference in the verification process.

Economic and distributional options:

The EU Commission is determined to introduce a common strategy to reduce climate impact from aviation. The Commission has also concluded that the best solution in the short and medium term appears to be the introduction of emissions trading. The EU Commission mentions that a fuel tax would be a good solution in the long run but that is it not possible in the short and medium term. According to our economic analysis in chapter 4 a common emissions trading scheme for more than one sector is more cost efficient compared to a fuel tax since the costs for all sectors will be lower if they are included in the same emissions trading system.

7 Maritime shipping

7.1 Introduction

Maritime shipping accounts for about 4% of the total greenhouse gas emissions in EU25 (EEA, 2006)[48]. If no measures are taken, fuel consumption from maritime shipping is projected to increase by 1-2% per year, which will result in increased CO_2 emissions (EC, 2001). A shift towards high speed ships will also increase the fuel consumption and thereby the CO_2 emissions. Still, ships have relatively low greenhouse gas emissions per tonne kilometer and sea transport is a comparably efficient transport mode – up to six times more fuel efficient than alternative transport modes per tonne kilometre (Swedish Commission against oil dependency, 2006).

So far, few mitigation policies have been directed towards maritime shipping, and IMO[49] has not yet agreed on strategies for implementing policies to reduce greenhouse gas emissions. However, competition, increased fuel prices and aims for increased profits, have resulted in successive improvements of fuel efficiencies. IMO states that there are limited possibilities to reduce greenhouse gas emissions from ships, especially by technical measures (IMO, 2000). The reduction potential by operational measures appears to be higher. According to Grundström & Lemieszewski (personal communication), examples of currently available operational measures are increased load, optimised (decreased) speed, optimised routing and preventing the development towards high-speed ships.

7.2 United Nations Convention on the Law of the Sea (UNCLOS)

Designing emissions trading systems for the maritime shipping sector requires information and knowledge about regulatory frameworks and existing or lacking international agreements.

The United Nations Convention on the Law of the Sea (UNCLOS) is a convention regulating the division of the sea and its resources including protection and use. The current formulation appears to prevent local and regional regulations on technical equipment of ships[50], but allows for local and regional operational rules. This implies that shipping companies could not be forced to install e.g. greenhouse gas measuring device, which indeed complicates inclusion of the shipping sector in emissions trading systems. Any emissions trading system including maritime shipping would therefore probably have to be voluntary, unless the writing of the convention is changed, which is very unlikely at least in the short and medium term (Grundström & Lemieszewski, personal communication).

[48] Including both national and international shipping
[49] IMO = International Maritime Organisation
[50] This is stated in UNCLOS, Section 3 about "Innocent passage" (especially Subsection A, article 21). See also full text in (UNCLOS, 2006)

This interpretation is also in agreement with the conclusion made in The Swedish Shipowners Association's report about a trading system for NO_x and SO_2, as described in the following section.

It has been out of the scope of this project to make a legal evaluation of UNCLOS and its influence on emissions trading. However, making such evaluation is one of the recommendations from this project, see further section 7.12. From now on, we base the analysis on the assumption that UNCLOS would prevent compulsory participation of the maritime shipping sector in emissions trading

7.3 Trading system for NOx and SO_2

Environmental effects of maritime shipping have been concentrated on NO_x and SO_2, due to their substantial contribution to acidification, eutrophication and air quality problems. In June 2006, the Swedish government appointed an inquiry to investigate the possibilities of an emissions trading system for NO_x and SO_2 including the shipping sector. The inquiry will be performed by The Swedish Maritime Administration, The Swedish Energy Agency, The Swedish Environmental Protection Agency and The Swedish Institute for Transport and Communications Analysis and it shall be presented in May 2007.

The Swedish Shipowners' Association (SSA) has proposed an emissions trading system for NO_x and SO_2, allowing the shipping sector to voluntarily participate in emissions trading with land-based installations (SSA, 2006). The system would serve as a kind of baseline and credit system for the shipping sector with ship owners as trading entities. The ship owners would earn credits for emissions below the baseline and these credits would be tradable to the land-based installations possibly including an exchange rate taking into account the lower abatement costs for the shipping industry. It would be common for the EU and include both shipping, land based industry and possibly other sources not capped by emission restrictions today. Today, land based industry have restrictions on NO_x and SO_2 emission e.g. by the EU IPPC directive (Integrated Pollution Prevention and Control) and since abatement costs for shipping are assumed to be lower than for land based installations, the shipping sector would probably be a supplier of emission reduction credits.

Emissions from land-based installations would be capped by an emission budget covering the installations regulated under the IPPC Directive (EC, 1996). The emission allowances are suggested to be allocated free of charge either by benchmarking or grandfathering, taking into account early abatement or investment in BAT etc. Banking of emission allowances should be permitted but the total amount of bankable emission allowances should be limited to avoid future peak loads. Trading would be allowed within the cap as well as with other non-capped sources voluntarily participating in reduction projects. To prevent exceeding of local air quality standards, the proposed system also takes into account local emission level restrictions. Processes for monitoring and verifying reported emissions are proposed to be handled by introducing some Central Administration of the trading scheme (as in the EU ETS).

In accordance with the above discussion about UNCLOS, it is stated in the SSA report that the convention prevents compulsory regional and local regulations and therefore the shipping sector would participate through voluntary emission reduction projects. By reducing the emissions below a pre-determined baseline, emission reduction credits would be generated, which could be traded to other non-capped parties or to land-based installations capped by emission budgets. The system would be supervised by a department of the Central Administration, which would be responsible for issuing credits and determining rules for definition of baselines, calculation of credits etc.

The ship owners would serve as trading entities in this system and only reductions below the baselines and inside the geographical boundaries of the system could generate emission reduction credits. As a consequence, the ship owners will have to monitor and record the actual emissions, the position of the ships and the actual time when the emissions occur. The emissions would be monitored and verified as follows:

- SO_2 would be monitored by verifying the sulphur content from the fuel purchasing receipts and by random follow-up inspection of the fuel tanks by an independent surveyor.
- NO_x emissions would be determined by certificates on engine installations. Monitoring of emissions levels would be done by accredited measuring companies and reductions would be verified by logging and from the amount of fuel used.

7.3.1 Geographical scope of the system

Land-based installations included in the proposed system are limited to installations covered in the IPPC Directive. For the shipping sector the geographic boundaries are suggested to be routes between EU ports as well as pre-established routes through the EU waters. These boundaries determine where emission reduction credits could be earned. Since a majority of the maritime traffic is found within 200 nautical miles from the coast line (Grundström & Lemieszewski, personal communication), the boundaries are assumed to cover a large part of the shipping in the EU.

7.3.2 Trading

The trading in the NO_x and SO_2 system could be either within the capped emission budget, between voluntary participants outside the capped emission budget, between capped and non-capped participants and possibly between participants and brokers as well.

The shipping sector is assumed to be a supplier of emission reduction credits to the land-based installations. Depending on the price development of the system, an exchange rate between the emission reduction credits and the emission allowances could be added (Grundström & Lemieszewski, personal communication). As mentioned above, local air quality restrictions will be taken into account when emission allowances and emission reduction credits are traded.

