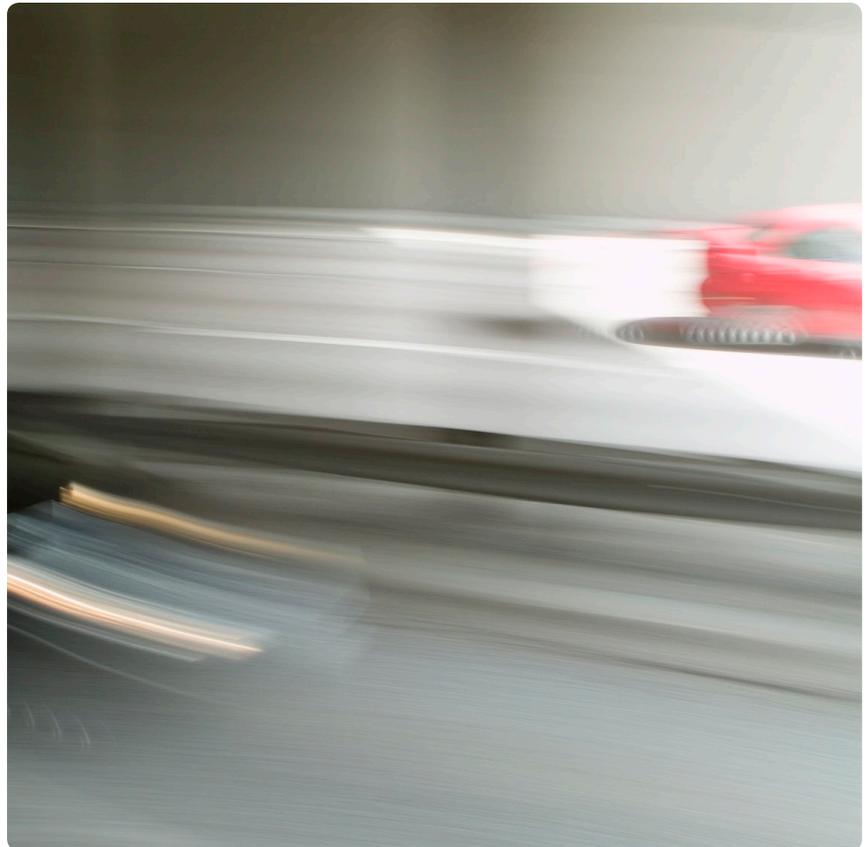
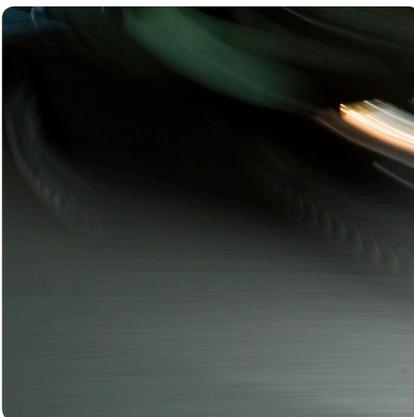
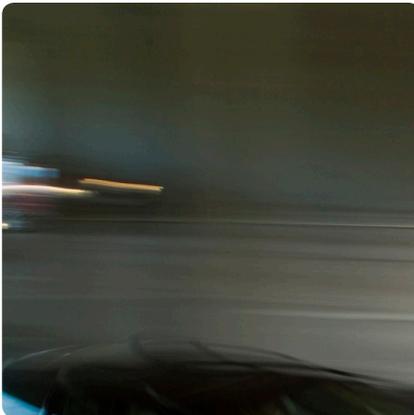


# Emissions trading and fuel efficiency regulation in road transport

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# Emissions trading and fuel efficiency in road transport

An analysis of the benefits of combining instruments

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# Preface

A number of actions have been taken to curb the carbon dioxide emission growth and to ultimately limit them. Despite these actions, emissions remain high. It has been considered to expand the emissions trading system. Several studies have been carried out regarding the possibility to include transports into the system. There is policy support for doing so. But even with all these studies - some of which include fairly clear recommendations - very little has happened. Perhaps the stumbling blocks are difficult to overcome, such as to change or replace existing instruments.

This report is intended to provide an overview of some of the studies carried out in this area and briefly test the ideas brought forward in them.

This report was commissioned by the Swedish Environmental Protection Agency. It was written by Bettina Kampman, Marc D. Davidson and Jasper Faber at CE, Delft, the Netherlands.

The authors have the sole responsibility for the content of the report and as such it can not be taken as the view of the Swedish Environmental Agency. Larsolov Olsson was their contact at the Swedish Environmental Protection Agency.

Swedish Environmental Protection Agency

Stockholm October 2008

SWEDISH ENVIRONMENTAL PROTECTION AGENCY

**Report 5896 · Emissions trading and  
fuel efficiency in road transport**

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# Summary

Despite EU and national climate policies, CO<sub>2</sub>-emissions in the transport sector have grown steadily in the past decades, whereas many other sectors have managed to reduce emissions. Now that increasingly ambitious CO<sub>2</sub>-emission reduction targets are being discussed for 2020 and beyond, the pressure on the transport sector to contribute to reaching these goals is clearly increasing.

One of the options for additional climate policy in road transport is CO<sub>2</sub>-emissions trading. The sector could, for example, be included in the EU ETS, or a separate trading system could be set up. The present report, that was commissioned by the Swedish Environmental Protection Agency (Naturvårdsverket), discusses these options. First, an overview is provided of the key literature published on this topic so far. Second, the potential drawbacks and benefits of combining this type of policy with a CO<sub>2</sub> emission regulation for new passenger cars is assessed.

## Literature on emissions trading in road transport

In the past years, various reports have been written on emissions trading in road transport. Some of these reports were broad, scouting studies; others went into somewhat more detail, focussing on specific options or effects. From these studies we conclude that emission trading could be an effective means to reduce CO<sub>2</sub> emissions in the road transport sector, if an upstream trading system is chosen, i.e. a system in which the oil companies are the trading entities. It is also concluded that a CO<sub>2</sub> tax on fuel may have the same effect as an emissions trading system, at lower cost for the society, provided that the tax rate is set at the appropriate level. This measure may, however, face political difficulties.

The societal costs of emission reduction are relatively high in the road transport sector. Consequently, if a separate trading system is set up for road (or surface) transport *and* the transport sector is required to reduce emissions by the same percentage as other sectors, then the price of emission allowances will be much higher than in the wider EU ETS. This could drive fuel prices up to a level that would be politically unacceptable. It also indicates that expensive measures are taken within the transport sector while cheaper measures within other sectors remain unused.

If road transport is included in the EU ETS, total costs of emission reduction are reduced and the price increase of fuel remains limited. However, this may lead to an increase of the price of allowances which may have a negative impact on competitive power of companies exposed to international competition, and lead to CO<sub>2</sub> leakage to countries outside the EU. This impact seems to be relatively low at lower levels of CO<sub>2</sub> reduction, but may increase as the cap is tightened further. Various means to reduce this impact are identified in the literature.

## Combining emissions trading with fuel efficiency regulation for vehicles

A solution to some of these problems might be to combine emissions trading with fuel efficiency regulation for vehicles\*. Fuel efficiency improvements in passenger cars are a relatively cost-effective measure to reduce emissions, with significant CO<sub>2</sub> reduction potential. However, due to temporal myopia of car buyers, this measure is insufficiently addressed by price incentives created by emissions trading. Fuel efficiency regulation might thus

- promote R&D and innovation efforts of the car and engine manufacturers,
- lower the costs of emission reduction in transport and
- weaken the negative effects of inclusion of transport in the EU ETS for other sectors.

Furthermore, fuel efficiency regulation can be introduced on a shorter timescale than emissions trading.

At the same time, an emissions trading system can be complementary to fuel efficiency regulation, as it can alleviate a number of disadvantages of regulation.

- It can increase the efficiency of CO<sub>2</sub> mitigation in road transport, since it promotes all available mitigation options.
- It offers certainty about the achieved emission reductions, and
- it has no rebound effect.

Furthermore, once it is implemented, it can achieve emission reduction in a relatively short term.

## Recommendations

As emission trading has a number of advantages, compared to more specific climate policies in road transport or to a CO<sub>2</sub> tax, we recommend to consider this policy option for the road transport sector when analysing and deciding on future policies for CO<sub>2</sub> mitigation. We also recommend to look at whether other combined policy options, including taxation, may help improve effectiveness and efficiency of climate policies in the sector.

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\* For the sake of discussion, we focus here on passenger cars.

# Sammanfattning

Trots EU:s och medlemsländernas respektive klimat politik har koldioxidutsläppen från transportsektorn stadigt ökat de senaste decennierna. Samtidigt har utsläppen i andra sektorer gått ner. När nu mer ambitiösa mål för minskning av koldioxidutsläppen diskuteras, för 2020 och längre fram, ökar trycket på transportsektorn att bidra till uppfylla dessa.

En möjlig ytterligare åtgärd är koldioxidutsläppshandel. Sektorn kunde t.ex. inkluderas i EU:s utsläppshandelssystem, eller också kunde ett separat handelssystem inrättas. Den här rapporten, skriven på uppdrag från svenska Naturvårdsverket, diskuterar dessa alternativ. Inledningsvis görs en översikt över den centrala litteratur som publicerats på området hittills. Sedan följer en bedömning av nackdelar och fördelar med att kombinera denna typ av styrmedel med de åtgärder som är på gång som rör koldioxidutsläppen från personbilar.

