NATUR VÅRDS VERKET

Emission Trading Systems for New Cars

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Emission Trading Systems for New Passenger Cars

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Preface

Why do we need a separate trading system for carbon dioxide emissions from new cars? Well, there are several reasons. The most obvious of these is that cars are a massive contributing factor to climate change emissions. What's more, they are relatively problematic to control, not least in Sweden, the country with the highest average carbon dioxide emissions from new cars in Europe. We need to achieve greater reductions in emissions than the current prognosis indicates. This is the case in most countries, which is why joint action on this issue would be welcomed and would potentially be more effective. However, how this might function in practice is still to be worked out.

This report gives a comprehensive background to the issue of controlling the impact of motor vehicles on climate change. Furthermore, it adds to our knowledge on how to implement market-based instruments. And, not least, it outlines a new and inventive concept for controlling carbon dioxide emissions from vehicles by using tradable units.

A group of experts including Björn Carlén from the Swedish Ministry of Finance, and Per-Ove Hesselborn from the Swedish Institute for Transport and Communications Analysis (SIKA) contributed to the study at working group meetings and by giving comments to draft versions of the report.

The report was written by Sirje Pädam and Joakim Johansson at Inregia AB. The authors have the sole responsibility for the content of the report and as such it cannot be taken as the view of the Swedish Environmental Agency.

Swedish EPA
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Summary

Carbon dioxide (CO_2) emissions are a global concern; impacts on the climate do not depend on where the CO_2 is emitted. To meet this concern, a worldwide program for cutting greenhouse gases was formed in Kyoto, Japan in December 1997. The Kyoto protocol formulates the general principles for a worldwide treaty on cutting greenhouse emissions and specifies reductions for the industrialised world.

The European Union has introduced an EU wide emission trading system (EU-ETS) that became operational in 2005 as an instrument for EU member states to meet their Kyoto obligations. Transports are not included, but may become a part of the EU-ETS in future revisions. Instead emissions from transports are regulated by other means, including fuel taxes.

To further reduce CO_2 emissions from passenger cars and to improve fuel efficiency, the European Community has adopted a separate strategy. An important element of this strategy are the Commitments of the European, Japanese and Korean Automobile Manufacturers Associations to achieve total new passenger car fleet average CO_2 emissions of 140 g CO_2/km by 2008/2009.

In this paper we assess the option of introducing an EU wide certificate/emission permit trading system for new passenger cars as an alternative to the commitments made by the European Automobile Manufacturers Associations. An overview of alternative trading systems is presented, possible objectives and evaluation criteria are discussed, arguments for introducing separate systems for new passenger cars are discussed, the potential for emission reduction through technological advances and changed consumer behaviour is analysed and a possible design of a system of tradable permits for new passenger cars is presented.

CAP-AND TRADE OR BASELINE-CREDIT?

In a cap-and-trade system a total limit (a cap) on emissions is defined. Emission permits that sum up to the limit or cap are then allocated among the agents generating the emissions. Having allocated the permits, trade is introduced. If certain conditions are achieved, trade will continue to the point where marginal abatement costs are the same across sectors and nations. Cost-effectiveness is then achieved. The EU-ETS is an example of a cap-and-trade system.

A baseline-credit system is an alternative. In such a system certificates or credits are based on the achievement of improvements in relation to a baseline. Agents with emissions lower than the predefined baseline receive credits and those exceeding the baseline will have to buy credits. The baseline is typically defined in relation to a rate-based value such as CO_2-emissions per kilometre or emissions per unit of output. A relative baseline system of this kind is thereby designed to control average emissions, e.g. per car and kilometre, rather than total emissions.

The cap-and-trade system has the advantage by allowing a larger variety of choices for adjusting emissions. Taking road transports as an example, total emissions can be reduced not only by reducing average emissions per car and kilometre but also by reducing total car fleet mileage e.g. by giving incentives to travellers to drive less, drive shorter distances or shifting to alternative modes of transport. If

the overall objective is to reduce emissions in a cost-effective manner across sectors and nations, including the transport sector in current EU-ETS would be an option to consider. The advantage of such a system is that it has the potential of providing incentives to agents to act in a way that will equalise marginal abatement costs across sectors (assuming also that current CO_2-based fuel taxes/other taxes linked to CO_2 emissions are adjusted accordingly), thus leading to cost-effective abatement.

The baseline-credit system, on the other hand, would concentrate on reducing average emissions and consequently target the behavioural changes necessary to reduce average emissions. If, for example, the objective is to increase energy efficiency through technological improvements, a baseline-credit system may therefore be the optimal choice. Moreover, myopic behaviour in the market for new passenger cars may lead to a situation where consumers' preferences and willingness to pay for CO_2-reducing technology is insufficient to cover the costs of developing the technology and put it to the market even if car manufacturers were to trade in EU-ETS and thereby receive monetary gains by developing technology that reduces fuel consumption and CO_2 emissions. A system such as the baseline-credit system may therefore be necessary in order to provide sufficient incentives to manufacturers to work towards increased energy efficiency in new cars through technological improvements.

The average CO_2 emissions from new cars sold in the market can be reduced in two ways; either by increasing the energy efficiency in each type of car put to the market (i.e. improved technology) or by providing incentives to consumers to choose the most energy-efficient cars already in the market. Achieving objectives such as 120 g CO_2/km for new car fleet most likely requires both of these. Also, in order to influence consumer behaviour it is important to make technology available to consumers at low cost. Consumers choose to pay for new technology only if the benefits of improved gas-mileage exceed the costs of higher car prices.

TECHNOLOGICAL IMPROVEMENT OR CHANGED CONSUMER BEHAVIOUR?

Considering technological improvements there are two ways in which to reduce specific CO_2 emissions: By reducing fuel consumption in vehicles with conventional combustion engines (petrol and diesel), or by using renewable, low-CO_2 fuels (partly) in conjunction with new engine technologies. Fuel consumption in vehicles with conventional combustion engines can in turn be reduced in a number of ways. Technological measures can be roughly divided into four categories: Improved engine technology, downsizing and enhanced transmission technology, energy management and hybridisation, and vehicle design.

The literature shows that conventional combustion engines have considerable potential for fuel-saving. In the case of petrol engines, it is thought that measures involving the drive train in a middle-size vehicle could achieve fuel savings of around 38 per cent. Further measures such as weight reduction, reduced rolling and air resistance, and promotion of fuel-efficient driving habits can result in 40 per cent or greater decrease in overall consumption. Diesel engines have lower savings potential than petrol engines because diesel engines are less wasteful than petrol engines when run at partial throttle, and significant increases in diesel motor efficiency have already been achieved. Nevertheless, hybridisation and improved transmission could result in savings of around 32 per cent. Additional savings could also be achieved with a reduction in vehicle weight, reduced rolling and air resistance, and by promoting fuel-efficient driving habits.

Turning then to consumer behaviour, it is important to recognise that consumers consider a large variety of characteristics before finally choosing the car that best fits their needs and their personal preferences. From a CO_2 point of view consumers should ideally be concerned about fuel efficiency more than any other characteristics. This, however, is not the case. Studies have shown that factors such as safety, prestige and powerful engines influence consumer behaviour more than does fuel efficiency, especially in times when disposable incomes increase. However, in spite of recent trends there seems to be a potential to provide incentives to consumers to shift to low-emitting cars without any large sacrifices being involved.

Consider, for instance, Volvo V70, which was the most popular new car model in Sweden in 2005. The emissions from the different petrol versions range between 214 and 266 g CO_2/km, whereas diesels are available with emissions ranging from 171 to 223 g CO_2/km. A movement form the highest CO_2/km per kilometre value to the lowest would thus imply savings of 95 grams per kilometre. To achieve these savings a consumer who currently prefers the highest emitting car has to change fuel, automatic transmission and engine power. However, brand, model or car size would not need to change. For most consumers the "adjustment cost" would thus be relatively low.

The above is an extreme case scenario involving only one car model. Considering instead the whole fleet of new passenger cars, our calculations show that there is a general potential to reduce CO_2 emissions from new cars by 13-30 g CO_2/km within the same car model (or approximately 8-15 per cent).

THE COST OF INCREASED ENERGY EFFICIENCY

The main purpose of a baseline-credit system for new passenger cars would be to provide incentives for car manufacturers to develop and introduce the technology in new cars required to reach the specified CO_2-objectives. However, this also means that consumers must find it worthwhile to buy a low-emitting car, i.e. the benefits of the improved technology, not the least in terms of increased gas mileage, must exceed the increase in sales price. The technological potential is large, but the benefits for consumers could be questioned since car buyers apparently do not judge energy efficiency as an important characteristic. Assuming unchanged market shares for petrol and diesel cars as well as small, medium and large sized cars, our calculations show that a reduction of the average emissions to 120 g CO_2 per car and kilometre in the EU would imply an increase in retail prices by 2 000 euro. There is technological potential to further reduce emissions to an average of 100 g CO_2 per kilometre. However, the cost increase for this additional reduction is about 6 000 euro.