7.4 Emissions trading of greenhouse gases

The following sections describe possibilities for including the maritime shipping sector in a trading system for greenhouse gases. The analysis is partly made on the basis of the proposed emissions trading system for NO_x and SO_2, aiming at finding synergies and analogies to this system. Designing emissions trading systems requires analyses of various design parameters, generally described in chapter 3. The following sections focus on possibilities for the maritime shipping sector only, covering the following design parameters:

- Coverage of greenhouse gases

- Geographic scope
- Interaction with Kyoto
- Trading entity
- Monitoring and reporting
- Allocation/determination of baselines
- Policy options

7.5 Coverage of greenhouse gases

The impact on the radiative balance of emissions from maritime shipping is associated with direct as well as indirect effects. The direct effects arise from greenhouse gas emissions dominated by CO_2, see Table 7.1.

Table 7.1 Greenhouse gas emissions from maritime shipping (EEA, 2006)

	Emissions in 2004 [Mton CO_2 equivalents]	**Of which CO_2**
National maritime shipping, EU15	21	98,6 %
National maritime shipping, EU25[51]	23	98,6 %
International bunker fuel oils, EU25	120	98,9 %

The indirect climate effects are caused by NO_x, SO_2 and soot particles. NO_x is associated with formation of ozone, having a warming effect, as well as the reaction with methane, which has a cooling effect. SO_2 affects the climate by formation of sulphate particles, resulting in a cooling effect. Furthermore both NO_x and SO_2 promote formation of aerosols, which probably have a cooling effect, but of unknown size. Finally, soot particles emitted from ships, have a slightly warming effect, although the size of this effect is estimated to be small (Wit et al., 2004; IPCC, 2001).

Altogether, the total radiative forcing of maritime shipping including direct and indirect effects is summarised in Table 7.2.

Table 7.2 Emissions from maritime shipping impacting the radiative balance

Substance	**Impact**	**Radiative forcing [W/m^2]**	**Reference**
CO_2	Warming	0,030	Endresen et al. (2003)
O_3 (from NO_x)	Warming	0,029	Endresen et al. (2003)
CH_4 (from NO_x)	Cooling	-0,028	Endresen et al. (2003)
Sulphate	Cooling	-0,020	Endresen et al. (2003)
Aerosols (from NOx & SO_2)	Probably cooling		Wit et al. (2004), IPCC (2001)
Soot particles	Warming		Wit et al. (2004), IPCC (2001)

[51] Calculated from data of total greenhouse gas emissions for the transport sector in EU25, and assuming the same relationship between GHG emissions from navigation and total transport sector in EU25 as in EU15.

It should be noticed that there are still large uncertainties related to the radiative forcing numbers given in Table 7.2. For instance, Wit et al. (2004) concludes that they do not take into account other global atmospheric chemistry reactions, lifetimes of NO_x, ship tracks etc. According to IMO (2000) the total radiative forcing of maritime shipping – including direct and indirect climate effects – is small or slightly negative.

Whether the indirect effects of NO_x, SO_2 and particles should be included in climate policies is an intricate issue. NO_x, SO_2 and secondary generated substances, are primarily associated with other effects than indirect climate change, i.e. acidification, eutrophication and air quality. They are also regionally or locally distributed, whereas greenhouse gases are globally distributed. It is therefore of great importance where NO_x and SO_2 emissions take place. Consequently, including the indirect effects of NO_x and SO_2 in an emissions trading scheme aimed at reducing the climate impact would stimulate increased emissions of especially SO_2 and would involve weighting and comparing of different environmental and health effects. These are issues outside the scope of this project, and have therefore not been investigated any further.

7.6 Geographic scope

The geographical scope is related to what geographic parts of the maritime shipping sector should be included in an emissions trading system. Examples of possibilities for maritime shipping are:

1. Global scheme for all shipping transports. Generally, the larger an emissions trading system gets, the more cost-effective it becomes. A global system including all sectors would thus be the most cost-effective but seems unrealistic, at least in the short term,
2. Fuel bought in the EU. A system like this could probably be feasible, but might still require international agreements of some kind, i.e. agreements with non-EU countries such as Russia, Croatia and Albania to avoid evasion,
3. Departing ships and boats from the EU (the whole journey, from departure to destination) disregarding final destination. This would be very similar to option 2 above, but would include all departing ships no matter if the fuel is bought within or outside the EU. As with no 2, a system like this might require international agreements of some kind, i.e. agreements with non-EU countries such as Russia, Croatia and Albania to avoid evasion,
4. Emissions on EU waters. This option would include emissions on EU waters, disregarding the place of departure or arrival of ships. It could be problematic and probably difficult to control, since it would include international shipping on EU waters no matter if there would be any anchoring at EU harbours or not, e.g. a ship going from Morocco to St Petersburg. The system would certainly need agreements with some non EU countries,
5. Only shipping between EU countries. This would have the smallest scope of the systems mentioned so far. It is probably also the easiest system to implement, at least in the short-time perspective.

The geographic scope proposed in the trading system for NO_x and SO_2 (SSA, 2006), is all routes between EU ports as well as some pre-determines routes on EU waters. This option corresponds to something between option 4 and 5 above, and would cover a large part of the shipping in the EU. It should also be mentioned that the shipping sector would probably have to participate voluntarily, due to restrictions in UNCLOS. Thereby, the actual scope will depend on the number of participants and would probably mean starting with a smaller scope and successively widening the system.

Finally, there is a risk of flagging out of European ships to countries not involved in the emissions trading system. This risk may vary depending on geographical scope of the system, but the risk is probably larger the smaller the system is.

7.7 Interaction with the Kyoto Protocol

At present, inland shipping is included in the Kyoto Protocol, whereas marine bunker oils are not. This makes inclusion of maritime shipping in the EU ETS problematic. However, our analysis is not limited to the definitions or scopes in the Kyoto Protocol and in fact has a Post-Kyoto time perspective. As it is unknown what will happen after Kyoto, it is still important to investigate various possibilities in relation to the Kyoto Protocol.

One reason why marine bunker fuel oils are not included in the Kyoto Protocol is the difficulty to determine accountability for emissions from maritime shipping. There are several options for assigning responsibilities for emissions, as described in section 3.3, but the parties of the UN Framework convention on climate change (UNFCCC) have not yet agreed on this. The method chosen determines possible designs of emissions trading and affects the geographical scope and trading entities as well (Klooster et al. 2006), but according to Wit et al. (2004), there is currently no adequate method for the maritime shipping sector.

In the absence of an international agreement on marine bunker fuels, an option could be to have a separate emissions trading system for the shipping sector, e.g. a baseline and credit system linked to the EU ETS. In such a system it is important to decide on beforehand how many credits are allowed to be sold to the EU ETS, in order to assure a minimum emission reduction within the EU ETS.

7.8 Trading entity

Section 3.4 contains a general discussion on trading entity. Below is a discussion of possibilities for the shipping sector, including ship manufacturers (upstream), fuel suppliers (upstream) and ship owners (downstream). Ship owners are chosen before passengers, since they are the ones actually operating the ships. In the proposed trading system for NO_x and SO_2, ship owners are chosen as trading entities, as they have the incentives to reduce the emissions and are used to trade.

Fuel suppliers as trading entity could be a possible option and would lead to limited numbers of trading parties, and thereby probably moderate transaction costs. Fuel suppliers would influence the emissions by increasing fuel prices, thereby selling less fuel, or by switching to less carbon intensive fuels. For the actual emitters this resembles a carbon tax. Depending on the design, an upstream system may facilitate the inclusion of the whole transport sector in a common trading scheme. It also enables inclusion of private boat transport, especially if applied to the whole transport sector. However, this trading entity would not be an option in a regional system for maritime shipping, due to risk of evasion (the fuel could be bought in countries outside the trading system) but in a global system this could probably work well. If fuel suppliers are the chosen trading entity it will be difficult to distinguish between passenger and freight shipping.