## Litteratur om utsläppshandel för vägtransporterna

De senaste åren har ett flertal rapporter skrivits om utsläppshandel för vägtransportsektorn. Vissa hade ett brett anslag, mer av förstudieprägel; andra gick in mer i detalj, genom att titta på specifika alternativ eller effekter. Av dessa studier drar vi slutsatsen att utsläppshandel kunde vara ett effektivt sätt att minska koldioxidutsläppen från vägtransportsektorn, förutsatt att en uppströmsansats väljs, d.v.s. ett system där bränslebolagen är handlande part. En annan slutsats är att en koldioxidskatt på bränslet kan ha samma effekt som ett handelssystem, och ha lägre samhällsekonomiska kostnader, förutsatt att skattesatsen blir tillräcklig. Men denna åtgärd kan emellertid ställas inför politiska svårigheter.

Kostnaderna för samhället för åtgärder att minska utsläppen från vägtransportsektorn kan vara relativt höga. Om ett separat utsläppshandelssystem etableras för vägtransporterna (eller marktransporterna) och det krävs att transportsektorn minskar sina utsläpp med samma procentandel som andra sektorer, då blir priset på utsläppsätterna mycket högre än i det etablerade utsläppshandelssystemet. Detta kunde driva upp bränslepriset till en nivå som skulle vara politiskt oacceptabelt. Det skulle innebära att dyra åtgärder genomförs i transportsektorn samtidigt som billigare åtgärder möjliga att genomföra i andra sektorer inte utförs.

Om vägtransporterna införs i det existerande utsläppshandelssystemet (EU ETS) kommer den totala kostnaden för utsläppsminskningen vara mindre och bränsleprishöjningen blir mer begränsad. Men detta kan medföra en ökning av priset på utsläppsätterna som negativt kan påverka konkurrensmöjligheterna för verksamheter som befinner sig i en internationell konkurrenssituation. Detta kan i sin tur leda till *läckage* av koldioxid till länder utanför EU. Men denna effekt ser ut att bli relativt begränsad vid lägre minskningsbeting för CO<sub>2</sub>-utsläppen. Den ökar dock sannolikt vid ett tuffare åtagande. Olika sätt att neutralisera denna effekt har påvisats i litteraturen.

### Samtidig utsläppshandel och krav på ökad bränsleeffektivitet för bilar

En möjlig lösning på några av dessa problem kan vara att kombinera utsläppshandel med krav på ökad bränsleeffektivitet på bilarna.<sup>1</sup> Förbättringar av bränsleeffektiviteten hos personbilar är en relativt sett kostnadseffektiv åtgärd att minska utsläppen, med avsevärd potential för CO<sub>2</sub>-minskning. Men beroende på kortsiktigt tänkande bilköpare räcker inte den prisreglerande effekt en utsläppshandel kan få för att leda till en tillräcklig bränsleeffektivisering. Men en bränsleeffektivisering kan således:

- understödja FoU och utvecklingssträvanden hos bil- och motortillverkarna
- minska kostnaden för utsläppsminskning i transportsektorn och
- lindra de negativa effekterna av att transporter tas in i utsläppshandelssystemet.

Dessutom kan bränsleeffektiviseringsstyrmedel införas på kortare varsel än utsläppshandel.

På samma gång kan ett utsläppshandelssystem bli ett komplement till styrmedel om bränsleeffektivisering och mildra en del nackdelar med sådana.

- Den kan öka effektiviteten hos åtgärderna att minska CO<sub>2</sub> från vägtransporterna, eftersom den behandlar alla möjliga åtgärder lika.
- Den ger klara besked om uppnådda utsläppsminskningar och
- den har inga bieffekter (*rebound*).

Dessutom kan utsläppshandeln, när den väl är införd, leda till minskade utsläpp relativt snabbt.

### Rekommendationer

Eftersom utsläppshandel har fördelar med sig jämfört med andra alternativa åtgärder att minska CO<sub>2</sub> från transportsektorn, rekommenderar vi att ett sådant system övervägs för framtiden. Vi rekommenderar också att man tittar vidare på andra kombinationer åtgärder – inkluderat skatter - som verksamt kan bidra till effektivisering av sektorn och effektiviteten av klimatpolitiken inom sektorn.

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<sup>1</sup> För enkelhets skull förs diskussionen endast inbegripet personbilar.

# Introduction

Despite EU and national climate policies, CO<sub>2</sub>-emissions in the road transport sector have grown steadily. Unless more stringent and effective policies are put in place, road transport emissions are expected to continue to grow in the next decades as well. Now that increasingly ambitious CO<sub>2</sub>-emission reduction targets are being discussed for 2020 and beyond, the pressure on the road transport sector to contribute to reaching these goals is clearly increasing.

One of the options for additional climate policy in road transport is CO<sub>2</sub>-emission trading. The sector could, for example, be included in the EU ETS. Alternatively, a separate emission trading could be set up in the road (or surface) transport sector, comparable but separate to the EU ETS. A number of reports have been written in recent years to assess the available options, and analyse their effects.

One of the aspects that has not yet been assessed in previous reports is the possible complementarity of emission trading and fuel efficiency regulation. Some argue that emission trading is sufficient to encourage road transport users to implement the most cost effective CO<sub>2</sub>-mitigation measures available. Others, however, expect that this will not be sufficient to utilize the full potential of cost effective options in the sector, due to the relatively low price elasticity in the sector. They argue that a cap and trade emission trading system should be accompanied by a number of other, more specific, policies that promote CO<sub>2</sub>-mitigation options that would otherwise not be utilized.

The Swedish Environmental Protection Agency (Naturvårdsverket) has now asked CE Delft to make an overview of the literature published on this topic so far. In addition, it has asked to make an assessment of the potential drawbacks and benefits of combining this type of policy with the CO<sub>2</sub> emission regulation for new passenger cars that is currently being discussed in the EU.

## Report structure

The results of the literature analysis are given in chapter **Literature Analysis** of this report. Chapter **Combining emissions trading with fuel efficiency regulation** provides an analysis of the advantages and disadvantages of the separate policies, and the potential complementarity between an emission trading system and CO<sub>2</sub> emission regulation for passenger cars. **Conclusions and recommendations** comes in the last chapter of this report.

## Literature analysis

In the past few years, various reports have been written on emission trading in road transport. Some of these reports were broad, scouting studies; others went into more detail, focussing on specific options or effects. In this chapter, we will analyse the available literature, and provide a comprehensive overview of the results of these studies.

### Relevant reports

After a literature scan, we selected the most relevant reports for this analysis. This selection was based on content (focus on CO<sub>2</sub> emission trading in road transport) and date of the study.

We thus included the following reports in this analysis:

- *Tools for Cutting European Transport Emissions. CO<sub>2</sub> Emissions Trading or Fuel Taxation?* Per Kågeson, SNS Förlag, Stockholm, 2008.
- *The Cost and Effectiveness of Policies to Reduce Vehicle Emissions, Summary and Conclusions*, OECD, International Transport Forum and Joint Transport Research Centre, Round Table, 31 January – 1 February 2008, Paris. Discussion Paper No. 2008-9, April 2008.
- *Price effects of incorporation of transportation into EU ETS*, M.J. Blom, B.E. Kampman, D. Nelissen, CE Delft, for the VROM Council (VROM-Raad) et.al., CE Delft, 2007.
- *Road transport emissions in the EU Emission Trading System*, Mikkel T. Kromann, Thomas Engberg Pedersen, Dinne Smederup Hansen (all COWI), commissioned by the Nordic Council of Ministers, TemaNord 2007:536, 2007.
- *Abatement costs for carbon dioxide reductions in the transport sector*, E. Särholm and J. Gode, IVL Swedish Environmental Research Institute, March 2007.
- *Designing an Emissions Trading Scheme Suitable for Surface Transport*, H. Watters and M. Tight, Institute for Transport Studies, University of Leeds, February 2007.
- *Greenhouse Gas Emissions Trading for the Transport sector*, IVL Swedish Environmental Research Institute Ltd. for Naturvårdsverket, 2006.
- *Dealing with transport emissions. An emission trading system for the transport sector, a viable solution?* CE Delft for Naturvårdsverket (Swedish Environmental Protection Agency), 2006.
- *Emissions Trading in the Transport Sector, Feasible Approach for an Upstream Model/Emissionshandel im Verkehr, Ansätze für einen möglichen Up-Stream-Handel im Verkehr (in German, with an English Executive Summary)*, Prof. Bergmann, FiFo, Fraunhofer ISI, IFEU, for Umweltbundesamt, 2005.

- *The use of transferable permits in transport policy*, Ch. Raux, Transportation Research Part D 9 (2004) 185-197, 2004.
- *The Impact of CO<sub>2</sub> Emissions Trading on the European Transport Sector*, P. Kågeson, 2001.
- *Tradeable Permits: Their Potential in the Regulation of Road Transport Externalities*, Verhoef, E.T., P. Nijkamp and P. Rietveld, Environment and Planning B: Planning and Design 24B 527-548, 1997.

An extensive summary of the main issues analysed in these studies, and their main conclusions, can be found in the Annex. In the following paragraph, we have gathered the main conclusions regarding what has been studied so far, and what the results were.

## Conclusions

Research into the potential and pros and cons of CO<sub>2</sub> emission trading in transport started in the 1990s and early 2000, with some more general and theoretical studies on this policy measure. In recent years, some more detailed studies were carried out, mainly focussing on the following issues:

1. how this measure could best be implemented (trading entities, transport modes to be included, administration, etc.),
2. the impact of an open or closed emission trading system on the current ETS sectors, on the CO<sub>2</sub> emission credit price, and on the transport sector itself.

Very detailed studies on the effects have not yet been carried out. The reports so far are mainly scouting studies, using limited marginal abatement cost data and calculation models to estimate the impact and mechanisms that will occur.

From these studies, we draw the following conclusions.

