

Dealing with Transport Emissions

An emission trading system for the
transport sector, a viable solution?

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An emission trading system for the transport sector,
a viable solution

Authors:
Jeroen Klooster and Bettina Kampman
CE, Delft

SWEDISH ENVIRONMENTAL
PROTECTION AGENCY

Orders

Phone: + 46 (0)8-505 933 40

Fax: + 46 (0)8-505 933 99

E-mail: natur@cm.se

Address: CM-Gruppen, Box 110 93, SE-161 11 Bromma, Sweden

Internet: www.naturvardsverket.se/bokhandeln

The Swedish Environmental Protection Agency

Phone: + 46 (0)8-698 10 00, Fax: + 46 (0)8-20 29 25

E-mail: natur@naturvardsverket.se

Address: Naturvårdsverket, SE-106 48 Stockholm, Sweden

Internet: www.naturvardsverket.se

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Preface

Innovative and far reaching measures are needed to slow down climate change. Emissions of CO₂ from the transport sector have been increasing steadily in many countries and Sweden is no exception to this trend. Because of the increased demand for transport services, slowing down or reversing these trends in the transport sector has proven to be very difficult. Emissions trading is a market mechanism which has recently been employed in the European Union for controlling climate gas emissions. The European Unions Emission Trading Scheme (EU ETS) currently covers most large industrial installations, but not transport.

As awareness about emissions trading grows the possibilities for using this policy tool for addressing emissions growth in the transport sector are increasingly being discussed. Much of the focus at present is on the aviation sector as the European Commission is currently preparing a report on how aviation could be brought into the EU ETS. However, other transport sectors will also come into the spotlight as consideration is soon given to expanding the EU ETS after 2012.

There are many options for how emissions trading could be applied to the transport sector(s). Such a scheme could conceivably cover all transport sectors or else comprise of separate schemes for sub sectors such as road transport. The scheme could be 'open' i.e. linked to the EU ETS and other trading systems, or 'closed', i.e. restricted to the sector itself. Then there are a wide number of other design options and criteria to consider.

To improve our insight into the feasibility and implications of emission trading being applied to transport, the Swedish Environmental Protection Agency asked CE Delft to prepare the present study. Besides a Swedish summary the report is in English. The authors have sole responsibility for the content of the report and it can therefore not be taken as the view of the Swedish Environmental Protection Agency.

Swedish EPA
Stockholm March 2006

Authors preface

Carbon dioxide (CO₂) emissions from transport are steadily increasing, even though various CO₂ mitigation policy measures have been implemented in recent years. A potential new policy measure for CO₂ mitigation in the transport sector is CO₂ emission trading.

This report by CE Delft for the Swedish Environmental Protection Agency (SEPA) assesses the possibilities for CO₂ emission trading schemes for the transport sector. Various schemes are investigated and assessed, for the transport sector as a whole and for specific transport modes (road, railways, maritime shipping and aviation). The report has a ‘scan like’ character, and provides a broad overview of current knowledge. Viable options as well as knowledge gaps are identified.

The major observations, conclusions and recommendations of this report are summarized as follows:

- For a quick glance it is sufficient to read the management summary.
- For more details please refer to the regular summary.

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Executive summary

Background: increasing transport CO₂ emissions

Carbon dioxide (CO₂) emissions from transport are steadily increasing, even though various CO₂ mitigation policy measures have been implemented in recent years. A potential new policy measure for CO₂ mitigation in the transport sector is CO₂ emission trading.

This report by CE Delft for the Swedish Environmental Protection Agency (SEPA) assesses the possibilities for CO₂ emission trading schemes for the transport sector as a whole and for specific transport modes (road, railways, maritime shipping and aviation).

Specific schemes have been assessed, based on the following types:

- Cap & trade (C&T) systems, setting emission ceilings in combination with tradable emission rights, and
- Baseline & credit (B&C) systems, setting a baseline emission standard in combination with bankable / tradable emission credits. In this type of scheme absolute CO₂ emissions are not regulated directly, only the relative emissions, such as for example the CO₂ emissions per vehicle kilometre.

Results: road

The main conclusions regarding road transport, the mode with the largest share in CO₂ emissions of transport are as follows:

C&T schemes in which end consumers (vehicle drivers) or fuel suppliers are the trading entity both seem feasible. However, if end consumers are the trading entity, transaction costs may be very high. B&C schemes for vehicle manufacturers seem feasible for passenger cars and light commercial vehicles. Transaction costs will be relatively low.

With a C&T scheme, meeting a specified CO₂ emission (reduction) target can be ensured. C&T systems generally encourage all means of CO₂ mitigation, whereas a B&C scheme only affects engine and vehicle technology. However flanking instruments could specifically enhance B&C schemes, such as for example a driver awareness program to stimulate environmentally friendly driving.

From the point of view of ensuring emission reductions in the sector itself, a closed system (i.e. not linked to EU ETS) may provide several benefits. As (domestic) transport does not face severe international competition, the risk of carbon leakage is small. A closed scheme can thus be economically justified. For political reasons there may also be an interest to guarantee that measures are taken to ensure reduced emissions, or at least to slow down emission growth, in the sector itself.

However, these benefits should be weighed against the better cost effectiveness of an open system. If the transport sector is allowed to trade with other sectors, emission reduction measures can be taken where costs are lowest. Since transaction costs generally also increase with scope and flexibility, total cost effectiveness will depend on the balance between these two costs. Furthermore, a closed system will

lead to different prices of CO₂ emission allowances in the transport sector, compared to those in the EU ETS.

Potential effects on competitiveness depend strongly on the design of the scheme, and on the stringency of the cap. The effect of introducing C&T emission trading would be very similar to an additional charge or CO₂ tax on fuel, which has much lower transaction costs.

Results: railways

Compared to road transport, diesel trains are responsible for a very minor share of total CO₂ emissions¹. For this reason no full appraisal has been carried out for emission trading schemes specifically aimed at diesel trains.

Results: maritime shipping

Provided an adequate CO₂ monitoring system comes into place, an international C&T scheme for shipping companies could be an attractive option in the future. An international B&C scheme for ship manufacturers could also be a viable option, provided that a CO₂ measurement system could be implemented and the scheme would apply for all (EU and non-EU) shipbuilders. However, these options were not analysed further in this report.

Results: international aviation

For aviation no full appraisal of options has been carried out, since much work has already been done on this issue. Instead two specific issues were addressed.

First, the potential *net* impact of inclusion of aviation in the EU ETS on other sectors via an increase in allowance prices was proved to be small, because most impacts cancel out. The impact on *specific* sectors can still be significant though. Second, emission abatement measures were addressed to ensure reduction within the aviation sector.

Results: all transport schemes

Concerning options for an all transport scheme, to a large extent the same arguments hold as discussed for the road sector. Most feasible appeared to be a C&T scheme with either end users or fuel suppliers as the trading entity.

An all transport scheme would require that the monitoring, registration and verification of CO₂ emissions be designed and implemented in all transport modes. Currently, lack of data is most significant in the maritime sector.

Design and development, implementation, monitoring and enforcement of the scheme will be much easier and hence transaction costs will be substantially less if fuel suppliers are the trading entity rather than end users. Since cost effectiveness of a trading system generally improves with increasing scope of the system, linking to the EU ETS would seem beneficial in that respect. However, this benefit should

¹ The analysis has been restricted to diesel trains as emissions of electric trains are already included in the current EU ETS for stationary sources.

be weighed against the potential benefits of a closed system that were mentioned earlier in the section on road transport.

Recommendations

When comparing the various emission trading schemes analysed, we recommend to analyse in more detail the B&C scheme for car manufacturers and the C&T scheme for fuel suppliers. For the latter scheme a step-by-step approach could be taken, by implementing such a scheme first for a single transport mode (e.g. road), and including other modes at a later stage.

For all these schemes there is a case for both a closed and (semi) open version. We therefore recommend to further assess the respective merits of both design options.

Finally, since emission trading is not the only policy option to reduce CO₂ emissions, we also recommend to look into potential alternative policies (e.g. CO₂ tax on fuel), and compare these more closely to emission trading systems.

Sammanfattning

Bakgrund: koldioxidutsläppen från transportsektorn ökar

Koldioxidutsläppen (CO₂) från transporterna ökar stadigt trots att man under senare år vidtagit flera åtgärder för att minska dessa utsläpp. En tänkbar ny åtgärd för att minska koldioxiden inom transportsektorn är handel med utsläppsrätter för koldioxid.

I den här rapporten som CE sammanställt för Naturvårdsverkets räkning utvärderas möjligheterna med ett handelssystem med utsläppsrätter för koldioxid inom transportsektorn som helhet samt för de separata transportsektorerna (vägar, järnvägar, sjöfart och flyg).

Särskilda handelssystem har utvärderats baserade på följande två typer:

- C&T (cap & trade, sv. *utsläppstak*)-system som sätter ett tak för utsläppen i kombination med utsläppsrätter som kan användas för handel, och
- B&C (baseline & credit, sv. ungefär *utsläppsmål*)-system som baseras på en nivå för utsläppen i kombination med utsläppsrätter som antingen går att förvandla i reda pengar eller att handla med. I den här typen av system är det inte de absoluta koldioxidutsläppen som regleras direkt, utan enbart de relativa utsläppen, som till exempel koldioxidutsläpp per fordon och kilometer.

Resultat: vägtrafiken

De viktigaste slutsatserna angående vägtransporter, den transportsektorn med de största koldioxidutsläppen, är dessa:

C&T-system där det är slutkonsumenten (bilförarna) eller bränsleleverantörerna som fungerar som handelsenhet verkar båda möjliga. Men om det är slutkonsumenterna som utgör handelsenhet kan transaktionskostnaderna bli mycket höga. Ett B&C-system för fordonstillverkare kan fungera för personbilar och lätta lastvagnar. Transaktionskostnaderna kommer att bli relativt låga.

Med ett C&T-system kan man garantera att ett specifikt mål för (minskade) koldioxidutsläpp kan uppnås. Ett C&T-system stimulerar i allmänhet alla typer av minskade koldioxidutsläpp medan ett B&C-system endast påverkar motor- och fordonstekniken. Det finns emellertid andra styrmedel som skulle kunna förbättra B&C-systemet, som till exempel eko-driving.

Vad gäller garantier för minskade utsläpp inom själva transportsektorn är ett slutet system (som inte är knutet till nuvarande utsläppshandelssystem i EU - ETS) att föredra. Den här fördelen skall emellertid vägas mot den högre kostnadseffektiviteten i ett öppet system. Om transportsektorn tillåts handla med andra sektorer kan åtgärder vidtas för minskade utsläpp där kostnaderna är lägst. Eftersom transaktionskostnaderna i allmänhet ökar med omfattningen och flexibiliteten, kommer den totala kostnadseffektiviteten att bero på balansen mellan dessa två kostnader. Dessutom kommer ett slutet system att leda till olika priser för koldioxidutsläpp inom transportsektorn i förhållande till de i EU ETS.

Möjliga effekter för konkurrenskraften beror mycket på hur programmet utformas och på var utsläppstaket sätts. Effekten av att införa utsläppshandel enligt ett

C&T-system skulle i mycket likna ytterligare en skatt eller koldioxidavgift på bränsle. Detta innebär mycket lägre transaktionskostnader.

Resultat: järnvägar

I jämförelse med vägtransporter står dieseltågen för en mycket liten del av de totala koldioxidutsläppen². Av den anledningen har det inte utförts någon fullständig utvärdering av utsläppshandelsystem som specifikt gäller dieseltåg.

Resultat: sjöfart

Under förutsättning att ett adekvat system för övervakning av koldioxid tas i bruk skulle ett internationellt C&T-system för rederier kunna bli ett attraktivt alternativ i framtiden. Ett internationellt B&C-system för fartygstillverkare skulle också kunna vara ett genomförbart alternativ, under förutsättning att ett system för koldioxidmätning skulle kunna införas och att programmet skulle gälla samtliga rederier (i och utanför EU). Dessa alternativ har dock inte analyserats vidare i rapporten.

Resultat: internationell flygtrafik

Ingen fullständig utvärdering har gjorts angående alternativ för flygtrafiken eftersom mycket arbete redan har gjorts på det här området. Istället togs två specifika frågor upp.

För det första, den potentiella *totala* inverkan på andra sektorer om flyget tas med i EU ETS via ökade priser för utsläppsrätterna visade sig vara små eftersom de flesta effekterna tar ut varandra. Påverkan på *specifika* sektorer kan emellertid bli betydande. För det andra, åtgärder för minskade utsläpp diskuteras för att om möjligt garantera en minskning inom flygsektorn.

Resultat: program för hela transportsektorn

Vad gäller alternativ för ett utsläppshandelsystem för hela transportsektorn gäller i hög grad samma argument som diskuterades för vägsektorn. Mest genomförbart verkade antingen ett C&T-system med slutanvändarna eller bränsleleverantörerna som handelsenhet.

Ett program för hela transportsektorn skulle kräva att övervakning av koldioxidutsläpp, registrering, kontroll osv. utformas och införs inom samtliga typer av transporter. För närvarande är bristen på information störst inom sjöfartssektorn.

Utformning och utveckling, införande, övervakning och genomförande av handelssystemet kommer att bli mycket lättare och alltså kommer transaktionskostnaderna att bli betydligt lägre om det är bränsleleverantörerna som är handelsenhet istället för slutanvändarna. Eftersom kostnadseffektiviteten hos ett handelssystem i allmänhet förbättras med omfattningen hos systemet skulle en koppling till EU ETS alltså kunna vara fördelaktig. Emellertid, denna fördel bör vägas mot den eventuella fördelen med ett slutet system som nämndes tidigare i avsnittet om vägtransporter.

² Analysen har begränsats till dieseltåg eftersom utsläppen från elektriska tåg redan finns med i den nuvarande EU ETS för stationära källor.

Rekommendationer

När man jämför de olika programmen för utsläppsrätter som har analyserats rekommenderar vi en närmare analys av B&C-systemet för biltillverkare och C&T-systemet för bränsleleverantörer. I det senare fallet skulle man använda sig av en steg-för-steg-metod där man först inför systemet i en enstaka transportsektor (t.ex. för vägtrafiken) för att i ett senare steg fortsätta till övriga sektorer.

I alla dessa program finns det argument för både en sluten och en (halv-) öppen version. Därför rekommenderar vi en ytterligare utvärdering av skillnaden mellan dessa två alternativ. Eftersom handeln med utsläppsrätter inte är det enda sättet att minska koldioxidutsläppen rekommenderar vi slutligen att man undersöker möjliga alternativa metoder (t.ex. koldioxidskatt på bränsle), och jämför dessa närmare med handeln med utsläppsrätter.

Summary

Background: increasing transport CO₂ emissions

Carbon dioxide (CO₂) emissions from transport, contributing to climate change, are steadily increasing in the European Union. Fuel efficiency improvements that have been achieved with improved engine and vehicle design have been counteracted, mainly by increases in transport volumes (especially in the road sector, aviation and shipping) and a trend toward heavier vehicles (in passenger cars). Policy measures implemented to date that have a direct or indirect impact on CO₂ emissions from transport include; voluntary agreements, investment in research and development, regulations, differentiated vehicle taxes, fuel taxes and infrastructure charges.

A potential new policy measure for the transport sector is CO₂ emission trading. Emission trading is a market-based instrument that aims to achieve emission reductions in the most cost effective manner. The political momentum for this type of measure in the transport sector appears to be increasing, due to the recent introduction of the EU emission trading scheme (EU ETS) for stationary sources and the call for effective CO₂ emission reduction policy in the transport sector, as many other sectors manage to reduce their emissions. In addition, the European Commission has recently concluded that emission trading is a potentially attractive policy to deal with the climate impact of aviation.

Objective and scope of the project

This report by CE Delft for the Swedish Environmental Protection Agency (SEPA) assesses the possibilities for CO₂ emission trading schemes for the transport sector. Various schemes are investigated and assessed, for the whole sector or for specific transport modes (road, railways, maritime shipping and aviation). The report has a 'scan like' character, and provides a broad overview of current knowledge. Viable options and knowledge gaps both are identified.

In this study, the following types of emission trading schemes are assessed:

- Cap & trade (C&T) systems, setting emission ceilings in combination with tradable emission rights and
- Baseline & credit (B&C) systems, setting a baseline emission standard in combination with bankable / tradable emission credits. In this type of scheme absolute CO₂ emissions are not regulated directly, only the relative emissions, such as for example CO₂ emissions per vehicle kilometre.

Subsequently various specific types of trading schemes have been identified and assessed, making use of the following system settings:

- Geographical scope: national or EU;
- Trading entity (the party that is required to hand in emission allowances): end users (vehicle owners), filling stations, fuel companies, refineries;

- Closed scheme (no linkage to EU ETS) or open scheme (linked to or embedded in EU ETS).

For the appraisal of potential emission trading schemes we have applied a two-stage approach. The *first stage appraisal* essentially dealt with the *practical* feasibility, and resulted in a selection of practically feasible schemes. These were subsequently assessed further in the *second stage appraisal*.

Results: road

The road sector is responsible for more than 80% of total transport energy requirements (in Sweden as well as in the EU) and is by far the largest CO₂ emitting transport mode. Major observations in the *first stage appraisal* on road sector emission trading schemes are the following.

The main differences between the various schemes assessed relate to the transaction costs involved, and the possibilities for emission reduction of the respective trading entities. Both C&T and B&C schemes directed at end users (vehicle drivers) lead to very high transaction costs and may be difficult to implement, compared to schemes aimed at fuel suppliers or car manufacturers. C&T schemes directed at end users have the advantage that the trading entity itself has direct access to a large number of emission reduction measures. Filling stations and fuel suppliers only have limited access to direct emission reduction measures (they can increase their sales of bio fuels). However, they will stimulate CO₂ reduction when they transfer the cost of emission allowances to the end users by increasing fuel prices.

B&C schemes aimed at vehicle manufacturers seem feasible for passenger cars and light commercial vehicles. Transaction costs will be relatively low, but vehicle manufacturers are not able to significantly influence vehicle use and thus have only limited impact on total emissions.

Obviously, coverage of CO₂ emissions would be much larger for an international than a national system.

Based on the results of the first stage appraisal, it was decided to focus on three emission trading schemes in the second stage appraisal:

- 1 A C&T scheme for the road sector, for end users.
- 2 A C&T scheme for the road sector, with fuel suppliers as trading entities.
- 3 A B&C scheme for passenger car manufacturers.

Major observations in the *second stage appraisal* on road sector emission trading schemes are the following:

Effectiveness

- The stringency of the emission cap or baseline is the main driving force of how effectively CO₂ emissions can be reduced. Clearly, this holds for all emission trading schemes analysed in this report.
- Both C&T schemes ensure meeting a specified CO₂ emission (reduction) target, provided accurate monitoring and enforcement is implemented. The B&C scheme only regulates relative performance related emissions (gram CO₂/km).

- In both C&T schemes, end users will be stimulated to use all options for emission reduction at their disposal: they can buy fuel efficient vehicles or renewable fuels, they can drive less or more fuel efficiently, or improve transport efficiency. However, the incentive may be less efficient in the case where fuel suppliers are the trading entity rather than end users, because the costs of emission allowances may not be passed on fully and efficiently to end users.
- The B&C scheme for car manufacturers can only ensure that the fuel efficiency of cars is improved, whereas the other (C&T) systems also encourage other means of CO₂ mitigation in the sector. Furthermore, it will take some time before the whole vehicle fleet is affected. The scheme can not be extended to heavy duty vehicles as long as no CO₂ emission tests exist for these vehicles.
- From the point of view of steering emission reductions in the transport sector itself, a closed system (not linked to EU ETS) is the preferred one. This can guarantee that emission reduction measures will take place within the transport sector.
- This benefit should however be weighed against the better cost effectiveness in an open system (linked to the EU ETS). If the transport sector is allowed to trade with other sectors, emission reduction measures can be taken where costs are lowest, and this may well be outside the transport sector.

Cost effectiveness

- The more flexible a trading scheme and the larger the scope, the lower the costs of CO₂ mitigation measures will be, for a given CO₂ emission reduction. These will thus be lower in an international scheme that is linked to the EU ETS. However, transaction costs generally increase with scope and flexibility. Total cost effectiveness will depend on the balance between these two costs.
- The cost effectiveness of a C&T scheme for fuel suppliers versus end users has not been quantified in this study. As argued above, the effectiveness of a fuel suppliers scheme may be slightly less compared to end users. However, taking into account the many practical obstacles resulting in high transaction costs for an end users scheme, the overall cost effectiveness of a fuel suppliers scheme could well prove to be better than the end users scheme.
- The B&C system is only directed at passenger cars, leading to reduced flexibility and scope. Transaction costs of this scheme are relatively limited. It is unclear however to what extent this efficiency loss can be compensated for by lower transaction costs. Therefore, a direct comparison of cost effectiveness with the C&T schemes is not possible. Flanking instruments may be introduced to induce mitigation measures in the other sectors.
- In a closed system, the price of CO₂ emission allowances in the transport sector would differ from that in the EU ETS. This might meet resistance from stakeholders.