THE DESIGN OF A SYSTEM FOR NEW PASSENGER CARS

It is our conclusion that an emission trading system for new cars should be separated from the EU-ETS and designed as a baseline and credit system, based on emission intensity.

Setting up a separate emission trading system for new cars as a baseline and credit system involves defining a baseline. It is natural to tie the baseline to the goals that are under discussion in the European Union i.e. 140 and 120 g CO_2/km. Different time frames have been discussed. One possibility is to reach 140 CO_2/km by 2008/2009 and 120 g CO_2/km by 2012. Earlier discussions about technological development show that this time frame is feasible.

Before trade can take place, demand and supply of credits need to be created. In a cap-and-trade system initial allocation of permits is a very important issue. In the baseline and credit system the allocation of credits is automatic: cars below baseline receive credits and cars above baseline need to purchase credits. In principle, this implies that no cost is imposed on the baseline car. High-emitting cars will become more expensive and low-emitting cars less expensive. The credits will work in a way similar to a system of subsidies for cars emitting below the baseline and taxes for those above.

Trade with credits need to perform in a way that supports attainment of the baseline. A possible solution is that credits are traded in a market that is similar to a stock exchange. The offers of sellers and the bids of buyers will meet in a market that ideally clears each trading day. As long as markets clear, there is attainment of the baseline. To overcome imbalances, an accommodating system that handles short time excess credits or shortages will need to be worked out.

There is also a need for an enforcement and compliance mechanism. Another issue to deal with is that there may be different incentives for buyers and sellers. Buyers will generally be obliged to buy credits. Sellers, on the other hand, may want to capitalise their credits later, or to bank them for coming periods. The differences in incentives can lead to shortages and an upward pressure on prices and fluctuating prices.

The issue whether trade of credits should take place downstream or upstream includes several options in the production-consumption chain. The recommendation is that the retailers should be the trading entity. We also suggest gradual reductions in baseline. However, the details of a system of baseline and credits will need further analysis.

Important issues in a future analysis will be designing mechanisms for compliance, monitoring and penalising. Incentive problems need also to be dealt with.

Sammanfattning

Koldioxidutsläpp (CO_2) är en global angelägenhet eftersom påverkan på klimatet är oberoende av var utsläppen sker. För att ta itu med frågan skapades ett världsomfattande program för att minska växthusgaserna i Kyoto i Japan i december 1997. Kyotoprotokollet formulerar de allmänna principerna för en världsomfattande överenskommelse för att minska växthusgaserna och specificerar reduktioner för de industrialiserade länderna.

Den europeiska unionen införde en EU gemensam marknad för handel med utsläppsrätter (EU-ETS) år 2005 för att EU:s medlemsländer ska kunna uppfylla sina Kyotoåtaganden. Transporter ingår inte, men kan komma att bli en del av EU-ETS i samband med framtida revideringar. Emissioner från transporter regleras på annat sätt, t.ex. genom drivmedelsskatter.

För att ytterligare reducera CO_2 utsläppen från personbilar och för att öka energieffektiviteten har EU infört en särskild strategi. En viktig beståndsdel i strategin är de europeiska, japanska samt koreanska biltillverkarnas frivilliga överenskommelser om att nå genomsnittliga CO_2 emissioner från nya bilar på 140 g CO_2/km till 2008/2009.

I den här rapporten bedömer vi möjligheten att införa en EU gemensam handel med utsläppsrätter/certifikat för nya bilar som ett alternativ till de frivilliga överenskommelser som tagits av biltillverkarna. En översikt över alternativa handelssystem presenteras, möjliga mål och utvärderingskriterier framförs, argument för att införa ett separat system för nya bilar diskuteras, potentialen för utsläppsminskningar och förändrat konsumentbeteende analyseras och slutligen presenteras en möjlig utformning av ett system för handel med utsläppsrätter för nya bilar.

HANDELSSYSTEM
MED UTSLÄPPSTAK ELLER CERTIFIKAT MED UTSLÄPPSMÅL?

I ett handelssystem med utsläppstak definieras en total utsläppsbegränsning (ett tak). Utsläppsrätter som summerar till begränsningen fördelas sedan mellan de agenter som ger upphov till utsläppen. När utsläppsrätterna har fördelats, introduceras handel. Givet vissa allmänna förutsättningar, kommer handel att fortgå till de marginella kostnaderna för utsläppsreduktion är lika för alla sektorer och länder. När detta är uppnått har reduktionerna skett kostnadseffektivt. EU-ETS är ett exempel på ett handelssystem med utsläppstak.

Ett system med certifikat och utsläppsmål är ett alternativ. I ett sådant system baseras certifikaten på förbättringar i förhållande till ett utsläppsmål. Agenter vars emissioner understiger den förutbestämda målnivån tilldelas certifikat och de vars utsläpp överstiger målnivån får köpa certifikat. Utsläppsmålet är i allmänhet definierat i förhållande till en standard, t.ex. CO_2-utsläpp per kilometer eller emissioner per producerad enhet. Ett relativt system med certifikat och utsläppsmål av detta slag utformas därmed för att kontrollera genomsnittliga utsläpp, t.ex. per bil eller per kilometer, istället för de totala emissionerna.

Handelssystem med utsläppstak har som fördel att den möjliggör fler alternativ till att minska utsläppen. Ett exempel från vägtransportområdet är att de totala

utsläppen kan minskas även på andra sätt än genom reduktioner av genomsnittliga utsläpp per bil och kilometer, detta genom att det totala antalet körda kilometer minskar för bilparken, t.ex. genom att ge resenärer incitament att köra mindre, köra kortare sträckor eller att byta till annat färdmedel. Om det övergripande målet med utsläppshandeln är att reducera emissioner på ett kostnadseffektivt sätt mellan sektorer och länder, bör en länkning av transportsektorn i EU-ETS övervägas. Fördelen med ett sådant system är att det ger agenterna incitament att agera på ett sätt som likställer de marginella åtgärdskostnaderna mellan sektorer (under antagande om att nuvarande CO_2-basereade drivmedelsskatter/andra skatter som beror av CO_2 utsläpp också anpassas därefter), och på så vis leder till att utsläppsreduktionen sker kostnadseffektivt.

Systemet med certifikat knutna till en målnivå skulle, å andra sidan, minska de genomsnittliga utsläppen och därmed inverka på beteendemässiga anpassningar som är nödvändiga för att reducera de genomsnittliga utsläppen. Om målsättningen är att öka energieffektiviteten genom teknisk utveckling kan ett system med certifikat vara det optimala valet. Dessutom kan kortsiktigt beteende på markanden för nya personbilar innebära att konsumenternas preferenser och betalningsvilja för CO_2-reducerande teknologi är otillräcklig för att täcka kostnaderna för teknisk utveckling och marknadsintroduktion. Detta även i det fall biltillverkarna deltar i handeln med utsläppsrätter på marknaden för EU-ETS och därigenom kan tjäna pengar på att utveckla teknologi som reducerar drivmedelsförbrukning och utsläpp av CO_2. Ett system med handel med certifikat kan därför visa sig nödvändigt för att ge tillverkarna tillräckliga incitament för att arbeta mot ökad energieffektivitet i nya bilar genom teknisk utveckling.

De genomsnittliga CO_2 utsläppen från nya bilar som säljs på markanden kan reduceras på två sätt: antingen genom att öka energieffektiviteten hos varje bilmodell (teknisk utveckling) eller genom att ge konsumenter incitament att välja de mest energieffektiva bilarna som redan finns på marknaden. Att nå mål som 120 g CO_2/km för nya bilar kommer sannolikt kräva båda dessa. Även för att påverka konsumenternas beteende är det viktigt att göra ny teknologi tillgänglig till låg kostnad. Konsumenterna är beredda att betala för ny teknik bara om nyttan av en lägre bränsleförbrukning överskrider kostnaderna i termer av högre priser på nya bilar.

TEKNISK UTVECKLING ELLER FÖRÄNDRAT KONSUMENTBETEENDE?