- *Emission trading can be an effective means to reduce CO<sub>2</sub> emissions*
  - The general conclusion is that emission trading could be an effective means to reduce CO<sub>2</sub> emissions in the road transport sector.
  - At least in theory, emission trading leads to implementation of the most cost effective CO<sub>2</sub>-mitigation measures, especially in an open system (i.e. if road transport is included in the EU ETS).
  - All the studies considered here agree that an upstream trading system is best for the road transport sector, i.e. a system in which the oil companies are the trading entities. This choice differs from the current EU ETS set up, in which end users are the trading entities. However, in transport an end user system is expected to lead to very large transaction costs, in view of the very large number of vehicle users.
  - Various studies state that a CO<sub>2</sub> tax on fuel may have the same effect as an emission trading system, at lower cost, provided that the tax rate is set at the appropriate level. This measure faces, however, political obstacles.

- Compared to a CO<sub>2</sub> tax, a trading system has the advantage of ensuring that the abatement target is achieved. It should be noted, however, that against this certainty about emission abatement stands *uncertainty* about the economic costs: the price of emission allowances is difficult to predict, and may fluctuate strongly.
  - Cost effectiveness is impeded due to market failures in the transport sector (e.g., car buyers do not take into account the fuel savings over the whole lifetime of the car). In addition, the short term price elasticity is relatively low in road transport, many mitigation measures take time to implement and to have an effect. On the other hand, however, an emission trading system has the advantage of providing simultaneous incentives for all mitigation options available, ranging from the purchase of fuel efficient cars or using a bicycle for short trips instead of a car, to moving house in order to reduce commuting distance.
- *Abatement cost in the road transport*
- All studies conclude that CO<sub>2</sub> mitigation in the transport sector (going beyond present (fiscal) policies) is more expensive than in other sectors<sup>2</sup>.
  - Consequently, if transport is required to achieve the same emission reduction in terms of percentage as other sectors *and* a closed (separate) trading system for the transport sector is set up, the price of emission allowances will be much higher within the transport ETS than in the wider EU ETS.
  - Inclusion of transport in the EU ETS will thus reduce overall costs of CO<sub>2</sub> mitigation, since cheaper options (in the other ETS sectors) will be implemented.
- *Potential impact on the EU ETS*
- If transport is included in the EU ETS *and* transport is required to achieve the same emission reduction in terms of percentage as other sectors, the price of emission allowances within the EU ETS is likely to increase. In that case, inclusion of the transport sector will affect the current EU ETS sectors, and may affect the competitive position of these sectors or of individual companies in the ETS. This may have negative economic effects, and may cause leakage of CO<sub>2</sub> emissions if industrial activities are relocated to countries outside the EU.
  - The actual impact on allowance price and competitive position of industry will depend on the level of international (global) competition that the companies face, and on policy design and implementation issues such as CO<sub>2</sub> credit allocation rules, CDM/JI availability and use and the emission cap imposed on the sectors.

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<sup>2</sup> It should be noted, however, that most studies assume this, and only very few studies have actually analysed cost effectiveness and marginal abatement curves in detail.

- Clearly, there is a general concern that inclusion of road transport in the EU ETS will raise the price of emission allowances (EUAs), and thus harm the industry and electricity sector already included in the EU ETS. So far, four studies have been published that analyse the potential impact of inclusion of road transport in the EU ETS on the EUa price [Kågeson, 2008][CE, 2007][COWI, 2007][IVL, 2006]. These studies all come to the conclusion that inclusion of road transport in the EU ETS will increase the price of emission allowances, and thus may have a negative impact on the current EU ETS sectors and may lead to leakage. Kågeson concludes that this effect will be limited at a target of 20% emission reduction in 2020, but increases at higher reduction targets. It is furthermore expected that potential negative effects can be reduced with specific design choices, such as regarding the allocation of emission allowances or (retroactive) reimbursements. This has, however, not yet been analysed in detail.
  - On the other hand, the transport sector will benefit from this policy, compared to a situation in which the sector has to achieve its own CO<sub>2</sub> reduction. Inclusion in the EU ETS should thus not only be assessed as a stand alone policy, but it should be compared to achieving the medium and long term CO<sub>2</sub> reduction targets by other means.
- *Inclusion in EU ETS versus a separate surface transport trading system*
- Even though the focus of most research seems to be on an open trading system (i.e. inclusion of road transport in the EU ETS), most studies do not explicitly conclude that this is the preferable option. They mainly conclude that the pros and cons of these two options should be properly weighed.
  - If one aims to reduce CO<sub>2</sub> emissions in transport itself, a closed system should be considered. This will also prevent any negative impact on the current EU ETS sectors. This will, however, reduce cost effectiveness of overall CO<sub>2</sub> mitigation. Detailed modelling work on the effect of a closed trading system has not yet been carried out.

# Combining emissions trading with fuel efficiency regulation

The present high oil prices and high fuel taxes already offer a substantial incentive to the European road transport sector to think economically about fuel use. For example, higher taxes on fuel is one of the reasons why in Europe the average fuel efficiency of cars is much higher than in the United States. Therefore, the social costs of further emission reduction are generally higher in the road transport sector than in other sectors. The fact that road transport emissions remain growing in spite of EU policies to curb emissions clearly shows the strong demand for transport. Therefore, from an economic point of view and at first sight, it would be unwise to require from the road transport sector the same emission reduction in terms of percentage as from other sectors.

Nevertheless, there is reason to require stronger efforts from the transport sector either through emission reduction against higher costs than in other sectors, or through payment for additional efforts by other sectors. The main reason is that the transport sector is *sheltered* from international competition. While European steel producers, for example, are exposed to competition from producers from non-EU countries, which do not require emissions allowances for their production, there is no such competition for the road transport sector. Higher costs will thus not lead to leakage (i.e. road transport being moved to a country without Kyoto obligations, preventing CO<sub>2</sub> emission reduction) or competitive disadvantages of EU road transport companies with respect to companies from countries without an ETS. Being sheltered from international competition thus justifies stronger efforts in road transport or additional incentives on top of the existing policies. Furthermore, there are reasons to assume consumers underestimate the fuel savings over the full lifetime of a car which can be achieved by buying more efficient cars. This may be seen as a kind of market failure justifying government intervention.

There are two obvious candidates for such further policies: emission trading and regulation of the fuel efficiency of new vehicles (i.e. of CO<sub>2</sub> emissions per km), each with its strengths and weaknesses. We discuss both and explain why there is good reason to combine both policies. For the sake of discussion, we focus on passenger cars.

## Comparison of both instruments

### **Advantages of emission trading over fuel efficiency regulation**

**Efficiency.** Compared to fuel efficiency regulation, CO<sub>2</sub>-emissions trading in road transport has the advantage that it leaves the choice of how to mitigate CO<sub>2</sub>-emissions to the end users, i.e. to the market. People can choose to drive less, make carpool arrangements, or buy a more fuel efficient car. Hauliers can improve their logistics, for example by increasing the load factor of their trucks or buy more fuel-

efficient trucks. Shippers can shift goods from road to rail, fuel suppliers can increase the share of biofuels. Everyone involved can implement what he or she considers to be a cost effective option, i.e. an option with lower cost than the cost of an emission allowance. In other words, emission trading offers an incentive to consider the whole palette of available CO<sub>2</sub>-reduction measures, which in theory leads to a more efficient reduction of emissions than by fuel efficiency regulation alone.

If transport is included in the wider EU ETS, the CO<sub>2</sub> price (and thus the reduction costs) will be lower compared to an emission trading system for the road transport sector only (CE, 2007)(COWI, 2007)(IVL, 2007).<sup>3</sup>

In that case the market may decide where throughout the economy emissions can best be reduced. Furthermore, inclusion in the EU ETS contributes to simplicity of governmental policy, when compared to a policy package with a number of policy instruments each aimed at specific mitigation measures.

**Effectiveness.** Compared to fuel efficiency regulation, CO<sub>2</sub>-emissions trading in road transport has the advantage that it offers certainty about the achieved emission reduction. A closed emission trading system for the transport sector could even achieve certainty that emissions are curbed within the transport sector itself. In the case of fuel efficiency regulation, the effects can only be roughly estimated in advance. Gains by improved fuel efficiency may partly be undone by a growth in demand, such as the number of cars or kilometres driven.

**No rebound effect.** In the case of fuel efficiency regulation, the emissions per kilometre travelled do indeed decrease. However, due to the higher fuel efficiency the price of travelling decreases as well, thanks to fuel savings. In principle, a higher efficiency has thus the same working as a lower fuel price. As a result, the number of travelled kilometres may increase.

On the basis of a review of 17 studies, Sorrell (2007) estimates the long-run direct rebound effect for personal automotive transport to lie somewhere between 10% and 30%. This means that if the fuel required per kilometer is reduced by 10%, the fuel consumption does not decrease by 10%, but by 7% to 9% instead.

On the basis of price elasticities for fuel use a somewhat higher rebound effect may even be expected<sup>4</sup>. Graham and Glaister (2002) conclude on the basis of de available literature that the price elasticity for the demand for fuel is -0.2 to -0.3 in the short term, increasing to -0.6 to -0.8 in the long term. The results by Goodwin et al. (2004) are similar: increasing from -0.25 within one year to -0.64 in the long term. These elasticities imply that if the fuel required per kilometre is reduced by 10%, the fuel consumption does not decrease by 10%, but about only 2.5% in the short term to about 7% in the long term instead (the latter being consistent with the

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<sup>3</sup> It should be mentioned that if inclusion of transport in the wider EU ETS leads to a price increase of emission allowances, there could be negative impacts for the other sectors related to competitiveness. This might increase the costs of the EU ETS.

<sup>4</sup> The theory of price elasticities can be used here as well, as we have argued above that reducing fuel consumption of cars has the same effect as reducing the fuel price.

long term Sorrel result). Goodwin et al. state that the price elasticity for private car use is more elastic than for cargo transport. That means that the rebound effect will be larger for private car use as well. In other words, a significant part of the environmental gains by efficiency improvement are undone by a resulting growth in demand.

Since emission trading offers a price signal for all reduction measures, there is no such rebound effect.