Ship manufacturers as trading entity would influence the emissions by developing more fuel efficient ships or ships run on less carbon intensive fuels. This would stimulate technological development and possibly fuel switch, but the total emissions would never be known from the beginning. The effects of emission reductions would also take long to see, as it would take time before the whole ship fleet is affected. A system like this is not directly influencing the actual emitters, and therefore it would have limited influence on the use of the ships, i.e. it would not stimulate eco-driving etc. A trading system with ship manufacturers as trading entity would be feasible with at baseline and credit system with relative emissions (e.g. emissions/km), but would require a global system, as the number of ship manufacturers in EU is limited and to avoid evasion. Such system could facilitate distinguishing between passenger and freight, but only for those ships built especially for one of these purposes and not combined ditto.

Ship owners are used to trade, have the incentives for reducing emissions and have influence on what ships and engines that are used and how. They can also change to more fuel efficient devices or engines run on alternative fuels, probably when replacing old ships and engines. The life time of ships is about 30-40 years (engines are changed more often) and therefore it can take long before any of these effects are seen. However, the ship owners can still influence the emissions by optimising speed and load. With ship owners as trading entity it might be possible to separate passenger and freight transport, although very often passengers and goods are transported at the same time. A trading system with ship owners as trading entity could be feasible with either a baseline & credit or a cap & trade system. The former (baseline & credit) would be comparable to the proposed NO_x/SO_2 system and such a system could possibly be linked to the EU ETS (or other systems or sectors) analogously as the proposed interaction between the NO_x/SO_2 system for the shipping sector and the land-based installations.

Administrative costs. The number of trading parties would be limited no matter which trading entity is chosen. Shipping companies would give the highest number of trading parties, but it would still be limited compared to e.g. car drivers for road transport. In this respect the transaction costs could be expected to be moderate. However, since there is currently no agreed methodology for determining the accountability of GHG emission from shipping and monitoring methods and data are lacking, administrative costs for setting up a system with monitoring, verification and sanctioning could be high (Klooster et al., 2006).

The conclusion from the above discussion is that ship owners would probably be the best choice of trading entity. This is also in line with the proposed NO_x/SO_2 trading system.

7.9 Monitoring and reporting

According to The Swedish Maritime Administration, CO_2 emissions from ships can, in theory, be monitored and verified, but there are still administrative problems related to data availability that have to be solved (Grundström & Lemieszewski, personal communication). Below is a list of existing registers/statistics on data from maritime shipping (Wit et. al., 2004):

- National and international statistics on bunker fuel oils, which could be used for verification,
- Lloyds Marine Intelligence Unit (LMIU) database. This is a comprehensive database containing all global ship movements for ships exceeding 100 tonnes gross tonnage. The database includes, among other things, information on vessel types, departures and arrivals,

vessel size, engine details etc. However, the database does not register fuel consumption either at sea or in-port, which is necessary information in order to be able to calculate CO_2 emissions,

- Bunker delivery notes for vessels exceeding 400 tonnes gross tonnage. The notes are required since 2005, and were an important step forward regarding information on fuel consumption. Yet, fuel consumption at specific routes, time periods, regions etc. can not be distinguished.

Taken together, bunker fuel statistics could be used for verification, the LMIU database as well as the bunker delivery notes could provide a lot of operational data, but the resolution still has to be improved before adequate monitoring and reporting systems could be put up for the maritime shipping sector.

7.10 Allocation/determination of baselines

Possible allocation options and principles are described on a general level in section 3.6. Below is a brief discussion on different allocation options for maritime shipping. As shown, the lack of monitoring data and statistics, make the options very limited with auctioning appearing to be the best option.

Grandfathering means free allocation in relation to historical emissions. This has been the most common allocation method in the EU ETS. However, lack of data on historic emissions would probably make grandfathering very difficult in the shipping sector. Furthermore, grandfathering rewards actors with high historic emissions, whereas actors who have taken action to reduce the emissions receive a lower allocation. This drawback can be circumvented by choosing an early base year, but this is probably not an option in the shipping sector due to lack of sufficient data.

Auctioning means that all participating actors have to buy the needed emission allowances. This method is not associated with the drawbacks mentioned above regarding grandfathering. In fact, no emission data is necessary and this option would therefore probably be feasible for the shipping sector. However, there will of course be a higher initial cost for the actors compared to grandfathering, but in the case of shipping (depending on choice of trading entity), these costs could probably be passed on to the consumers.

Benchmarking means allocation in relation to some pre-determined performance measures. This option is dependent on data of high quality to set up accurate benchmarks. However, the method favours early emission reduction actions. Again, lack of data would probably rule out this option.

No allocation means that the shipping sector would not be allocated any emission allowances (or other credits) at all. Instead they would have to buy these from other participants. This option requires linking to EU ETS, from which emission allowances could be bought. It represents an environmentally stringent mitigation option since more participants would be part of the same cap. One advantage is that no emission data is required.

Of the above mentioned allocation options, auctioning seems to be the best choice of allocation method, partly due to lack of data for shipping sector. This option would also facilitate the inclusion of new entrants, since there would be no need for historical data. Allocation of emission allowances is only necessary in cap and trade systems. If baseline and credit is chosen, the problem would instead be how to **determine the baselines**. Determining baselines would just as grandfathering or benchmarking require data availability.

7.11 Economic effects

In chapter 4, economic calculations are made for various options for emissions trading schemes for the transport sector and linkages to the industry sector.

The whole transport sector is treated together and the analysis is based on the assumption that the abatement costs for reducing greenhouse gas emissions are higher in the transport sector than in the industry. Assuming that the MAC-curve for the whole transport sector used in the economic analysis can be applied to the shipping sector, and that there were no obstacles for including the shipping sector in a cap and trade system, the results unambiguously show that it would be more cost-effective for the shipping sector to be part of the same cap as the sectors currently included in the EU ETS than levying CO_2 taxes. A separate cap for the shipping sector and the industry would cause the shipping sector the same costs as a CO_2 tax.

7.12 Conclusions for the maritime shipping sector

The UN Convention on the Law of the Sea currently appears to prevent any local or regional rules for the shipping sector. Consequently, the shipping sector could not be forced to participate in local or regional emissions trading systems for greenhouse gases, but would have to participate on voluntary basis. The UNCLOS restrictions together with lack of monitoring data make it difficult to apply a cap and trade system for the shipping sector at present. As long as these restrictions remain, we believe that voluntary participation in a baseline and credit system linked to the EU ETS is a better alternative.

The scheme for NO_x and SO_2, proposed by the Swedish Shipowners Association could to a great extent be translated to an analogous emissions trading system for greenhouse gases. The European maritime shipping sector would then act in a baseline and credit system possibly linked to the EU ETS or any other trading system for greenhouse gases (e.g. with other transport sub sectors). In such a trading system, we suggest that the ship owners serve as trading entities allowing credits to be bought from or sold to other ship owners or to the market. One dilemma would be how to determine the baselines for each ship owner, as operational data is currently not completely available and fuel quality varies among European countries.

Below are summaries of design parameters for the maritime shipping sector.