Teknisk utveckling som reducerar CO_2 utsläpp är möjlig att uppnå med två metoder: Antingen genom att reducera drivmedelsförbrukningen i konventionella förbränningsmotorer (bensin och diesel), eller genom att använda förnybara drivmedel med låga CO_2 utsläpp (delvis) tillsammans med nya motorteknologier. Drivmedelsförbrukningen i fordon med konventionella förbränningsmotorer kan i sin tur reduceras på många vis. De tekniska lösningarna kan delas in i fyra kategorier: Förbättrad motorteknologi, förminskning av motorkapaciteten och förbättrad utväxling, energisparande åtgärder och hybridisering samt fordonsdesign.

Litteraturöversikten visar att de konventionella förbränningsmotorerna har en stor energieffektiviseringspotential. För bensinmotorer uppskattar man att åtgärder i drivlinan i medelstora fordon skulle kunna uppnå drivmedelsbesparingar på cirka 38 procent. Utöver det skulle åtgärder som viktminskning, minskat rull- och luftmotstånd samt sparsam körning kunna resultera i åtminstone en 40 procentig reduktion av drivmedelsförbrukningen. Dieselmotorer har en mindre sparpotential än bensinmotorer eftersom dieselmotorerna är mer effektiva än bensinmotorer när bilen inte går på full gas. Dessutom har betydande förbättringar redan uppnåtts i effektiviseringen av dieselmotorer. Trots detta skulle hybridisering och förbättrad utväxling kunna resultera i besparingar på omkring 32 procent. Ytterligare besparingar kan uppnås genom reducerad fordonsvikt, rullmotstånd och sparsam körning.

När det gäller konsumentbeteende så är det viktigt att ta hänsyn till att konsumenter överväger ett flertal egenskaper hos ett fordon innan de slutligen väljer den bil som bäst passar deras behov och smak. Från ett CO_2-perspektiv borde energieffektivitet ha större betydelse än någon annan egenskap. Så är dock inte fallet. Studier har visat att andra egenskaper som säkerhet, prestige och kraftfulla motorer påverkar konsumentbeteendet mer än energieffektivitet, i synnerhet i samband med att de disponibla inkomsterna stiger. Trots detta och frånsett aktuella trender verkar det finnas en potential att genom tillräckliga incitament få konsumenter att välja mer energieffektiva bilar, utan att det behöver leda till stora uppoffringar.

Volvo V70, som var den populäraste bilmodellen i Sverige 2005 kan tas som exempel. Utsläppen från olika bensinvarianter är tillgängliga från 214 till 266 g CO_2/km, och dieslarna från 171 till 223 g CO_2/km. Ett byte från det högsta värdet på CO_2/km per kilometer skulle kunna ge en besparing på 95 gram per kilometer. För att nå detta skulle en konsument som i nuläget föredrar den högst emitterande bilen behöva byta drivmedel, automatväxel och motorstyrka. Däremot skulle varken bilmärke, modell eller bilstorlek behöva bytas ut. För de flesta konsumenter skulle ”anpassningskostnaden” kunna vara relativt låg.

Ovanstående exempel är dock ett extremfall och omfattar bara en bilmodell. Om man istället betraktar hela nybilsflottan, visar våra beräkningar att reduktionspotentialen från nya bilar ligger på 13-20 gram CO_2/km inom samma bilmodell (eller cirka 8-15 procent).

KOSTNADEN FÖR ÖKAD ENERGIEFFEKTIVITET

Huvudsyftet med ett handelssystem med certifikat för nya personbilar är att ge incitament till biltillverkare att utveckla och introducera teknik i nya bilar för att nå de specificerade CO_2-målen. Det betyder att även konsumenterna måste tycka att det är lönsamt att köpa en energieffektiv bil, d.v.s. fördelarna med den förbättrade tekniken, inte minst i termer av en lägre drivmedelsförbrukning måste överskrida kostnaderna i termer av högre priser på nya bilar. Den tekniska potentialen att öka energieffektiviteten är betydande, medan fördelarna för konsumenterna kan vara små eftersom bilköpare inte anser energieffektivitet vara en viktig egenskap. Under antagande om oförändrade markandsandelar för bensin och diesel liksom för små, medelstora och stora bilar, visar våra beräkningar att en reduktion i genomsnittliga utsläpp till 120 g CO_2 per bil och kilometer i EU skulle innebära en prisökning på cirka 2 000 euro för en ny bil. Det finns teknisk potential att ytterligare reducera utsläppen till ett genomsnitt på 100 g CO_2 per kilometer. Prisökningen för en ny bil för den ytterligare ökningen skulle dock vara omkring 6 000 euro.

UTFORMNING AV ETT HANDELSSYSTEM FÖR NYA PERSONBILAR

Vår slutsats är att ett handelssystem för utsläppsrätter för nya bilar bör separeras från EU-ETS och utformas som ett system med certifikat och utsläppsmål, som baseras på emissionsintensitet.

Att sätta upp ett separat system för utsläppshandel för nya bilar med certifikat innebär att utsläppsmål behöver definieras. Det är naturligt att knyta utsläppen till de mål som diskuteras i EU d.v.s. 140 och 120 g CO_2/km. Olika tidpunkter har diskuterats. En möjlighet är att nå 140 CO_2/km till 2008/2009 och 120 g CO_2/km till år 2012. Genomgången av teknisk utveckling visar att dessa tidsperspektiv är möjliga.

Innan handeln kan börja måste utbud och efterfrågan skapas på certifikat. I ett handelssystem med utsläppstak är den initiala fördelningen av utsläppsrätter en viktig fråga. I ett system med certifikat som baseras på målnivå uppkommer den initiala allokeringen automatiskt: bilar som ligger under målnivån erhåller certifikat och bilar som ligger över måste köpa certifikat. I princip, innebär detta att ingen kostnad tas ut för ”målnivåbilen”. Bilar med höga utsläpp blir dyrare och bilar med låga utsläpp billigare. Certifikaten kommer att fungera på ett sätt som liknar ett system med subvention av bilar som släpper ut mindre än målnivån och beskattning av bilar som släpper ut mer.

Handeln med certifikat bör fungera på ett sätt som stödjer uppnåendet av utsläppsmålet. En möjlig lösning är att handeln med certifikat sker på en marknad som liknar en aktiebörs. Säljarnas och köparnas bud möts på marknaden som idealt klarerar varje handelsdag. Så länge marknaderna klarerar uppnås målnivån. För att lösa eventuella obalanser behöver ett utjämningssystem utformas för att hantera kortsiktiga över- eller underskott av certifikat.

Det finns också ett behov av mekanismer för upprätthållande och efterlevnad. En annan fråga som behöver hanteras är att incitamenten för köpare och säljare kan skilja sig åt. Köparna kommer att vara tvingade att köpa certifikat. Säljarna, å andra sidan, kanske vill vänta till senare med att kapitalisera sina certifikat eller att spara dem för att använda dem vid ett senare tillfälle. Skillnaderna i incitament kan leda till ett underskott på certifikat med stigande priser och betydande prissvängningar.

Frågan om handeln med certifikat ska ske nedströms eller uppströms innebär ett flertal valmöjligheter i konsumtions- produktionskedjan. Rekommendationen är att bilhandlare ska vara den handlande nivån. Vi föreslår också att utsläppsmålet reduceras gradvis. De exakta detaljerna för ett system med certifikat och utsläppsmål kommer dock att kräva ytterligare analys.

Viktiga frågor att ta upp i en fortsatt analys kommer att vara utformningen av mekanismerna för efterlevnad, uppföljning och bestraffning. Incitamentsproblematiken behöver också behandlas.

1. Introduction

To meet the global concern of CO_2 emissions, a worldwide program for cutting greenhouse gases was formed in December 1997. The Kyoto protocol formulates the general principles for a worldwide treaty on cutting greenhouse emissions and specifies reductions for the industrialised world. The European Union has introduced an EU wide emission trading system (EU-ETS) that became operational in 2005 as an instrument for EU member states to meet their Kyoto obligations. Currently the EU-ETS includes CO_2 emissions from large point sources. Transports are not included, but may become a part of the EU-ETS in future revisions. Instead emissions from transports are regulated by other means, including fuel taxes.

To further reduce CO_2 emissions from passenger cars and to improve fuel efficiency, the European Community has adopted a separate strategy. (EU Commission, 2006). An important element of this strategy are the Commitments of the European, Japanese and Korean Automobile Manufacturers Associations to achieve total new passenger car fleet average CO_2 emissions of 140 g CO_2/km by 2008/2009. The Council and the European Parliament have specified as an objective for the Community strategy to meet by 2010 an average CO_2 emission figure for new passenger cars of 120 g CO_2/km.

The European and the Japanese Automobile Manufacturers Associations have indicated that they see no possibility to achieve 120 g CO_2/km by 2012 in a cost-effective manner by technical measures. (EU Commission, 2005). It is at present unclear what the kind of regulation that shall take over from 2009. Inclusion of new cars into the existing EU wide emission trading offers an option for reaching the stricter objective.