Stimulating innovation

- Innovations in the transport sector are stimulated most in closed trading systems, since emission reductions within the sector are then mandatory. In an open system, the drive for innovation depends on the cost effectiveness of measures available in the emission ‘bubble’, compared to that of measures in other sectors. Innovation might then take place within other sectors.
- A B&C scheme for car manufactures can specifically encourage technological innovation in that sector.

Competitiveness

- Potential effects on competitiveness depend strongly on the design of the scheme. For example, the potential effect on the competitiveness of transport companies will be limited in case of an EU scheme compared to a national scheme.
- In a C&T scheme for fuel suppliers, end users located near country borders may be stimulated to purchase fuel outside of the scope of the scheme. However this problem is less important in the case of a large trading entity such as the EU. The B&C scheme for car manufacturers can be expected to have limited effect on the *overall* competitiveness of car manufacturers, if all are included in the system.
- Sectors (and companies) that use transport will be confronted with a cost increase in their product chain. This cost increase will depend on the costs of emission allowances, i.e. on the cap or baseline set, and on the scope of the scheme. If the system is open, the effects on the transport sector and likely on other sectors as well will be smaller than in a closed system, due to the improved cost effectiveness.
- Both under closed and open systems, the potential revenues from an auction could be returned to the sector to limit the economic impact.

Flanking instruments

- Introduction of flanking instruments may in general strengthen the proposed and analysed emission trading schemes and may overcome some of their weaknesses with respect to (cost) effectiveness and stimulating innovation.
- For example, a B&C system for passenger cars could be enhanced by specific instruments for the other road sectors. Also, a driver awareness program could be introduced to teach how to drive environmentally friendly, so emission reduction options outside the domain of passenger car manufacturers are also used to a full extent. All systems could be enhanced with tax (or other) incentives or regulations for bio fuels, as well as specific research and development (R&D) subsidies to stimulate innovation and the development of new techniques.
- Flanking instruments could also be used to prevent negative side effects. For example, emission trading might lead to a shift to diesel cars. If this is deemed to be undesirable because of the larger impact of diesel cars on local air quality, excise duties could be adjusted (possibly revenue neutral) to prevent such a shift.

Alternative policy options

- Alternative policy options could bring about the same effects as emission trading. Especially with fuel suppliers as trading entities, this would be the case with an additional charge or CO₂ tax on fuel. This tax would have the benefit of much lower transactions costs. The environmental impact will be uncertain, but the maximum costs to consumers is known, whereas under C&T emission trading systems the reverse holds.
- Bearing in mind the fact that in the road sector fuel tax is a commonly used instrument, stakeholders might oppose having ‘double instruments’ (emission trading *and* fuel tax) and may press for compensation (lower fuel tax).

Results: railways

Compared to road transport, diesel trains are responsible for a very minor share of total EU25 CO₂ emissions: around 0.5%³. For this reason no full appraisal has been carried out for emission trading schemes specifically aimed at diesel trains.

Results: maritime shipping

The attributed share of maritime shipping (combined passenger and freight) in the total CO₂ emissions of the EU25 was estimated to be nearly 4% (based on bunker fuels sold).

Provided an adequate CO₂ monitoring system comes into place, an international C&T scheme for shipping companies could be an attractive option in the future. This scheme could in principle be linked with ETS. Regarding ship builders as trading entity, an international B&C scheme could also be a viable option provided that a CO₂ measurement system could be implemented, and the scheme also would apply for shipbuilders outside the EU (like the current voluntary agreement for car manufacturers).

In consultation with SEPA, it was decided not to carry out a full appraisal of these options.

Results: international aviation

Regarding emission trading schemes for aviation no full scale appraisal of options has been carried out, since much work has already been done on this issue. Instead two specific questions are addressed.

First, it was shown that the *net* impact of inclusion of aviation in the EU ETS on other sectors is smaller than often expected. The reason is that on a macro level the effects of increases in allowance prices on EU ETS sectors cancel out to a large extent. EU ETS sectors that are currently buyers on the allowance market will have to pay more, but current sellers will be able to sell their excess allowances at higher prices. However the impact on *specific* sectors could still be significant.

The second question addressed how it can be ensured that emission reduction measures will take place within the aviation sector. Fuel efficiency improvements are expected to continue, but are most likely annulled by growth in air travel. Flan-

³ The analysis has been restricted to diesel trains as electric trains are already, indirectly, included in the current EU ETS for stationary sources.

king instruments may however be brought into action to limit the non-CO₂ climate impacts of aviation. It is shown that flanking instruments for control of NO_x emissions are compatible with emission trading.

Results: all transport schemes

Concerning viable options for an all transport inclusive scheme, to a large extent the same arguments hold as were relevant when discussing the individual transport modes.

From the analysis it was shown that B&C schemes cannot act as a basis for the entire transport sector, as credits in different sub sectors / transport modes cannot be traded across the whole transport sector, unless very crude assumptions are used regarding lifetime mileage and fuel consumption of the vehicles or vessels.

Therefore, two C&T schemes were selected as being potentially feasible:

- C&T scheme with end users as the trading entity.
- C&T scheme with fuel suppliers as the trading entity.

These schemes would require that CO₂ emission monitoring, registration, verification etc. have to be designed and implemented in all transport modes. Currently, lack of data is most significant in the maritime sector.

In case of a C&T scheme with end users as trading entity, a very large number of parties would be involved in the scheme: all car drivers, hauliers, ship owners, rail companies and airlines operating within the geographical scope of the scheme. These parties would have – at least initially – unequal market power, e.g. compare the owner of a large container ship to a car driver. However, these differences in market power could diminish as intermediary organisations may emerge to trade on behalf of a great many individual end users (like stock brokers on the stock exchange).

Design and development, implementation, monitoring and enforcement of the system will be easier and hence transaction costs will be substantially less if fuel suppliers are the trading entity rather than end users.

The environmental effectiveness of the schemes analysed and their costs depends primarily on the stringency of the cap set. Since cost effectiveness of a trading system improves with increasing scope of the system, the cost effectiveness of a system that includes all transport modes can be expected to perform better in this respect than that of a scheme limited to any of the modes. Linking to the EU ETS would further improve cost effectiveness.

From the point of view of steering emission reductions in the transport sector itself, a closed system is the preferred one. This will guarantee, provided a strict cap or baseline is set, that the transport sector will reduce its own emissions thus also stimulating innovation as a side effect. Drawbacks to a closed system are reduced cost effectiveness, and different prices of CO₂ emission allowances in the transport sector, compared to those in the EU ETS.

Recommendations

After comparing the various emission trading schemes we recommend further analysis of the C&T scheme for fuel suppliers as well as the B&C scheme for car manufacturers. We also recommend to further look into the possibilities to include transport in the EU ETS, since this will improve cost effectiveness of CO₂ mitigation.

A scheme in which end users are the trading entity would meet a number of practical problems. Involving a very large number of trading entities, this scheme would face practical difficulties in including all end users, and they might well be unable to participate effectively. The huge numbers of trading entities would also lead to high transaction costs, with only limited benefits in terms of efficiency or effects on competitiveness compared to a scheme based on fuel suppliers.

A C&T scheme for fuel suppliers is, in principle, feasible for all transport modes, although this would require a lot of work on improvements in data monitoring (of maritime shipping, in particular), policy design and implementation. A step by step approach could be taken, by implementing such a scheme first for one or more transport modes (e.g. road), and including other modes in a later stage.

The B&C scheme for car manufacturers has limited transaction costs, stimulates innovation in that industry, and can be implemented relatively easily. Hence we recommend also to investigate this option in more detail, which could be implemented in parallel with a C&T scheme.

A decision regarding whether or not to pursue any of the schemes analysed here does not only require further development of technical and legal issues, but also political considerations and choices need to be addressed.

For all the schemes mentioned there is a case for both a closed and (semi) open version. We therefore recommend to further assess the respective merits of both design options. As (domestic) transport does not face severe international competition, the risk of carbon leakage is small. For this reason it can be economically justified to design a *closed* scheme for transport. But also for political reasons there may be an interest to guarantee that measures are taken to ensure reduced emissions, or at least to slow down emission growth, in the sector itself.

On the other hand, in the case of a closed scheme, the question is whether the government is willing to accept higher CO₂ mitigation costs (€/ton CO₂) in the transport sector, compared to other sectors. The same question can be raised with respect to the price of CO₂ emission credits in the transport sector compared to that in the EU ETS.

Finally, since emission trading is not the only policy option to reduce CO₂ emissions, we also recommend to look further into potential alternative policies (e.g. CO₂ tax on fuel), and compare these more closely to emission trading systems.

1 Introduction

1.1 Background: increasing transport emissions

Carbon dioxide (CO₂) emissions from transport, contributing to climate change are steadily increasing. Fuel efficiency improvements that were achieved with improved engine and vehicle design were counteracted, mainly by increases in transport volumes (especially in aviation, shipping and the road sector) and a trend toward heavier vehicles (in passenger cars).

Policy measures implemented to date that have direct or indirect impacts on CO₂ emissions from transport include:

- Regulations.
- Vehicle taxes.
- Fuel taxes.
- Infrastructure charges.
- Investment in research & development.

The political momentum for emission trading in the transport sector appears to be increasing⁴, due to several reasons. The first reason is the recent introduction of the EU emission trading scheme (EU ETS) for stationary sources. Expanding the current scope to mobile sources could be an option. Secondly, the call for effective CO₂ emission reduction policy in the transport sector will be louder as many other sectors manage to reduce their emissions whereas the CO₂ emissions from transport continue to increase. Thirdly, the European Commission has recently concluded that emission trading is a potentially attractive policy to deal with the climate impact of aviation, and perhaps also of maritime shipping. Note that the emissions associated with electric rail transport are already (indirectly) included in the current EU ETS, since this scheme includes power stations.

Emissions from surface transport are included under countries' commitments under the Kyoto Protocol (and the EU burden sharing agreement)⁵. This also holds for emissions from domestic aviation and inland shipping. At the international stage, however, no agreement has so far been reached on how to allocate emissions from international aviation and shipping to specific parties. Technically speaking, no party has taken responsibility for these emissions.

Currently at the level of the European Commission, the merits of emission trading are being assessed with respect to international aviation and shipping. Concerning *aviation* the European Commission recently has published a Communication (COM(2005) 459 final), making it clear that the Commission favours emission trading over other economic instruments for dealing with the climate impact of aviation. Inclusion of aviation in the existing emission trading scheme would be a viable option.

⁴ See for example COM(2005) 459 final and studies carried out for the Commission (e.g. (CE Delft, 2005) for aviation; (IIEP/TNO/CAIR, 2005) for road and (ENTEC, 2005) and (NERA, 2004) for shipping).

⁵ Note that only emissions from specific sectors (e.g. power sector) have been included in the EU ETS, whereas the scope of the Kyoto protocol is much larger.

It remains to be seen yet if the EU Member States also favour the inclusion of (some of) the transport sub sectors into the EU ETS. An emission trading system has the advantage of ensuring that emissions are reduced where costs are lowest. This advantage generally increases with increasing scope of the trading system. Limiting the system to the transport sector only, or to a part of the sector, will thus reduce at least the short term cost effectiveness of the measure. However, setting up a separate emission trading system for transport with a relatively tight emission target may be more effective to reduce CO₂ emissions in the transport sector itself, as the sector does not have the opportunity to purchase allowances from other sectors. This may have political advantages. Furthermore, it may increase cost effectiveness of emission reductions in the longer term, since it stimulates the sector to develop technologies that reduce CO₂ emissions.

This present report by CE Delft for the Swedish Environmental Protection Agency (SEPA) assesses the possibilities for emission trading systems for the transport sector as a whole and for specific transport modes.

1.2 Objective and scope of the project

In this report CE Delft deals with the following related objectives:

- | | |
|---|---|
| 1 | To identify different emission trading scheme designs for carbon dioxide / greenhouse gas emissions of the transport sector as a whole and individual sub sectors separately. |
| 2 | To appraise these emission trading schemes based on a set of criteria. |

The geographical scope of the different emission trading systems assessed in this report will primarily be at the EU scale, and not restricted to a national (i.e. Swedish) level. Furthermore, a broad range of transport modes and transport sub sectors is included in the assessment.

The project focuses on emissions of CO₂, being also the major component of the current EU ETS. Other greenhouse gases emitted by the transport sector, such as fluorinated gases (used in air conditioning and refrigerant systems for example) are not included.

The project scope is limited, as it has a 'scan like' character, primarily based on current knowledge identifying viable options and knowledge gaps. In later stages - outside the scope of this project - the most interesting options may be worked out in more detail. It should be noted that this report evaluates a range of different emission trading design options and different groupings of transport sub sectors, against a range of criteria. There is some comparison with other types of policy instruments, however this is not the main objective of this report.

One of the objectives of SEPA is to find out whether an instrument such as emission trading can provide sufficient incentive to ensure that emission reductions take place within the transport sector. The so-called steering effect will therefore be one of the criteria with which the different schemes will be assessed. Attention will also be paid to the possibilities for policy design to ensure this steering effect. Beforehand, it should be clearly noted though, that the underlying idea behind emission trading is that emission reductions can take place where they are cheapest to

society. This may contradict with the wish to ensure emission reductions within the transport sector itself.

Last but not least, political acceptance will, of course, play a role in the discussions and decision making process on emission trading. However, we have decided not to use this criterion explicitly in our assessment, but to rely as much as possible on technical and economic criteria. In the concluding chapter and in our recommendations however, we pay some attention to the issue of political acceptability.

1.3 Structure of the report

In section 2 the methodology of the study is worked out in detail. Subsequently in sections 3, 4, 5, 6 and 7 we present the results of the appraisal for the transport modes selected: road sector, railways (diesel), maritime shipping, aviation and the transport sector as a whole. Section 8 contains the conclusions of the study and some recommendations based on these conclusions.

2 Methodology of the study

In this section we discuss the methodology applied in this study. In section 2.1 we first present a typology of emission trading schemes. Subsequently in section 2.2 we discuss the framework for appraisal of emission trading schemes. As discussed with SEPA, the following transport modes have been selected for assessing the merits of setting up an emission trading scheme:

- Road sector.
- Railways (diesel).
- Maritime shipping.
- Aviation.
- Transport sector as a whole.

2.1 Types of emission trading schemes

There are several characteristics that can be used to distinguish trading schemes. These characteristics are listed and worked out subsequently:

- Geographical scope.
- Sector scope.
- Trading entity.
- Emission control, i.e. either a cap & trade or baseline & credit scheme (these terms will be explained below).
- Closed or open schemes.
- Use of Kyoto project mechanisms.

Geographical scope

The scope can either be a national or an international system. In this study, a national system will refer to a Swedish system. An international system will primarily refer to an EU system, although a larger scope is not excluded beforehand⁶.

Sector scope

Another distinction is whether the trading system would hold for:

- A specific sub sector of a transport mode, e.g. passenger cars.
- A specific transport mode such as all road transport.
- All transport modes.

Electric rail transport has been excluded from the scope of the systems analysed, since the electricity used for the rail transport is already included in the EU ETS. Including the CO₂ emissions of electricity generation for electric trains would mean that these emissions are subjected to an emission trading system twice. For this electricity, two emission credits would then have to be handed over, one at the source and one at the client. This would clearly be neither fair or efficient, and not

⁶ It might also be borne in mind that certain EEA countries - notably Norway and Switzerland - might well be persuaded to join an EU scheme.

in line with the current ETS⁷. Rail transport with diesel trains are included in the analysis.

Trading entity

The trading entity refers to the party that is required to hand in emission allowances. Many different parties can in theory be eligible to do so, depending on their position in the product chain (upstream, middle stream, downstream). For example, in the *road sector* we can distinguish under a *national system*:

- Down stream: vehicle drivers (end users).
- Middle stream: filling stations.
- Upstream: fuel suppliers⁸.
- Far upstream: oil refineries.

In case of an *international system*, other types of trading entities may (also) be selected. For example, in the road sector this can imply vehicle manufacturers (upstream), vehicle importers (upstream) and vehicle dealers (middle stream).

Note that the definition of the trading entity is not always straightforward, and various options may exist even within these categories. For example, in case of public transport, aviation or passenger ferries, the end users could be defined as either the individuals that are being transported, or the company responsible for operating the transport service, or alternatively a public body that oversees it. In this report, we have decided that we consider the public transport company and the aviation and ferry operators to be the end users. In other words, we call the person or company that is in charge of using the fuel the end user.

⁷ Furthermore, the electricity used for the trains would need to be tracked and administered accurately, in order to determine the CO₂ emissions caused. This is currently not the case.

⁸ Note that the difference between filling station and fuel supplier may not be as clear for all transport modes as it is for the road sector.

Emission control and trading scheme

A third distinction that can be made is the way the overall level of emissions is controlled. We distinguish between the following main types of schemes:

- Cap & trade (C&T).
- Baseline & credit (B&C).

The main feature of a *Cap & Trade* (C&T) emission trading scheme is that a fixed ceiling (cap) is set to a certain type of emission (CO₂, NO_x) in combination with tradable emission rights. The permits are initially allocated in some way (grandfathering or auctioning), typically among existing sources. Each source covered by the program must hold permits to cover its emissions, with sources free to buy and sell permits from each other. The current EU Greenhouse Gas Emission Trading Scheme (EU ETS) is an example of a C&T scheme. During the first trading period from 2005 to 2007, the ETS covers only CO₂ emissions from large emitters in the power and heat generation industry and in selected energy-intensive industrial sectors.

Baseline & Credit (B&C) schemes have a different angle, providing tradable credits to facilities that reduce emissions more than required by some pre-existing regulation (baseline) and allow those credits to be counted towards compliance by other facilities that would face high costs or other difficulties in meeting the regulatory requirements. In this type of scheme no absolute CO₂ emissions can be capped, but only the relative emissions, such as for example the CO₂ emissions per vehicle kilometre. An example of a B&C system is the recent Californian proposal that is aimed at car manufacturers. In the Californian system, car manufacturers have to achieve a reduction of average CO₂ emissions of new cars over the coming years. Manufacturers that achieve lower average emissions than the norm can sell credits to manufacturers that do not achieve the norm.

Closed or open schemes

The issue of whether an emission trading scheme for the transport sector should be an open or closed scheme relates to the potential linkage to the EU ETS (or other emission trading schemes). We distinguish three possibilities, discussed briefly below:

- 1 An open scheme: inclusion in the EU ETS.
- 2 A semi-open scheme: linkage to the EU ETS.
- 3 A closed (fully separate) scheme: no linkage to the EU ETS.

An *open scheme* would mean that transport (or one or more transport modes) would be included in the EU ETS. This would mean it has to adhere to the definitions and regulations set out in Directive 2003/87/EC. Alternatively, the definitions and regulations of Directive 2003/87/EC would have to be amended to account for the particularities of the transport sector.

A *semi-open scheme* implies that the transport sector is not embedded in the EU ETS, but some sort of linkage would exist: credits under the transport scheme can be traded with credits under the EU ETS.

These two options (open or semi-open scheme) have several implications with respect to the characteristics of the trading system used in the transport sector. For

example, the EU ETS is directed at absolute emissions (cap & trade), thus a system in which vehicle manufacturers are the trading entity is less feasible, as such a system primarily targets relative emissions (baseline & credit). Nevertheless, linking such a B&C system with the ETS C&T system is not entirely impossible. It could, for example, be included in or linked to the ETS if the emission factors of new cars (the base of a car manufacturer B&C system) were converted to total emissions over the life time of the car, by assuming an average mileage over the lifetime of the car. This is discussed in, for example (Öko-Institut, 2002). In general, linking of a cap & trade system to a baseline & credit system can be problematic but it is not necessarily impossible.

Emission allowances⁹ (AAUs) have already been allocated to countries for sectors that are currently not included in the EU ETS such as the transport sector, except international aviation and shipping however. An issue for further discussion will be then how the emission reduction target of the system relates to the commitments of a country under the Kyoto Protocol if (parts of) the transport sector were to be included or linked to the ETS.

One possibility for linking the transport sector to the EU ETS is by making use of project mechanisms, analogous to the Kyoto project mechanisms of joint implementation (JI) and clean development (CDM), see below. Emission credits could then become available to EU ETS trading sectors by emission reduction projects in the transport sector. This would not necessarily violate the integrity of the Kyoto Protocol, because AAUs of the non trading sectors under the EU ETS (such as the transport sector) could be used as emission credits and be transferred to the EU ETS sectors. Verification of emissions reductions would however be a major issue to address in these circumstances. These are complicated issues and would merit a separate study. For this reason, we do not further pursue this option in this study.