Coverage of greenhouse gases

The impact on the radiative balance caused by emissions from maritime shipping is a complex issue, as it is related to both direct effects from emissions of greenhouse gases (mainly CO_2) and indirect effects due to emissions of NO_x, SO_2 and soot particles. Overall the impact on the radiative balance of emissions from maritime shipping is estimated to be small or slightly negative.

Geographic scope

There are several geographical scope options for maritime shipping. One option is all departures from EU ports, which corresponds to the suggested geographical scope for aviation. Another possibility is all routes between EU ports and some pre-determined routes on EU waters. This option could be easier to implement as it corresponds to the geographical scope of the proposed NO_x/SO_2 system. However, it is important to bear in mind that the UNCLOS restrictions imply that the scope of a trading system for maritime shipping will depend on the participating actors and would probably mean starting with a smaller scope and successively widening the system.

Interaction with Kyoto

Currently, marine bunker fuel oils are not included in the Kyoto Protocol, partly because the parties of the UNFCCC have not yet agreed on a method for how to determine accountability for emissions. Before an international agreement is met, the best solution would probably be a voluntary emissions trading system for maritime shipping with a gateway or other possibility to interact with the EU ETS.

Trading entity

Fuel suppliers, ship manufacturers or ship owners are possible trading entities, of which ship owners are probably the best choice as they have the right incentives to reduce the emissions and they are used to trade. This is also in line with the proposed NO_x/SO_2 trading system.

Monitoring and reporting

CO_2 emissions from ships can, in theory, be monitored and verified, but the data availability has to be improved. The LMIU database and bunker delivery notes could provide a lot of valuable information, but the resolution still has to be improved to assure accurate monitoring. Bunker fuel oil statistics could be used for verification.

Allocation /determination of baselines

In a baseline and credit system, baselines have to be determined for each participant. We have not investigated options for determining baselines in this project, but recommend this as a future task for research and development. Due to the current lack of data, improvement of data availability is necessary.

If it was possible to set up a cap and trade system for the shipping sector, we conclude that auctioning is the most cost-effective method for allocating emission allowances.

Policy options and economic analysis

There are other possible policy options for reducing greenhouse gas emissions from ships than emissions trading. Among these are CO_2 taxation, voluntary agreements between IMO and ship owners, environmental indexing (e.g. CO_2 indexing) and designing emission standards for ships. The economic analysis made in this project shows that it would be more beneficial for the maritime shipping sector to be part of the same cap as the current EU ETS sectors than if a CO_2 tax is applied to the shipping sector.

Concluding remarks

Shipping is international and a global trading system would be the best and also most cost-effective option. It would also reduce the risk of evasion and leakage of emissions. However, international shipping is not included in the Kyoto Protocol and a global trading scheme would require agreements among the parties of the UNFCCC on how to determine accountability for emissions of greenhouse gases from ships.

8 Stakeholder interviews

In order to gain a better understanding of the views of some important stakeholders, five semi-structured interviews were conducted during October 2006.

The interviewees were Bertil Arvidsson, Sweship, Birgitta Resvik, Confederation of Swedish Enterprise, (CSE), Lars-Erik Axelsson and Staffan Thonfors, Swedish Forest Industries Federation (SFIF), Kalle Keldusild and Jenny Ryman, Swedish Civil Aviation Authority, (SCAA) and Magnus Nilsson, the Swedish Society for Nature Conservation, (SNF).

This section contains a summary of the principal messages put forward by the interviewed organisations and some reflections around those messages.

Keldusild and Ryman stressed that their comments were made in their personal capacity and do not necessarily reflect the positions of their respective organisations. In order to facilitate the reading, we have used the abbreviations for the organizations.

Principal comments from Bertil Arvidsson at Sweship:

- Sweship are positive to integrating transports in the EU ETS
- The first priority should be to keep the system simple and pragmatic, focusing on the main sources of emissions.
- Transport of goods and personal transport should be treated separately. In a first step, only transport of goods should be integrated in the EU ETS.
- The system must keep a level playing field between shipping and road transports.
- A downstream approach, with transport buyers as trading entities, is preferred. This would avoid conflicts with UNCLOS and result in more emission reductions than an upstream solution would.
- Allowances for transports should be allocated free of charge to transport buyers. The allocation should be based on benchmarks and estimated transport needs.
- Combining ETS with a CO_2 tax is not a good solution.

IVL Comment: Sweship's members would be directly affected by the introduction of emissions trading in the shipping sector. Sweship have also put substantial effort into a proposal for how an emissions trading system for NOx and SO_2 could be designed for the shipping sector. Consequently, Arvidsson was able to give detailed feedback and suggestions on most design options for a greenhouse gas trading system. Sweship strong focus on the shipping industry provides deep insights on how that sector can be expected to respond and develop under an ETS. The most notable suggestion is to use transport buyers as the trading entity, and also allocate allowances to them based on transport needs.

Principal comments Birgitta Resvik at the Confederation of Swedish Enterprise:

- CSE have not yet formed a position on whether transports should be integrated in the EU ETS or not.
- The indirect effects of an integration of transports are still poorly understood and must be analysed further before a full integration of transports can be recommended or discarded. The main worry is the potential rise in electricity prices should transports be integrated in the EU ETS.
- The effectiveness of applying emissions trading in the transport sector must be compared to other available policy options. Such analyses are still lacking.
- Sweden is heavily dependent on transports. This should be recognized when designing any policy instruments directed at the transport sector.
- Should transports be integrated in the EU ETS, auctioning would be the most cost-effective allocation method. Revenues from such an auction could also, to a certain degree, compensate the government for the loss of tax revenues if the CO_2 tax on transports is abolished.
- A combination of ETS and CO_2 tax could be acceptable, not the least for fiscal reasons. CSE also see the need for other policies in the transport sector, for instance stimulating technology innovation, market demand and energy efficiency through other means than an increased carbon price.
- Investments in infrastructure are very important for creating possibilities for better logistics solutions and transport efficiency. Such investments are not primarily stimulated through an ETS.

IVL comment: The Confederation of Swedish Enterprise represent a very broad set of stakeholders, which is also reflected in their cautious and balanced approach to emissions trading. It is notable that they would like to see better analyses of indirect effects before they can take a stand for or against integrating transports. It is also notable that CSE support auctioning in the transport sector and that they see a combination of ETS with CO_2 tax and other policies as a possible solution. In light of the more common view expressed by industry, "one policy instrument for one objective", this is slightly surprising.

Principal comments by Lars-Erik Axelsson and Staffan Thonfors the Swedish Forest Industries Federation:

- SFIF are sceptical to integrating the transport sector in the EU ETS.
- The main worry is that integrating transports would cause a sharp increase in electricity prices, which would cause severe problems for Swedish and European industry.
- Dynamic and indirect effects of integration have not been thoroughly analysed. They need to be understood better before any decisions to include transports in the EU ETS are taken.

- It would be unacceptable if emissions from the transport sector were allowed to rise significantly at the expense of other sectors. Even if textbook theory suggests that integration offers gains in effectiveness, the negative consequences could be severe. Rather, SFIF supports the objective to decouple transport volumes from economic growth. An integration of transports in the EU ETS would jeopardize that objective.

- Should transports be included, SFIF leans towards an upstream solution, although the issue has not yet been analysed fully. Downstream solutions would increase transaction costs. In particular, SFIF do not consider a solution where transport buyers are the trading entity to be appropriate as it would create problems with accountability, monitoring and reporting of emissions.