1.1 Purpose and organisation

The purpose of this study is to assess the option of introducing an EU wide certificate/emission permit trade system for new passenger cars. A review of current trends in passenger car markets and technological reduction potentials has been made to asses the reduction potentials. For this purpose several studies have been reviewed that consider issues connected to the topic of CO_2 emissions reductions from new passenger cars.

In Section 2 an overview of alternative trading systems is presented. Section 3 discusses the relations between objectives and evaluation criteria and presents possible arguments for introducing separate systems controlling emissions from new passenger cars. Section 4 discusses the potential for emission reduction through technological advances as well as changed consumer behaviour. In Section 5 the design of a system of tradable permits for new passenger cars is further developed.

2. An overview of alternative trading systems

This section presents an overview of alternative trading systems that can be implemented to control CO_2 emissions. The purpose is not to cover all possible systems, neither is it to analyse the pros and cons of each system, but rather to present some interesting alternatives that can serve as starting points for the discussion of potential trading systems for new passenger cars. The presentation focuses on the general case, implying rational and well-informed agents having low or insignificant transaction costs. Subsection 2.1 presents the principles of a cap and trade system, subsection 2.2 discusses alternative baseline and credit systems and subsection 2.3 discusses issues regarding upstream and downstream.

2.1 Cap-and-trade

In a cap-and-trade system a total limit (a cap) on emissions is defined. Emission permits (or allowances), which sum up to the limit or cap are then allocated among the agents generating the emissions. Having allocated the permits, trade is introduced. Assuming profit maximizing, well-informed agents and insignificant transaction costs, we can expect the following agent behaviour. Agents with low abatement costs will supply permits to the market (thereby choose to reduce their emissions) as long as the price of a permit exceeds the marginal abatement cost. Agents with high abatement costs will demand permits from the market (thereby choose not to reduce their emissions) as long as the price of a permit is lower than the marginal abatement cost. For an individual agent the assumed behaviour drives marginal abatement costs to equal the price level. Given that all agents take the price as given, trading continues to the point where marginal abatement costs are the same across sectors and nations. Compliance is established by comparing actual use or emissions with the assigned cap as adjusted by any acquired or sold permits and fining those emitting more than their permit holdings allow.

Current ETS system and possible expansions

The European Union Emission Trading Scheme (EU-ETS), which became operational on January 1st in 2005[1], is a cap and trade system covering large stationary emitters in Europe. The EU-ETS covers over 11.500 energy-intensive installations across Europe, which represent close to half of EU's emissions of CO_2. These installations include combustion plants, oil refineries, coke ovens, iron and steel plants, and factories making cement, glass, lime, brick, and ceramics, pulp and paper. The scheme initially specifies two periods, the first from 2005-2007, and the second from 2008-2012 (the second corresponding to the first commitment period of the Kyoto Protocol). Allocation of allowances is mostly based on grandfathering and will be decided separately for the two periods. In the coming period at least 90

[1] The Directive 2003/87/EC which establishes the scheme was issued in September 2003.

percent of allowances have to be handed out for free. Allocations for the second period are currently under preparation and allow countries to include other sectors than those currently included and may allow for an opt-in of transports.

2.2 Baseline and credits

Certificates or credits are based on the achievement of improvements in relation to a baseline. Entities with emissions lower than the predefined baseline receive credits and those exceeding the baseline will have to buy credits. If the baseline is defined in terms of total emissions the system will have great similarities to the cap-and-trade system. Alternatively, a baseline and credit system can be based on emission intensity. Such a baseline is typically defined in relation to a rate-based value such as CO_2-emissions per kilometre or emissions per unit of output. That is, a relative baseline system of this kind is designed to control average emissions rather than total emissions, e.g. emissions per car and kilometre in the fleet rather than emissions from the whole fleet (which depends on average emissions as well as number of cars and kilometres per car). This type of system does thus not necessarily guarantee reduction of total emissions. If output (e.g. total vehicle kilometres) grows rapidly, total emissions could also grow even if average emissions per unit of output are reduced. Introducing this type of system to increase the energy efficiency in *new* passenger cars also implies that total emissions may be difficult to control for a different reason. Increased energy efficiency means higher gas mileage for the consumer and thus lower fuel expenditures per kilometre driven. This could give rise to the so-called rebound effect, i.e. a situation where increased energy efficiency leads to an increase in average kilometres per car and year (simply put: if price decreases demand increases). With a (long term) price elasticity on fuel of –0.6 (Hagler Bailly, 1999) a ten per cent increase in energy efficiency would lead to a six per cent increase in mileage.

2.3 Downstream, upstream and personal carbon allowances

Designing an emission trading system also involves defining the level of application of trade in the production or consumption chain. Downstream trading applies to end users of fossil fuel or cars, i.e. actual emitters, including households and power plants. Regulating upstream means that earlier stages of the production chain will be made accountable for meeting the cap or baseline. Instead of actual emitters, producers of fuels or vehicles are to comply with targets. In many cases downstream regulation can be superior to upstream, because end users tend to have a larger variety of actions to reduce emissions. However, in the case of carbon dioxide, as long as separating and depositing carbon dioxide is not an economically viable option for small and medium sized emitters and due to the large number of end user heterogeneity, a downstream approach would lead to high administration and monitoring costs. Most authors conclude that the trade off between transaction costs and economic efficiency favours upstream trading (FlexMex (2003), CE-Delft (2006), etc). One of the major advantages of upstream emissions trading is that it increases coverage to most sources.

There are, however, studies that challenge the conclusion that upstream is superior for reducing carbon dioxide emissions. The British Tyndall institute has, for instance, suggested a cap and trade system for end users using so called electronic “Domestic Tradable Quotas”. By making payment for fuel and heating simultaneous with monetary payments, authors conclude that transaction costs need not be prohibitive. Neither would allocation need to be associated with high transaction costs. Initial allocation of quotas would be made for free on an equal per capita base. In principle, this allocation rule can be judged fair. However, differences in energy efficiency among households may call for additional measures to protect poor individuals from becoming worse off. (Starkey and Anderson, 2004).

2.4 Summary

A cap-and-trade system and a baseline-credit system are rather similar *if* the baseline is defined in terms of total emissions, e.g. total emissions from the entire transport sector. If, however, the baseline is defined in terms of average emissions such as emissions per vehicle and kilometres the two mentioned systems will be rather distinguished. The obvious difference is that the cap-and-trade system aims at controlling total emissions whereas the baseline-credit system aims at controlling average emissions. However, the cap-and-trade also has an advantage from an economic efficiency point of view by allowing a larger variety of choices for adjusting emissions. Taking road transports as an example total emissions can be reduced not only by reducing average emissions per car and kilometres but also by reducing total car fleet mileage by reducing either the number of cars in the fleet or the mileage per car e.g. by giving incentives to travellers to drive less, drive shorter distances or shifting to alternative modes of transport. On the other hand, since the baseline-credit system concentrates on one of these variables – reducing average emissions – it targets the specific incentives necessary to reduce the emissions from the average car put to the market. As will be shown below, great possibilities exist to increase energy efficiency in new cars by making better use of technology that already exist. If the objective of the system is to increase energy efficiency through technological improvements, a baseline-credit system may therefore be the optimal choice. It may also be the optimal choice from an economic efficiency point of view *if* there are reasons to believe that market failures such as asymmetric information and myopic behaviour hinders a cap-and-trade system or a uniform tax system from generating sufficient incentives for technological change.

3. Why controlling emissions from new cars?

This section presents some arguments for controlling CO_2 emissions from new passenger cars. Subsection 3.1 discusses the overall objectives of controlling global emissions of CO_2, subsection 3.2 discusses reasons for treating the transport sector separately from other emitting sectors, and subsection 3.3 discusses possible arguments for implementing specific measures to control emissions from new passenger cars.

3.1 Reducing emissions globally and in the EU

The institutional framework for global emission trading

CO_2 emissions are a global concern; impacts on the climate do not depend on where the CO_2 is emitted. Even if specific countries choose to set their own objectives, nationally or for specific sectors, the overall objective should always be to contribute to the reduction of the global emissions.

THE KYOTO PROTOCOL

The Kyoto Protocol is an agreement made under the United Nations Framework Convention on Climate Change (UNFCCC). Countries that ratify this protocol commit to reduce their emissions of CO_2 and five other greenhouse gases, or engage in emission trading if they maintain or increase emissions of these gases. The Kyoto Protocol now covers more than 163 countries globally[2]. Principles established under the agreement include the following:

- Kyoto is underwritten by governments and is governed by global legislation enacted under the UN's aegis
- Governments are separated into two general categories: developed countries (including EU15), referred to as Annex 1 countries, and developing countries, referred to as Non-Annex 1 countries.
- Any Annex 1 entity failing to meet its Kyoto targets is subject to a fine and further penalised by having its reduction targets increased by 30%
- Kyoto includes "linking mechanisms" which allow Annex 1 economies to meet their GHG targets by purchasing GHG emission reductions from elsewhere.