It should be noted that the rebound effect may partly be undone if the higher fuel efficiency results in higher purchasing costs. Although it is unlikely that consumers will drive less because they have less to spend on fuel after purchasing a more expensive car, it is rather more likely that some fewer cars will be sold. Goodwin estimates the price elasticity for vehicle stock at -0.08 in the short term and -0.25 in the long term. Clearly, this price elasticity is lower than the price elasticity for fuel consumption. This means that if the price of cars increases due to fuel-efficiency standards, this will hardly keep consumers from buying cars. However, an effectively lower fuel price due to a higher efficiency does increase the number of kilometres driven and thus the fuel consumption. Therefore, there still will be a net rebound effect.

**Time lag.** Fuel efficiency regulation can only have an impact on new cars. Only a relatively limited share of the car park is replaced every year, however. Since an average car remains in the car park for more than 16 years (in Sweden, the average scrapping age in the EU is 14.4 years)(Klemola, 2006), there will always be a significant time lag between policy intended to increase efficiency (either through emission trading or regulation) and a significant reduction of the average CO<sub>2</sub>-emissions of the car park. Emission trading, however, offers an incentive for measures which can be taken instantaneously as well, such as driving less, carpooling, *et cetera*. It can thus achieve an emission reduction right from the start.

### **Advantages of fuel efficiency regulation over emission trading**

**Time lags.** CO<sub>2</sub>-prices under the EU ETS are relatively low at present, but are anticipated to rise strongly in the future due to more stringent European targets. Therefore, the price incentive of the EU ETS will not only slowly affect fuel efficiency due to the slow replacement of the car park, but also due to the slow increase of the EU ETS market price. Fuel efficiency regulation could anticipate on these more stringent European targets by immediately setting tight standards.

Secondly, it is unlikely that road transport could be included in the EU ETS before 2015. Therefore, there is another 7 years before this policy might be implemented (at the earliest). If road transport emissions are allowed to grow unhampered in these years, achieving ambitious CO<sub>2</sub>-goals for 2020 and beyond will be even more difficult, and mitigation costs will increase. Fuel efficiency regulation, however, could be introduced on a much shorter time scale, once the EU has reached agreement on this (currently, a 130 gr/km target is being discussed for 2012). It should be noted, however, once more that only a relatively limited share of the car park is replaced every year.

**Temporal myopia of car buyers.** When choosing a car, consumers generally focus on the immediate costs and benefits, and disregard the costs of fuel over the full lifetime of the car. Since a higher fuel efficiency generally lowers the costs over the full lifetime of the car, but either increases the present purchasing costs or lowers the possible desired performance (such as engine performance or car size), such efficiency gains are generally not given priority. Although some *discounting* of future benefits or cost savings, say 4% a year, is normal economic behaviour, the short-sightedness or temporal myopia of consumers with respect to future fuel savings due to their choice of car is rather extreme (20% per year or more; see for example Dreyfus and Viscusi, 1995; Frederick *et al.*, 2002; Kleit, 2004). Since the ‘normal’ social preference for present over future benefits is much less, as can be deduced from market interest rates, this temporal myopia may be considered a form of market failure which may justify government intervention. By imposing fuel efficiency regulation, governments could solve this problem of temporal myopia.

**We will illustrate the impact of this market failure with a quantitative example.**

Imagine someone is deciding between two cars with a fuel efficiency of either 8.9 or 7.0 litre per 100 km. Furthermore, assume a fuel price of 1.25 Euro (11.65 krone) per litre, 13,500 kilometres per year, and a lifetime of 18 years.

In that case, choosing the more efficient car saves fuel costs over the full lifetime of the car of about 5,800 Euro without discounting.

At a discount rate of 4%, the fuel savings are about 4,100 Euro.

At a discount rate of 20%, the fuel savings are about 1,500 Euro.

In other words, at a discount rate of 20% the fuel savings largely evaporate and the purchasing costs (in Euros or loss of comfort) of the more fuel-efficient car may only be 1,500 Euro higher than of the other car. Furthermore, it should be noted that the first owner will generally experience only a fraction of this amount, since he or she normally will sell the car within a few years.

**Long term innovation.** Car manufacturers will be hesitant to invest in innovative R&D for CO<sub>2</sub>-mitigation measures, if the EUa price is expected to remain at a relatively low level, or if there is serious doubt about the future development of the EUa price. However, technical innovation is key to achieving significant CO<sub>2</sub>-reduction in this sector in the longer term. Other policies such as CO<sub>2</sub>-regulation, preferably with long term, ambitious goals, might thus be necessary to encourage industry to look for innovative solutions, and implement them in the cars they offer for sale. This is likely to reduce future cost and increase the potential of CO<sub>2</sub>-mitigation measures.

**Price insensitivity.** Many experts doubt whether a limited CO<sub>2</sub> price has any significant effect on the CO<sub>2</sub> emissions of the transport sector. Some effects will occur, but these effects will be limited as long as the EUa<sup>5</sup> price remains at the levels predicted for the ETS in the coming years, or even above that level. So if road

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EUa = EU emission allowance

transport would be included in the EU ETS *and* transport is required to achieve the same emission reduction in terms of percentage as other sectors, the sector would probably buy a large part of their emission credits, rather than reduce CO<sub>2</sub> within the sector.

The effects on road transport emissions is illustrated in Table 1 where the impact of CO<sub>2</sub> price on petrol price and CO<sub>2</sub> emissions of road transport are calculated. A price elasticity of 0.25 was used to estimate the emission reduction, a reasonable mid-term price elasticity based on Goodwin (2004).

**Table 1. Fuel price increase and estimated CO<sub>2</sub> reduction of road transport, using a price elasticity of 0.25.**

EUa price (Euro/ton CO <sub>2</sub> )	price increase of petrol (%)	CO <sub>2</sub> emission reduction
20	4%	1.0%
50	10%	2.6%
100	21%	5.2%

**Negative impact on other EU ETS sectors within an open trading system.** As mentioned earlier, iff road transport would be included in the EU ETS *and* transport is required to achieve the same emission reduction in terms of percentage as other sectors, then the price of emission allowances within the EU ETS will increase (CE, 2008)(COWI, 2007)(IVL, 2006). In that case, inclusion of the transport sector will affect the current EU ETS sectors, and may affect the competitive position of these sectors or of individual companies in the ETS. The actual impact will depend on the level of international (global) competition that the companies face, and on policy design and implementation issues such as CO<sub>2</sub> credit allocation rules and the emission cap imposed on the sectors (see, for example, (Kågeson, 2008), for an analysis of the effect of the latter). So far, this has not yet been studied in detail. Fuel efficiency regulation has no such negative impact.

**Negative impact on transport within a closed trading system.** Since the short term price elasticity of the sector is relatively low (see, e.g., Goodwin (2004)), it can be expected that the price signal (i.e. the price of emission credits) needs to be relatively high if any significant CO<sub>2</sub> mitigation is to be achieved in the short term. As CO<sub>2</sub> mitigation in road transport is relatively expensive the price of emission allowances will be much higher in a closed trading system than in the wider EU ETS, if transport is required to achieve the same emission reduction in terms of percentage as other sectors,. This would have a number of disadvantages. First of all, this could drive fuel prices up to a level that would be politically unacceptable. Second, a difference in allowance price between the two separate trading schemes indicates inefficiency: expensive measures are taken within the transport sector while cheaper measures within other sectors remain unused. Because of the previously mentioned effect of temporal myopia, fuel efficiency regulation may reduce the costs of emission reduction.

In the longer term, empirical evidence suggests that the price elasticity in the sector can be quite high (Goodwin, 2004), suggesting that mitigation options exist, but that it takes time before car users and transport businesses (can) respond fully to a price increase.

## Fuel efficiency improvements under a trading system

If road transport would be included in the ETS and no CO<sub>2</sub>-regulation or other types of specific fuel efficiency policy would be in place for passenger cars, the ETS CO<sub>2</sub>-price would be the only measure that promotes fuel efficiency improvements. In the following, we estimate the impact of that effect (for various CO<sub>2</sub> prices) on Swedish CO<sub>2</sub> emissions, and compare that to the CO<sub>2</sub> reduction achieved by fuel efficiency regulation<sup>6</sup>.

As a (simple) baseline, we assume that the total CO<sub>2</sub> emissions of passenger car transport kilometres driven in Sweden will increase with 1.5% per year. We also assume that in the baseline, the emission factor of new cars will stay constant from 2006 onwards, on the 2006 level.

We then estimate the effect of a CO<sub>2</sub> price (i.e. of a price of an emission allowance) on the car purchase behaviour using price elasticities from literature. Assuming that the oil companies fully divert the EUa price to consumers, we can calculate the resulting fuel price increase. This price increase can then be converted to a CO<sub>2</sub> reduction of the road transport sector, using a fuel price elasticity. (Goodwin, 2004) concludes from a literature review that the price elasticity for fuel consumption per vehicle with respect to fuel price is about -0.16 in the short term, and -0.43 in the long term, although the ranges found in the literature were large. In our calculations, we used a somewhat conservative value of -0.2. We furthermore assumed that it takes 15 years to achieve this maximum effect (as only a small share of the car park is renewed each year).

The effect of fuel efficiency regulation is estimated assuming that a regulation will be implemented that requires an average 130 g/km in 2012, and 100 g/km in 2020. As the Swedish car park has a fuel efficiency that differs quite significantly from the average EU park, we assumed that the fuel efficiency of the new cars bought in Sweden will reduce with the same percentages as the average EU park. This means that the average CO<sub>2</sub> emissions of new cars in Sweden will reduce from 189 g/km in 2006 to 154 g/km in 2012, to 118 g/km in 2020. Using data on

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<sup>6</sup> It should be noted that we have build a relatively simple model for these calculations. The results should thus be considered to be rough estimates. More extensive modelling of the car park developments in the two scenarios and in the baseline would be required for more accurate calculations.