IVL Comment: The members of the Swedish Forest Industries Federation will be affected indirectly thorough changes in prices on carbon and, in particular, on electricity. Hence it is logic that SFIF's main concern is how integrating transports will affect the price of electricity. At the same time, being large consumers of transports, the forestry industries have an interest in keeping the prices on transports from rising too rapidly.

Principal comments by Keldusild and Ryman at the Swedish Civil Aviation Authority:

- They are positive to including aviation in the EU ETS. This should be done as soon as possible.

- The main benefit of an integration of aviation in the EU ETS would be that it would introduce market based environmental policies in the sector for the first time.

- It is important to recognise that the structure of the aviation industry is different to other transports. The aviation industry still has close connections with nation states, although deregulation is increasing.

- It is unclear whether the EU has the legal opportunities to regulate flights departing to or from airports outside the union.

- Only CO_2 should be covered by trading as the scientific knowledge is still too low to allow sufficiently accurate estimates of the climate impact of other emissions. However, it is important that other policies are introduced for NOx, particles and contrail and cirrus formation in order to avoid trade offs between CO_2 and these factors.

- Aircraft operators should be the trading entity. This would provide the best incentives for emission reductions. Further, an upstream solution would resemble a fuel tax, an instrument which is fiercely opposed by the aviation industry.

- Allocation should be done based on benchmarks.

- Monitoring and reporting should not cause any significant problems in the aviation sector.

IVL Comment: The Swedish Civil Aviation Authority has a different role compared the other interviewees, in that they are an authority and not an independent organisation. In that sense they are more directly part of the formation of climate policy in general, even though they have a natural focus on the aviation sector and the interests of that sector.

Principal comments from Magnus Nilsson at the Swedish Society for Nature Conservation, (SNF).

- SNF is positive to the principle of emissions trading, but sceptic to including in particular the road transport sector in the EU ETS.
- Since shipping and aviation are not currently subject to carbon taxes, including them in the EU ETS would be a positive step. The preferred solution would, however, be to create a separate trading system for them.
- The main problem with including road transports would be carbon leakage. That is, there is a risk that emitting industries in Europe would simply shift production to outside the scheme if the prices of allowances and electricity are driven up too high as a result of the inclusion of road transports. Such a development is of no benefit to the environment.
- Another worry is that since policy makers can be expected to be anxious to protect industry from rising allowance prices, the cap will be determined by what price level the industry can sustain. If the transport sector is included, this will result in a cap that is far too lax.
- Separate trading scheme for road transports is OK in principle, although the benefits of such a policy compared to a tax are not obvious.
- A general comment is that more innovative policies should be contemplated.
- Differentiated policies (and marginal costs for emissions) across sectors can be motivated if a faster overall reduction rate can be obtained by such an approach. That is, equal marginal costs for emissions across the economy is not the silver bullet of climate policy. However, capping transport emission is in itself not a priority.
- An upstream solution, with fuel suppliers as trading entities, seems more suitable than a downstream system. The main argument for this is the lower administrative costs associated with an upstream system.
- Auctioning is the preferred allocation method, due to efficiency reasons as well as arguments for environmental effectiveness.

IVL Comment: The Swedish Society for Nature Conservation stresses that their primary concern is the environment, not the economy. However, it is worth noting that the arguments put forward by SNF for not including road transports in the EU ETS are almost identical to the ones expressed by Confederation of Swedish Enterprise. That is, carbon leakage is taken seriously by both industry and the environmental movement. It is also worth pointing out SNF:s positive view on trading as a principle, although they would also like to see other innovative policy instruments.

9 Discussion and conclusions

9.1 General conclusions on integration of the transport sector in an ETS

The conclusions given in this section is based primarily on the analysis in chapter 4.

If the transport sector is fully integrated into a common ETS with industry, as opposed to having two separate systems, and assuming that abatement costs are higher for transports than for industry, we conclude that:

- **Allowance price in the ETS will increase; the cost of carbon emissions in the transport sector will decrease.** Allowance price will increase, due the transport sector buying allowances from industry thus increasing the demand for allowances. For transportation, however, the price on allowances will be considerably lower than the tax level necessary to achieve the 10% reduction in the reference case[52].
- **Impacts on industry may be significant**. In the industry sector, regardless of allocation, the marginal operating costs, including the shadow price on allowances will increase. Price on electricity will increase in liberalised markets and for some industries this will constitute a double impact (higher price on allowances and on electricity). Production in carbon emitting industries will decrease and the EU may experience structural impacts such as closures and relocation of industry to countries outside the EU (carbon leakage). On the other hand, with a higher price on allowances, new carbon efficient technologies that previously have not been economically viable, such as certain renewable energy technologies may become profitable and may experience a market breakthrough.
- **There will be significant changes in the distribution of emissions between sectors.** In an emissions trading system reductions will take place where they have the lowest cost. Assuming that marginal abatement is cheaper in the industry sector, this sector will perform a larger amount of abatement than in the reference case and emissions in this sector will decrease. In the transport sector, emissions reductions will be smaller than in the reference case. The emissions in the transport sector may even increase above the projected emission level in 2008-12. CO_2 emissions will remain unchanged, since this is a prerequisite for the study.
- **Impacts on the transport sector may be significant.** In the transport sector, with a significantly lower price on carbon emissions, fuels will become cheaper and marginal operation costs will decrease considerably. Ongoing carbon reduction programmes with relatively high abatement costs, such as low carbon fuel chains and CO_2- efficient vehicles, may become unprofitable. Transportation will increase considerably compared to the reference case.

[52] The reference case is explained in detail in chapter 4, and corresponds to a system where the transport sector is regulated by taxation and industry by emissions trading. The same reduction targets for CO_2 emissions are set for both sectors.

- **There will be significant changes in the distribution of costs.** Compliance costs will increase significantly within industry sector, mainly due to the higher price on allowances. Compliance costs for the transport sector will decrease considerably, which is mainly due to the sector being able to buy allowances at a much lower price than the corresponding tax in the reference case.
- **Total costs for compliance will decrease, if structural changes in the different sectors are not accounted for**. For emissions trading systems in general, increasing the number of installations, sectors and gases will increase the number of available emission reduction options and hence decrease the total costs for achieving a given carbon emission target. We estimate, with less certainty that integrating transportation in the EU ETS is likely to decrease the total costs for compliance, if structural effects are not accounted for. This is due to the differences in abatement costs between the sectors. Abatements that in the reference case were performed in the transport sector will instead be performed in the industry sector where abatement is cheaper. Structural changes, which are not accounted for in this study, may include production changes, closures and relocation in the industry sector to countries outside the EU (carbon leakage).
- **The pressure on sectors outside the ETS will be lower.** In the case of a future climate regime where nations will have quantitative emission reduction targets (like in the Kyoto Protocol) it may become easier for sectors outside the trading system to fulfil their emission targets since they will no longer compete with the growing transportation sector for the available emission volumes in the non trading sector.
- **There exist other considerations than to lower total CO_2-emissions.** The issue of how to control the transport sector clearly involves other considerations than to only minimise costs for reaching a climate target. Transportation is also responsible for other environmental impacts that today are, at least partly, controlled through fuel and CO_2 taxes. But apart from that, safeguarding a certain balance between industry and transportation may be an objective in itself. If so, it may be motivated to protect the industry and to constrain the growth of transportation, even if this may lead to higher total CO_2 compliance costs. If the tax instrument is removed from the transport sector it may become more difficult to control this sector specifically.
- **The difficulty to assess dynamic and structural effects makes full integration a high risk alternative.** Compared to the reference scenario, an ETS where transportation is fully integrated with industry will lead to considerable changes in where abatement takes place and where costs are taken. Assessing the impact of such changes is a challenging task, and the total consequences for society are difficult to foresee. Thus a full integration carries high risks.
- **With free allocation to industry the distributional impacts on industry are reduced.** Free allocation to industry will significantly decrease the total costs for this sector compared to if auction is applied. If 90 % of the allowances to industry are issued at no cost industry will be able to sell allowances to the transport sector and these revenues will be important. If 100% of the allowances are issued at no cost to industry, the revenues from sold allowances will be higher than the total abatement costs for industry (since abatement costs for industry are always lower than the allowance price). Free allocation is therefore a powerful means for lowering the distributional impacts on industry if transport is included in the ETS.
- **Dynamic impacts on industry will still exist with free allocation.** Free allocation will provide large revenues to industry. However, the impacts on industry due to a higher