Kyoto foresees a cap-and-trade system that imposes national caps on the emissions of Annex I countries. The agreements are nationally based. However, Kyoto also

[2] Wikipedia, http://en.wikipedia.org/wiki/Kyoto_Protocol

enables groups of several Annex I countries to join together to create a so-called 'bubble', or a cluster of countries that is given an overall emissions cap and is treated as a single entity for compliance purposes.

THE EU EMISSION TRADING SCHEME AND ALTERNATIVE SCHEMES

The EU elected to be treated as such a group, and created the EU Emissions Trading Scheme (ETS) as a market-within-a-market. The scheme went into operation on 1 January 2005, although a forward market has existed since 2003.

The UK established its own learning-by-doing voluntary scheme, the UK ETS, which runs from 2002 through 2006. This market will exist alongside the EU's scheme.

Canada and Japan will establish their own internal markets in 2008, and it is very likely that they will link directly into the EU-ETS. Canada's scheme will probably include a trading system for large point sources of emissions and for the purchase of large amounts of outside credits. The Japanese plan will probably not include mandatory targets for companies, but will also rely on large-scale purchases of external credits.

Next to the EU-ETS, the most important sources of credits are the Clean Development Mechanism (CDM) and the Joint Implementation (JI) mechanism. Both of these allow the creation of new Carbon Credits by developing emission reduction projects in Non-Annex I countries (in the case of CDM) and in Annex I countries (in the case of JI).

Several non-Kyoto carbon markets are already in existence as well, and these are likely to grow in importance and numbers in the coming years. These include the New South Wales Greenhouse Gas Abatement Scheme, the Regional Greenhouse Gas Initiative (RGGI) in the United States, the Chicago Climate Exchange, the State of California's recent initiative to reduce emissions, the commitment of 131 US mayors to adopt Kyoto targets for their cities, and the State of Oregon's emissions abatement programme.

Alternatives to emission trading in the EU

Several possibilities exist to reduce the total CO_2 emissions in the EU. One alternative is to introducing a trade scheme such as current EU-ETS for all emitting sectors. An alternative would be to introduce/reach an agreement about a uniform CO_2 tax, e.g. CO_2-based fuel tax, across all states and sectors. Both of these alternatives are equally efficient in theory, if one disregards issues related to imperfect information and positive transaction costs. In theory, both alternatives lead to the fulfilment of CO_2-reduction to a predetermined level in a cost-effective manner, by equalising the marginal abatement cost across sectors and states. Note also that the systems could coincide. Current EU-ETS does not include all sectors contributing to CO_2 emissions. The transport sector is a main contributor excluded from the system. One alternative would thus be to include the transport sector in current EU-ETS, the premises being that all main emitting sectors should be included in the same system. Another alternative would be to control the emissions from the transport sector through taxes – note that CO_2-based fuel taxes already are implemented in several countries in the EU. Yet another option would be to introduce a separate trade system (cap-and-trade or baseline-credit) for the transport sector.

3.2 Reducing emissions from the transport sector

The CO_2 emissions from the transport sector can be controlled in a number of ways. The optimal way may depend on the particular objectives to be achieved as well as the particular reasons why the market is unsuccessful in spontaneously achieving these objectives.

If the overall objective were to reduce emissions in a cost-effective manner across sectors and member states, including the transport sector in current EU-ETS would be an option to consider. The advantage of such a system, at least in theory, would be that it provides incentives to agents to act in a way that will equalise marginal abatement costs across sectors. It requires, however, that the transport sector is not simultaneously subject to CO_2-based fuel taxes or other taxes linked to CO_2 emissions; cost-effectiveness requires that the total "price" paid by agents for emitting CO_2 is equal across sectors and nations.

However, also the presence of asymmetric information or myopic behaviour may lead to a situation where a uniform trade scheme such as the one mentioned above will fail to generate cost-effective abatement activities across sectors and nations. The reason why a scheme of this kind is needed in the first place is that the market fails in spontaneously generate cost-effective agent behaviour. However, the market may fail for different reasons in different sectors, implying that the optimal scheme to be introduced may differ as well. One difference between the transport sector and the sectors currently included in the EU-ETS is that when it comes to transportation it is primarily the *use* of the vehicles rather than the *production* that gives rise to the emissions. Since consumption has a much longer time span than production, market failures associated with myopic behaviour may be more of a concern in the transport sector than in other sectors, at least seen from a CO_2 emission point of view. Myopic behaviour in the market for new passenger cars may, for example, lead to a situation where the price consumers are willing to pay for new technology that increases the energy efficiency of new cars is insufficient to cover costs, even if car manufacturers were to trade in EU-ETS and thereby receive monetary gains by developing technology that reduces fuel consumption and CO_2 emissions. That is, a separate system may be necessary in order to provide sufficient incentives to increase the energy efficiency in new cars.

There are other reasons why transport sector should not necessarily be included in current EU-ETS. As mentioned above, other systems besides a uniform trade scheme may also have the potential of producing cost-effective outcomes. For example, CO_2-based fuel taxes already exist in the EU. Other taxes or charges are also possible as an alternative to a trade scheme controlling the emissions from the transport sector.

Other reasons for treating the transport sector separately from other sectors may also exist. Sweden, for example, has chosen to impose national CO_2 reduction target levels that are more stringent than what is required by the obligations to the EU. Moreover, specific objectives have been imposed for the transport sector that are more stringent than the national objectives. If specific objectives are set for the transport sector, for whatever reason, a separate system may be necessary in order to guarantee fulfilment of these objectives. One possible reason for imposing specific objectives for the nation (or specific sector) could be to state a good example, e.g. with the intent to attract additional countries to the Kyoto protocol or allow for more ambitious target levels in future international climate change treaties.

3.3 Reducing emissions from new passenger cars

The question is whether to implement a separate system for new passenger cars or include new passenger cars in the system implemented for the entire transport sector. There are two possible reasons to treat new passenger cars separately. First, asymmetric information or myopic behaviour can lead to a situation where incentives to increase energy-efficiency in new cars by technological improvements are insufficient. As shown below there is a great potential for reducing CO_2 emissions from new cars by introducing technology that already exist. The difficult part is to create incentives for manufacturers to make this technology commercially viable. If a general cap-and-trade system or uniform taxes are believed to be insufficient to create such incentives, then there may be an argument to introduce a separate system for new cars.

Another possible reason for introducing a separate system for new cars is that side effects such as outsourcing or relocation of economic activities to low-wage countries may differ between sectors. There is a limit to how much the price of a permit in current EU-ETS can be raised. One reason is that the industries included in the system could relocate parts or all of their operations if the costs of the operations are increased high enough. Car manufacturing is different in the sense that it is primarily the use of the car, rather than the production of the car, that gives rise to the emissions. Since the use of a car is tied to a specific geographical area more than the production of the car – i.e. it is easer to relocate production than to relocate consumption – it may be possible to sustain higher permit prices in the transport sector than in other sectors. This could be a reason for introducing a separate system for the transport sector. If a baseline-credit system is introduced, where manufacturers that produce cars emitting less than the baseline receive credits and where manufacturers that produce cars emitting more than the baseline are forced to purchase credits, no costs would thus be imposed on manufacturers whose average car emits equal to or less than the baseline.

Another argument for introducing a separate trade system controlling the CO_2 emissions from new passenger cars is that such s system can be seen as a possible replacement measure after 2008 when the producer commitments (regarding average CO_2 emissions from new cars) run out.