A closed (fully separate) scheme means that the transport sector is not connected at all to the EU ETS. Credits under the transport emission scheme can only be traded within the transport scheme itself.

A rationale for this third option is that it could be economically justified to design specific climate policies for specific sectors. Regarding emission trading this relates to dealing with differences in risk of carbon leakage between sectors. Some sectors (cement, aluminium, paper etc.) currently included in the EU ETS are vulnerable to higher energy prices and hence face a major risk of 'carbon leakage' due to relocation of activities. Other sectors, like for instance (domestic) transport, may be much less sensitive to such leakage. They will not move out of a country because of high carbon prices. If all sectors are dealt with in an uniform way, i.e. through an integrated ETS, then the stringency of the cap set may not go further than the lowest common denominator, i.e. what the most vulnerable sector can bear. Such a system (i.e. an open, integrated system) may not be very effective in reducing emissions.

⁹ Parties to the UNFCCC that have ratified the Kyoto Protocol already have binding commitments that include emissions from transport except those from international aviation and shipping. Emission allowances are named Assigned amount units (AAUs) under the Kyoto Protocol.

However if major discrepancies are expected to occur between a separate transport sector scheme and the EU ETS with respect to the cost of emission reduction (and hence the price of emission permits), the political acceptance of a closed scheme for transport may be lacking.

Kyoto project mechanisms

Related to the linkage with the EU ETS is the issue of whether the Kyoto project mechanisms can be used. We judge it practically feasible under all three discussed types of systems. In fact, inclusion in the EU ETS or linkage to the EU ETS would require that all project mechanisms would also be accessible for the transport sector¹⁰. A fully separate system can either be designed with or without access to the Kyoto project mechanisms. Access would imply that demand for such credits would come from two separate markets¹¹.

Allocation of allowances

Before emission trading with a cap & trade scheme can be started, initial emission credits have to be allocated to the trading entities. There are several methods to do this, which may or may not inflict direct costs on the trading entities¹². So far, in the EU ETS and in emission trading schemes in the US (PEW, 2003), this allocation has been done by ‘grandfathering’, where allowances are distributed without charge to the entities. This type of allocation usually has the most support from industry. An alternative would be to auction the credits (possibly returning the revenue to the parties involved), or to distribute the credits based on future emission prognoses.

Allocation of allowances is usually an issue that leads to much debate, because of its significant economic impact. An overview of pros and cons of various options can be found for example in (PWC, 2002). For the aviation industry, CE Delft (2005a) identified auctioning as the most favourable option, because auctioning could circumvent potential unfair treatment related to ‘early action’ and newcomers to the market. It could also prevent entities from making windfall profits by passing on the costs of freely distributed allowances to end consumers. We do not discuss the topic of allocation methods further in this report.

¹⁰ The earlier point on verification would apply equally here.

¹¹ For example the fuel supplier industry in Switzerland has proposed the so called ‘Climate cent’, being a voluntary measure of the industry. One cent will be added to fuel prices. The revenues will be used to buy climate certificates on the international market for CDM-projects. It is expected that the transport sector can then meet its reduction targets by reducing about two thirds of the emissions on international markets and the remainder in Switzerland (information by Dr. Maibach, Infrac).

¹² Under the current EU ETS regulation, Member States are required to grandfather at least 95% of the emission allowances. At most 5% may be auctioned.

2.2 Appraisal framework

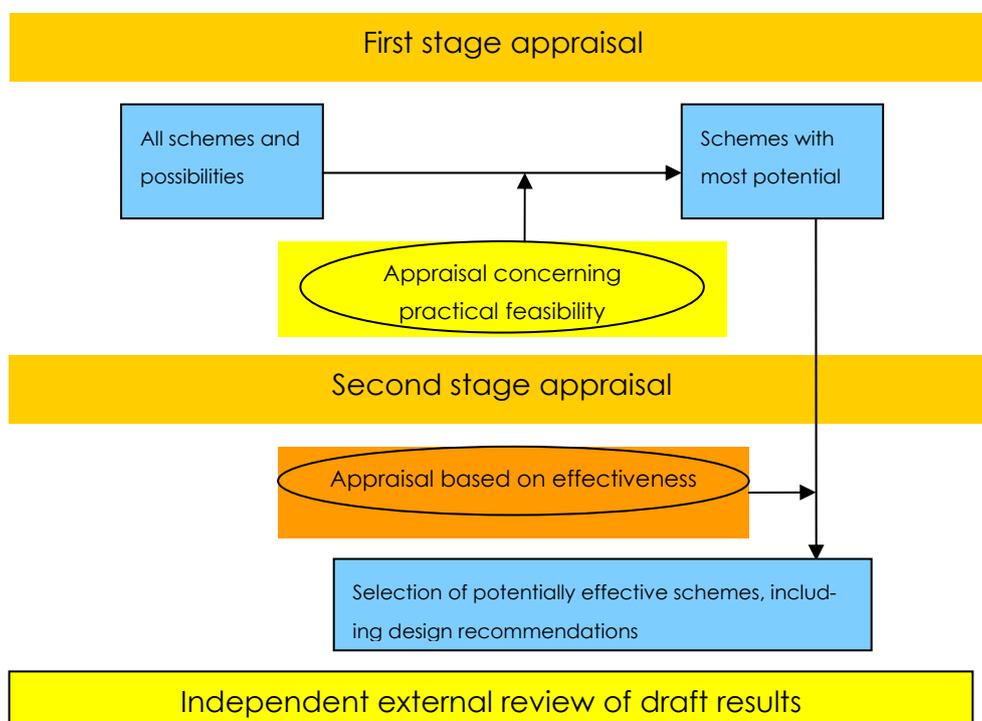
Overview of appraisal process

An overview of the full appraisal scheme of emission trading schemes for transport (modes), as used in this report, is provided in figure 1. The appraisal consists of two stages.

The *first stage appraisal* of emission trading schemes essentially deals with the *practical* feasibility. Issues at stake are the availability of essential information, the level of CO₂ emissions et cetera. The results of the first stage appraisal lead to a first selection of practically feasible schemes.

In the *second stage appraisal* the selected schemes will be further assessed, mainly with respect to effectiveness.

Figure 1 Overview of appraisal framework ETS



2.3 First stage appraisal: practical feasibility

In the first stage appraisal we will appraise schemes based on the following criteria.

Unambiguous responsibilities

Information concerning the amount of CO₂ emissions for which the trading entity will be made responsible, must be available at the trading entity. For example, refineries cannot be made responsible for emissions of public transport only as they cannot know whether fuel delivered will ultimately be used in public or private transport.

Transaction costs

Transaction costs do entail much more than just the costs involved with the trading activity itself. Transaction costs consist of public costs as well as private costs for the respective trading entities in the case of introducing an emission trading scheme. Underneath the most important elements of such public and private costs are specified.

- Public costs:
 - Costs of development and setting up of trading system.
 - Costs of development and setting up system(s) of monitoring, verification and sanctioning.
 - Operational - yearly - costs concerning the system(s) mentioned above.
- Entity costs:
 - Costs related to implementing emission trade at the level of the entity.
 - Costs involved with developing trading strategies.
 - Costs involved with transactions and risk management.

Transaction costs can vary considerably among the types of emission schemes as well as compared to a general fuel tax (PWC, 2002). Schemes with expected high transaction costs are, generally speaking, not preferable from both the viewpoint of economic efficiency as well as political acceptability (PEW, 2003).

Emission reduction possibilities of trading entity

In general, schemes in which trading entities have multiple options to reduce emissions and thus can respond in a flexible way to emission trading are more cost effective than schemes where such flexibility is lacking. For example, a car driver can choose to use a more fuel efficient car, drive less or drive in a less fuel consuming manner. The driver has the opportunity to base his or her decision on the costs and availability of the various options, personal preferences, etc.

In contrast, if fuel suppliers were the entity to surrender allowances, their only options to reduce emissions would be to raise fuel prices or to replace fossil fuels with bio fuels. Fuel buyers (i.e. end users) can then react to this price increase by lowering their fuel consumption, again with all options at their disposal. Car manufacturers, however, can only influence the fuel efficiency or price of the new cars that they offer. Therefore, if they are the trading entity, the scheme does not provide an incentive for other, potentially cheap, options such as reducing vehicle kilometres or driving with a more fuel efficient driving style.

Scope of emissions

This criterion relates to the scope of emissions that are included in the scheme. Together with the previous criterion, it thus forms an indication of the potential for emission reduction. Transport modes differ substantially with respect to their share in the overall transport volume and thus also concerning their share in the overall amount of CO₂ emissions. This holds both for the national (Swedish) and the inter-

national (EU) level. However, viewed from the EU-level, a single national scheme will contribute only in a marginal sense to a reduction of CO₂ emissions.

Technical feasibility

Technical feasibility relates to the technical feasibility of monitoring and verification. We will not go into detail with respect to the institutional feasibility. For example, baseline and credit systems related to the end consumer are generally more complicated to monitor and verify than those related to manufacturers. For the end consumer, in some way emissions would have to be related to the performance (e.g. mileage) of the vessel or vehicle. It would be easier to verify the 'standard' emissions of, say cars, during the type approval before they enter the market.

Furthermore, if there is a major risk of evasive behaviour, the scheme will not be feasible. Evasion could occur if trading entities are (to a large extent) outside the geographical scope of the emission scheme.

The schemes will be appraised by means of qualitative scores (++ , + , 0 , - , --). Resulting from this appraisal will be a set of emission trading schemes that have 'passed' the test of practical feasibility.

2.4 Second stage appraisal: effectiveness

The second stage appraisal will continue with the schemes resulting from the first stage appraisal. The second stage appraisal will go deeper into the specific details of the selected schemes, making use of literature and in some cases consulting experts.

The selected schemes will be assessed using the following criteria:

- Environmental effectiveness: amount of overall CO₂ reduction.
- Steering effect: potential to ensure CO₂ emission reduction within the sector itself (see below).
- Cost effectiveness: expected price level of emission allowances (see below).
- Possibility of using flanking instruments to enhance environmental effectiveness.
- Stimulating innovation / technological development.
- Competitiveness of (sub) sector (EU versus non-EU countries).
- Relevant side effects, like for instance the potential impact on the existing EU ETS of inclusion of other sectors.

We elaborate the criteria 'steering effect' and 'cost effectiveness' in some more detail below.

Steering effect

By steering effect, we mean the extent to which the instrument may be effective in ensuring emission reductions or efficiency improvements within the transport sector itself.

For example, in an open scheme (i.e. if the transport sector is included in or linked to the EU ETS), in case of high marginal abatement cost within the sector, emission reductions will take place in other sectors. This is one of the most important principles of emission trading: emission reductions take place where they are

cheapest. The transport sector will then pay for the reductions in other sectors, whilst emissions in the sector itself are hardly affected. This would be the most cost effective option.

However, regarding the issue of potential carbon leakage related to the degree of international competition (refer to section 2.1), it could be economically justified to design a closed scheme for transport. But also for political reasons there may be an interest to ensure that measures are taken to ensure reduced emissions, or at least to slow down emission growth, in the sector itself. This is particularly the case for sectors for which there are trends of high growth in emissions.

Clearly, this comes at a price. Assuming well-functioning markets and well-informed trading entities, a closed scheme would prevent entities from being able to take advantage of the most cost-effective options¹³. Tradeoffs across sectors are not possible in these cases. However, such tradeoffs would not only make sense from an economic point of view, they may also make targets more negotiable. Open trading schemes provide countries with the flexibility to focus on those sectors where they can reduce emissions with the least economic and political pain (Bodansky, 2003). Sector targets, in contrast, may be more vulnerable to economic distortions between countries if different circumstances prevail in the same sector in different countries.

In an open scheme, the steering effect depends strongly on the amount of allowances allocated to the sector, and on how the price of allowances on the (larger) market relates to the costs of emission reductions within the sector. If the marginal abatement costs in the sector are relatively low, reductions will take place within the sector and allowances may be sold to other sectors.

Cost effectiveness

Emission trading can be a successful instrument to lower the cost of meeting emission reduction goals, as economic theory and practical experience has shown (see for practical experiences (PEW, 2003)).

The criterion cost effectiveness is defined here as cost of CO₂ emission reduction, commonly expressed in €/tonne CO₂ reduced. The trade price of emission allowances generally represents the cost of the most expensive emission abatement measure that is implemented to achieve the cap. In the current EU ETS, for example, the industry will implement all measures that can reduce CO₂ emissions at lower cost than the price of allowances, however if measures available are more expensive they will rather buy allowances.

The criteria applied in the second stage appraisal are mostly qualitative (+++, +, 0, -, --), aimed at an overall assessment of the various options, and identification of

¹³ In economic theory a perfect, transparent market is assumed, enabling all economic actors (in this case trading entities) to obtain perfect information so as to making a purely rational, economic decision. In practice no such perfect market exists. The costs of gathering and analyzing information on costs and benefits of competing alternatives (e.g. investing in emission reduction or buying emission credits) forms part of the transaction costs for trading entities in the emission trading market.

the main opportunities and hurdles. Where quantitative studies have been carried out previously, a more quantitative assessment is provided.

The result of the second appraisal phase is a reduced set of transport modes and emission trading schemes that are best suited to reduce (the sector's) CO₂ emission. This will result in recommendations regarding how to design the systems such that they score best on the aforementioned objectives.

3 Road sector

3.1 First stage appraisal

In this section we roughly appraise the feasibility of the different types of road sector schemes imaginable. In this appraisal we will focus on ‘killer’ arguments, on the base of which certain types of schemes can be excluded. Schemes that cannot be excluded are scored on criteria as described in section 2.3. First, national schemes are discussed, and subsequently international schemes. The scores are presented in tables 1 and 2.

However we start off with some more general notions regarding road sector schemes (regardless of national or international schemes) including a discussion of the possible entities that can be made responsible for emissions.

3.1.1 General notions regarding road sector schemes

Trading entities

To focus the analysis of emission trading in the road transport sector, we first discuss the possible trading entities. As noted in section 2.1, trading entity is defined as the party that is required to surrender allowances. The pros and cons of the different options are discussed below here.

End consumers, the vehicle drivers, could be the trading entities. For example, when paying the fuel bill, motorists could be required to hand over CO₂ allowances as well.

Alternatively, the trading entity could be the *filling stations*. They could be made responsible for handing over allowances to cover the CO₂ emissions associated with the fuel they have sold.

Fuel suppliers could also be identified as trading entities, that is the oil or trading company supplying the filling stations and in some cases end consumers directly.

Looking even more upstream in the system, *refineries* could be considered to be the trading entities. However, at the level of refinery it is currently not feasible to determine the market at which the fuel will be used. Two problems may therefore arise. First, some fuels, e.g. LPG, can be used for other purposes than (road) transport. Second, it cannot yet be determined with certainty whether the fuel produced will be used on the national (Swedish) market or in other countries. The reason is that refineries also serve trading firms. At the level of the refinery, there is no knowledge about the final destination of the products delivered to trading firms. Therefore, refineries cannot know for certain whether the product is to be used nationally or internationally, and in the transport sector or in other sectors. Refineries are for this reason not included as potential trading entity.

The trading entities discussed above are very much related to the fuel flow and therefore to total CO₂ emissions. They are feasible both in national and international schemes.

Alternatively, one can identify car manufacturers as trading entity, covering all new vehicles sold on the market. This would also be an upstream system. Assigning this type of entity is not so much directed at overall fuel flow, but may influence fuel efficiency of new cars effectively. In an international scheme a baseline and credit system may be imposed on vehicle manufacturers (or possibly dealers or importers of vehicles) for fuel efficiency. This can be measured in emissions of CO₂ in grams/kilometre on the standard test cycle.

However we do not consider this B&C option as adequate for a national scheme for two reasons. First, free movement of goods in the internal (EU) market. Member States do not have the authority to pose additional requirements on products sold on their domestic market¹⁴. Second, requirements in one country will only have a small influence on manufacturers, because the market is likely to be regarded as too small to adapt production lines to it.

Unambiguous responsibility

Currently, the only possibility for a C&T scheme directed at a specific sub sector of road transport, such as passenger cars, freight transport (including delivery vans) or public transport (buses) is to apply downstream at the end consumers. Further upstream in the chain, it cannot yet be determined for what purpose the fuel will be used. For example, passenger cars take in the same fuel as some delivery vans and the same holds for heavy duty vehicles (HDVs), buses and some cars and vans¹⁵. For this reason, it would be practically infeasible to distinguish the fuel sold at the filling station for the purpose of e.g. freight transport and public transport¹⁶.

Transaction costs

As mentioned in section 2, transaction costs consist of public and private costs. Depending on the size of the respective costs and benefits, certain schemes may be less appropriate to implement compared to others.

Public costs are related to the setting up systems of trading, monitoring, verification and sanctioning as well as the operational costs of these systems concerning the establishment of relevant data (for instance fuel input, fuel output, emission factors, CO₂ calculations) as well the yearly costs of independent verifiers and a (National) Authority.

Private entity costs are related to implementing emission trade at the level of the entity, costs involved with developing trading strategies and costs involved with the actual transactions and risk management (for instance hedging).

Some of the transaction costs are, at least to a certain extent, independent of the number of entities. For instance concerning the setting up of systems, it will not make that much difference if this applies to 10.000 or 100.000 entities. In fact eco-

¹⁴ Note the analogy to the current discussions on soot filters on diesel cars. The Netherlands want to make it mandatory for car manufacturers to install such filters on all new cars, but cannot do so due to EU regulations.

¹⁵ Furthermore diesel fuel is also being used by non-road machinery, petrol by working equipment et cetera.

¹⁶ If all road transport would be included this problem does not exist.

nomies of scale may occur if expressed in costs per entity. Other transaction cost types are however (at least) partially dependent on the number of entities involved with trading. This is to a large part determined by the location in the product chain where emission trading will take place.

Looking however at the huge differences in numbers of entities relating to upstream, middle stream or downstream trading systems (hundreds versus tens of thousands versus tens of millions) the argument of economies of scale will not hold when moving from upstream to downstream. The reason is that the benefits in economies of scale are outweighed by the expected rise in especially the costs of monitoring, verification and transaction.

Concerning the road sector, as demonstrated clearly in PWC (2002), Öko Institut (2003), UBA (2005), overall transaction costs will be much higher in downstream systems (trading entity = end user = car user) compared to an upstream scheme consisting of fuel suppliers or vehicle manufacturers as trading entity.

UBA (2005) comments that in Germany downstream emission trading schemes are not regarded as economically feasible in the road transport sector. Therefore, in Germany downstream schemes are not regarded as politically feasible either (UBA, 2005). Only upstream schemes are being worked out in more detail there.

The Swedish FlexMex2 Commission (Ministry of Sustainable Development, 2005) has, amongst other tasks, looked at the feasibility of bringing the transport system into the trading system for example as an opt-in in 2008. They also concluded that a downstream trading scheme for the transport sector would not be feasible and suggested two upstream alternatives.

In our appraisal, middle and downstream schemes will therefore score negative and double negative respectively.

Emission reduction possibilities of trading entity

Schemes that take place downstream, at the end consumer, have an important advantage: the entity responsible has the most practical options for fuel use reduction at hand. The end consumer can decide to drive less, to drive more moderately and save fuel accordingly, to keep up tire pressure, etc. However, motorists cannot directly influence technological improvements to the vehicle, such as starter-stop alternators, variable valve timing and engine downsizing. Such developments necessarily take place at the manufacturer. Only at the moment of purchase can motorists partly¹⁷ influence the technology of the vehicle. Nonetheless, a downstream scheme will provide incentives for end consumers to opt for fuel efficient cars.

Motorists would also receive incentives to buy fuel efficient cars and reduce the fuel consumption if the entity would be the filling station or the fuel supplier, through an increase in fuel prices. Increasing fuel prices is the main measure that these entities can take to influence fuel consumption. This price increase may be more or less directly linked to CO₂ emissions, depending on how the fuel supplier

¹⁷ Motorists are dependent on the vehicles that are on offer. Only by opting for specific cars can motorists influence manufacturers to place special emphasis on certain vehicle characteristics such as fuel economy.

chooses to pass on the costs of emission allowances¹⁸. In addition, fuel suppliers can increase the share of bio fuels as a response to the trading scheme.