allowance price are unchanged, including higher marginal production costs, decreased output, altered investments and closures of installations. The discussion of dynamical impacts on industry and transportation (as described in case 3), remain relevant. In the transport sector we expect lower fuel prices, increased transportation, increased emissions and that several current and planned CO_2-reduction programmes become unprofitable.

- **The sizes of the sectors are important.** Linking a minor part (10%) of the transport sector to the ETS, for instance aviation, shipping or goods transports, will have a certain impact on allowance price compared to the reference case. However, this impact will be significantly lower than if the whole transport sector is linked. Emissions for industry will decrease somewhat, while emissions from the included part of the transport sector will increase significantly, even more than in a fully integrated system. Total compliance costs will increase somewhat for industry and decrease dramatically for the part of the transport sector included in the ETS.
- **A hybrid system may moderate the impacts on allowance prices and cost distribution.** In a hybrid system, where the transport sector is fully integrated with the EU ETS but with the tax level sustained within the transport sector the impacts on allowance price and cost distribution can be moderated as compared to if the tax is removed. Total costs for compliance, allowance price, emissions and distribution of costs will lie in between the cases with separate systems and a fully integrated system.

Uncertainties in abatement costs may have an impact on our conclusions. Our analysis is strongly dependent on the assumption that marginal abatement costs are considerably higher in the transport sector than in the industry sector. For reasonably low levels of abatement, we have been able to support this assumption through data on abatement costs and by comparing the current tax levels on industry and transportation. We have also investigated the consequences on our results if the transport sectors´ marginal abatement costs are 50% lower than assumed in our other cases, but still a factor 2.5 higher than in industry. In an integrated system this would reduce the impact on allowance price and costs for industry. However, compared to our reference case with separated systems the impacts would still be significant and our earlier conclusions would remain valid. For large reduction levels the uncertainty in abatement costs increase. In the industry sector it may well be that abatement costs increase rapidly if reduction levels reach 30-50%, since an important part of the industrial emissions are associated with chemical processes such as cement production, steel production and mineral oil refining. We have not been able to assess abatement costs at these high levels and compare them to abatement costs in the transport sector. If abatement costs at high abatement levels are higher in industry than in transportation, this may influence our conclusions. These uncertainties in impacts may be seen as an argument per se against integrating the whole transport sector into the EU ETS.

9.2 Effectiveness and costs of alternative architectures – integrated emissions trading schemes

In Table 9.1 we summarise the effectiveness and costs of six alternative integrated emissions trading schemes. The assessment is done in relation to a reference case where each of the four sectors (industry, road transport, aviation and shipping) is subject to a 10% reduction target and that these reductions should be realised within the sector, i.e. no trading between sectors is allowed. We have described how these architectures meet five criteria; effectiveness, distribution of costs and emissions, impacts on carbon price/dynamic effects, level playing field/competitiveness and administration costs. The first four criteria are based on the analysis in chapter 4, while comments on practical, legal and political issues are drawn from the sector specific chapters 5-7.

Explanation of criteria:

Effectiveness: Measure of the total cost to society to reach a given emission reduction target. The more effective the system, the lower the total cost of reaching the target. In this study we compare the total costs associated with different options to integrate the transport sector in the EU ETS with the case with separate policies and equal reduction targets in each sector. Important factors determining effectiveness are market size (measured in emission volumes) and how the abatement costs differ between and within sectors.

Distribution of costs and emissions: Measure of to what extent emission reductions and compliance costs are redistributed between sectors. "Large impacts" mean that there are large redistributions of costs and emissions compared to the reference case. This factor is mainly determined by how much the abatements costs differ between sectors, with great differences resulting in large redistribution of costs and emissions. Free allocation reduces compliance costs for firms and can thus compensate for distributive effects caused by the trading.

Carbon price/dynamic effects: These include, for instance, changes in investment patterns, employment and output. Ultimately, these effects are determined by how much the variable cost of a sector is affected by the trading scheme and to what extent these can be passed on to consumers. Allowing trading between a sector with relative high abatement costs, e g road transport, and a sector with lower abatement costs, e g industry, will increase the carbon price and thus the variable costs for industry, whereas the carbon price for road transportation will decrease. This happens regardless if allowances are free or auctioned. A significant increase in carbon prices risk causing a decrease in production, carbon leakage and closures.

Level playing field/competitiveness. Measure of to what extent sectors with similar products face equal carbon costs.

Administrative costs. Measure of costs for managing the system, including costs for emissions monitoring, verification, data management and transaction of permits. The number of trading entities has significant implications for administrative costs.

Table 9.1 Implications of different architectures of integrated emissions trading schemes. Reference: Separate policies - all with 10% reduction targets.

Architecture	**Effectiveness**	**Distribution of costs and emissions between sectors**	**Carbon price / dynamical impacts**	**Level playing field / competitiveness**	**Administrative costs**
No 1. Industry +road+ shipping+ aviation	High	Large impact on distribution: Industry: large increase in costs, unless free allocation Road, SA: large decrease in costs, significant increase in emissions	Large impact: Industry: large impact in carbon price Road: large decrease in carbon price SA: large decrease in carbon price	High	Medium[53]
No 2 Industry + Road	High	Large impact on distribution: Industry: large increase in costs, unless free allocation Road: large decrease of costs, significant increase in emissions	Large impact: Industry: large increase in carbon price Road: large decrease in carbon price	Medium	Medium[53]
No 3 Industry + shipping +aviation	Medium	Medium impact on distribution: Industry: some increase in costs SA: Large decrease in costs, significant increase in emissions	Medium impact: Industry: moderate increase SA: large decrease in carbon price	Medium	Low
No 4 Industry + goods transport	Medium	Moderate impact on distribution: Industry: moderate increase on costs, unless free allocation Road, SA: significant decrease of costs and increase of emissions	Medium impact Industry: moderate increase in carbon price Road, SA: large decrease in carbon price	High	Medium/Low
No 5 Road +shipping + aviation	Low	Medium impact on distribution: Road: moderate impact on costs and emissions SA: Uncertain. Impacts can be significant Possible decrease in costs and increase in emissions depending on MAC	Medium impact: Road: Moderate impact SA: Uncertain. Possible decrease in carbon price, depending on MAC	Medium	Medium[53]
No 6 Shipping +aviation	Low	Impact depends on MAC in shipping and aviation.	Impact depends on relative MAC in shipping and aviation.	Medium	Low

Road: Road transport sector
SA: Shipping and aviation sectors.

[53] Assuming an upstream approach on trading entity in the road sector.