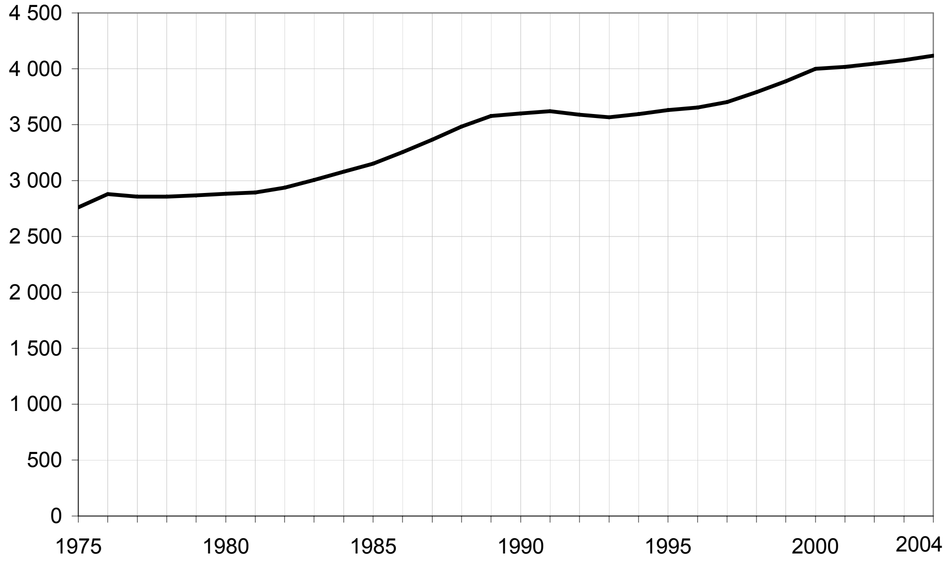
4. Reduction potential

This section gives a background to the mechanisms of reducing CO_2 emissions from new cars. Subsection 4.1 describes trends in car ownership and fleet consumption. In subsection 4.2 the technical possibilities are discussed and in subsection 4.3 the possibilities of affecting consumer behaviour. Subsection 4.4 discusses the costs for reducing emissions from new passenger cars.

4.1 Trends in car ownership and fleet consumption

In Sweden, car ownership has grown approximately at the same rate as the economy during the past 30 years. The number of cars per 1 000 inhabitants has increased from about 300 to 450 during the period, meaning that currently there is close to one passenger car per every two persons in Sweden.

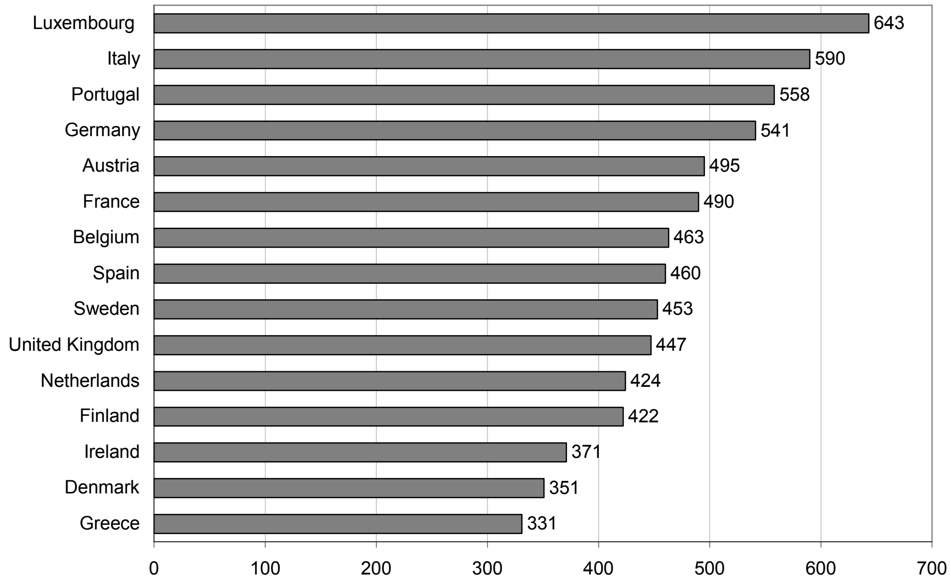
Figure 4.1 Number of passenger cars in Sweden 1975-2004, thousands



Source: SIKA

Comparing the number of cars per inhabitants with other EU15 countries shows that Sweden has a lower number of cars than the EU15 average of 495, see figure below.

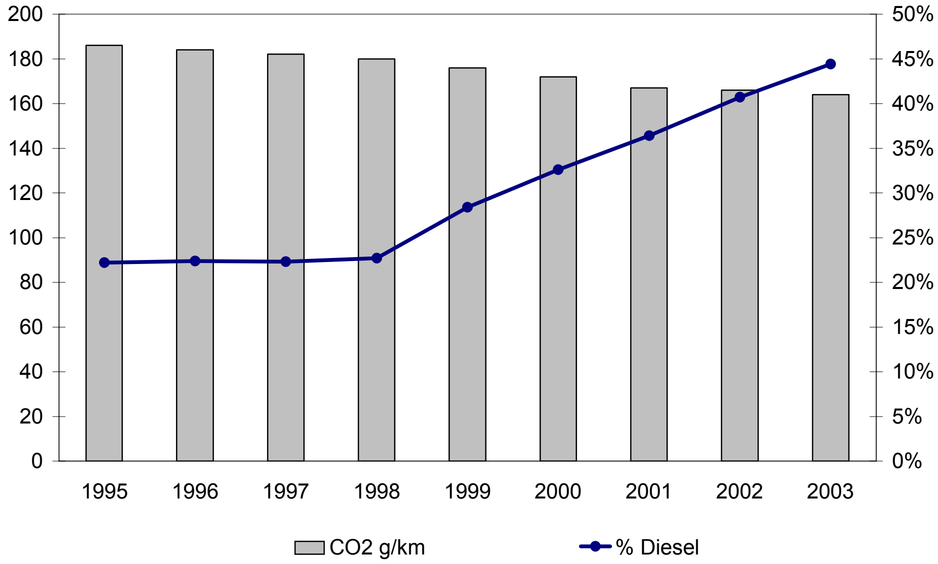
Figure 4.2 Passenger cars per 1000 inhabitants in EU15 countries in 2002



Source: Eurostat

The latest monitoring report from the European Commission shows that carbon dioxide emissions from new cars were reduced from 186 to an average of 164 g CO_2/km in EU15 between 1995 and 2003. (EU Commission, 2005). Part of this improvement comes from a larger share of diesel cars, which are more fuel-efficient. During the monitored time period, the share of diesels among new cars increased from 22 to 44 percent, see figure.

Figure 4.3 Emissions from new passenger cars CO_2/km and the share of new dies el cars in EU15 1995-2003



Source: EU Commission, 2005

All EU15 countries lowered their average CO_2 emissions from new passenger cars between 1995 and 2003. However, the spread between countries is relatively large and has probably been increasing during the time period. In 2003, the group of countries having the lowest emissions included Portugal, Italy, France, Spain and Belgium. Portugal noted the lowest average emissions of 149 g CO_2/km and Sweden had the highest with 197 g CO_2/km. Portugal with its 149 g CO_2/km is relatively close to the ACEA agreement already. In the other end of the distribution Sweden stands out by having average emissions that are 20 grams higher than the second worse country on the list, Finland.

Table 4.1 Country specific average emissions from new passenger cars CO_2/km in EU15 in 2003

	Number of new registrations	Average CO_2
EU	13 578 185	165*
A	299 684	163
B	457 926	157
DK	102 125	168
F	1 987 599	154
FIN	143 404	177
GER	3 152 589	175
GR	202 291	168
IRE	143 463	165
IT	2 240 345	152
LUX	43 723	173
NL	486 484	172
POR	193 655	149
SP	1 318 814	156
SW	257 011	197
UK	2 549 038	171

Source: Authors' calculation based on reporting presented in annexes of EU Commission (2005)
*Note: Data not adjusted by 0.7%, because not all member states submitted necessary data. The effect of the adjustment would be for volumes to move into lower categories

It is not possible to point out any single reason why countries differ in the way shown by the table. Discussions in Sweden have suggested several possible reasons why Swedish consumers buy cars with higher CO_2-emissions than consumers in other European countries. Swedish taxing has been unfavourable to diesel cars[3], thus holding back diesel penetration on the Swedish market (about 10 percent of new registrations in 2003). Also the fact that diesel engines have been traditionally difficult to start at low temperatures may offer an explanation to why Sweden has a low share of diesels. The need to drive long distances may offer another explanation to why car buyers would like to choose large high emitting cars. This could hold for Sweden, Finland and Germany, but not for France and Spain. Disposable incomes do have an impact, but not a very strong explanatory power for explaining the pattern above.

[3] From October 2006 vehicle taxation will change.

One other reason to a large share of high emitting cars could be the influence from company purchases. Buyers of company cars generally have low price sensitivity and little interest in fuel efficiency. In Sweden and the UK about 50 percent of new cars are sold to companies, which is the largest company penetration in Europe, thus offering another explanation to why CO_2-emissions from new cars are relatively high in both countries.

A recent report from the Swedish institute for growth policy studies (ITPS) notes that there is a tradition among consumers to prefer domestic products.[4] The reason why Swedish cars are large and high emitting may be that the domestic brands Volvo and Saab have a small home market and therefore need to produce cars with high profit margins i.e. large cars. Another important trend during the past ten years is the increase in large cars SUV (Sports utility vehicles). This trend, however, is not unique for Sweden. The table below shows simultaneous increases in small cars (small/lower medium) and other cars (SUV/Sports cars). The reduction has taken place in mainly in the upper medium segment.