If vehicle manufacturers are the trading entity, they basically have three different means to improve the fuel efficiency of the cars sold:

- By technological fuel efficiency improvements of engines or cars.
- By shifting production to cars that use fuels that emit less CO₂ (for example, a short term option would be a shift towards (current) smaller, more fuel efficient cars or from petrol to the more fuel efficient diesel cars).
- By influencing consumers choice, encouraging the sales of more fuel efficient cars (for example with advertisements or by adjusting prices of cars).

Clearly, manufacturers can only influence the fuel efficiency of new vehicles sold. They cannot influence vehicle use. Vehicle manufacturers can furthermore enable the use of bio fuels (or perhaps hydrogen, in the longer term), by offering cars that can run on these fuels. For example, they can offer flex fuel cars that can run on both petrol and bio-ethanol, or on any blend of these two fuels, or cars that can run on that high blends of biodiesel. However, since these cars can also run on (fossil) petrol or diesel, therefore bio fuel use is (currently) not guaranteed.

In the assessment, end consumers receive the score ‘++’, whereas vehicle manufacturers score ‘+’ and fuel suppliers and filling stations score ‘-’.

Scope of emissions

Clearly, the total scope of emissions included in the scheme will depend on whether the whole road transport sector is included in the system or only a sub sector (e.g. goods transport or all vehicles over, say, 3.5 tonnes gross vehicle weight) and whether the system is national or international.

Furthermore, the scope will be smaller if vehicle manufacturers are the trading entity, compared to systems which are linked to fuel sales or consumption. As discussed in the previous criterion, vehicle manufacturers can only influence the sales of new vehicles. Vehicle use is not affected, and neither are vehicles already on the market.

Technical feasibility

Baseline and credit systems related to the end consumer are complicated, especially when they relate to real life fuel economy. In some manner emissions have to be related to the performance (e.g. mileage or freight tonne-kilometres) of the vehicle. Furthermore making consumers subsequently trade would be rather complicated as well as monitoring and verifying transactions and related emissions. For these reasons, B&C systems related to end consumers are excluded from further analysis.

A cap & trade scheme that takes place at end consumers is not straightforward either. First of all, a system would have to be set up to allocate emission credits to all end consumers of road transport (several million in case of Sweden, more than 150 million in an EU system). Then, all of these people and companies would have

¹⁸ Although the price increase is likely to be linear with the amount of fuel purchased, relative price increases for petrol, diesel and LPG do not necessarily correspond to the associated CO₂ emissions per litre fuel.

to manage their emission credits, sell surplus credits or buy additional ones. Finally all transactions would have to be registered, monitored and enforced. Although not unfeasible, it would require quite a technically complex system to enable all this at the scale of end users.

Hence C&T schemes related to end consumers will score negative on this criteria.

A linkage to fuel sales at filling stations might be less complicated. One problem to overcome however would be to include the emissions from vehicles that get their fuel directly from the refinery or trading firms. This is sometimes the case for the large truck companies. It seems that this is not an insurmountable problem, and that this option is technically feasible.

3.1.2 First appraisal of national schemes

As stated in section 3.1.1, we can exclude two types of emission trading systems already: B&C systems related to end consumers and, concerning *national schemes*, the options in which vehicle manufacturers (or importers / dealers) are the trading entities. The first are too complicated from a technical point of view, the second is not feasible because of European legislation.

Linkage national ETS to EU ETS

In principle linkage to the EU ETS could be feasible for a national ETS for the road sector. Linking of a cap & trade system like the EU ETS to a baseline & credit system will be problematic but not impossible.

Scope of emissions

Total CO₂ emission of transport in Sweden amounted to 21.8 Mt in 2000¹⁹ (EC, 2003). This is expected to grow to 24.5 Mt in 2030. No specific CO₂ emissions levels for different transport modes are provided in (EC, 2003). However, energy requirements in Mt of Oil equivalents are given for different transport modes. These provide a reasonable proxy for the CO₂ emissions per mode.

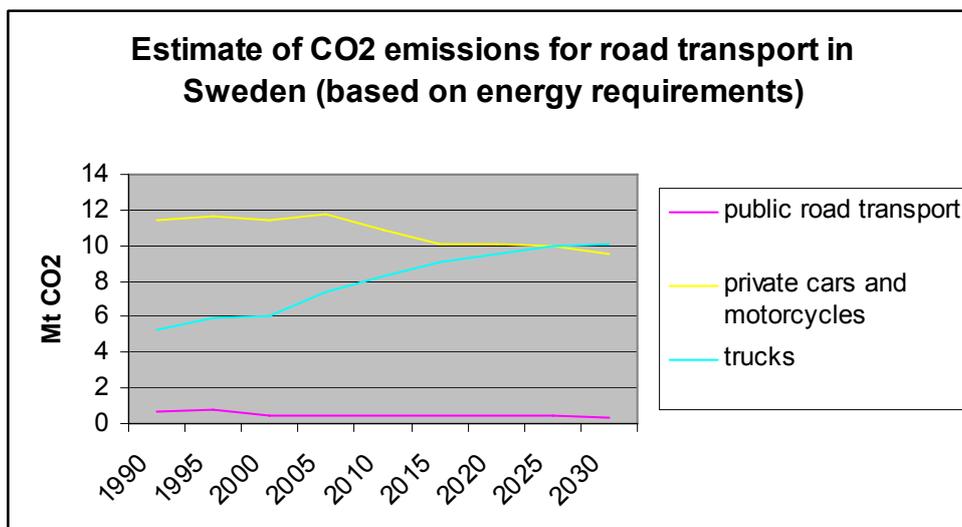
For road transport, public transport is responsible for 2.5% of the energy requirements, trucks for 33.8% and passenger cars and motorcycles for 63.7% (numbers for 2000). In total, road transport is responsible for 82.5% of energy requirements by transport in 2000. Figure 2 provides an overview over time, using energy requirements as proxy for CO₂ emissions.

It is clear from figure 2 that the private cars and trucks are responsible for the lion's share of emissions from road transport in Sweden. Emissions from trucks are projected to grow substantially over the coming period.

A scheme directed at all road transport will be assessed '++', schemes related to freight or passenger cars only by '+', and a scheme directed at public road transport only by '-'.

¹⁹ Excluding marine bunkers.

Figure 2 Overview of national (Sweden) energy requirements(CO₂ proxy)



Note: Emissions for the different road transport modes have been estimated based on the relative energy requirements and CO₂ emissions from transport sector as a whole.

In Table 1 the different national schemes are scored based on the considerations previously made in this section.

Table 1 Appraisal of practical feasibility of a national scheme for road transport

Entity	System	Mode	Emission reduction possibilities of trading entity	Transaction costs	Scope of emissions	Technical feasibility
End consumer	C&T ²⁰	Passenger	++	--	0	-
End consumer	C&T	Freight	++	-	0	0
End consumer	C&T	Public	++	-	-	0
End consumer	C&T	All road	++	--	+	-
Filling station	C&T	All road	-	-	+	0
Fuel supplier	C&T	All road	-	0	+	0

- ++ Favourable
- + Quite favourable
- 0 Neutral
- Quite unfavourable
- Unfavourable

²⁰ C & T: Cap and trade system.

3.1.3 First appraisal of international schemes

In this section, international schemes that are aimed at road transport are assessed. The general arguments put forward in section 3.1.1 remain valid for this section.

National emissions from road transport are included in the Kyoto targets, although road transport does not currently take part in the EU ETS. One of the arguments put forward is that transaction costs would be very high if all motorists were to participate.

Some remarks about vehicle manufactures as trading entity

One of the most prominent European measures introduced up to now to curb CO₂ emissions from road transport has been the voluntary **commitment by car manufacturers to bring down average emissions of their new sales** passenger vehicles. In this system, it is not the absolute emissions that are capped, but the relative emissions, the CO₂ emissions per kilometre. The voluntary agreements will end in 2008/2009. There is some doubt whether the agreed targets of 140 g CO₂/km will be met. The European Union has furthermore set a target of 120 g CO₂/km on average, for all new passenger cars in 2010.

We consider vehicle manufacturers as a serious option for trading entity. This does not hold for vehicle dealers and importers. The reason is that manufacturers have more opportunities to reduce emissions by implementing technical improvements. Dealers and importers can only modify prices or use public relations tools such as advertisements to steer consumers choices.

Any scheme based on vehicle manufacturers as trading entity is necessarily a baseline & credit scheme. No information on the use of the vehicle and hence on total CO₂ emitted is available at that level.

As explained in section 2.1, a B&C system is related to relative fuel efficiency and not at absolute emissions. Therefore, it would not be an easy task to link international schemes based on baseline & credit systems to the EU ETS, which is a cap & trade absolute scheme. It could be done, though, if an average total mileage is assumed per car (for example, 150.000 km for a petrol car) (Öko Institut, 2002).

Emission reduction possibilities of trading entity

As discussed in section 3.1.1:

- Vehicle manufacturers have access to many technical improvements to vehicles, but cannot change the use of the vehicle.
- End consumers only have an indirect impact on technological improvements. They can however opt for fuel efficient vehicles at purchase or drive in a more fuel efficient way.
- Fuel suppliers and filling stations can influence fuel consumption indirectly by adjusting fuel costs or by supplying low carbon fuels such as bio fuels.

For this reason, end consumers are scored ‘++’, whereas manufacturers score ‘+’ and fuel suppliers and filling stations score ‘-’ on this criterion.

Technical feasibility

To design a system aimed at vehicle manufacturers, accurate emission factor measurements are crucial. For passenger vehicles fuel efficiency is measured during well defined test cycles, leading to a figure for CO₂ emissions per kilometre. However, comparable systems do not exist (yet) for other types of vehicles, such as light commercial vehicles, heavy duty vehicles and buses.

For light commercial vehicles, a similar measurement system will probably be developed in the future (European Commission, COM(2005) 269 final). However, designing a similar system for freight traffic relating to vehicle specifications would not be straightforward. The reason is that the truck market is very different to that for passenger vehicles. Trucks can differ substantially, both in size and function (ranging from 3.75 up to 40 tonnes gross vehicle weight, refrigerated trucks, refuse vehicles, etc.), and trucks are often modified after they are bought. Moreover, fuel economy does to a large extent depend on the type of trailer that is used behind the lorry. Lorries can use different trailers. Furthermore, truck engines are usually only tested on a test bench, and this is a further barrier to deriving a meaningful measure of on road CO₂ emissions.

For these reasons it has proven difficult to develop an indicator for fuel economy that can be used for all types of trucks. Such an indicator does not currently exist.

Somewhat similar considerations play a role regarding public transport. In recent years a diversification of buses used for public transport has taken place. There is no standard bus. Instead the carrying capacity of buses in public transport varies widely, from relatively small buses to articulated buses. Diversification is however small compared to the truck market, and at first sight it appears it should be feasible to develop an indicator relating fuel economy to carrying capacity. However this would probably not be precise enough to have the desired effect on purchasing behaviour.

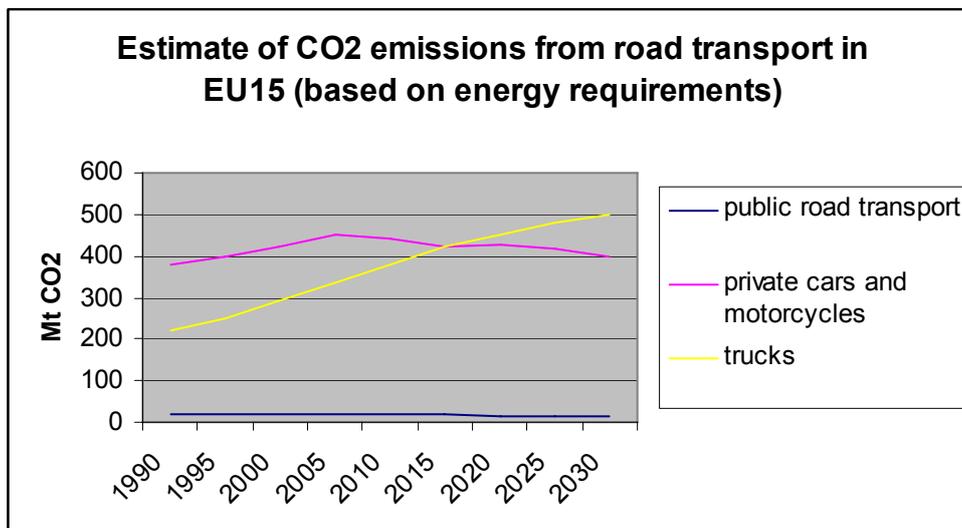
Scope of emissions

Total CO₂ emissions of transport in the EU15 amounted to 902.2 Mt in 2000²¹ (EC, 2003). This is expected to grow by 26% to 1140.2 Mt in 2030. No specific CO₂ emissions levels for different transport modes are provided in (EC, 2003). However, energy requirements in Mt of Oil equivalents are given for different transport modes. These are used as proxy for the CO₂ emissions per mode.

For road transport, public transport (including touring cars) is responsible for 2.2% of the energy requirements, trucks for 40.0% and passenger cars and motorcycles for 57.7% (numbers for 2000). In total, road transport is responsible for 81.6% of energy requirements by transport in 2000. Figure 3 provides an overview over time, using energy requirements as proxy for CO₂ emissions.

²¹ Excluding marine bunkers.

Figure 3 Overview of international (EU15) energy requirements(CO₂ proxy)



Note: Emissions for the different road transport modes have been estimated based on the relative energy requirements and CO₂ emissions from transport sector as a whole.

It is clear from Figure 3 that the private cars and trucks are responsible for the lion's share of emissions from road transport in the EU15. Emissions from trucks are projected to take over private cars in 2015 as main contributor. Whereas emissions from passenger cars are expected to decrease slightly over the coming decades, emissions from trucks are forecasted to increase steadily. Emissions from public transport play a minor role.

A scheme directed at all road transport will be assessed '++', schemes related to freight or passenger cars only by '+' and a scheme directed at public road transport only by '-'.

The above considerations (completed with some other notions) are presented schematically in Table 2.

Table 2 Practical feasibility of international schemes for road transport

Entity	System	Mode	Emission reduction possibilities of trading entity	Transaction costs	Scope of emissions	Technical feasibility
End consumer	C&T	Passenger	++	--	+	-
End consumer	C&T	Freight	++	-	+	-
End consumer	C&T	Public	++	-	-	0
End consumer	C&T	All road	++	--	++	-
Filling station	C&T	All road	-	-	++	0
Fuel supplier	C&T	All road	-	+	++	0
Vehicle manufacturers	B&C ²²	Passenger	+	+	+	++
Vehicle manufacturers	B&C	Freight	+	+	+	-
Vehicle manufacturers	B&C	Public	+	+	-	0
Vehicle manufacturers	B&C	All road	+	+	++	-

++ Favourable
+ Quite favourable
0 Neutral
- Quite unfavourable
-- Unfavourable

3.2 Selection of feasible emission trading schemes

Based on the discussion in the previous section, we can make the following observations:

- B&C schemes directed at end consumers may lead to high transaction cost and may be difficult to implement (technical feasibility).
- C&T schemes directed at end consumers may also lead to high transaction cost, but have the advantage that the trading entity itself has direct access to a variety of emission reduction measures.
- Filling stations and fuel suppliers have no access to emission reduction measures.
- B&C schemes aimed at vehicle manufacturers seem feasible for passenger cars and light commercial vehicles, however they can only affect the fuel efficiency of new cars (i.e. alternative fuels, car use and existing cars are not included).
- Coverage of CO₂ emissions is much larger for an international than a national system.
- Public transport is only responsible for about 2% of total CO₂ emissions from road transport.

As remarked, filling stations and fuel suppliers have only access to one direct emission reduction measure, namely increasing the share of bio fuels in their sales. Their other option is to increase the price of their (fossil) fuels). Introducing emission trading would then be perceived by end consumers as an additional charge on fuel.

²² B & C: Baseline and credit system.

Increasing fuel taxes, or implementing a CO₂ tax on fuels, would achieve a comparable effect, however with much lower transaction costs and much less problems with the technical feasibility. The most important difference would be that an additional charge on fuel would lead to an unknown environmental impact but known cost impact on end consumers, while imposing a cap or bringing the road sector under the EU ETS would have the opposite effect: a known environmental impact, but unknown cost impact on end consumers. Charge levels could however be adjusted periodically so to have a reasonably well predictable environmental impact.

Based on these considerations and a discussion with SEPA, it was decided to look at three options in the second stage appraisal:

- 1 A C&T scheme for the complete road sector, for end consumers.
- 2 A C&T scheme for the complete road sector, with fuel suppliers as trading entities.
- 3 An international B&C scheme for passenger car manufacturers.

The focus will be mainly on the first option. The other two options are included for comparison.

3.3 Second stage appraisal

The second stage appraisal is mainly concerned with an assessment of the effectiveness of the various options, and of potential side effects. As explained in section 2.4, the following criteria will be used in the appraisal:

- Environmental effectiveness: amount of overall CO₂ reduction.
- Steering effect: potential to ensure CO₂ emission reduction within the sector itself.
- Cost effectiveness: expected price level of CO₂ emission allowances.
- Stimulating innovation / technological development.
- Competitiveness of (sub) sector (EU versus non-EU countries).
- Relevant side effects, like for instance the potential impact on the existing EU ETS of inclusion of other sectors.
- Possibility of using flanking instruments to enhance environmental effectiveness.

Furthermore, alternative policy options will be discussed that may achieve similar effects.

As mentioned above, the following emission trading systems will be assessed and compared:

- 1 C&T scheme for the complete (public and private) road sector in Sweden respectively in the EU. The end consumers (car drivers and transport companies) will be the trading entities in this scheme. A specified absolute CO₂ emission cap will be put on the road sector including allocation to the trading entities.
- 2 C&T scheme for the complete (public and private) road sector in Sweden respectively in the EU. The fuel suppliers (oil companies) will be the trading entities in this scheme. A specified absolute CO₂ emission cap will be put on the road sector including allocation to the trading entities.

- 3 B&C scheme for passenger car manufacturers in Sweden respectively the EU, comparable to the present scheme in California, USA. Car manufacturers will be the trading entities in this scheme. Car manufacturers have to achieve a specified reduction of average CO₂ emissions per kilometre of new cars over the coming years (= baseline). Manufacturers that achieve lower average emissions than the baseline can sell credits to manufacturers that do not achieve the baseline.

Furthermore, two variants of these systems will be considered:

- A A closed system, where emission trading is limited to the road transport sector only.
- B An open system, in which the scheme is linked to or included in the EU ETS, and trading with other sectors included in the ETS is allowed.

3.3.1 Environmental effectiveness

How effectively CO₂ emissions can be reduced depends primarily on how ambitiously the emission cap or baseline is set, in case of C&T and B&C schemes respectively.

Nevertheless, there are some general notions regarding environmental effectiveness of these schemes:

- The two C&T schemes ensure meeting a specified CO₂ emission (reduction) target (provided accurate monitoring and enforcement is implemented).
- In both C&T schemes, end users have all options for emission reduction at their disposal: consumers or transport companies can buy fuel efficient vehicles or renewable fuels, they can drive less or more fuel efficient, or improve transport efficiency (e.g., by improving logistics of goods transport, by car pooling, etc.). The B&C scheme is only aimed at the sales of fuel efficient passenger cars.
- The effectiveness of the C&T scheme does not depend on the trading entity: in both cases the cap acts as an upper limit.
- If the schemes are closed, the emission reduction has to take place in the sector itself.
- If the schemes are open, i.e. included in or linked to the EU ETS, the specified emission reduction is also ensured. However, it is not specified *where* the reduction will take place, only that it will take place within the ‘bubble’ of the C&T system. What will happen in the transport sector will depend on the relative cost of emission reduction measures in the various sectors included in the ETS, and on the preference of vehicle users (i.e. car drivers, shippers or hauliers). Two different scenarios may apply:
 - In the first scenario, emission reduction measures are relatively expensive in the transport sector, or vehicle users may choose not to react for other reasons. Emission credits will then be bought by the transport sector from the sectors where reduction measures are cheaper. More emissions are then reduced in other sectors than in the case without transport included in the ETS, actual emission reduction in transport is limited.

- In the second scenario, emission reductions in the transport sector are cheaper than in other sectors, and vehicle users react by taking additional reduction measures. These measures have an additional value now: apart from fuel savings, credits can be sold to other sectors. Emission reductions in transport would then be higher than in a closed system.

It is difficult to predict which scenario will be valid. Empirical evidence shows that an increase of fuel price has a significant effect on fuel consumption, especially in the longer term (Goodwin, 2004). Furthermore, a recent report illustrates that fuel efficiency improvements in cars can be cost effective, up to a certain point (IEEP, 2005). However, it is also clear that many people are willing to pay a high price for their mobility.