Conclusions on architectures

We draw the following conclusions on the different architectures:

- Architecture 1 (Industry and all transport) and architecture 2 (Industry and road transport) will lead to significant impacts on carbon price and on the distribution of costs and emissions. With less certainty, we estimate that total compliance costs will decrease if dynamic effects are not accounted for. These dynamic effects could include production changes and closures. A hybrid system, where the transport sector also pays carbon tax, may offer a compromise. This would lead to lower impacts on carbon price and on the re-distribution of costs and emissions. But with a hybrid system we would also lose some of the gains in effectiveness. We recommend that the dynamic effects and abatement costs for transportation are further investigated in order to better assess the impacts of integrating road transport to the EU ETS.
- Architecture 3, with industry, aviation and shipping in an integrated ETS, offers increased effectiveness combined with a relatively low impact on allowance price and therefore moderate cost increases for industry, while administrative costs are kept reasonably low. We also expect moderate redistributions of costs and emissions, which may facilitate implementation. Since aviation and shipping are not paying a carbon tax today, this is a strong reason for including them, whereas we do not recommend that road transport is integrated in the EU ETS before potential dynamic effects of such a scheme are better analysed. An important note is that inclusion of shipping seems to require participation on a voluntary basis.
- Architecture 4 (industry and goods transportation) offers increased effectiveness combined with relatively low impact on allowance price, and therefore moderate cost increases for industry. There are, however, a number of challenges associated with this architecture: First, it is difficult to separate goods transportation from transportation of people in the aviation sector. Even if it would be possible, it would for the aviation sector only cover a small part of the emissions[54] and it would not result in any restrictions or reductions in the growth of passenger air transport. Secondly, separating goods from transportation of people in the road transport sector is difficult to combine with an upstream approach to trading entities, which we recommend. Third, road transportation today pays a considerably higher carbon cost than industry, aviation and shipping. Integrating road transport of goods with industry, aviation and shipping would probably require that road transportation keeps the fuel tax in order to avoid large increases in the carbon price. Such a hybrid system would increase the complexity of the system.
- Architecture 5 (road, shipping and aviation) offers low gains in effectiveness. Moreover, there is a risk for large impacts on allowance price and compliance costs in the aviation and shipping sectors.
- Architecture 6 (shipping and aviation in common scheme) offers small gains in effectiveness since the linked sectors are relatively small. Moreover, it is difficult to assess the impacts of an integration since there are great uncertainties in the estimated abatement costs for aviation relative shipping.

[54] Approximately 80% of all European air traffic is due to tourism. The remaining 20% is a mixture of business travel and freight. (European Union Committee Publications, 2006).

9.3 Choice of design parameters and impact of architecture

Below we summarise which options for design parameters we recommend in the different sub sectors of the transport sector in relation to different architectures. For a more detailed discussion on the design parameters, please consult chapters 5-7. Unless otherwise noted, the given options are preferred and independent of the choice of architecture.

Coverage of greenhouse gases

- Road: CO_2 only since this is the major part of the greenhouse gas emissions from this sector.
- Aviation: CO_2 only. Flanking instruments for NO_x should be introduced. Better knowledge and metrics for cirrus and contrail formation are needed before instruments for these effects can be applied.
- Shipping: CO_2 only. Other emissions (NO_x and SO_2) reduce the impact on the radiative balance but cause other environmental distortions.

Geographic scope:

Even though the choice of geographic scope is little impacted by the overall architecture, the competition between transport modes might be affected and hence preferably the geographic scope should be as similar as possible for all included transport sectors (road, aviation and shipping). The smallest geographical scope considered in this study for the aviation sector was intra EU flights only. For the road transport sector it is likely that the geographical scope would be the EU and hence there is no risk for some destinations being included in the road transport sector but not in the aviation sector. To also include international flights (e.g. all flights arriving at EU airports) probably mean little for the competition with other transport modes since aviation is the most CO_2 intensive mode and currently untaxed. The geographical scope proposed for the maritime shipping sector is all routes between EU ports and maybe also some pre-determined routes on EU waters. It is important to bear in mind that if the interpretation of UNCLOS holds true[55], each ship owner would decide whether to join an emissions trading system or not, and correspondingly the scope of the trading system depends on the number of participating actors.

- Road: EU.
- Aviation: All flights departing from and arriving at European airports.
- Shipping: Voluntary system. Depending on interest from ship owners.

Interaction with Kyoto:

- Road: The interaction with Kyoto is not an issue for the road sector.
- Aviation: A gateway solution is the best option for most of the architectures. In such a solution the aviation sector is only allowed to sell as many allowances to the other sectors as the sector as a whole already has bought from the non-aviation sectors. That the gateway solution is the best option is based on the current analysis which implies that it is most likely that the aviation sector would become a net buyer of allowances if included together with the industry (hence abatement costs are assumed to be higher in the aviation sector). This might change if also other sectors are included in the trading scheme. If for instance the road transport sector would

[55] The interpretation is that UNCLOS appears to prevent compulsory participation of the shipping sector in a local/regional emissions trading system.

be included in the same system, as architecture no 1 and 5 suggests, other sectors might have higher abatement costs than the aviation sector and hence the aviation sector might be a net seller. This will increase the difficulties of having a gateway solution.

- Shipping: The shipping sector is assumed to be included on voluntary basis, and the actors in this sector could be either net sellers or buyers. This means that a gateway solution could be used also for this sector, if the sector is a net seller the linked system will have to decide how many allowances the shipping sector should be allowed to sell (set a limit).

Trading entity:

- Road: Depending on the aim of the introduction of the trading scheme. If the purpose is to create a single price on CO_2 emissions and to reduce the total cost of reaching an emissions target, the best choice of trading entity for the road transport sector is **fuel suppliers**. We see no hindrance[56] in linking systems with upstream (as fuel suppliers would be) and downstream approaches (which is the case for the industry sector currently included in the EU ETS). A downstream approach in the road transport sector including only **vehicle owning companies** may also be an option. However, a downstream approach for part of the road transport sector must be designed to deal with different fuel taxes for different actors if the vehicles included in emissions trading would be exempted from fuel taxes whereas private vehicles still should pay fuel taxes. If the aim with the introduction of an emissions trading scheme for the road transport sector is to introduce incentives to develop more fuel efficient vehicles and to develop vehicles powered by alternative fuels, **car manufactures** is the best choice of trading entity. In an architecture where only goods transportation is included together with the industry sector, fuel suppliers can not be the trading entities. Instead the trading entity must either be **vehicle owning companies** or **the company buying transport services**. If vehicle owning companies are the trading entities most of the emissions from goods transportation would be covered. The alternative where transport buyers are trading entities would probably need to be voluntary[57] and would therefore have lower coverage of emissions. Again, fuel taxes might have to be different for actors in the sector included in emissions trading and actors that remain outside. One solution would be to add emissions trading on top of the fuel tax, which would result in goods transport and the industry having different prices on their CO_2 emissions (as is the case today). One reason of including industry and goods transport in the same emissions trading scheme is to create a "level playing field" for the emissions related to industry (both direct emissions and the goods transport emissions). However, with different prices (emissions trading plus fuel taxes compared to only emissions trading) between goods transport and industry there will not be a level playing field.

- Aviation: Aircraft operators
- Shipping: Ship owners.

Monitoring and reporting:

- Road: Depending on trading entity, see chapter 5.5.
- Aviation: The reported fuel consumption by operators. Data available at EUROCONTROL could be used as reference in the verification process.
- Shipping: Data availability must be improved. Bunker fuel oil statistics could be used if fuel suppliers are trading entity (which is not our recommended solution, and mainly viable in a global system).