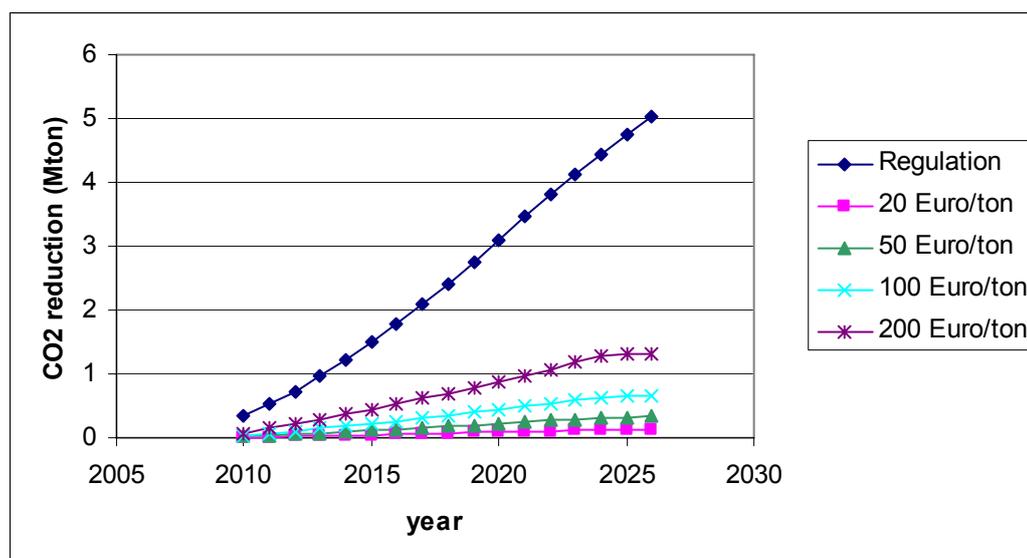
the kilometres driven per car (depending on the age of the car), the total CO<sub>2</sub> emissions of passenger cars, and assuming that the targets will be met by linear reduction of the CO<sub>2</sub> emission factor, we can then calculate the CO<sub>2</sub> emissions reduced with this regulation.

The results of these calculations are shown in 0, for different values for the EUa price (20, 50, 100 and 200 €/ton)<sup>7</sup>. It can be seen that both policies need time to effectively reduce fuel consumption of the car park. The resulting CO<sub>2</sub> reduction achieved with the fuel regulation is much higher than that of fuel efficiency improvements achieved with the emission trading system, even at the high allowance prices of 100 or 200 €/ton CO<sub>2</sub>. At the allowance prices expected for the short of medium term (20-30 €/ton), hardly any fuel efficiency improvement is expected. Even if the price rises in the longer term, for example due to higher economic growth or due to tightening of the cap over the years, the price needs to rise to levels far beyond the current level before the fuel efficiency of the car park is at the level that achieved by the regulation that is assessed here.

Clearly, we can conclude that the regulation assumed here will be much more effective in using the fuel efficiency improvement potential available for passenger cars than the emission trading system, even if the EUa price is increased significantly. The ETS only is not likely to encourage car buyers to opt for fuel efficient cars, as long as the EUa price remains at the levels analysed here. It should not be forgotten, of course, that the ETS also encourage many other CO<sub>2</sub> mitigation options, where this analysis is limited to fuel efficiency improvements of passenger cars.

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<sup>7</sup> In this graph, it is assumed (for illustration only) that emission trading is implemented from 2010 onwards. It can further be noted that the results for the emission trading system are equal to a situation with a CO<sub>2</sub> tax.



CO<sub>2</sub> emission reduction in Sweden that can be achieved with fuel efficiency improvements of new cars, as promoted with either emissions trading or fuel efficiency regulations.

## Interaction of the two policies

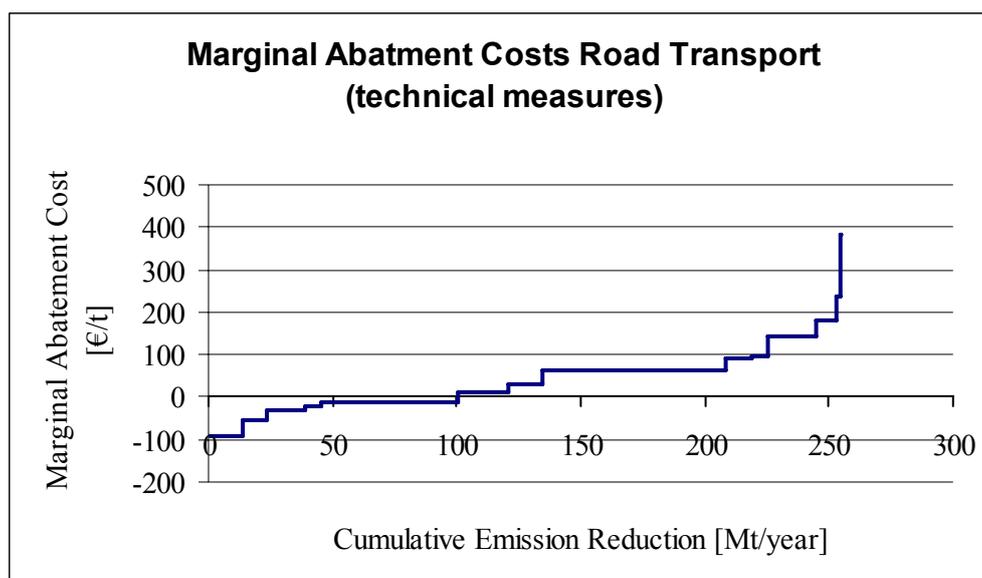
In conclusion, the idea behind a combination of emission trading and fuel efficiency regulation is that regulation addresses a cost-effective measure which is nevertheless not easily addressed by price incentives. Emission trading, however, offers an incentive to consider a much wider palette of measures to reduce emissions than fuel efficiency alone. In combination, both instruments offer a strong incentive for the full spectrum of measures. Since fuel efficiency may substantially reduce emissions (in the longer term) against reasonable costs, fuel efficiency regulation may substantially lower the price of emission allowances which would arise in a closed ETS for the transport sector. Consequently, the impact of inclusion of transport in the wider EU ETS would be lower as well. Furthermore, it is to be expected that the combination of (effectively) higher fuel prices and fuel efficiency standards offers a strong incentive for R&D and innovation with respect to fuel efficiency.

The impact of this R&D and innovation on the EUa price can be illustrated with the following example.

In (CE, 2008), a marginal cost curve is derived for the road transport sector, in which the potential and cost of the currently available technical CO<sub>2</sub> mitigation options is included (EU wide, 2020). The result is shown in 0. Each step in this curve represents a specific mitigation option, such as improved internal combustion engines, lightweight materials and aerodynamics, hybrid drives and ecodriving for passenger cars and light duty vehicles, and 44 and 60 ton trucks, more efficient engines, low rolling resistance tyres, ecodriving, low emission air conditioning and improved aerodynamics for heavy duty trucks.

From this curve, the marginal costs of a certain emission reduction can be found, and, according to economic theory, this will be the CO<sub>2</sub> price for that reduction target.

A significant part of the mitigation options in this curve, about 110 Mton/year, is related to fuel efficiency improvements in passenger cars that could be used to meet a CO<sub>2</sub> regulation: lightweight materials and aerodynamics, improved engine technology, low resistance tyres and low viscosity lubricants. The cheapest of these options has marginal costs of about 13 €/ton CO<sub>2</sub>, the most expensive 96 €/ton. The potential and cost estimates were based on data derived for (TNO, 2007) and on assumptions regarding the maximum uptake of a technology in the car park in 2020.



Marginal abatement cost curve of the road transport sector for the EU, in 2020 (from CE, 2008).

As fuel efficiency is only one of the factors that consumers consider when buying a car (and, for many people, not a very important one), R&D efforts of car manufacturers in the past were only partly aimed at improving fuel efficiency of their cars. Once an ambitious fuel regulation is in place, manufacturers will be encouraged to invest more in R&D in this area, as successful innovation in fuel efficiency technology can result in a competitive advantage: if a car manufacturer can produce more attractive cars (for example, more comfortable, bigger or more powerful) with low CO<sub>2</sub> emissions than his competitors, it is likely he will increase his market share. Successful R&D and innovation may lead to a cost breakthrough or technological improvement of existing fuel efficiency technology (for example of hybrid drives), it may also result in the development and market implementation of new technologies that are not yet available (for example of biofuels with high GHG reduction from algae).

These will have an effect on the marginal abatement cost curve, and thus on the EUa price at a given CO<sub>2</sub> emission reduction target:

- If the CO<sub>2</sub> reduction of existing technologies is improved, the reduction potential of these options in the cost curve will increase, i.e. the corresponding 'step' in 0 will become longer, and everything to the right will shift further to the right. If the costs of existing technology is reduced, the marginal cost of the corresponding 'step' will reduce, resulting in a lower level of the step. Both effects may result in a lower marginal cost at a given target, i.e. in a lower EUa price<sup>8</sup>.

<sup>8</sup> The cost reduction effect was, to some extent, included in the cost curve shown above. A learning curve was applied to the technologies, taking into account that costs of a technology reduce once it is produced in larger quantities (typically, if production volumes double, costs of a product will reduce by 10-20%, due to learning, larger scale of production, technological improvements, etc).

- If a new technology is developed, this can be included in the cost curve. As in the previous case, the mitigation options to the right of this new option will shift to right, and the EUa price at a given target may reduce. At the start of a new technological development, costs are likely to be high, but these will reduce once it is matured, used and produced on a large scale.

# Conclusions and recommendations

In this report, we have first made an overview of the literature published on emission trading as a means to reduce CO<sub>2</sub>-emissions by road transport. Second, we have made an assessment of the potential drawbacks and benefits of combining this type of policy with the CO<sub>2</sub> emission regulation for new passenger cars that is currently being discussed in the EU. The most important conclusions are the following.