- If end users are the trading entity, the scope of the scheme must be further defined. Are all people and companies based in Sweden or in the EU (depending on whether it is a national or an international system) obliged to participate in the system? How are people or companies from outside Sweden or the EU treated in the system? Can the fuel that is bought outside the scope of the system also be included?
- If fuel suppliers are the trading entity, defining the scope of the scheme would be easier: all fuel sold in Sweden or in the EU (depending on whether it is a national or an international system) can be included.
- In case of a B&C scheme for passenger car manufacturers, the system is only targeted at the fuel efficiency of new passenger cars. The potential effectiveness is thus lower than that of the first two schemes, where other emission reduction options such as renewable fuels²³ or mileage reduction are also stimulated. Furthermore, goods transport can not be included in this scheme (as discussed in section 3.1.3). However, as mentioned before, the actual effect depends on the targets set: an ambitious baseline for vehicle manufactures may reduce emissions more than a lenient cap on transport emissions.
- Effectiveness can deteriorate if end users (i.e. emitters) have the possibility to evade the system. In all trading schemes analysed here, evasion is possible. In case of the B&C system for car manufacturers, the system can be evaded by importing used cars (in stead of buying a new car) and by postponing the replacement of the existing cars (i.e. extending their lifetime). The C&T schemes for end users or fuel suppliers can be evaded by filling up in countries outside the scope of the system - comparable to the current practice of particularly international goods transport companies to fill up in countries where diesel prices are lowest. Evasion can thus be expected to be lower if the emission trading system is implemented on an EU scale rather than on a national scale, since the average distance to a country outside the scheme will be larger on an EU scale, and for all vehicle types there is a limit to how far it makes sense to tanker fuel in this way.

²³ Regarding renewable fuels e.g. bio fuels, an issue arises that should be addressed with respect to emission trading. In the case of bio fuels, the amount of CO₂ emitted in the vehicles is equal to the amount taken up by the crop that is used to produce the bio fuels. However, when looking at the life cycle of the bio fuels, greenhouse gas emissions may be very significant. Therefore, the true potential of bio fuels with regard to the reduction of greenhouse gases requires a life cycle approach, rather than the approach used in conventional emission trading systems.

3.3.2 Steering effect

With a closed C&T system, the amount of emission reduction in the transport sector can be controlled directly. When a trading system in the transport sector is linked to or included in the EU ETS, governments can not control the emissions of the sector directly.

That potential drawback may be alleviated by combining the trading scheme with flanking instruments. These could be used to steer where and how (i.e. in what (sub)sector, by what means) the emission reductions will take place. For example, reducing the registration taxes of fuel efficient cars can provide an additional incentive to buy fuel efficient cars. If this policy measure is then combined with a C&T system, the combined effect of these two measures is likely to increase the sales of these cars. Flanking instruments are discussed further in section 3.3.7.

The car manufacturer B&C system allows control of the relative emissions of new passenger cars, and promotes technological innovation in the car manufacturing sector. Total emissions are, however, only influenced indirectly, since car use itself is not affected by this system. Furthermore, this scheme does not provide an opportunity to directly stimulate alternative, renewable fuels, although it can promote the sales of cars that can run on bio fuels, as mentioned earlier. Again, flanking instruments may be used to fill these gaps.

When implementing a closed system in order to steer technological developments or emission reductions, the result will be that the price of a CO₂ emission allowance in the road transport sector will differ from that in the EU ETS. In both trading schemes, the price will be transparent and publicly available. This can be expected to lead to a debate on whether or not such price differences could be justified and would be acceptable.

3.3.3 Cost effectiveness

As explained earlier, the cost effectiveness of trading systems is likely to improve with increasing scope of the system. An increased scope of the system makes available many more measures to reduce emissions. This increases the flexibility of the trading entities, and enables the use of the most cost effective measures to reduce emissions. Therefore, in general, open schemes are more cost effective than closed trading schemes.

Because the cheapest measures will be taken first, a more stringent target will lead to higher costs per emission unit avoided. The cost effectiveness thus deteriorates with more stringent targets. It should be noted that the cost of emission reduction measures are partly off set by the fuel savings they imply.

In general, more flexible schemes make it possible to ensure emission reductions at lower costs and are thus more cost effective. IEEP (2005) calculates and compares the cost effectiveness of various trading B&C schemes for car manufacturers. The results show that the cost of reaching a fixed fuel efficiency target is reduced significantly when the trading scheme is made more flexible, e.g. when trading between manufacturers is allowed for. Fuel efficiency savings during the

lifetime of the vehicles more than compensate the additional costs of emission reduction measures up to a certain target (in this report, about 130 g CO₂/km).

We now turn to a more direct comparison of the cost effectiveness of the three schemes under study. For this comparison, we assume that all schemes reduce emissions equally, ensured by differentiated target setting.

- A C&T for fuel suppliers may be less efficient than a C&T for end consumers, because it is unclear how incentives will be passed on to end consumers. It may however well be that the lower transaction costs in the C&T for fuel suppliers compensates efficiency and that the cost effectiveness in the C&T for fuel suppliers is better than in the C&T for end consumers.
- The B&C system is only directed at passenger cars. This is less flexible, because emission reductions in the freight sector do not qualify. Also, behavioural measures such as driving less, or more fuel efficiently cannot help meeting the target. It is unclear to what extent this efficiency loss, without flanking instruments, can be compensated for by lower transaction costs. Therefore, a direct comparison of cost effectiveness with the other schemes is not possible.
- The B&C relates only to new cars. If we would compare schemes based on the assumption of equal emission reduction of one year after introduction, the B&C would most probably require huge (and unrealistic) efforts by the manufacturers. This would lead to much higher emission reductions under this scheme, the car market being penetrated by the new fuel efficient cars, in later years than under the other schemes. A better comparison would therefore be after ten years of introduction. Then the fact that the B&C is only directed at new cars no longer influences cost effectiveness comparisons. It does remain however that an adjustment in the targets set will take longer in a B&C system to work through than under a C&T system.

Actual cost effectiveness of a trading system can be strongly dependent on oil price and technological development. If the oil price goes up, cost savings due to fuel savings will increase, and cost effectiveness will improve. Obviously, the opposite effect will occur if the oil price decreases. If technological development reduces the cost of emission abatement technologies, cost effectiveness will also improve.

Furthermore, it should be noted that a flexible trading system is aimed at optimising cost effectiveness in the short term. This does not have to be true for the longer term as well. In the longer term, especially the promotion of new technological developments may well prove cost effective, even though this comes at a price in the short term. New technology may require high investments at the start of its development, and cost may not be competitive then. Once the technology is more mature, and produced at larger scale, the costs may reduce significantly, resulting in an improved cost effectiveness. As can be seen in the following sections, innovation may be stimulated by designing a closed trading system, but alternatively, flanking instruments can be implemented in addition to an open system.

In this analysis, we have looked at macro economic cost effectiveness of CO₂ mitigation. There is one remark that should be added:

- Cost effectiveness for end consumers, fuel suppliers or car manufacturers can be quite different (as shown, for example, in (IEEP, 2005)). For example, only

end users will benefit from fuel savings. Fuel suppliers or car manufacturers will only be faced with the additional cost of the trading system. Their costs will thus depend on

- A How they react to the trading scheme (i.e. adapt their behaviour to the new policy).
- B Whether or not they can recover any additional remaining costs by passing them on to the end consumers, and
- C Whether these cost increases will reduce their sales and revenues.

3.3.4 Stimulating innovation

In general, innovations in the transport sector are stimulated most in closed trading systems, since emission reductions in the sector are then mandatory. In an open system, the drive for innovation depends on the cost effectiveness of measures available in the emission ‘bubble’, compared to that of measures in other sectors. Innovation might then take place within other sectors.

Clearly, the drive for innovation depends strongly on the stringency of the cap or baseline. Innovation will only be promoted when the cap or baseline is ambitious, and can not be achieved with commonly available technology.

Essential for stimulating innovation is setting and sticking to long term goals and to the choice of instrument (in this case emission trading), for example deciding on a scheme to reduce the cap or benchmark over time. The industry then knows what to expect and can develop investment strategies accordingly. The sector can anticipate on the future developments, and investments in the development of new technology can be justified from a business point of view: the return on investments can come from the sales of emission credits, or the avoidance of the obligation to buy additional credits.

It is indeed essential that long term goals and choice of instruments are clear and stable. Otherwise this will create uncertainties to the industry that may hamper the drive for innovation and a preference to buy emission permits instead of investing in new emission reducing technologies. Currently this seems to be happening caused by the fact that the principles of the allocation and the cap set for future trading periods (2008-2012 and beyond) are not yet clear²⁴. As a result industry cannot fully anticipate the price of credits in the medium term.

3.3.5 Competitiveness

In general, whether introducing an emission trading scheme leads to distortions in competition depends on the extent to which competitors on the same market face the same regime.

For a C&T scheme for all end consumers, freight transporters may be disadvantaged if the scheme would not hold for foreign transporters. This would depend on the design of the scheme. For example, will the scheme apply for all kilometres driven or fuel burned on Swedish or EU territory, or will it be related to fuel sales? In the former situation, distortions in competition will be relatively small. However,

²⁴ In the Netherlands for instance such arguments have come to light whilst preparing for the next round of emission trading (2008-2012) (information Dutch Ministry of Economic Affairs).

transport price increases may work through to other sectors, which might be competing with industries in countries outside the scope of the scheme, and not facing higher transportation costs.

In a C&T scheme for fuel suppliers, end consumers located near countries borders may be stimulated to purchase fuel outside of the scope of the scheme. To what extent this will lead to (more) serious distortions depends on the impact of ETS on fuel prices and the current fuel price differentials between countries²⁵.

The B&C scheme for car manufacturers can be expected to have limited effect on the overall competitiveness of car manufacturers, if all are included in the system. However, the competitiveness of some companies might be affected quite severely, depending on the details of the scheme chosen, such as the nature of the baseline (IEEP, 2005). Some of the companies currently produce models with relatively high average fuel consumption, whereas others will already be much closer to the future target. Depending on the flexibility of the system and the trading allowed, the costs of the first group of manufacturers may increase significantly, which will reduce their competitiveness. Obviously, the second group will benefit in this case²⁶.

In general a closed emission trading scheme will affect competitiveness more than an open scheme (assuming equal emission reduction), since cost of abatement measures will be higher.

To determine the impact of the inclusion of the transport sector (or parts of it) in the EU ETS on the costs of current trading sectors and subsequently on international competitiveness, one should take into account the shortfalls of the different sectors and their emission reduction cost curves. Sectors that are currently net buyers of emission allowances, will only be able to meet their commitments at higher costs. They will have to buy their allowances at the new and higher market price, and may be able to take some reduction measures themselves at costs between the old and new price. Sectors that are currently net sellers will most probably remain so and can even sell their allowances at higher prices than before. More of their reduction measures may become cost effective and they are likely to be better off. This issue is dealt with in more detail in section 6, focusing on the inclusion of international aviation in the EU ETS.

Finally we would remark that both under closed and open systems, the potential revenues from an auction could be returned to the sector to reduce the economic impact of the emission trading scheme in itself.

3.3.6 Relevant side effects

Various side effects may be expected from the implementation of an emission trading system in the transport sector. These will depend on the design of the system chosen.

²⁵ Such distortions already do occur.

²⁶ It should be noted that this could be regarded as being in line with the polluter pays principle. Those parties that pollute most, or in this case produce the most polluting cars, pay the most. Although emission trading thus affects the competitive position of certain car manufacturers, this does not necessarily constitute an economic distortion.

In case of a closed system, other sectors are only indirectly affected, by the cost increase of transport. Sectors (and companies) that use transport will thus be confronted with a cost increase of their transport related inputs. This will lead to a cost increase of those products and services that use transport. This cost increase will depend on the costs of emission allowances, i.e. on the cap or baseline set, and on the scope of the scheme.

In general, if the system is open, the effects on both the transport sector and on other sectors will be smaller than in a closed system, due to the improved cost effectiveness. The actual effect depends on the relative costs of emission mitigation in the transport sector. If emissions are reduced mainly in other sectors, the effects on the transport sector will be smaller than in a closed system, since the emission reductions will be achieved at lower costs. Other sectors will reduce emissions more than in the case without this scheme, but these costs will be paid for by the transport sector. If costs are lower in the transport sector than elsewhere, additional emission reduction will be achieved in the transport sector.

If a C&T system is implemented for fuel suppliers or fuel end users, the use of bio fuels may be encouraged (depending on whether the emission allowance price is high enough to make bio fuels competitive). Independent on whether the system is open or closed, this will affect sectors using or producing biomass: the agricultural sector, the food and fodder industry, the electricity sector. The price of biomass will increase due to the increasing demand. In general, this will have positive effects for the agricultural sector (that provides the biomass), but the other sectors will be affected negatively.

Other side effects are the following:

- Technological innovations that are developed to achieve the goals in the transport sector may prove useful in other sectors, leading to cost reductions there.
- Increasing transport efficiency and reducing mileage (effects of a fuel price increase) reduces air pollutant emissions and congestion.
- However, if fuel efficiency is improved by a shift to diesel (in passenger cars), this may increase air pollutant emissions (NO_x, PM₁₀), unless stringent emission reduction measures are implemented (for example, the Euro 5 emission standard is achieved). This could be remedied by introducing flanking instruments, see also the next section.

3.3.7 Possibility of using flanking instruments

Introduction of flanking instruments may in general strengthen the proposed and analysed emission trading schemes and may overcome some of their weaknesses with respect to (cost) effectiveness and stimulating innovation. Note that the use of flanking instruments will, in general, have a negative effect on the cost effectiveness of the policy: emission reduction by emission trading will provide the most cost effective means of emission reduction. Also from the perspective of political feasibility, it may be desirable to have one all encompassing scheme. For example, there may be a political liability that industry will only agree with introduction of C&T system under the condition that no new instruments are introduced to steer the market.

However, these two issues will need to be weighed against the other criteria discussed so far. Also, flanking instruments may encourage innovation and the development of fuel efficient technologies improving cost effectiveness in the longer term.

In the discussion above, reference has been made to flanking instruments at several instances. We will discuss some instruments briefly.

A disadvantage of a B&C system is that it only provides incentives for car manufacturers. Other emission reduction techniques, such as less driving or driving more fuel efficiently, are not directly targeted. This could be remedied, however, by the introduction of flanking instruments. Programs teaching drivers how to drive fuel efficiently already exist in several countries. (Reducing) speed limits on highways is also an option. Less driving could be stimulated by all kinds of measures, ranging from levying higher excise duties to spatial planning.

Use of renewable fuels could be targeted through a separate program, either obliging fuel suppliers to provide a certain amount of bio fuels or by tax incentives.

The B&C scheme discussed so far only targets passenger cars because no standard test is available for HDVs. Flanking instruments could however provide specific emission reduction measures in this sector as well. These instruments could be aiming for technological innovation by R&D programs but also for transport savings, environmentally friendly driving, etc.

More in general, specific subsidy programs and R&D programs could ensure a steering effect in the transport sector.

Side effects may also be remedied by flanking instruments. For example, a shift to diesel may be considered undesirable due to the impact this may have on local air pollution. Flanking instruments to be considered are strict regulation of the air pollutants through the existing system of Euro emission standards. Alternatively, fuel excise duties could be adjusted (possible revenue neutral) so to make it relatively more expensive to drive a diesel car compared to a petrol car. This could also come about by a change in the current registration and circulation taxes.

Flanking instruments can also be introduced to prevent evasive behaviour. Earlier it was mentioned that in a B&C system, people might start to import cars from outside of the scheme. Specific regulations of fiscal instruments could control this kind of behaviour.

One other issue to consider is whether flanking instruments may distort the market for emission reductions. For example, reducing registration taxes for fuel efficient cars makes emission reductions more profitable within the road transport sector. In an open scheme, the price of allowances will go down. The road sector will purchase less emission allowances and other sectors will have to buy allowances where previously they were a net seller. Whether or not this may lead to adverse effects for other trading sectors goes beyond the scope of this study.

3.3.8 Alternative policy options

The emission trading systems under investigation achieve effects that may also be realized with other types of policy measures. Since emission trading is an economic, market based instrument, pricing options are most likely alternatives to achieve similar results.

A C&T scheme aimed at fuel suppliers leads to average fuel price increases equal to the allowance price, dependent on how fuel suppliers choose to pass on costs. Furthermore, fuel suppliers may choose to replace part of the current fossil fuels with bio fuels or other renewable fuels²⁷, if the additional costs of bio fuels are lower than the credit price. The fuel price increase will then encourage end users to reduce fuel consumption. End users can react by opting for more fuel efficient cars, alternative fuels such as bio fuels, or reducing mileage.

A C&T scheme with end users as trading entity will not lead to fuel price increases, but end consumers will be faced with cost increases directly related to their (fossil) fuel use. The effect will thus be very similar as if fuel suppliers are the trading entity. Therefore, these two options score quite similarly on the effectiveness criteria analysed in this report.

An alternative policy option for both schemes is therefore an excise duty tax increase, preferably in the form of a CO₂ tax on fuel. This would be much easier to implement (at least on a national scale), and the effects on fuel suppliers and end consumers would be very similar. The main advantage would be much lower bureaucratic effort and thus transaction costs, since it would involve only a limited number of parties and it would be in line with the current excise duty system. A calculation of the emission credit cost per litre diesel and petrol is provided in Table 3, for three different CO₂ emission credit prices. This would be the equivalent level of CO₂ tax on the fuel²⁸.

Table 3 Costs of emission rights per litre, for three different allowance prices

Allowance price	€/t CO ₂	Petrol			Diesel		
		10	30	50	10	30	50
CO ₂ emissions/litre	kg/l	2,31	2,31	2,31	2,59	2,59	2,59
Costs of emission rights per litre	€/litre	0,023	0,069	0,116	0,026	0,078	0,130

However, there is a fundamental difference with a C&T emission trading system. A C&T system ensures that the emission cap will be met, but the costs of meeting that cap are uncertain. With a CO₂ tax on fuel, this is the other way round: the maximum costs of CO₂ mitigation are known beforehand, but the emission levels cannot be known exactly.²⁹ The emission reduction will thus be less than anticipated when mitigation costs are higher than expected. Likewise, the effect will be higher when costs are lower than anticipated.

Regarding the B&C scheme for car manufacturers, alternative measures that could lead to similar effects are a differentiated tax system on cars (either of the registration tax or of the circulation tax) and of course a continuation of the voluntary system currently in place. The differences between the B&C system and tax measures are comparable to the differences between a fuel CO₂ tax and a C&T

²⁷ Currently, only bio fuels are available. However, in the future, hydrogen produced from renewable energy might become a feasible option as well.

²⁸ Note that current excise duties are not considered to be CO₂ taxes.

²⁹ However, the fuel demand elasticity with respect to price it is relatively well understood, at least under current conditions.

system for fuel suppliers or end users. The tax differentiation will encourage the sales of fuel efficient cars, but it will not ensure that a fixed target is met. The general effect of this measure is that manufacturers will be encouraged to implement fuel efficiency measures that are cheaper than the tax, and buyers will be directed towards more CO₂-efficient cars.

3.4 Conclusions

The assessment of the three schemes discussed in the second stage appraisal leads to the overview as presented schematically in Table 4. In this table the scores on the evaluation criteria of the first stage appraisal are presented as well as these criteria will also play their role in the overall assessment of the schemes.

B&C schemes aimed at vehicle manufacturers perform best with respect to transaction costs compared to C&T schemes.

Fuel suppliers as trading entity have only limited access to emission reduction measures. Measures they can take is to adjust the price of the fuel sold or to stimulate the demand for bio fuels.

A B&C scheme for car manufactures has several benefits, compared to a more general C&T scheme: it can encourage technological innovation, which may reduce the CO₂ reduction potential and cost effectiveness in the longer term.

However, such B&C scheme also has disadvantages, compared to C&T schemes directed at fuel sales or use. The main weak point is the limited scope of the scheme: it can only encourage fuel efficiency improvements in new passenger cars. However, this is a short term disadvantage, which will disappear after 10-15 years, when the car park is renewed. The other (C&T) systems analysed in this second stage appraisal include the whole transport sector, and also encourage other means of CO₂ mitigation in the sector. This type of system can be complementary to a more general, C&T system.

From the point of view of steering emission reductions in the transport sector itself, a closed system is the preferred one. This will guarantee - provided a strict cap or baseline is set - that the transport sector will reduce its own emissions. This benefit should however be weighed against the reduced cost effectiveness respectively the macro economic efficiency compared to an open system in which the transport sector is allowed to trade with other sectors and where emission reduction occurs where costs are least.