Table 4.2 New passenger car registrations in EU15 – breakdown by seg-

Years	Small	Lower Medium	Upper Medium	Executive	Others #	Unknown
1990	30.4	27.7	22.9	13.0	2.4	2.7
1995	32.9	31.4	18.7	14.0	2.9	0.1
2000	32.7	34.2	15.7	12.7	4.6	0,1
2001	32.8	33.8	15.9	12.6	4.9	0.1
2002	32.7	33.9	14.8	12.7	5.7	0.1
2003	34.2	32.4	13.7	12.9	6.6	0.1

SUVs, sports cars etc.

Source: Association Auxiliaire de l'Automobile (AAA)

Source: Kågeson (2005) p 6

In many respects, current trends in car ownership work in the wrong direction if we are to achieve an average of 140 g CO_2/km.

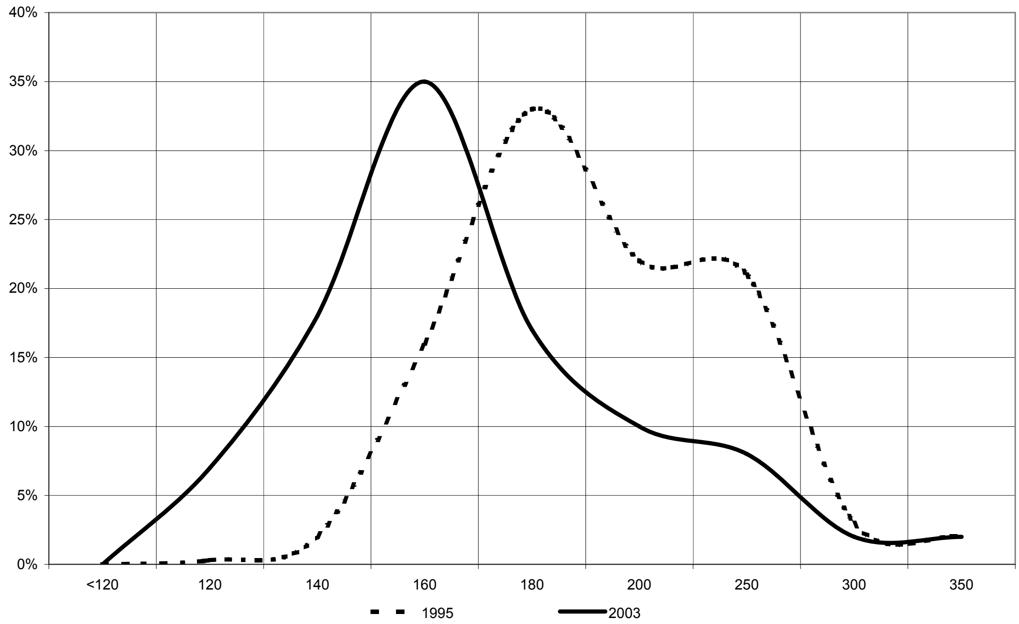
4.2 Reduction potential from new technology

In previous subsection it was mentioned that the average emissions from new passenger cars sold in EU15 has decreased from 186 to 164 gram CO_2/km between 1995 and 2003. The figure below shows the same type of statistics for ACEA

[4] Itps (2005) Stor, tung och svårstyrd: Om restriktioner i syfte att påverka bilparkens struktur. Elin Vinger A2005:020.

members during the same time period. The focus is on the distributions of emissions rather than on average emissions.

Figure 4.4 Distribution of CO_2/km from new cars sold by ACEA members in 1995 and 2003



Source: Appendix of Com(2005)269 final. Brussels 22.6.2005

The figure shows that between 1995 and 2003 the peak of the distribution curve shifted from about 180 to 160 g CO_2/km. It also appears that the peak has become narrower, i.e. there concentration of cars around the peak in 2003 is greater than it was in 1995. However, also in 2003 the distribution remains widespread, including a rather large number of cars emitting more than 200 g/km but few cars emitting less than 120 g/km.

It is expected that additional measures, such as alternative systems of tradable permits for new cars, would affect emissions similarly by shifting the distributions curve further to the left and make it narrower. It is also quite likely that the peak of the curve will continue to lie slightly below the average emission level, i.e. there are more cars to the right of the peak (higher emissions) than to the left of the peak (lower emissions). If this condition remains true also after the introduction of trading schemes or other measures to control the emissions from new cars, it implies that reaching average levels of 120 or 100 g CO_2/km requires a movement of the peak slightly to the left of these target levels. The distribution of 2003 shows, however, that there is hardly any supply of new cars with emission levels below 120 g CO_2/km. This means that unless technological development succeeds in increasing the supply of low-emitting cars, these target levels cannot be achieved.

Technological potential

Achieving objectives such as 120 g CO_2/km for new car fleet requires both changes in consumer behaviour and improved technology. Consumer demand needs to shift from high-emitting to low-emitting cars, while technological improvements are necessary to provide a wide range of low-emitting cars conforming to consumer preferences regarding e.g. vehicle size and performance.

In order to influence consumer behaviour it is necessary that new technology is made available to consumers at low cost. Consumers choose to pay for new technology only if the benefits of improved gas-mileage exceed the costs of higher car prices. Taxes, charges, subsidies or similar measures could be implemented to affect consumer choices. Nevertheless, the possibility of influencing consumer behaviour by introducing new technology will be higher if technology can be introduced in a variety of cars without dramatic price increases.

When discussing technological improvements and CO_2 emissions the following facts should be kept in mind:

- CO_2 emissions are proportionate to the amount of fuel used. Full combustion of a litre of petrol gives emissions of 2.28 kg CO_2, while a litre of diesel gives 2.58 kg. Diesel engines, however, use between 15 and 20 % less fuel than comparable petrol fuelled engines. (SRU, 2005)
- Alternative fuels are available that give less CO_2 emissions than do petrol or diesel engines.

This basically means that there are only two ways in which to reduce specific CO_2 emissions: By reducing fuel consumption in vehicles with conventional combustion engines or by using renewable, low-CO_2 fuels (partly) in conjunction with new engine technologies.

Fuel consumption in vehicles with conventional combustion engines can be reduced in a number of ways. Technological measures can be roughly divided into the following categories:

- Improved engine technology
- Downsizing and enhanced transmission technology
- Energy management and hybridisation
- Vehicle design

IMPROVED ENGINE TECHNOLOGY

When optimising the combustion process a distinction must be made between diesel and petrol engines.

Options for improving petrol engine technology include direct fuel injection and variable valve trains. In conventional petrol engines, petrol and oxygen are mixed outside the combustion area. Losses occur because load control is managed by a throttle valve and this results in increased fuel consumption, especially at partial throttle. This is where significant savings potential is offered by engine control using direct fuel injection combined with stratified charge operation or variable valve control times (8 to 10 per cent reduction), cylinder cut-out (6 per cent reduction) and reduced idling speed (1 to 2 per cent reduction), especially in unfavourable partial throttle conditions (Schmidt et al., 1998; Salber et al., 2001). Consumption could be cut by up to 18 per cent overall (Schmidt et al., 1998; Salber et al., 2001; Merker, 2002; Mehlin et al., 2002; VDA, 2001, p. 22).

Diesel engines use between 15 and 20 per cent less fuel than comparable petrol engines. However, specific CO_2 emissions during combustion of one litre of diesel are about 13 per cent higher than with petrol. The lower consumption levels with diesel are due both to a significantly higher compression ratio and direct fuel injection. Despite combustion with excess air, high-speed fuel injection can still lead to localised starvation and hotspots. Further development of diesel engines thus places its main focus on better injection processes to allow more homogeneous mixtures and ultimately lower emissions (Thiele and Merker, 2004). Lesser potential for optimising consumption lies in improved exhaust gas recirculation and further friction reduction (about 2 per cent each) (Mehlin et al., 2002). In the longer term, the combustion processes in petrol and diesel engines are expected to converge (Steiger, 2003).

DOWNSIZING AND ENHANCED TRANSMISSION TECHNOLOGY

Both petrol and diesel engines attain the best degree of efficiency within a certain performance range. Downsizing and improved transmission aim to ensure that this range is exceeded as rarely as possible. In downsizing, engine capacity reduction forces the engine to work harder. Downsizing is supplemented by forced induction (turbocharging or electronically supported induction) to maintain the engine power (Ellinger et al., 2002). Automatic gear boxes with wider gear spacing (6 or 7 gears) and hydraulically or electronically supported gear change can reduce consumption by around 10 per cent (Hofmann et al., 2002). Automatic gear boxes could be further developed to use continuously variable transmission (CVT) for additional savings of up to 8 per cent (Ellinger et al., 2002).