Emission trading is an efficient and effective means to reduce emissions in the transport sector. In the case of emission trading, the market itself determines where emissions can be reduced against lowest costs. Fuel efficiency regulations obviously only promote one specific CO<sub>2</sub> mitigation measure (albeit one with high reduction potential).

Many of the studies on emission trading in road transport conclude that it is a feasible and cost effective policy measure if trading is placed upstream. Many also stress that CO<sub>2</sub> taxes may achieve the same GHG reduction effect, at lower cost. Raising fuel taxes is, however, politically difficult, and it does not ensure meeting a CO<sub>2</sub> reduction target.

Due to the combination of already high fuel prices and fuel taxes, *and* strong demand for transport, the societal costs of emission reduction are relatively high in the road transport sector. Consequently, if a closed trading system is set up for the transport sector *and* the transport sector is required to reduce emissions by the same percentage as other sectors, then the price of emission allowances will be much higher than in the wider EU ETS. This would give two problems. First, this could drive fuel prices up to a level that would be politically unacceptable. Second, a difference in allowance price between the two separate trading schemes indicates inefficiency: expensive measures are taken within the transport sector while cheaper measures within other sectors remain unused.

An alternative to such a closed system is to include road transport in the wider EU ETS. In that case, the total costs of emission reduction are reduced and the price increase of fuel remains limited. However, if the transport sector is required to reduce emissions by the same percentage as other sectors (i.e. the total cap for the EU ETS is increased proportionally), then the price of allowances will increase and other sectors will have to make higher costs. In other words: other sectors have to make room for the fact that transport hardly reduces emissions. This may have a negative impact on competitive power of companies exposed to international competition, and lead to CO<sub>2</sub> leakage to countries outside the EU. A limited number of studies has analysed this impact so far, using relatively rough abatement cost curves. From these studies we can conclude that the impact seems to be relatively low at lower levels of CO<sub>2</sub> reduction, and increases as the cap is tightened further. Various means to reduce this impact are identified.

A solution to these problems might be to combine emission trading with fuel efficiency regulation for vehicles<sup>9</sup>. Fuel efficiency improvements in passenger cars are a relatively cost-effective measure to reduce emissions, with significant CO<sub>2</sub> reduction potential. However, due to temporal myopia of car buyers, this measure is insufficiently addressed by price incentives that are created by emission trading. Fuel efficiency regulation might thus

- promote R&D and innovation efforts of the car and engine manufacturers,
- lower the costs of emission reduction in transport and
- weaken the negative effects of inclusion of transport in the EU ETS for other sectors.

Furthermore, fuel efficiency regulation can be introduced on a shorter timescale than the inclusion of transport in the EU ETS.

At the same time, we conclude that an emission trading system can be complementary to fuel efficiency regulation, as it can alleviate a number of disadvantages of the regulation.

- It can increase the efficiency of CO<sub>2</sub> mitigation in road transport, since it promotes all available mitigation options (incl. those in goods transport).
- It offers certainty about the achieved emission reductions, and
- it has no rebound effect.

Furthermore, once it is implemented, it can achieve emission reduction in relatively short term, whereas fuel efficiency regulation requires some years before significant changes in the car park are achieved.

## Recommendations

- Emission trading has a number of advantages, compared to more specific climate policies in road transport, or to a CO<sub>2</sub> tax. We thus recommend to consider this policy option for the road transport sector when analysing and deciding on future policies for CO<sub>2</sub> mitigation, and continue research into its possibilities, drawbacks and effects.
- We recommend to further look into the potential impact of inclusion of road transport in the EU ETS on the competitiveness of the EU industry, and into possible ETS design options and flanking policies to limit these negative effects. These potential negative effects should then be weighed against potential negative effects of alternative CO<sub>2</sub> mitigation options.
- A closed system might have advantages compared to inclusion in the EU ETS, but has not yet received much attention. We therefore recommend to further analyse its effect on the transport sector. One of the issues we think should be assessed, is how the CO<sub>2</sub> price might develop (for a gi-

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<sup>9</sup> For the sake of discussion, we focus here on passenger cars.

ven emission cap), and whether CO<sub>2</sub> regulation and other (flanking) policies may effectively limit the price.

- Emission trading (or a CO<sub>2</sub> tax on fuel) should not be considered as an *alternative* for policies in the transport sector aimed at specific mitigation options such as fuel efficiency regulation, but rather as *complementary*.
- This report only provides a rough analysis of what will happen in the road transport sector once these policies are in place. A more extensive analysis, possibly with modelling work, can give much more accurate and detailed insight.
- This study has shown that there are advantages in combining different types of climate policy in the transport sector. We expect that addition of other policy options could further improve the efficiency and effectiveness of climate policy (e.g., road charging, biofuel policy, spatial planning, ...). Optimal climate policy in transport may well require a whole package of measures. We therefore recommend to also look at how other combinations of possible policy options may help improve policy effectiveness and efficiency in the sector.

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# Annex - Literature overview

## Brief outline and summaries of the main literature on this topic

TOOLS FOR CUTTING EUROPEAN TRANSPORT EMISSIONS. CO<sub>2</sub> EMISSIONS TRADING OR FUEL TAXATION?

- *Per Kågeson, SNS Förlag, Stockholm, 2008*

### – Types of emission trading in road transport that have been studied

All transport in the EU ETS.

### – What has been studied, to what extent?

A comparison is made of two general policy instruments that can be used to guarantee a cost efficient reduction of GHG emissions: the same carbon tax in all EU countries and all economic sectors, or emissions trading for all sectors in all EU countries under a common cap. These two options are analysed and compared, with respect to efficiency and cost.

### – Approach, methodology

The report features a comprehensive analysis of these two options, mainly based on literature and own estimates regarding mitigation costs and potential of various GHG reduction measures in road transport.

### – Main conclusions

The simplest method to guarantee that the EU will be able to meet its commitment would be to gradually reduce the cap on emissions within the EU ETS and at the same time introduce a harmonised CO<sub>2</sub> tax on emissions from the non-trading sector (incl. road transport). This assumes, however, that the EU member states allow the EU to make an exception to their right to decide on matters of tax rates.

A somewhat more complicated but entirely feasible alternative would be to extend the emissions trading to all sectors of society by adopting an upstream approach for the new sectors and auctioning the emission allowances allocated to them.

In both cases, installations that are both fuel-intensive and subject to global competition could be either compensated in advance by free allocation of allowances, or retroactively by reimbursement.

It is difficult to prevent competition between companies covered by the existing trading scheme and the non-trading sector. They will compete, for example, for biofuel, and perhaps also for CDM and JI projects.

If the Commission's proposal for how to split the burden between the EU ETS and member states is accepted, there is a good chance of achieving a GHG

reduction of 20% without having to raise fuel taxes by more than the equivalent of the forecast price in the ETS: €30-40/tonne. The uncertainty in this estimate is, however, significant.

The risk of having to raise fuel taxes substantially is a great deal larger in a case where the Community's commitment is a 30% reduction. This is likely to result in a major difference in price increase between the trading and the non-trading sectors, as well as between individual member states.

The EU should assess by 2012 whether the model for burden sharing and the common policy instruments are sufficient to reach the 2020 target. If the assessment shows that difficulties will arise in maintaining similar levels of marginal abatement cost in the EU ETS and the non-trading sector or between member states, the trading scheme should be broadened to include all CO<sub>2</sub> emissions from sources in the EU 27.

#### THE COST AND EFFECTIVENESS OF POLICIES TO REDUCE VEHICLE EMISSIONS, SUMMARY AND CONCLUSIONS.

- *OECD, International Transport Forum and Joint Transport Research Centre, Round Table, 31 January – 1 February 2008, Paris. Discussion Paper No. 2008-9, April 2008.*

#### – *Types of emission trading in road transport that have been studied*

Cap-and-trade GHG policies are (briefly) discussed as incentive based instruments, with either drivers as trading parties or with trade at upstream level (e.g., refineries).

#### – *What has been studied, to what extent?*

Emission trading is not the main focus of this paper, it rather provides a discussion on the pros and cons of combining CO<sub>2</sub> taxes with the CO<sub>2</sub> standards of new passenger cars. However, emission trading is considered as an alternative to CO<sub>2</sub> taxes, as both are what is called incentive based policies. Many of the arguments brought forward in this paper also apply to a combination of emission trading with CO<sub>2</sub> standards.

#### – *Approach, methodology*

The paper was based on discussions during an expert workshop.

#### – *Main conclusions*

Regarding a cap-and-trade system, it is argued that allocating free GHG permits on a per capita basis would make the program politically more acceptable. However, there is still debate on the cost of such a system. Furthermore, free permits imply a loss of valuable public tax revenue, and to a stronger extent than with standards. Administrative cost of trade at upstream levels are likely to be lower, but then the social acceptance advantage is lost, weakening the case for a cap-and-trade system.

Regarding combining fuel economy regulations and fuel taxes, two general arguments were found in favour. First, if prevailing levels of fuel taxes fail to stimulate the desired level of reduction in fuel consumption, and if increasing taxes is not politically feasible for the foreseeable future, regulating fuel economy is attractive. It may be more costly, but this approach trades off these costs against political expediency. Second, there are imperfections in the market for vehicles that are not satisfactorily dealt with by fuel taxes. These are related to a) insufficient information, b) frictions in markets for used cars, c) inappropriate incentives in company car markets, and d) uncertainty for manufacturers about the reactions of car buyers and competitors to producing more efficient but more expensive vehicles.