Table 4 Feasibility of selected emission trading schemes for road transport (full appraisal)

Entity	System	Mode	Included in / linked to ETS or closed system	Emission reduction possibilities of trading entity	Transaction costs	Scope of emissions	Technical feasibility	Environmental effectiveness *	Steering effect	Cost effectiveness	Possibility of using flanking instruments	Stimulating innovation *	Competitiveness ***	Side effects ***
End consumer	C&T	All road	Open/linked	++	--	++	-	++	-	++	+	0	0/-	0
End consumer	C&T	All road	Closed	++	--	++	-	++	+	+	+	0/+	-	0/-
Fuel supplier	C&T	All road	Open/linked	-	+	++	0	++	-	+	+	0	0/-	0
Fuel supplier	C&T	All road	Closed	-	+	++	0	++	+	0	+	0/+	-	0/-
Vehicle manufacturers	B&C	Passenger	Open/linked	+	+	+	++	+	-	+	+	0/+	0/- **	0
Vehicle manufacturers	B&C	Passenger	Closed	+	+	+	++	+	+	0	+	+	- **	0/-

- * = depending on stringency of cap or baseline
 ** = this may be different for individual companies
 *** = comparison mainly between open/linked versus closed schemes

- ++ Favourable
 + Quite favourable
 0 Neutral
 - Quite unfavourable
 -- Unfavourable

4 Railways (diesel)

4.1 First stage appraisal

In this section we roughly appraise the feasibility of the different types of railway schemes imaginable. Having fewer ‘dimensions’ compared to road transport, we will discuss national and international schemes in an integrated approach. The scores are presented in Table 5.

Unambiguous responsibility

As with road transport, a downstream scheme directed at a specific sub sector of rail transport, passengers versus freight, seems the most straightforward option. In this case this means at the level of railway operators. However further upstream in the chain, at the level of fuel suppliers many of whom might deliver direct to rail depots, a scheme may also be feasible.

Emission reduction possibilities of trading entity

Railway operators have some flexibility in selecting the most fuel efficient types of diesel trains when buying new trains or locomotives. However the average lifetime of trains and locomotives is several decades³⁰. So, at least in the short and medium run, very little flexibility can be expected. In the long run a switch to electric trains could be made.

Fuel suppliers have limited flexibility; they can mainly react by adjusting the fuel price. Train / locomotive manufacturers have access to many technical improvements, but cannot influence the actual use of the vehicle.

Manufacturers and railway operators score ‘+’ on this criteria, fuel suppliers ‘-’.

Transaction costs

In the rail sector the number of ‘players’ is small be it for railway operators, fuel suppliers or manufacturers. For this reason transaction costs will not be too high³¹. All trading entities score ‘+’ here.

Technical feasibility

Baseline and credit systems related to railway operators must be related to the performance (e.g. mileage) of the locomotive / train. To make railway operators subsequently trade will probably be rather complicated.

Concerning locomotive / train manufacturers as trading entity, a B&C system based on fuel economy may be less complicated, although not straightforward as fuel economy is also influenced by the actual number of cars, vans or wagons in freight

³⁰ However operators may be reworking the engines and/or replacing them more frequently.

³¹ On the other hand, in a closed system the number of trading entities may be too low to enable market liquidity.

trains, and there would be important differences between locomotives and diesel multiple units.

Regarding B&C systems an average fuel consumption and thus CO₂ emission per train kilometre may be derived from current data. A more sophisticated system for rail traffic be it passenger or freight relating to vehicle specifications, geography and type of train will anyway be less straightforward.

B&C as well as C&T schemes related to railway operators will score ‘-‘ on this criteria.

Refineries as trading entity

Concerning refineries as trading entity, the same arguments can be raised as in road transport (refer to section 3). Refineries cannot know for certain whether the product is to be used nationally or internationally, and in the transport sector or other sectors. Refineries are for this reason not included as potential trading entity.

Linkage national ETS to EU ETS

In principle linkage to the EU ETS could be feasible for a national ETS although it appears unlikely in practice. Linking of a cap & trade system like the EU ETS to a baseline & credit system will be problematic but not impossible.

Scope of emissions

Rail transport EU-wide, based on diesel contributes for less than 1% to the overall emission of CO₂ respectively GHG in the EU: in CE Delft (2005b) the share is estimated to be around 0.6%, far less than the other transport modes considered. Setting up an emission trading scheme for a rail sub sector (only diesel) that is responsible for a very minor contribution to total CO₂ emissions, is not efficient in our view³².

The above considerations (completed with some other notions) are presented schematically in Table 5.

³² In Sweden however the diesel based contribution to rail CO₂ emission is more substantial than the EU-average. Nearly 10% of total train kilometres is diesel based (source: www.sika-institute.se).

Table 5 Feasibility of emission trading schemes for rail (diesel)

Entity	National / International	System	Mode	Emission reduction possibilities of trading entity	Transaction costs	Scope of emissions	Technical feasibility
Railway operator	National	C&T	Passenger / Freight	+	+	--	-
Railway operator	International	C&T	Passenger / Freight	+	+	-	-
Railway operator	National	B&C	Passenger / Freight	+	+	--	--
Railway operator	International	B&C	Passenger / Freight	+	+	-	-
Train / loc. Manufactures	International	B&C	All rail	+	+	-	+
Fuel supplier	National	C&T	All rail	-	+	--	0
Fuel supplier	International	C&T	All rail	-	+	-	0

++ Favourable

+ Quite favourable

0 Neutral

- Quite unfavourable

-- Unfavourable

4.2 Selection of feasible emission trading schemes

Compared to road transport but also to aviation and shipping, diesel trains are responsible for a very minor share of total EU25 CO₂ emissions: around 0.5%.

For this reason we did not perform a second stage appraisal designing emission trading schemes specifically for diesel trains except as part of the 'all transport' schemes (refer to section 7).

5 Maritime shipping

Maritime shipping contributes significantly to climatic change and air pollution. Until now, however, Parties to the United Framework Convention on Climate Change (UNFCCC) have not been able to agree on a methodology to assign responsibility for greenhouse gas emissions from maritime shipping. In addition the International Maritime Organization (IMO) has not been able to agree on any action to ensure effective implementation of mitigation policies to reduce greenhouse gas emissions from shipping.

Moreover, the allocation options under discussion would not be feasible at the moment, due to lack of monitoring data (CE Delft, 2004). It is recommended there that research activities should be instigated to arrive at accepted and robust bottom-up methodologies for calculating CO₂ emissions from ships.

The feasibility and possible design of emission trading options in the maritime shipping sector depend on the allocation option chosen, since this largely determines the geographical scope of the trading system and the most logical trading entity. Deciding on an allocation option is a prerequisite for setting up emission trading in this sector, because it determines which part of maritime emissions are included: all emissions of the bunker fuels sold in the EU, EU-based ship operators, trips with an EU departure port or destination et cetera.

It is in this light that the first stage appraisal of emission trading schemes regarding maritime shipping should be viewed.

5.1 First stage appraisal

In this section we roughly appraise the feasibility of the different types of maritime shipping schemes imaginable. As with railways, we will discuss potential national and international schemes in an integrated approach. The scores are presented in Table 6.

Unambiguous responsibility

Schemes directed at distinguishing between passengers and freight shipping are difficult to implement, since for some sub sectors of shipping (such as ferries), both passengers and goods are transported at the same time. If it is nevertheless considered appropriate to analyse, it should be applied downstream. In this case this means at the level of shipping companies.

Further upstream in the chain respectively fuel suppliers, it may not yet be possible to determine for what purpose the fuel will be used.

Emission reduction possibilities of trading entity

Shipping companies have some flexibility in selecting the most fuel efficient types of ships and engines when purchasing additional ships or replacing old ones. However the average lifetime of ships is 30-40 years, so, at least in the short and medium run, the influence of a change in purchasing behaviour will be limited. Engines

are refurbished or replaced more frequently. Shipping companies furthermore influence emissions by adjusting operational parameters such as speed and load factor. Refineries and filling (bunker) stations have very limited emission reduction possibilities; they can only reduce their sales by increasing fuel price. Ship manufacturers have access to many technical improvements, but again it takes some time for this to have real impacts on the market. They cannot influence the use of the ship.

Manufacturers and shipping companies score ‘+’ on this criteria, fuel suppliers ‘-’.

Transaction costs

The number of trading entities is not very large, shipping companies being the relatively largest group compared to fuel suppliers and manufacturers. For this reason transaction costs will not be too high. However setting up the trading system itself including monitoring, verification and sanctioning will be quite complicated. This holds especially for B&C systems. These schemes score ‘-’. C&T-schemes score ‘0/-’ here.

Technical feasibility

The allocation option to be agreed at international level will determine the data needs and the most likely candidate to act as a trading entity. Fuel suppliers (via bunker stations) in principle could act as trading entity, but may induce massive evasion behaviour towards countries outside the geographical scope of the emission trading scheme (depending on the scope chosen). Also the tankering possibilities for shipping are much greater than for other modes.

Shipping companies currently lack accurate monitoring methodologies and data sources to calculate CO₂ emissions from ships, but a fuel monitoring and reporting could (technically) be set up. For ship builders, a B&C system based on fuel economy could be developed, perhaps in line with the CO₂ indexing system currently under development by the IMO. However also here holds that a large majority of ship builders will be outside the EU³³.

B&C as well as C&T schemes related to shipping companies, fuel suppliers and manufacturers will all score ‘-’ on this criteria.

Refineries as trading entity

Concerning refineries as trading entity, the same arguments can be raised as in road and rail transport (refer to section 3). Refineries cannot know for certain whether the product is to be sold or used nationally or internationally, and in the transport sector or other sectors. Refineries are for this reason not included as potential trading entity.

³³ The same holds for car manufacturers. Separate agreements have been set up with European car manufacturers (ACEA), Japanese (JAMA) and Korean (KAMA) manufacturers. Also manufacturers from non-EU countries have consented to bring down CO₂ emissions on a voluntary basis. The main difference with shipping however is that cars are sold and used within the boundaries of the EU25. Ships are used (and refuelled) anywhere in the world.

Linkage national ETS to EU ETS

In principle linkage to the EU ETS could be feasible for a national ETS although it appears unlikely in practice. Linking of a cap & trade system like the EU ETS to a baseline & credit system will be problematic but not impossible.

Scope of emissions

The attributed share of maritime shipping (combined passenger and freight) in the national total CO₂ emissions of the EU25 was estimated to be nearly 4% in 2002 (CE Delft, 2005, based on bunker fuels sold). This is much less than the road sector, but more than international aviation and rail (diesel). The share for Sweden could be somewhat higher based on the role of ferries in passenger transport.

The above considerations (completed with some other notions) are presented schematically in Table 6.

Table 6 Practical feasibility of international schemes for international shipping

Entity	Sys-tem	Mode	Emission reduction possibilities of trading entity	Transac-tion costs	Scope of emissions	Technical feasibility
Shipping company	C&T	Passen-ger	+	0/-	0/+	--
Shipping company	C&T	Freight	+	0/-	+	--
Shipping company	B&C	Passen-ger	+	-	0/+	--
Shipping company	B&C	Freight	+	-	+	--
Fuel sup-plier	C&T	All shipping	-	0/-	+	--
Ship manu-facturer	B&C	Passen-ger	+	-	0/+	-
Ship manu-facturer	B&C	Freight	+	-	+	-

++ Favourable

+ Quite favourable

0 Neutral

- Quite unfavourable

-- Unfavourable

5.2 Selection of feasible emission trading schemes

Provided an adequate CO₂ monitoring system comes into place, an international C&T scheme for shipping companies could be an attractive option in future. This scheme could in principle be linked with ETS. However exploring this option will require quite substantial (technical) research. In addition, implementation would be very difficult from a political point of view, in view of the global nature of shipping companies.

Regarding ship builders as trading entity, an international B&C scheme might be an option in the long term, provided that the scheme also would apply for manufacturers outside the EU (like the current voluntary agreement for car

manufacturers).³⁴ Such a scheme could potentially be based on the CO₂ emission indexing scheme³⁵ for ships, currently under development within the International Maritime Organization (IMO).

In parallel to the IMO initiatives, the EU is also working on development of policies for emission reductions in shipping, including CO₂ emissions. In 2003, a research study, mainly focusing on NO_x and SO₂, was commissioned by the EU to investigate the possible effects and feasibility of various market-based instruments in shipping. A follow up study has recently been commissioned and is expected to come out near the end of 2006.

In consultation with the Swedish EPA, and in view of limited time and budget available, it was decided not to investigate these options further in this project.

³⁴ However, cars are generally sold and registered within the member state where they will be most used, so it is easy to prevent sales by manufacturers who do not comply. This is not the case for shipping, and this may lead to further flagging out to third countries.

³⁵ The basic principle of a CO₂ emission index is that it describes the CO₂ efficiency of a ship, i.e. the CO₂ emission per tonne cargo or passenger per nautical mile.

6 International aviation

6.1 First stage appraisal

6.1.1 Introduction

In this section the possibilities for an emission trading scheme for aviation will be discussed. We will not make a full scale appraisal of all options here, because a lot of work has already been done on this issue (see e.g. CE Delft (2005a) and Öko Institut (2004)). An important input to current discussions on future European policy is CE Delft (2005a). In that report, several options for the design of an ETS linked to the current EU ETS are discussed.

We will first briefly look at design options not widely discussed up to now. Subsequently, we will quickly move forward to the core of the current discussions with respect to aviation and emission trading.

An important issue related to aviation that also holds for shipping, is that the climate impact differs from the climate impact from its CO₂ emissions alone. NO_x emissions and contrail formation also contribute to climate change. In IPCC (1999) the total climate impact of aviation was estimated at two to four times the impact of its CO₂ emissions alone. This estimate yet does not take into account the possible impact from cirrus cloud formation, induced by aviation. Scientific uncertainty was at that time judged too large to estimate the size of the impact of cirrus clouds. This still holds even though since 1999, scientific knowledge has progressed and estimates have been further refined. The important implication remains however, that in designing policy aimed at reducing the climate impact of aviation, note should be taken of these other impacts. For example, an open emission trading scheme in which GHG emission allowances could be traded with other sectors may be less effective in curbing the climate change impact if other sectors sell their allowances to the aviation sector. Another example, instruments aimed at reducing emissions of CO₂ or GHGs may result in trade offs with for example NO_x emissions. This may affect the overall environmental impact of the policy measure.

6.1.2 Feasible alternatives

The objective of the above-mentioned CE Delft study was to look at the potential means to integrate emission trading for aviation under the current EU ETS scheme. This earlier report looked at international schemes (scope) with a cap & trade system, linked to the EU ETS and with use of Kyoto Project Mechanisms. Alternative options were not assessed. Here in this report we will briefly assess several alternative options, these being:

- A national system.
- An international system, not linked to EU ETS, cap & trade.
- An International system, baseline & credit.

Subsequently, the options with the most potential will be developed further and assessed.

A national scheme

In theory, the introduction of a national emission trading scheme for aviation may be feasible. In relation to the flights that would fall under such a system, there are several options. First, it could refer to domestic flights only. Alternatively, to all flights either departing from or arriving at national airports. A third option would be to include all flights from airlines based within the nations territory:

- Compared to an international scheme, the environmental impact of a national scheme is limited.
- The limited impact of national scheme may not warrant the costs of setting up the system. Alternative options such as fuel taxation may be just as effective at much lower costs of implementation.

An international scheme, not linked to EU ETS, cap & trade

A second alternative is an international scheme that is not to be linked to the EU ETS, but is based on a cap & trade scenario. Such a system could either be closed or open. A closed emission trading scheme would leave little flexibility to reduce emissions. Because mitigation measures in the aviation sector are relatively expensive, an open scheme may be more cost effective.

Alternatively, it may be possible to set up a separate open system for aviation, linked to other schemes but not to the EU ETS. However, we cannot find any advantages of linking to an alternative scheme and not to the EU ETS. The EU scheme is currently one of the largest emission trading markets for GHGs and there appears to be no reason to opt for linkage to alternative schemes.

An international scheme, not linked to EU ETS, baseline & credit

A baseline and credit system is also an option. Such a system could be directed at airlines or manufacturers and mainly aims to increase fuel efficiency. Overall emissions could not be capped, see also section 2.1.

During the last 30 years, fuel efficiency has already improved drastically in the aviation sector. Energy intensity (energy use per passenger kilometre) more than halved between 1973 and 1998 (IEA, 2004). This has been partly due to the wish for more fuel efficient aircraft by airlines, prompted by fuel costs. The environmental impact of increased pressure on fuel efficiency improvements may be limited.

A recent study by the aviation industry (Green, 2005) identified operational and technological advances that could cut the climate change impact of aviation by 90% over the next 50 years (GBD, 2005). Aircraft fuel efficiency per passenger kilometre could be reduced by a factor of 3. Such improvements would be stimulated in a cap & trade system as well as under a baseline & credit system.

The environmental impact of B&C may be smaller than of a C&T system, especially if applied to manufacturers. The reason is that it appears that only aircraft sold on the EU market could be included (analogue to a system for passenger car manufacturers). Due to the relatively long period to design a new aircraft, and engines, impact may be small initially.

A B&C scheme for manufacturers is not a viable option. There are too few manufacturers to ensure liquidity of the market in allowances. Moreover, operational

measures such as increasing the load factor of aircraft would not be further stimulated under a B&C scheme for manufacturers.

A B&C scheme for aircraft operators appears better suitable. A key point would then be how to account for different loads, i.e. passengers versus freight. Another point to address would be how to avoid perverse incentives. For example, if emissions are related to freight carried, it might become profitable, from the perspective of the emissions allowances required for the flight, to fill up the aircraft with dummy passengers or luggage to achieve a better relative performance.

For a further discussion on a performance standard and how best to design such a standard, see CE Delft (2002).

However, comparing B&C to C&T schemes, a B&C scheme would have much more administrative and transaction costs compared to a C&T scheme, under the assumption of trying to achieve a similar reduction in absolute emissions. Also, historically, demand growth has greatly exceeded improvements in efficiency, leading to significant growth of total fuel consumption in the sector. From this perspective, a C&T scheme would be likely to have a greater impact on total emissions than a B&C system.

6.2 Selection of second stage work

Since attention within the EU is presently focused on the feasibility of including aviation in the EU ETS, in the second stage appraisal this report focuses on two specific issues agreed to with SEPA. These are:

- 1 How could one determine the impact that the inclusion of aviation into the EU ETS might have on the allowance price on the market?
- 2 If aviation is included into the EU ETS is it possible to design the scheme to ensure that emission reduction activities take place within the aviation sector (a steering effect)?

These issues are elaborated in the next sections.

6.3 Impact from inclusion of aviation on allowance price

In this section we discuss *how* one could determine the impact of inclusion of aviation on the allowance price. We will not so much actually carry out this exercise, but more describe the lines along with such a study could be carried out and which indicators could be of use.

We will start by a brief summary of the mainly qualitative analysis carried out in CE Delft (2005a). Then we discuss the methodology that could be applied for a more elaborated assessment.

6.3.1 CE Delft study

Before going into a discussion of the results of CE Delft (2005a) we first elaborate on some general notions regarding the impact of inclusion of aviation on the EU ETS market. The reason is that the calculations and results in CE Delft (2005a) are determined partly by the assumptions they are based on. By elaborating on how different factors may influence the impact on the EU ETS market, the results of CE Delft (2005a) can be put in the right context.

Factors influencing impact

The (net) impact of inclusion of aviation in the EU ETS on the market for allowances is determined by several factors.

In the first place, this impact is determined by the size of the shortfall in emission allowances. Under shortfall we will understand the difference between the Business as Usual (BaU) emission level and the amount of allowances allocated to the sector (e.g. by grandfathering or auctioning). The shortfall thus indicates how much allowances should be bought and / or how much emission reduction measures should be taken within the sector. The shortfall will be a positive number if the amount of allowances allocated to the sector is restrictive, i.e. it is lower than the BaU emission level. The sector can respond by reducing emissions within the sector or by purchasing allowances on the market. In the latter case, there is a net demand of the aviation sector on the EU ETS.

Whether the sector will respond by taking reduction measures or by purchasing allowances depends on the costs of reduction measures relative to the price of allowances on the market. If, on average, reducing emission is cheaper than purchasing allowances, the aviation sector might become a net supplier of allowances.

In CE Delft (2005a) three different options for inclusion of aviation in the EU ETS are defined. These options differ in many aspects and for the exact definition of the options we refer to the original report. In brief:

- Option 1: all intran EU flights (flights both departing from and arriving at an EU airport) and inclusion of a multiplier to account for non-CO₂ climate impacts.
- Option 2: all flights departing from an EU airport, CO₂ only but with the possibility of introducing flanking instruments.
- Option 3: all flights with emissions in EU airspace, CO₂ only but with the possibility of introducing flanking instruments.