[56] It would however mean that the Directive 2003/EC/87 would have to be amended since it is written in a way that assumes a downstream approach.
[57] For more information on this option see section 5.5.3.

Allocation

- Road: Auctioning, unless a baseline & credit system involving car manufacturers is chosen. Then baseline determination will replace allocation.
- Aviation: Auctioning.
- Shipping. Determining of baselines.

Type of trading scheme

- Road: Cap & trade (for all suggested trading entities except car manufacturers and transport buyers for which baseline & credit is preferred)
- Aviation: Cap & trade
- Shipping: Baseline & Credit, in the case of a voluntary system. If a mandatory system would be possible to implement Cap & Trade would be better since it is easier to integrate with other Cap & Trade schemes.

Goods transport

A solution with only goods transport included in and ETS may be difficult to implement for the shipping and the aviation sector since both goods and passengers are transported at the same time and it might be difficult to distinguish between emissions caused by the transportation of passengers vs. the transportation of goods. In addition a system that only requires emission allowances for emissions from cargo transportation would not create any incentives or limitations at all to the growth of passenger transportation. Having such a system for the aviation sector would rather complicate the system (since the distinction between passenger and goods would have to be made) than simplify it. In addition it would reduce the amount of emissions included in the system and hence decrease effectiveness. Due to these reasons we see no reason for differentiating between passenger and cargo transportation by air. For the shipping sector a system only including the emissions from goods transportation would still include the majority of emissions and hence it is a possible solution for this sector.

10 Further research

We recommend that the dynamic effects and abatement costs for transportation are further investigated in order to better assess the impacts of integrating road transport to the EU ETS.

We also see the need for better data on abatement costs in most sectors (both the transport sub sectors and the industry sector). A thorough study on EU level would be helpful in many aspects not only for determining the design of emissions trading.

In addition we think it is important to make a thorough legal evaluation of UNCLOS to investigate the potential possibilities of designing an emissions trading scheme in line with current regulation or to identify obstacles that would have to be changed in order to introduce a common EU regulation.

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Appendix 1 Case 6 Hybrid. Transport and Industry in common ETS, Transport pays current CO_2 tax, 100 €

In this case we keep a CO_2 tax of 100 € in the transport sector and include transportation in the ETS. In the graph, a dotted help line corresponds to the transport MAC-curve shifted down by 100 €. In this case, the transport sector will abate down to a point were the dotted line crosses the industrial MAC-curve. The reason for this is that for every ton avoided, the transport sector will save allowances and also saves the 100 € tax. The dotted line crosses the industrial Mac-curve when the transport emissions are 95% and the industrial emissions 85%. At this point the allowance price is 50 €/ton. For the transport sector, this is the optimal point. With higher emissions the cost for allowances (50 €) plus the price for tax (100 €) will be higher than the abatement cost (< 150 €). Here reducing emissions will be cheaper than buying allowances and paying tax. On the other hand, with lower emissions, the cost for abatement (> 150 €) will be higher than the cost for tax plus allowances. Here, buying allowances will be cheaper than reducing emissions. For industry, this is also the optimal point, where marginal abatement costs are equal to allowance price.

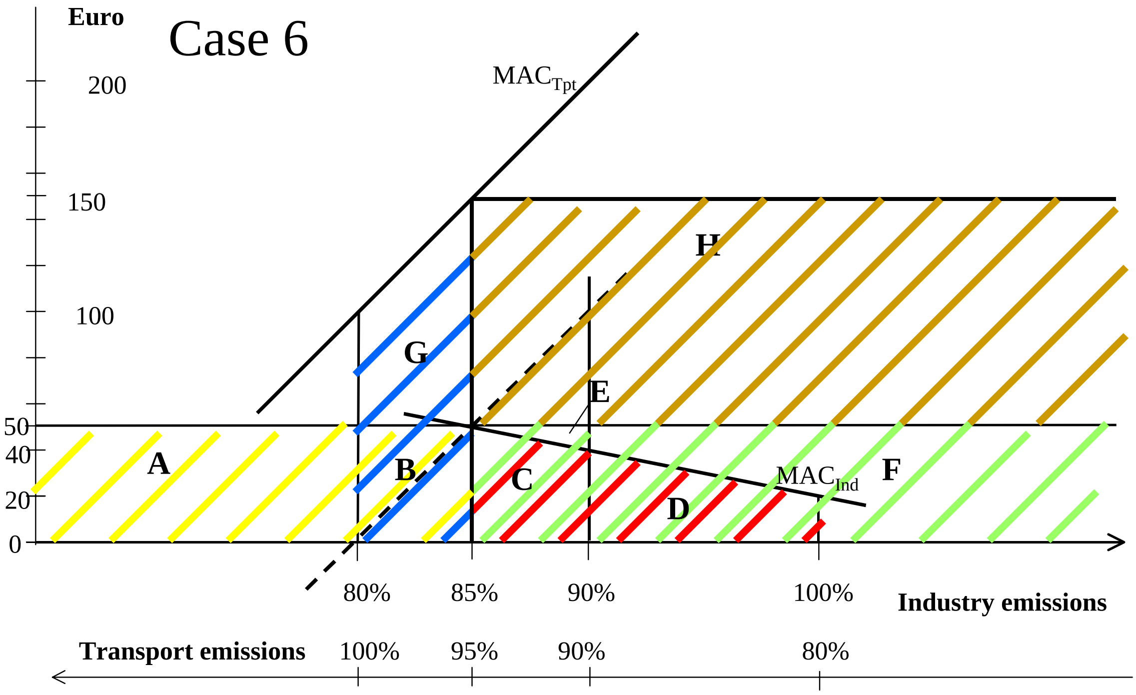

Figure I.

Results

The results are illustrated in the figure above. With a hybrid system, allowance price will be 50 €, as opposed to 40 € in a separate ETS and 67 € in an integrated ETS.

For industry, emissions are 85%, as compared to 90% in the reference case or 76.7% in a fully integrated system. Costs for abatement are 525 units (CD (red)) and costs for allowances are 4250

(AB (yellow)). With auction, total costs on industry are 4775 units, compared to 3900 units in a separate system and 6122 units in an integrated system. With free allocation, there will be additional revenues of 4500 units. Including these revenues, total costs for industry will be 275 units in a hybrid system, as compared to 300 units in a separate system and 122 in an integrated system.

For the transport sector emissions are 95%, as compared to 90% in the reference case or 103.3% in a fully integrated system. Costs for abatement are 625 units (BG (blue)), costs for allowances 4750 (CDEF (green)) and costs for tax 9500 (H (brown)). Total costs n transports in a hybrid system will be 14875 units, as compared to 19500 units in a separate system and 6611 units in an integrated system. State revenues in a hybrid system, assuming auctioned allowances will be 18500 units, as compared to 21600 units in the reference case or 12000 in an integrated system.

Total costs on society with a hybrid system will be 1150 units, as compared to 1800 units in the reference case and 733 units in an integrated system.

In a hybrid system as described above, were the transport sector is fully integrated with the ETS but with the tax level sustained, the impacts on allowance price and cost distribution can be moderated. Allowance price, emissions and costs will lie in between the cases with separate systems (case 2) [58] and a fully integrated system (case 3) [58].

[58] Case 2 and case 3 is presented in chapter 4.