#### PRICE EFFECTS OF INCORPORATION OF TRANSPORTATION INTO EU ETS

- *M.J. (Martijn) Blom, B.E. (Bettina) Kampman, D. (Dagmar) Nelissen CE Delft, for the VROM Council (VROM-Raad) et.al.CE Delft, 2008.*

##### – Types of emission trading in road transport that have been studied

Main focus: Including the transport sector (incl. road transport) in the EU ETS. In addition, a brief comparison with a separate trading system for the transport sector.

##### – What has been studied, to what extent?

First, the effect of integrating transport in the current EU ETS on the price of EU allowances (EUa) was determined, under different reduction scenarios. Second, an indication was given of the effects of this CO<sub>2</sub> price increase on competitiveness of the European industry and electricity sector.

##### – Approach, methodology

The study was based on existing data and literature, and a relatively simple calculation model, using a two step approach:

- First, the EUa price increase of integration in a common scheme was determined. To this end, marginal abatement cost curves were constructed for both the current ETS sectors and the transport sector.
- Second, a global indication was given of the effects of this CO<sub>2</sub> price increase on competitiveness of the European industry and electricity sector, based on a quick literature scan on economic effects of climate policies.

Two scenarios were analysed:

- 22% emission reduction in 2020 (compared to 1990), with 50% CDM/JI<sup>10</sup>;
- 28% emission reduction in 2020 (compared to 1990), without CDM/JI.

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Clean Development Mechanisms and Joint Implementation.

- Main conclusions
- Findings regarding abatement costs are in line with findings in other literature: CO<sub>2</sub> abatement is more expensive in the transport sector than in the current ETS sectors. However, it is also concluded that: there is a significant potential of ‘no regret’ abatement measures in both sectors, with higher economical benefit than costs.
- In the first scenario, inclusion of the transport sector in the EU ETS leads to an increase of the EUa price from €50 to €65 per tonne CO<sub>2</sub>. In the second scenario, the target can not be reached by the EU ETS sector alone, according to the cost curve used. When transport is included, the target is achievable, albeit at high EUa price: € 480 per tonne CO<sub>2</sub>. However, at these high reduction levels, the uncertainties in the data increase significantly.
- The EUa price is very sensitive to the availability of (low cost) CDM and JI.
- As long as the EUa price increase is limited as in the first scenario, the overall effects on competitiveness are expected to be small. However, this by no means excludes significant effects on a sector or firm level.
- As an alternative, a separate emission trading system could be set up for the transport sectors. At higher abatement levels, this system can be expected to lead to implementation of less cost effective CO<sub>2</sub> abatement measures. However, it would have the advantage that the emissions of the sector can be capped without the risk of affecting the ETS sectors by increasing the price of the EUa’s.

#### ROAD TRANSPORT EMISSIONS IN THE EU EMISSION TRADING SYSTEM

- *Mikkel T. Kromann (COWI) Thomas Engberg Pedersen (COWI) Dinne Smederup Hansen COWI, commissioned by the Nordic Council of Ministers TemaNord 2007:536, 2007.*

#### – Types of emission trading in road transport that have been studied

Including road transport in the EU ETS

#### – What has been studied, to what extent?

Effects in focus:

- Impacts on the allowance price
- Secondary effects on the electricity and heat generation sector and the energy-intensive industry in the Nordic countries

Effects on road transport sector are largely ignored, because the road transport sector is expected to buy allowances for other ETS sectors, and is fairly inelastic to the resulting increased costs.

An analysis of how reduction requirements may be distributed between sectors already in the ETS today, and the non-ETS sectors

– Approach, methodology

Based on numerical modelling, using a top-down macroeconomic model, as well as a bottom-up energy system model describing in detail the Nordic energy system. Three allocation schemes and five scenarios are analysed, results are provided for 2015.

– Main conclusions

- The inclusion of road transport will tend to increase the allowance price, as the demand for allowances will increase. Thereby the production costs of energy-intensive firms and other firms will increase.
- Governments may allocate a larger number of allowances to accommodate some of the increased demand. This will tend to restrict the increase in the allowance price. However, this will increase the need for reductions in the remaining non-trading sectors. Depending on the specific allocation this may imply that the non-trading sector reduction costs per tonne increases to the detriment of consumers, ETS sectors and non-trading sector firms.
- Thus, the allocating authorities are confronted with the task of finding the right balance between reductions in the trading and non-trading sectors.
- Including the road transport sector in the trading system will provide significant benefits to the Nordic countries, as well as other EU member states, by reducing the overall CO<sub>2</sub> abatement costs compared to the situation when road transport is not included. The size of this cost reduction depends on how road transport specifically is included in the ETS, and differs between countries depending on the climate policy of each individual country. In particular the balancing of reductions to be made within and outside the ETS is of great importance. A wrongfooted balance might require that reductions with high unit costs are carried out, while reductions with low unit costs are not, e.g. the transport sector might be required to make reductions, which could be carried out more cheaply in the energy sector.

ABATEMENT COSTS FOR CARBON DIOXIDE REDUCTIONS IN THE TRANSPORT SECTOR

- *E. Särholm and J. Gode, IVL Swedish Environmental Research Institute, March 2007.*

– Types of emission trading in road transport that have been studied

None

– What has been studied, to what extent?

This study looked at GHG abatement costs and potential of GHG mitigation measures in the transport sector.

– Approach, methodology

The abatement costs for 26 carbon dioxide reducing measures, grouped into six different categories, have been calculated. To this end, interviews were held with Swedish companies that are or could be involved in these measures. Abatement costs and reduction potentials were calculated based on data from these companies. Note that the aim was not to derive a complete overview of measures, to derive national reduction potentials or marginal abatement curves.

– Main conclusions

The overall result shows that efficiency measures are cheaper than fuel-shift measures. Most efficiency measures had abatement costs far below 0 SEK/ton CO<sub>2</sub>. The cheapest fuel-shift measure (low blending of biofuels) has a negative cost when taxes are included, but most other fuel-shift measures are considerably more expensive. Abatement costs for fuel-shift measures are much higher in the transport sector than in the energy sector.

DESIGNING AN EMISSIONS TRADING SCHEME SUITABLE FOR SURFACE  
TRANSPORT

- *H. Watters and M. Tight, Institute for Transport Studies, University of Leeds, February 2007.*

– Types of emission trading in road transport that have been studied

All types, this study reviews the possible ways to reduce GHG emissions from the transport sector through an emission trading scheme.

– What has been studied, to what extent?

The main elements of emission trading schemes are introduced and discussed, including the establishment of an emission target, methods of permit allocation and temporal flexibility. Different scheme designs are also described, including baseline and credit, cap and trade, open and closed and voluntary schemes. Approaches to emissions trading are discussed, such as domestic quotas, personal carbon allowances and the European Emissions Trading Scheme (EU ETS).

– Approach, methodology

The report first provides a general overview of possible approaches. Those which have the greatest potential for the transport sector are covered in more detail, including fuel permits in an upstream and downstream application, and trading amongst vehicle manufacturers. The strengths and weaknesses of each approach are evaluated, and the challenges to the successful implementation of an emissions trading scheme are explored (in terms of monitoring and enforcement, political and public acceptability and technological feasibility). Alternative approaches, including taxation and mandatory fuel efficiency improvements are discussed and compared in terms of their effectiveness and acceptability.

– Main conclusions

The report concludes with recommendations for development of a trading scheme in the UK based on the available evidence. These were, in the short term, a mandatory trading scheme amongst vehicle manufacturers to improve vehicle fuel efficiency, and inclusion of aviation in the EU ETS. In the longer term, a system of personal carbon allocations and industrial carbon rationing are recommended. Alternative approaches such as a carbon tax on fuel and mandatory enforcement of clean technologies and fuels appear unlikely to deliver similar or better results, for various reasons.

## GREENHOUSE GAS EMISSIONS TRADING FOR THE TRANSPORT SECTOR

- *IVL Swedish Environmental Research Institute Ltd. for Naturvårdsverket, 2006.*

– Types of emission trading in road transport that have been studied

Main focus was inclusion of the EU transport sector in the EU ETS in 2013. A separate trading system was also analysed, as comparison.

– What has been studied, to what extent?

- 1) An economical analysis of the consequences for the transport sector, including an analysis of how the total cost for reaching an emission target will be affected, comparing an integrated (open) system with separate (closed) system.
- 2) An analysis of design possibilities
- 3) Examination of the acceptance among different actors for different options.

– Approach, methodology

Effects on EUa price were analysed using graphical analysis, based on marginal abatement cost curves. These curves were based on limited data, and the assumption that abatement costs are much higher in transport than in the EU ETS sectors. 7 scenarios were analysed.

– Main conclusions

If the transport sector is integrated in the EU ETS, as opposed to having a separate system:

- the allowance price in the EU ETS will increase, the cost of carbon emissions in transport will decrease.
- Impacts on industry may be significant: higher allowance and electricity prices, reduced production in industry, carbon leakage, but also enhanced profitability of renewable energy and energy efficient technologies.
- Limited CO<sub>2</sub>-reduction in the transport sector, or even an increase.

- Since it is assumed that CO<sub>2</sub>-taxed on transport fuels are abolished, fuels will become cheaper in that sector.

#### DEALING WITH TRANSPORT EMISSIONS. AN EMISSION TRADING SYSTEM FOR THE TRANSPORT SECTOR, A VIABLE SOLUTION?

- *CE Delft for Naturvårdsverket (Swedish Environmental Protection Agency), 2006.*

- *Types of emission trading in road transport that have been studied*

All types, the study assesses the possibilities for CO<sub>2</sub> emission trading schemes for the transport sector as a whole and for specific transport modes.

- *What has been studied, to what extent?*

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; closed scheme (no linkage to EU ETS) or open scheme (linked to or embedded in EU ETS). Cap & Trade (C&T) and Baseline & Credit (B&C) systems have been assessed. The report has a ‘scan like’ character, and provides a broad overview of current knowledge.