For each of these three options, the potential impact in 2012 of inclusion of aviation on the EU ETS is discussed. This was done based on the assumption that the amount of allowances allocated to the sector is equal to the 2008 emission level³⁶. Hence, the shortfall equals five years of business as usual growth under each of the three options.

The absolute size of the shortfall differs under the three options, because the options include different amounts of absolute emissions. This is due to differences on the following two design elements³⁷:

- 1 Coverage of climate impacts.
- 2 Geographical scope.

³⁶ This assumption was made to give some indication of the potential impact of inclusion of aviation in the EU ETS. The actual amount of allowances will of course be the outcome of a political decision process.

³⁷ Note that a third design element could potentially also influence the impact on the market. This is the interplay with the Kyoto protocol. Under options 2 and 3, trade restrictions would occur in case the aviation sector was to become a net seller of allowances. This would influence the impact on the EU ETS market.

First, the coverage of climate impacts is of importance because in one of the scenarios a so-called multiplier of 2 is applied to cover the full climate impact of aviation. That means that for each allowance short, the aviation sector would need to purchase two allowances on the EU ETS market instead of one.

Second, the geographical scope determines which flights fall under the scheme. Under the first option discussed in CE Delft (2005a), the geographical scope is all intran EU flights. This covers about 71 Mt (BaU emission level in 2012). The second option includes all flights departing from an EU airport, and amounts to 178.5 Mt. The third option relates to all flights with emissions in EU airspace, amounting to 156.5 Mt.

In Table 7 the amounts of CO₂ and the shortfall is given for each of the options considered in CE Delft (2005a). It also includes an estimate, based on model calculations, of the amount of emission reduction that will take place within the sector, and the amount that will be purchased on the EU ETS. Note that this is influenced by the methodology to allocate allowances (e.g. grandfathering versus auctioning), we refer to the original report.

Table 7 Absolute and proportional CO₂ emission reduction of the three policy options in 2012 compared to BaU scenario in 2012 based on AERO-MS

	Option 1	Option 2	Option 3
BaU emissions in 2012	71 Mt	178.5 Mt	156.5 Mt
Baseline emissions 2008	60.7 Mt	152.6 Mt	133.8 Mt
Allowance price: €10 per tonne CO₂ eq.³⁸			
Total reduction of CO ₂ eq., of which:	20.3 Mt ³⁹	25.9 Mt	22.7 Mt
– Reduced within the aviation sector	0.3 Mt	1.1 Mt	2.0 Mt
– Purchased from other sectors	19.9 Mt	24.8 Mt	20.7 Mt
Allowance price: €30 per tonne CO₂ eq.			
Total reduction of CO ₂ eq., of which:	20 Mt	25.9 Mt	22.7 Mt
– Reduced within the aviation sector	0.7 Mt	3.2 Mt	5.6 Mt
– Purchased from other sectors	19.3 Mt	22.7 Mt	17.1 Mt

Source: CE Delft (2005a).

Note1: the exact specifications of each option can be found in CE Delft (2005a).

Note 2: under the assumption that opportunity costs are not passed on.

As can be seen, the amount of reductions within the sector is relatively small at the assumed allowance prices of € 10 and € 30 at the EU ETS market.

³⁸ The term CO₂ equivalent applies here because some of the allowances bought from other sectors may be based on emission reductions of other gases covered by the Kyoto Protocol (e.g. methane, F-gases) which are achieved under the EU ETS in other sectors.

³⁹ The total reduction of CO₂ equivalents under Option 1 is not equal to the growth of emissions in the aviation sector between 2008 and 2012. This is due to the multiplier of 2, assumed to capture the full climate impact of aviation. Because of the multiplier, for each additional emission unit two allowances will have to be purchased from other sectors. The amounts of reduction within the aviation sector are presented without the multiplication factor. If the allowance price is higher, the reduction within the sector will be larger and the overall reduction smaller, because the multiplier affects less allowances.

CE Delft (2005a) compare the amount of emissions that is expected to be purchased on the EU ETS market with the amount of allowances allocated to the EU ETS sectors (about 2,200 Mt). Using this method the additional demand on the market is estimated at about 1% of the total number of allowances on the EU ETS market, please refer to Table 8.

Table 8 Absolute and relative amount of allowances by the aviation sector from the EU ETS in 2012

	Allowances (in million tonne)	% of present allowances in ETS
Allowances CO₂ emissions present Emission Trading System (2005-2007)		
Allocated CO ₂ emissions	2,200 Mt	100.0%
Allowances bought by aviation from other sectors (2012)		
Allowance price € 10 per ton		
Option 1	20.0 Mt	0.9%
Option 2	24.8 Mt	1.1%
Option 3	20.7 Mt	0.9%
Allowance price € 30 per ton		
Option 1	19.3 Mt	0.9%
Option 2	22.7 Mt	1.0%
Option 3	17.1 Mt	0.8%

6.3.2 Alternative approach to determine impact on EU ETS

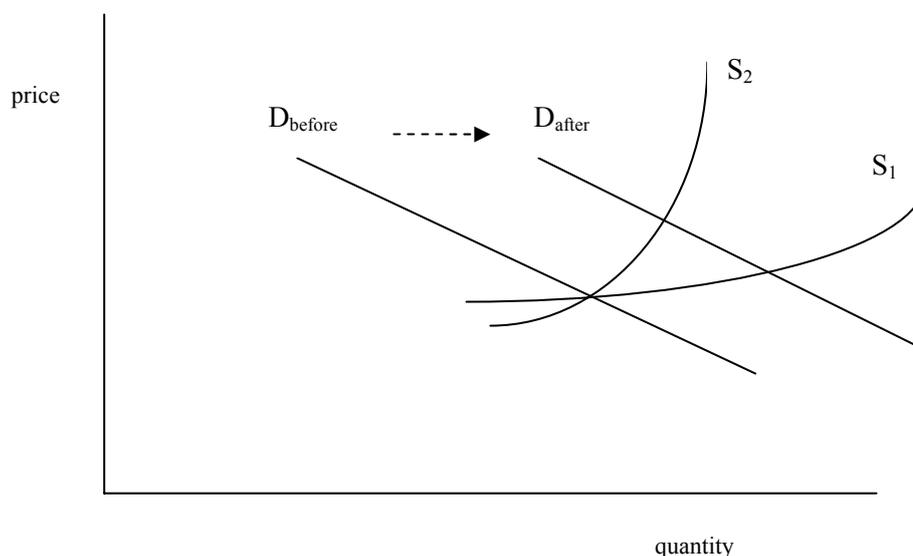
Since the publication of CE Delft (2005a) the impact analysis has received some attention. To some, the comparison of the likely demand from the aviation sector to the total amount of allowances allocated under the EU ETS does not provide the best indication of the impact of inclusion of aviation on the allowance price. We therefore elaborate here on how a more refined indication of the potential impact of inclusion of aviation on the market for allowances could be obtained⁴⁰.

The impact of additional demand for allowances on costs for other sectors is not easily determined. In economic terms, the additional demand from the aviation sector can be regarded as a shift of the demand curve to the right. Demand increases at a given price. If the supply curve of allowances of all sectors together⁴¹ is sloping upwards (and is not completely horizontal or vertical), this will mean that both the quantity traded and the allowance price will increase. The extent to which depends on the slopes of the demand and supply curves. The slope of the supply curve is determined by the cost curve for emission reduction measures. If the cost curve is relatively flat, the price increase of allowances will be small, if the slope of the cost curve is steep, the price increase will be larger.

⁴⁰ It should be noted that days before finalizing this study, a report by ICF became available. This report (ICF, 2006) builds on the assumption in CE Delft (2005a) of a 2008 historic baseline and applies model calculations to determine the impact on the allowance price under nine different scenarios. ICF comes to the conclusion that under the none of these scenarios, the additional demand of aviation on the EU ETS market leads to an increase in allowance price. This holds even under the assumption that the aviation sector itself does not take any mitigation measures and buys all the required allowances on the EU ETS market. For a further discussion, we refer to ICF (2006).

⁴¹ Note that this curve also includes the supply of Certified Emission Reduction (CERs) from the Clean Development Mechanism and the of Emission Reduction Units from Joint Implementation.

Figure 4 Setting a price for emission allowances



This is further elaborated in Figure 4. In situation 1, the supply curve S_1 is relatively flat. Inclusion of aviation causes a horizontal shift from the demand curve D_{before} to D_{after} . Given the flatness of the supply curve (the cost curve for emission reductions in all sectors), this leads to a relatively large increase in the allowances traded, and to only a small price impact.

In situation 2, on the other hand, the supply curve S_2 is relatively steep. Additional emission reduction measures are thus relatively expensive. The same shift in the demand curve will lead in this situation to only a small increase in traded quantity, but a large price increase.

The important question relates to the aggregate impact on the EU ETS sectors. This depends on the aggregate supply curve. If the slope is relatively flat, such as S_1 , the price increase will be small and additional emission reduction measures at costs close to the previous allowance price will free up additional credits. These credits can be bought by the aviation sector. Alternatively, if the slope is relatively steep (S_2), the traded amount will not increase much, and the additional demand from the aviation sector will push other players off the market. Sectors that were net buyers in the reference situation may no longer be willing to buy against the higher price. The higher price of allowances leads to reduced demand for their products⁴². Here some benefits will be lost to the EU ETS sectors. At the old prices it was worth it to purchase allowances or take emission reduction measures, but this has become too costly at the new prices. On average, the point where it would become too costly will be halfway between the old and new price. To the extent that fewer allowances are bought by the EU ETS sector, the surplus lost is about half the price increase. The aggregate impact on EU ETS sectors can be estimated by multiplying half the price increase by the fall in allowances purchased by the

⁴² Please note that this is in accordance with the aim of internalisation policies.

EU ETS sectors. Both the fall in allowances purchased by the EU ETS sectors and the price increase depend crucially on the slope of the demand and supply curve. The fall in allowances purchased by the EU ETS sectors will be between zero (in case of a horizontal supply curve) and the shortfall of the aviation sector (in case of a fully vertical supply curve).

To determine the impact of the inclusion of aviation in the EU ETS on the EU ETS sectors calls for an analysis of the demand and supply curves. This would require a sophisticated analysis of the aggregate cost curve of emission reduction measures.

To determine the impact on costs of different sectors, one should take into account the shortfall of these different sectors and their emission reduction cost curves. Sectors that were buyers in the reference scenario will only be able to oblige to their commitments at higher costs. They will have to buy their allowances at the new and higher market price, and may be able to take some reduction measures themselves at costs between the old and new price. Sectors that were net sellers under the reference scenario will most probable remain so and can even sell their allowances at higher prices than before. More of their reduction measures may become cost effective and they are likely to be better off.

The notion that inclusion of aviation raises prices and that all EU ETS sectors are subsequently worse off does clearly *not* hold. Net sellers of allowances are likely to be better off than before, net buyers are expected to be worse off. These effects cancel out to a large extent.

Even though the *net impact* may be relatively small because the impact on buyers (under the BaU scenario) and sellers cancel out to a large extent, the impact on a *specific sector* could be significant. Such distributional effects depend in part on how a sector is treated in the National Allocation Plan⁴³.

Second best alternative

A very rough indication on whether the net impact on the EU ETS sectors is likely to be large or small compared to the impact of the EU ETS scheme itself may be obtained by comparing the additional demand from the aviation sector to the traded volume in the reference situation. This would not so much provide information on the aggregate impact of inclusion of aviation to the EU ETS sectors, but would give an indication of how large this impact is compared to the impact of the EU ETS itself.

⁴³ In order to get a good grip on the impact of inclusion of aviation on a specific sector, a more elaborate analysis is required, taking into account the shortfall of the sector and its emission reduction cost curve.

Apart from the information on shortfall or demand by the aviation sector, information on the traded volume (in the year for which one would want to have the impact assessed) is needed. The current market does not provide much information on this. In November 2005 on average 1.6 MT EUA were traded daily. However, the EU ETS started in 2005 the market it is not yet fully developed. Prospex (2005) notes that many market participants expect higher trading volumes for 2006 and surge further in 2007 as companies gain an understanding of the actual emission allowances they will need to surrender. Moreover, some markets are not in the scheme yet as not yet all registries are operative. Also, smaller companies and players in southern and eastern Europe still have to enter the market, according to Prospex (2005). Borrowing allowances from next years allocation, as is allowed in the first period (2005-2007) may also impede liquidity. It is therefore widely expected that trade volumes will increase in the coming years.

Based on a solid market analysis, the trade volumes for future years could be estimated. These could then be related to the additional demand provided by the aviation sector to provide a rough indication of the size of the aggregate impact on the EU ETS sectors.

6.4 Steering effect in the aviation sector

An important criterion for SEPA is the steering effect of environmental policy. Will inclusion of aviation in the EU ETS lead to implementation of further emission reduction measures within the sector? Clearly, this depends on the marginal abatement cost curve in the sector relative to the allowance price on the market.

6.4.1 Aviation sector emission reduction possibilities

An often-heard argument is that emission reduction measures are relatively costly in the aviation sector. Inclusion of the aviation sector would therefore not lead to additional abatement measures in the sector, but the sector would buy all, or most, of its shortfall from other sectors.

At the same time, however, there is evidence of substantial fuel efficiency improvements in the aviation sector. Improvements (measured in fuel use per passenger kilometer) are estimated at around 70% since 1960 (see e.g. Lee, 2000)⁴⁴. Reductions have come about through improvements in engine design, aerodynamics and operational measures such as increasing the load factor of aircraft. For the future, the industry has committed itself to very ambitious further fuel efficiency improvements. Under the ACARE vision 2020 (ACARE, 2001), the industry has set a target of a 50% cut in CO₂ emissions per passenger kilometer (relative to 2000 levels).

How can it be that reduction measures are on the one hand marked as very expensive, while on the other hand large reductions have taken place and are envisaged for the future?

⁴⁴ However, note that using an earlier reference year would lead to very different conclusions. This is due to the phase out of very fuel efficient piston engines and the introduction of not very fuel efficient jet engines around the 1950s, see NLR (2005).

The reason for this phenomenon is that emission reductions have larger benefits than fuel savings. Aircraft have to carry the weight of fuel while flying, this leads to a substantial fuel penalty, the additional fuel use for carrying the fuel. If aircraft become more fuel efficient, they can instead of carrying the fuel, carry passengers or freight. For this they receive revenues. The benefits of a more fuel efficient aircraft are therefore not only in the fuel savings as such, but also in the revenues from the freight or passengers they can carry instead. Hence, relatively costly CO₂ emission reduction measures may still be worthwhile for the aviation sector to pursue compared to other sectors, as these measures also generate additional income.

Does this mean that including aviation in the EU ETS would not lead to additional emission reduction measures because they are already so expensive? If additional costs are associated with fuel use, the benefits of improving fuel efficiency become larger and more measures may become cost effective. However it could well be the case that emission trading would only lead to a small additional cost of fuel use, and, depending on the emission reduction cost curve, possibly only a few new emission reduction measures would become cost effective.

6.4.2 Results from CE Delft study

Table 9 provides an overview of the results from model calculations in CE Delft (2005a). It presents the extent to which emission reductions are achieved within the sector are provided for the options considered in CE Delft (2005a). Calculations are based on abatement cost curves imbedded in the model used. If opportunity costs are passed on⁴⁵, ticket prices will increase more and hence the demand effect will be larger. Therefore the reduction within the sector is larger in this case. Also, if the allowance price is higher, more cost effective reduction measures can be taken within the sector and hence the reduction within the sector will be larger.

⁴⁵ Refer to the discussion on opportunity costs in CE Delft (2005a).

Table 9 Absolute and proportional CO₂ emission reduction of the three policy options in 2012 compared to BaU scenario in 2012 based on AERO-MS

	Option 1	Option 2	Option 3
BaU emissions in 2012	71 Mt	178.5 Mt	156.5 Mt
Baseline emissions 2008	60.7 Mt	152.6 Mt	133.8 Mt
Opportunity costs not passed on			
Allowance price: €10 per tonne CO₂ eq.			
Total reduction of CO ₂ eq., <i>of which:</i>	20.3 Mt	25.9 Mt	22.7 Mt
– Reduced within the aviation sector	0.3 Mt	1.1 Mt	2.0 Mt
– Purchased from other sectors	19.9 Mt	24.8 Mt	20.7 Mt
Allowance price: €30 per tonne CO₂ eq.			
Total reduction of CO ₂ eq., <i>of which:</i>	20 Mt	25.9 Mt	22.7 Mt
– Reduced within the aviation sector	0.7 Mt	3.2 Mt	5.6 Mt
– Purchased from other sectors	19.3 Mt	22.7 Mt	17.1 Mt
Opportunity costs passed on fully			
Allowance price: €10 per tonne CO₂ eq.			
Total reduction of CO ₂ eq., <i>of which:</i>	20.3 Mt	25.9 Mt	22.7 Mt
– Reduced within the aviation sector	1.4 Mt	3.2 Mt	2.0 Mt
– Purchased from other sectors	17.8 Mt	22.7 Mt	20.7 Mt
Allowance price: €30 per tonne CO₂ eq.			
Total reduction of CO ₂ eq., <i>of which:</i>	20 Mt	25.9 Mt	22.7 Mt
– Reduced within the aviation sector	3.9 Mt	9.2 Mt	5.6 Mt
– Purchased from other sectors	12.8 Mt	16.8 Mt	17.1 Mt

Source: CE Delft (2005a).

Note: the exact specifications of each option can be found in CE Delft (2005a).

6.4.3 Ensuring a steering effect

In this section we discuss the options for policy design to ensure a steering effect in the aviation sector.

First of all, as is clear from section 6.4.1, fuel efficiency improvements within the sector since the 1960s have been substantial and are likely to continue in the coming 15 years. However, these have been overshadowed by the rapid increase in air traffic volumes, leading even to a rapid increase of the sector's overall emissions.

The emission trading scheme can be designed to maximize the emission reduction within the sector⁴⁶. Clearly, auctioning of allowances would lead to an increase in ticket prices and thereby induce a demand effect. If airlines would pass on costs through ticket prices, the reduction within the sector is also larger. Both lead to demand effects, thereby reducing the output of the aviation sector.

In general, open emission trading schemes are not designed to ensure emission reductions in specific sectors. This contradicts the precise aim of emission trading: to ensure emission reductions are taken where they are cheapest. If one is looking to ensure the aviation industry itself takes further actions, other instruments may be more appropriate. However, flanking instruments could be introduced to target non-CO₂ climate impacts of aviation. As noted in section 6.1.1., the climate change impact of aviation is larger than the impact from the CO₂ emitted alone. Policies designed to mitigate CO₂ should therefore be tested on their influence on the other

⁴⁶ There may also be differences in the steering effect from a B&C system compared to a C&T system, partly depending on the targets set in each scheme. Since the scheme under development by the European Commission is a C&T scheme, we do not pursue this issue further.

climate impacts of aviation. Trade offs should be avoided. Flanking instruments could be applied to prevent possible trade offs, but also to direct other climate impacts of aviation and to ensure progress is achieved with respect to the non-CO₂ impacts⁴⁷. In this way, some sort of steering effect, albeit not directly on CO₂ emissions, but on other climate impacts, could be enforced. We will briefly look at potential flanking instruments and assess their compatibility with emissions trading.

The non-CO₂ climate change impacts of aviation are (mainly) related to emissions of NO_x at altitude, the formation of contrails and possibly the formation of cirrus clouds⁴⁸. The link between aviation and the formation of cirrus clouds is still poorly understood and requires further study before concrete policy measures can be justified. We will therefore focus on flanking instruments to mitigate the impacts of NO_x and contrail formation. For a discussion on the political and practical background of these options, we refer to CE Delft (2005a).

There are several possible instruments to address the NO_x emissions from aircraft. Certification and/or charges may be applied. These instruments can both be related to the emissions during the landing and take off (LTO) cycle or to the cruise phase of flights. Already, certification of emissions of NO_x during the landing and take off (LTO) cycle takes place. Also, some airports have introduced airport charges related to the LTO emissions of NO_x. It is for these reasons that focusing on emissions during the LTO cycle may have practical advantages. However, the NO_x emissions during the cruise phase are responsible for the climate change effect and it is these one would ultimately want to control for⁴⁹. Engine manufacturers have indicated in the Aviation Working Group that there is a strong positive relationship between NO_x emissions during the LTO phase and the cruise phase. Therefore controlling NO_x emissions from the LTO phase may be an effective way to reduce cruise NO_x emissions.

All four possible combinations of certification & charges and LTO & cruise phase may be introduced alongside an emission trading scheme. NO_x certification or charges could be effective ways to reduce the climate impact from aviation. They are compatible with emission trading and do not conflict with the system.

⁴⁷ Even if these non-CO₂ impacts are addressed in the ETS by for example a multiplier, use of flanking instruments might be justified on the grounds of preventing negative trade offs. This depends on the specific non-CO₂ impact and the flanking instrument at hand.

⁴⁸ Refer to CE Delft (2005a) for an overview of current understanding of aviation climate impacts.

⁴⁹ Note that there are good reasons to control for NO_x LTO emissions as well, from a perspective of local air quality.

7 All transport inclusive scheme

7.1 First stage appraisal

Concerning viable options for an all transport inclusive scheme, the major part of our analysis concerning the individual transport sub sectors holds. Subsequently we have taken the results of that analysis as a basis for discussing the merits of an all transport inclusive scheme.

A major result from the previous analysis is that B&C schemes cannot act as a basis for the entire transport sector, as credits in different sub sectors / transport modes cannot be traded transport sector wide, unless very rough assumptions are used regarding lifetime mileage and fuel consumption of the vehicles or vessels.

From the resulting C&T schemes the following options come forward as being potentially feasible:

- C&T scheme for the overall transport sector in Sweden respectively in the EU. The end users (car drivers, transport companies, public transport service providers, airlines and shipping companies) will be the trading entities in this scheme. A specified absolute CO₂ emission cap will be put on the transport sector including allocation to the trading entities.
- C&T scheme for the overall transport sector in Sweden respectively in the EU. The fuel suppliers (oil companies) will be the trading entities in this scheme. A specified absolute CO₂ emission cap will be put on the transport sector including allocation to the trading entities.

It was decided by SEPA to analyse these two options further in the second stage appraisal.

7.2 Second stage appraisal

These two options were also further appraised for road transport (section 3.3).

Many of the specific characteristics, pros en cons mentioned there also apply to the case in which all transport modes are included in the trading system. We therefore use that analysis as a basis, without repeating the common issues in detail.

Before we look at the effectiveness criteria, we will first look into the possible definitions of the scope of these schemes.

7.2.1 System scope

An emission trading system for all domestic transport could be defined in several ways. The main options are:

- 1 All road and rail transport, aviation, inland shipping and maritime shipping is included that have both a domestic or EU origin and destination⁵⁰.
- 2 All road and rail transport, aviation, inland shipping and maritime shipping is included that takes place in Swedish or EU territory.

⁵⁰ Domestic transport here refers to transport with origin and destination within the geographical scope of the scheme. In an international EU scheme, a trip from Brussels to Paris will be included, but trips from the EU to North America will not.

- 3 All transport end users (car drivers, transport companies, etc.) based in Sweden or in the EU are included in the scheme⁵¹.
- 4 One could also define the scope as the CO₂ emissions that are due to fuel sold in Sweden or the EU.

The first two options require that the end user is the trading entity. The latter scheme could be feasible for both trading entities analysed here (end users and fuel suppliers).

The definition of scope will affect the impact on competitiveness of companies in the transport sector (and related industries), as well as the design and implementation of the scheme (i.e. emission administration, trading, monitoring, verification, etc). Furthermore, the potential effectiveness and cost effectiveness of the system are both related to the scope, since a larger scope will increase the volume of emissions included, as well as the emission reduction options.

7.2.2 Environmental effectiveness

The environmental effectiveness of these schemes, i.e. the amount of overall CO₂ emission reduction, depends primarily on the cap set, as discussed in section 3 on road transport.

However, also evasion of the system can reduce effectiveness, as discussed in section 2. Especially international transport may have the possibilities to evade the system. The extent to which this may reduce effectiveness, depends on the exact scope:

- Evasion can be expected to be relatively limited if a suitable geographical scope is chosen: the cost saving of evading the trading system will not be large enough to compensate the additional cost of a detour. However, if the scheme causes a significant cost increase for industry, there is a risk of relocation to countries outside the scope of the scheme.
- If the system scope is defined as the CO₂ emissions that are due to fuel sold in Sweden, evasion will be larger. Especially international maritime and aviation transport and, albeit to a much lesser extent international road and rail transport have opportunities to buy their fuel elsewhere.

Environmental effectiveness of the scheme is also related to monitoring and enforcement of the system. In all cases analysed here, monitoring and enforcement are technically possible. However, costs of monitoring and enforcement (both part of the transaction costs related to a scheme) and further work required for the implementation of the system, will depend on the scope of the trading system.

⁵¹ This definition would have to be further defined in a later stage of policy development, since in international goods transport there are generally a number of parties and countries involved. Determining the most suitable party to be involved in the scheme (from a legal and practical point of view) will not be done here.

7.2.3 Steering effect

As in road transport (see section 3.3.2), whether or not the governments can steer the emission reduction in the transport sector itself will depend on whether the trading scheme is an open scheme or not (i.e. linked to the ETS or not).

In a closed scheme, CO₂ reduction measures (or even absolute emission reduction) in the sector itself can be enforced. However, this will lead to different price levels of emission allowances in the transport sector, compared to the EU ETS. The government and stakeholders would have to be willing to accept that the costs of the emission allowances and therefore the CO₂ mitigation costs (€/ton CO₂) in the transport sector is likely to differ from those in other sectors.

7.2.4 Cost effectiveness

Since cost effectiveness of a trading system improves with increasing scope of the system, the cost effectiveness of an open scheme can be expected to perform better in this respect compared to a closed scheme. Furthermore, a trading scheme that includes all transport modes will result in a more favourable cost effectiveness than a comparable system that is limited to road transport only.

Especially in the rail and maritime transport sector, there are currently no or very limited CO₂ mitigation policies or fuel taxes in place⁵², compared to the road sector where significant fuel taxes are levied. For this reason only limited CO₂ reduction measures have been taken in these non-road modes: if fuel is relatively cheap, only relatively limited investments in fuel savings are justified⁵³. Therefore, expanding an emission trading system to these modes can be expected to improve cost effectiveness of overall CO₂ mitigation (although costs will increase in the sectors itself).

When transaction costs are included in the cost effectiveness comparison, the C&T scheme with fuel suppliers as trading entity is the most attractive of the two, since there are many fewer parties involved in the emission trading system, which will simplify and thus reduce cost of administration, monitoring and enforcement.

In case of an all transport C&T scheme, in which end users are considered to be the preferred trading entity, the resulting market on which emission allowances are traded consists of parties with unequal market power. Individual consumers (with small amounts of emission allowances each) have to trade and compete against parties such as shipping or airline companies with a much larger volume of allowances to sell or buy. However, these differences in market power could diminish as intermediary organisations may emerge to trade on behalf of a great many individual end users (e.g. like stock brokers on the stock exchange).

⁵² Refer to (CE, 2005 for a recent overview of emissions and policies of non-road modes.

⁵³ Note that this does not hold for aviation, as explained in section 0.

7.2.5 Stimulating innovation

The degree in which innovation in the transport sector will be stimulated by a C&T emission trading scheme depends on:

- A The scope of the system.
- B The 'tightness' of the cap.
- C The (anticipated) development of the cap in the longer term.
- D The existence and effectiveness of flanking instruments.

In an open system, CO₂ mitigation options will be implemented that can be well outside the transport sector itself. In a closed system, reduction measures must be taken in the transport sector itself. Furthermore, the tighter the 'cap', both in the short term and in the long term, the more industry will invest in the development and implementation of new CO₂ abatement technology.

7.2.6 Competitiveness

The effect of a transport emission trading scheme on the competitiveness of transport companies depends very much on the design of the scheme. Clearly, if the sector is required to reduce CO₂ emissions, this will result in additional costs for the sector. How significant this effect is will depend on the price of the emission credits, i.e. on the level of the emission cap and the scope and flexibility of the system. Furthermore, the effect will vary between individual end users (for example transport companies and shippers), since some will be faced with higher costs than others. Again, these effects depend on the exact design of the scheme.

In general, one can conclude that transport companies that are subjected to competition with companies outside the scope of the scheme will face a negative effect on their competitiveness. This effect will be highest in case end users are the trading entity, and the scheme is set up nationally rather than on an EU level. In that case, transport companies from outside Sweden have more favourable conditions than Swedish companies. The same holds for an EU scheme, although the effect will be more limited then: in road, rail and aviation transport, non- EU companies have limited access to the EU market.

As mentioned earlier (in section 3.3.5), some part of the international transport may have opportunities to evade the scheme, and thus evade the effect on the additional cost and its negative effect on competitiveness.

Incorporating all transport modes in an emission trading system will provide a fair and equal treatment of all transport companies included in the scheme. However, since CO₂ emission of the various modes are not equal (per tonne kilometre, for example), the costs will not increase equally. Depending on the design of the scheme, competitiveness of the various modes will change due to an emission trading scheme.

When comparing an all transport scheme to a scheme in which only part of the sector is included (for example, only road transport), the first will have less impact on competitiveness of transport companies.

However, transport price increases may work through to other sectors, which might be competing with industries in countries outside the scope of the scheme,

and not facing higher transportation costs. This might translate into higher costs of these sectors and/or changes in their use of transport.

7.2.7 Relevant side effects

We expect very similar side effects in this case as discussed for the road sector, in section 3.3.6:

- Transport will become more expensive due to the system (depending on the cap and design, marginal abatement costs, oil price, etc.). Other companies that make use of transport will thus be faced with a cost increase.
- If the scheme results in the increased use of bio fuels, the price of biomass is likely to increase. This can be expected to have a positive effect on the agricultural sector, but a negative effect on other sectors that use biomass (for example, the food and fodder industry, and (in some countries) the electricity sector).
- Technological innovations that are developed to achieve the goals in the transport sector may prove useful in other sectors, leading to cost reductions there.
- Increasing transport efficiency and reducing mileage (effects of a transport (e.g. fuel) price increase) reduce air pollutant emissions and congestion.
- However, if fuel efficiency is improved by an increased share of diesel in passenger cars, this may increase air pollutant emissions (NO_x, PM₁₀), unless stringent emission reduction measures are implemented.

7.2.8 Possibility of using flanking instruments

The various types of flanking instruments mentioned in section 3.3.7 can also be used to support a more general transport sector emission trading scheme, and to stimulate specific (for example technological) developments in the transport sector as a whole. Alternatively, flanking instruments could be used to account for particularities within a specific transport mode.

In general, the potential of flanking instruments discussed previously can also be used to address avoidance behaviour, negative side effects and trade offs in the transport sector as a whole. Specific R&D programs and subsidies can be applied to stimulate innovation. Subsidies for technologies that reduce fuel consumption could be used as incentives for technology development and market introduction in other transport modes as well.

Differentiation of taxes could be more difficult to implement since there is currently no registration or circulation tax on marine vessels, diesel locomotives or aircraft, and, with few exceptions, no fuel tax is currently charged on marine or aviation bunker fuels. Differentiation of these taxes thus requires introduction of these taxes in the non road modes first.

Finally, opportunities exist for tax differentiation in the non road modes, such as differentiation of harbour dues for fuel efficient maritime ships, if the CO₂ index development is successful.

7.2.9 Alternative policy options

Ideally, an alternative to a C&T scheme that covers all transport modes would also cover all modes, treating all modes equal and fair. In the road sector, it was concluded

that a CO₂ tax on fuel would achieve the same effects as a C&T emission trading scheme, if the level of the tax would be equal to the expected cost of emission credits. This tax could be implemented relatively easily, since fuel excise duties are already levied on all fuels used in road transport. The CO₂ tax however will not guarantee a specific CO₂ emission reduction, as a C&T scheme would, but it maximises the specific cost of CO₂ mitigation. The emission reduction achieved may be smaller or larger than anticipated, depending on the cost of mitigation measures.

Similarly, a CO₂ tax on fuels for all modes would thus be the best alternative policy option to an all transport emission trading scheme. However, excise duties not always exist in the non road modes, making implementation of a CO₂ tax on fuel much more difficult. Moreover, this is currently not possible from a legal perspective. For example, in the maritime sector, fuel taxes are currently not allowed due to international agreements.

Other, perhaps more feasible alternative policy options that would also result in CO₂ emission reductions throughout the transport sector are likely to be limited to specific sub sectors or modes. Examples are road pricing and financial incentives for fuel efficiency improvements or bio fuels. For maritime shipping and aviation, policy options to reduce CO₂ emissions are currently being analysed for the European Commission. However, policies with a more limited scope would not provide the same integral approach to transport emissions as an emission trading system would.

7.3 Conclusions

The environmental effectiveness of the schemes discussed depends primarily on the cap set, as discussed in section 3 on road transport.

Enlarging the geographical scope of the system will improve environmental effectiveness and reduce evasion.

Since cost effectiveness of a trading system improves with increasing scope of the system, the cost effectiveness of an open scheme is better than that of a closed one, and a scheme that includes all transport modes can be expected to perform better in this respect than that of a scheme limited to road transport only.

From the point of view of steering emission reductions in the transport sector itself, a closed system is the preferred one. This will guarantee - provided a strict cap or baseline is set - that the transport sector will reduce its own emissions, stimulating innovation as a side effect.

This benefit should be weighed against the improved cost effectiveness and macro economic efficiency of an open system in which the transport sector is allowed to trade with other sectors and where emission reduction occurs where costs are least. Potential long term benefits of innovation should be estimated and included in this comparison.

Monitoring and enforcement of the system will be easier if fuel suppliers are the trading entity rather than end users, since there will be less parties in the system to monitor and control. Costs of monitoring and enforcement, and potential further work on the implementation of the system, will furthermore depend on the scope of the trading system.

8 Conclusions and recommendations

8.1 Conclusions

Emission trading systems can stimulate the implementation of the most cost effective measures to reduce emissions. The larger the scope of the trading system and the more flexibility incorporated (i.e. trading options), the lower the cost of achieving a certain emission reduction. A CO₂ emission trading system in which the whole transport sector is included will thus lead to more cost effective CO₂ reduction than a system in which only a part of the sector (for example, road transport only, or car manufacturers only) is included. Equally, including or linking the transport sector in the EU ETS will further improve the cost effectiveness of emission abatement measures that can be taken. All sectors involved in the system will benefit from this. The most cost effective emission reduction measures (from a macro-economic point of view) will then be implemented.

A similar conclusion can be drawn regarding the geographical scope of the scheme: an international (for example, EU) trading scheme will lead to lower specific emission reduction costs than a national scheme. Furthermore, enlarging the scope makes the system fairer, providing the same treatment for all transport modes and/or nationalities.

However, there is a drawback to increasing the flexibility and the scope of an emission trading system: more flexibility and a larger scope will lead to higher transaction costs and system complexity. Designing and reaching agreement on a system will be more difficult, and data administration, monitoring, verification and enforcement will get increasingly complex and expensive with an increasing number of trading entities. It should however be noted that even though total complexity and costs will increase, average or specific transaction costs (i.e. costs per trading entity, or costs per tonne CO₂ reduced) may well decrease with increasing scope.

System complexity and transaction costs may be reduced by opting for an emission trading entity that is relatively upstream in the transport chain.

If fuel suppliers would be the trading entity, administration, monitoring and enforcement can be linked to the fuel tax system that already exists for road and rail transport, and the bunker fuel sales administration that is currently being set up for maritime transport. If, however, end users would be the trading entity, a new administrative, monitoring and enforcement system would have to be set up. Furthermore, as the number of trading entities would be several orders of magnitude higher, transaction costs would increase significantly.

A B&C system for car manufacturers has some distinct advantages over a C&T system for road transport. This type of system would be fairly easy to implement, since all monitoring and verification procedures are already available. Furthermore, the number of parties involved would be very limited, compared to the other trading

schemes analysed, which limits transaction costs. Also, technological developments in that industry are promoted directly. However, its scope is limited. For example, mileage is not affected, since it does not provide an incentive to drive less or increase transport efficiency. Furthermore, it can only have an impact on new cars, so that the short term effect is limited. This drawback will, however, diminish over time.

From the point of view of both steering emission reductions and promoting innovation in the transport sector itself, a closed system is the preferred one. This will guarantee, provided a strict cap or baseline is set, that the transport sector will reduce its emissions. This benefit should however be weighed against the reduced cost effectiveness respectively macro economic efficiency of an open system in which the transport sector is allowed to trade with other sectors and where emission reduction occurs where costs are least. If innovation is promoted, this assessment and comparison should also look at the expected long term developments, since innovation is aimed at improving cost effectiveness of emission reductions in the longer term.

In road transport, alternative policy measures might achieve a similar CO₂ reduction. Due to the transaction costs involved in emission trading systems, alternative policy measures like a CO₂ tax on fuel can even be more cost effective than an emission trading system limited to the transport sector. A CO₂ tax on fuels in all transport modes is currently not feasible, since in maritime shipping, fuel taxes are currently not allowed.

The major advantage of an emission trading scheme, compared to a pricing policy such as a CO₂ tax, is that the target - reduction of emissions - will certainly be achieved whereas this is not by definition the case with the alternative measures. Furthermore, if the emission trading system of the transport sector is linked to or included in the EU ETS, cost effectiveness of CO₂ mitigation may improve significantly.

8.2 Recommendations

This report provides an overview of the most important aspects of various potential emission trading schemes in the transport sector. Many issues are addressed, but need further elaboration if it is decided to continue development of one or more of these schemes.

What schemes to pursue?

When comparing the various emission trading schemes analysed, we recommend to analyse in more detail the C&T scheme for fuel suppliers as well as the B&C scheme for car manufacturers. We also recommend to further look into the possibilities to include transport in the EU ETS, since this will improve cost effectiveness of CO₂ mitigation.

A scheme in which end users are the trading entity would meet a number of practical problems. Involving a very large number of trading entities, this scheme would lead to high transaction costs, with only limited benefits in terms of efficiency or effects on competitiveness compared to scheme based on fuel suppliers.

A C&T scheme for fuel suppliers is, in principle, feasible for all transport modes, although this would require a lot of work on improvements in data monitoring (of maritime shipping, in particular), policy design and implementation. A step by step approach could be taken, by implementing such a scheme first for one or more transport modes (e.g. road), and including other modes at a later stage.

Since a CO₂ tax on fuel would provide very similar effects as a C&T scheme for fuel suppliers, we also recommend to consider this option as an alternative policy measure. With the exception of shipping, where fuel taxes are currently not legally feasible, this would provide a relatively cheap and easy to implement alternative⁵⁴.

The B&C scheme for car manufacturers has limited transaction costs, stimulates innovation in that industry, and can be implemented relatively easily. Hence we recommend to also investigate this option in more detail, which could be implemented in parallel with a C&T scheme.

Political considerations

A decision regarding whether or not to pursue any of the schemes analysed here does not only require further development of technical and legal issues, also political considerations and choices need to be addressed:

- As (domestic) transport does not face severe international competition, the risk of carbon leakage is small. For this reason it can be economically justified to design a closed scheme for transport. But also for political reasons there may be an interest to guarantee that measures are taken to ensure reduced emissions, or at least to slow down emission growth, in the sector itself.
- On the other hand, especially in the case of a closed scheme, the question is whether the government is willing to accept higher CO₂ mitigation costs (€/ton CO₂) in the transport sector, compared to other sectors. The same question can be raised with respect to the price of CO₂ emission credits in the transport sector compared to that in the EU ETS.
- In case end users are considered to be the preferred trading entity, is it feasible and acceptable from both an economic and social point of view that all end users have to administer their emission credits, buy or sell credits if necessary, and report to the authorities? In the case of road transport, these requirements would apply to all car and truck drivers, and they would have to operate on a joint credit market. If the other modes are included in the system, maritime ship owners, airlines and railway companies would be included as well. This would result in very high transaction costs as well as – at least initially - a market where parties have unequal market power, where individual consumers (with small amounts of emission allowances each) have to trade and compete against parties such as shipping or airline companies with a much larger volume of allowances to sell or buy. However, these differences in market power could diminish as intermediary organisations may emerge to trade on behalf of a great many individual end users.

⁵⁴ However, international efforts (e.g. across the EU) to harmonise fuel taxation levels have not to date been very successful.

- Once emission trading is in place, it can be expected that other, less cost effective policy measures that are aimed at CO₂ mitigation in the transport sector will be scrutinized by the stakeholders involved. As discussed in the report, combining various policy measures may be very effective to support and steer certain developments in the sector. However, this may also be perceived as increasing the burden on the sector.

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Dealing with Transport Emissions

An emission trading system for the transport sector, a viable solution?

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In 2005 the EU scheme for trading of CO₂ emission allowances started. A wide range of stationary sources are covered. Transport, however, is not included, even though it contributes to a large portion of total greenhouse gas emissions in the EU. Is emission trading in the transport sector feasible? Could emission trading contribute to reducing emissions of gases from the transport sector ?

This may be possible, certainly if a number of recommendations suggested by CE (Solutions for environment, economy and technology) in this study for the Swedish Environmental Protection Agency were to be followed.