- *Approach, methodology*

A two stage approach was applied. The first stage appraisal dealt with the practical feasibility, and resulted in a selection of practically feasible schemes. These were subsequently assessed further in the second stage appraisal.

- *Main conclusions*

Main conclusions regarding road transport<sup>11</sup>:

- 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 CO<sub>2</sub> emission target can be ensured. C&T systems generally encourage all means of CO<sub>2</sub> mitigation, whereas the B&C scheme only affects engine and vehicle technology. However, flanking instruments could enhance B&C schemes.
- From the point of view of ensuring emission reductions in the sector itself, a closed system may provide 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. There may also be an interest to

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Other modes were assessed, but were left out of this summary.

guarantee that measures are taken to reduce emissions, or to slow down emission growth, in the sector itself.

- 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. A closed system will lead to different prices of CO<sub>2</sub> emission allowances in the transport sector, compared to those in the EU ETS.
- Potential effects on competitiveness depend on the design of the scheme, and on the stringency of the cap.
- An additional charge or CO<sub>2</sub> tax on fuel may have the same effect on the transport sector, at much lower transaction costs.

EMISSIONS TRADING IN THE TRANSPORT SECTOR, FEASIBLE APPROACH FOR AN UPSTREAM MODEL/EMISSIONSHANDEL IM VERKEHR, ANSÄTZE FÜR EINEN MÖGLICHEN UP-STREAM-HANDEL IM VERKEHR (IN GERMAN, WITH AN ENGLISH EXECUTIVE SUMMARY)

- *Prof. Bergmann, FiFo, Fraunhofer ISI, IFEU, for Umweltbundesamt, 2005.*

– *Types of emission trading in road transport that have been studied*

An upstream emission trading system, all transport modes, both open and closed.

– *What has been studied, to what extent?*

The main task of this study was the development of a concrete emissions trading approach for the transport sector, using an upstream approach.

– *Approach, methodology*

One of the main objectives of this study was to keep the transaction costs of a trading system in the transport sector at a minimum level. The study does not make use of economic modelling to assess the impacts of emissions trading in the transport sector.

– *Main conclusions*

- The best solution: All owners of fuels – refineries, fuel trading companies or importers – who bring their goods into the transport sector in purpose of energetic use have to obtain a specific amount of emissions certificates.
- The economical impacts: First of all, in Germany allocative failure in fuel taxation between diesel and petrol can be diminished regardless of the prices for CO<sub>2</sub>. As a result, consumers of diesel, particularly in road traffic will bear a relatively higher burden.
- An upstream approach has only indirect effects on the motorcar industry and refineries. Technical CO<sub>2</sub> reduction can primarily be realised via an increased consumer demand for more fuel-efficient vehicles, new propulsion technology

or alternative fuels based on renewable energies. In addition, an upstream approach focuses primarily on CO<sub>2</sub> reduction that can be obtained by changes in consumer behaviour (economical way of driving, avoidance of unnecessary journeys, creation of car pools, changes in the modal split, etc.).

- The saving-potential increases with a rising price for CO<sub>2</sub>. However, in the case of an open trading system – a linkage to the existing EU ETS – we estimate the amount of transport emissions that could actually be reduced to be relatively small. The results of various previous studies show that fuel prices would increase by a minimum of 1,3 Cent to a maximum of 8 Cent per litre in average. Considering these price effects, that no adaptation reactions – especially from end-consumers – concerning mobility adjustments will occur. Even though it is shown that there are many relatively cheap and cost-efficient avoidance options in the transport sector, and many reduction measures are quite cost-efficient, these moderate increases of fuel prices would not prompt economic actors to take action.
- An emissions trading system in the transport sector could result in distortion of competition. Generally emissions trading raises fuel prices in all participating countries in the same way. All commercial actors in this market are faced with the same absolute surplus costs. Therefore the competitive capability of companies from different EU countries is not affected. Existing differences in tax rates can be even reduced.
- To conclude, the research team is not convinced that the full potential of existing adaptation options in the transport sector can be tapped by an open emissions trading. The transport sector will then cope with additional CO<sub>2</sub> costs without tapping the potential of relatively cheap adaptation options. This will result in the purchase of emissions rights from other participating sectors, especially from the industry and energy sector. Thus, these sectors would face higher avoidance costs and certificate prices.
- An isolated trading system with a sectoral emissions cap is an appropriate approach to secure absolute emissions reductions in the transport sector. Also a national certificate solution could be a way to keep an administratively defined sectoral reduction path. A closed trading, on the other hand, would cause different prices for CO<sub>2</sub> and result in economic inefficiencies.

#### THE USE OF TRANSFERABLE PERMITS IN TRANSPORT POLICY

- *Ch. Raux, Transportation Research Part D 9 (2004) 185-197, 2004.*

#### – Types of emission trading in road transport that have been studied

permit systems (mainly cap and trade) in transport, to target GHG emissions, air pollutant emissions, noise, congestions, land use, etc.

#### – What has been studied, to what extent?

A general and very broad analysis of the potential of permit systems in transport, assessing the potential to use these systems to target various environmental nuisances, including GHG emissions.

– Approach, methodology

A theoretical analysis of the main pros and cons of permit systems, and two case studies: the Austrian Ecopoint program, and the ZEV program in California.

– Main conclusions

permits can address greenhouse gas and regional atmospheric pollutant emissions, and are suitable for congestion on a restricted time–space basis. Permits applied to mobile sources are technically feasible at acceptable financial cost for protecting sensitive geographical areas, and schemes applied to automakers for unitary vehicle emissions are also viable.

THE IMPACT OF CO<sub>2</sub> EMISSIONS TRADING ON THE EUROPEAN TRANSPORT SECTOR

- *P. Kågeson, 2001.*

– Types of emission trading in road transport that have been studied

To investigate how CO<sub>2</sub> permits in combination with km charging would affect the transport sector. Where road fuels are concerned the distributing oil companies would have to obtain permits corresponding to their sales.

– What has been studied, to what extent?

Aim: to analyse how a common European scheme for CO<sub>2</sub> emissions trading covering all sectors of society would affect the transport sector. Transport externalities other than CO<sub>2</sub> are assumed to be internalised by kilometre charging, road fuels will no longer be subject to taxation.

– Approach, methodology

The analysis is based on the assumption that the equilibrium price of CO<sub>2</sub> permits required for the Kyoto commitment of the European Union will be around 65 Euro per tonne. CDM/JI is ignored/excluded.

– Main conclusions

- The EU's Kyoto goal can be reached at a marginal abatement cost around 65 Euro per tonne of CO<sub>2</sub> in a case where emissions trading replaces all current taxes on fossil fuels. In a case where emissions trading is supplementary to today's energy and carbon taxes, a total marginal abatement cost around 80 Euro per tonne of CO<sub>2</sub> is estimated.
- Having to buy emission permits would significantly raise the cost of fuel and electricity used in rail, aviation and short sea shipping, as these modes are currently not taxed at all. The resulting long-term improvement in specific energy efficiency is estimated at around 25 per cent compared to trend for rail and 20 and 40 per cent respectively for aviation and sea transport.

- A combination of CO<sub>2</sub> emissions trading and km charging would moderately raise the variable cost of driving a gasoline car. The cost of using diesel vehicles would rise considerably in most Member States. Annual mileage per car would therefore decline somewhat. The fuel, however, would become cheaper than today (especially gasoline) and this would reduce the incentive to buy fuel-efficient vehicles. The reform would thus hamper the introduction of new, more efficient, technologies that might be needed for meeting more long-term commitments.
- Emissions trading would not encourage the introduction of biofuels in road transport, due to their high cost. Road fuels would also in future be produced from crude oil or natural gas. The latter would be the base for hydrogen used in fuel cells.
- A common CO<sub>2</sub> tax covering emissions in all sectors of society would provide the same incentive as emissions trading. Being based on a legal cap, emissions trading has the advantage over CO<sub>2</sub> taxation of ensuring that the abatement target is achieved. CO<sub>2</sub> taxation would meet the same objective only in a case when the tax rate is set at (or above) the efficient level. Emissions trading could therefore be regarded as an optimal solution.

#### TRADEABLE PERMITS: THEIR POTENTIAL IN THE REGULATION OF ROAD TRANSPORT EXTERNALITIES

- *Verhoef, E.T., P. Nijkamp and P. Rietveld, Environment and Planning B: Planning and Design 24B 527-548, 1997.*

#### – Types of emission trading in road transport that have been studied

A very broad range of tradeable permit schemes are assessed, for a variety of external costs, for example vehicle ownership permits, road usage permits, tradeable vehicle miles, tradeable fuel permits, tradeable parking permits, tradeable permits in the automobile industry, tradeable permits in the fuel industry.

#### – What has been studied, to what extent?

Main aim: to identify the potential of tradeable permits in the regulation of road transport externalities

#### – Approach, methodology

A theoretical, qualitative (economical) analysis

#### – Main conclusions

- Tradeable permits, as a means to regulate road transport externalities have the attractive property of yielding cost-effective outcomes in the realization of certain policy targets, while offering the possibility of keeping the transfers from regulatees to the regulator to a minimum.
- Tradeable fuel permits offer the most attractive, user oriented application of tradeable permits, providing simultaneous incentives to reduce mobility in the

short run and to purchase environmentally friendly and energy efficient cars in the longer run.

Additional incentives to affect size and composition of the car fleet may be given through vehicle ownership permits, weighted for the environmental quality of the car. A full policy package may include various tradeable permit systems.

# Emissions trading and fuel efficiency regulation in road transport

REPORT 5896

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Transports are responsible for a large part of the greenhouse gases, and most of the gases are caused by road vehicles. People are encouraged by different societal instruments to choose more effective means of transport. However, transport emissions must still be significantly reduced. Would emissions trading help? Yes it could, according to the authors of this report. However, it remains to work out how it should be done. For that reason, alternative measures should not be disregarded.