ENERGY MANAGEMENT AND HYBRIDISATION

Vehicles in city traffic do not actually use their engine power for about 45 per cent of the time (Steiger, 2003). Thus, in city traffic in particular, fuel savings of up to 25 per cent could be achieved by an automatic start-stop mechanism that uses a flywheel system to switch the engine on and off (Neumann and Schindler, 2000). Automatic engine cut-off can result in an overall reduction in fuel consumption of up to 4 per cent (Ellinger et al., 2000). Savings of 3.9 per cent have been achieved in the VW 3 l/100 km Lupo (Mehlin et al., 2002).

In further hybridisation (strong or parallel hybrid), an electric motor with sufficient capacity to power the vehicle independently is installed alongside a conventional combustion engine. This allows three different operating methods: combustion engine, electric motor and a combination of both. The electric motor is usually designed for driving around town and the combustion engine for motorways and other longer distance travel. Use of the combustion engine at unfavourable partial throttle can thus be avoided: while performance demands are lower, the combustion engine still operates at a favourable level of efficiency with excess energy being used to recharge the battery. This also allows targeted downsizing of the combustion engine in that its weaknesses at partial throttle can be compensated for by the electric motor. The parallel hybrid enables regenerative braking, meaning that braking energy is recovered and stored in the batteries. Along with reduced emissions (with the exception of NO_x) (Wallentowitz and Neunzig, 2001), the advantages of the parallel hybrid over petrol and diesel engines make for potential reductions in fuel consumption of between 25 and 34 per cent (Isensee, 2002; Concawe et al., 2003).

The disadvantages of hybrid vehicles are their dual energy storage and dual engines. These affect the vehicle's weight and cost. Further developments (e.g. a starter generator system and associated omission of a starter motor and dynamo) will, however, enhance opportunities for serial production of hybrid vehicles (WB BMVBW, 2002). Toyota already offers a second generation hybrid in the form of its widely marketed Prius model which puts out only 104g CO_2/km and carries less than 100 kg extra weight. Some European manufacturers have presented newly developed hybrid vehicles and have announced plans to put them into production (VDA, 2004).

VEHICLE DESIGN (WEIGHT, ROLLING AND AIR RESISTANCE)

In addition to drive train enhancement and optimised energy management, better fuel efficiency could be achieved by reducing vehicle weight along with air and rolling resistance. A reduction in vehicle weight offers the greatest potential for reduced fuel consumption. A steady increase in vehicle weight has been observed over time: increased demands for comfort, safety, performance and versatility have all resulted in heavier vehicles. To compensate for the additional weight, stronger engines had to be installed. In many cases, this also meant installing bigger fuel tanks, which further increased the vehicle's weight. Thus, from 1995 the average weight of a vehicle rose by around 100 kg and reached 1,214 kg in 2002 (ACEA and offices of the EU Commission, 2001; 2003).

This vicious circle regarding vehicle weight could be broken with the use of new materials and new assembly methods. VW expects potential reductions in vehicle weight of between 30 and 35 per cent overall (Neumann and Schindler, 2000). A study conducted by Arthur D. Little on the outcomes of introducing a CO_2 reduction target of 120 g/km by 2012 reported potential weight reductions of 15 per cent for small cars, 18 per cent for middle-class cars and 30 per cent for luxury vehicles (Arthur D. Little, 2003, p. 26). The reduction in fuel consumption resulting from reduced vehicle weight lies in the region of 0.3 to 0.8 l/100 km per 100 kg weight reduction (Mehlin et al., 2002; Isensee, 2002). A 10 per cent weight reduction in the VW Lupo achieved fuel savings of 8 per cent. Other studies contain considerably more conservative figures, with fuel savings of 3.5 per cent per 10 per cent weight reduction (Arthur D. Little, 2003, p. 116).

A 30 per cent reduction in tyre rolling resistance can achieve fuel savings of between 2 and 6 per cent depending on driving speed (Schedel, 2001). The Federal Environmental Agency (UBA) estimates that the use of low-rolling-resistance tyres offers a potential CO_2 reduction of between 2 and 5 per cent in passenger cars and between 3 and 9 per cent in commercial vehicles (Kolke et al., 2003). Additionally, a 10 to 20 per cent reduction in drag is thought possible with the use of more aerodynamic vehicle bodies without any significant restriction as regards passenger comfort (Enquete Commission, 2002, p. 216 f). The resulting achievable fuel saving potential in light commercial vehicles lies at around 4 per cent (EU Commission, 2004).

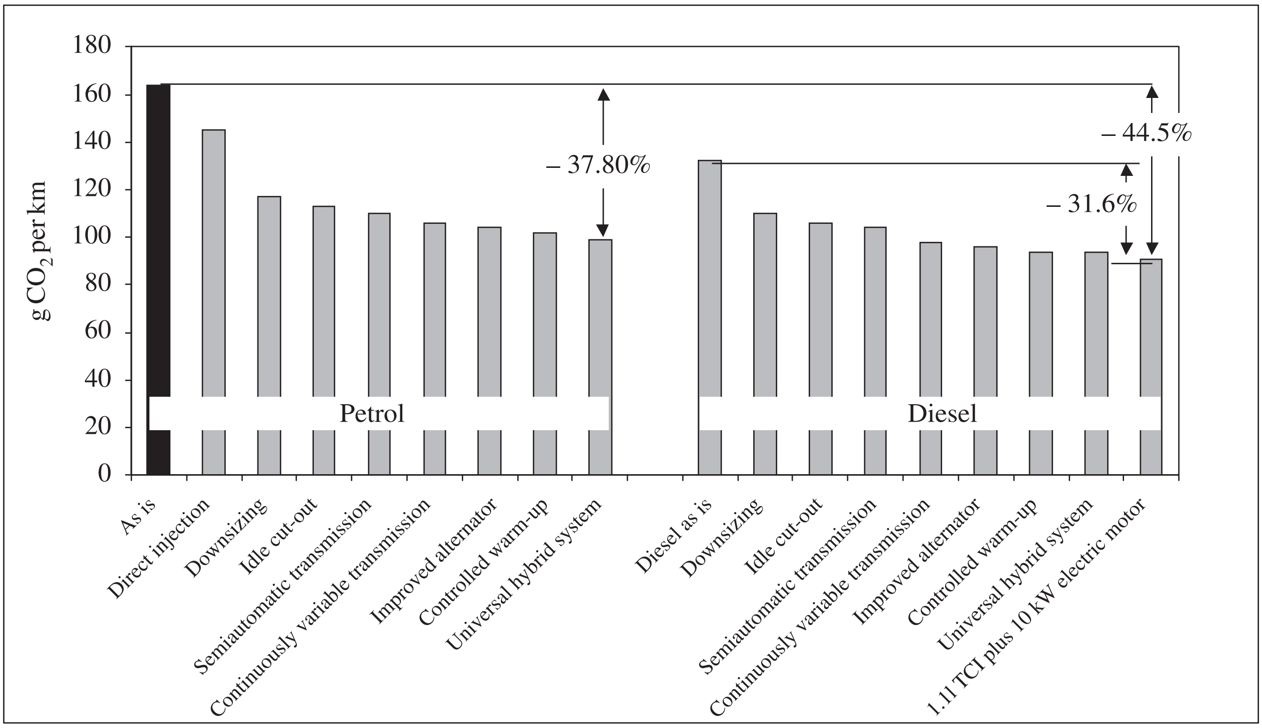
Potential for reduced consumption: Summary

Combustion engines still have considerable potential for fuel-saving and associated CO_2 reduction. In the case of petrol engines, it is thought that measures involving the drive train in a middle-size vehicle (with CO_2 emissions of 164 g/km) could achieve fuel savings of around 38 per cent (Figure 4.5; and similarly Ellinger et al., 2002; Lang et al., 2004; Enquete Commission, 2002, p. 216 ff; Kolke, 1999, p. 47). Further measures such as weight reduction, reduced rolling and air resistance, and promotion of fuel-efficient driving habits can result in a 40 per cent or greater decrease in overall consumption (see also Josefowitz und Köhle, 2002).

Future savings potential expected from diesel motors is significantly lower compared with petrol engines because diesel engines are less wasteful than petrol engines when run (as is often the case) at partial throttle (Fischer, 1998). Also, significant increases in diesel motor efficiency have already been achieved with the use of electronically regulated direct fuel injection with extremely high charging pressures. Nevertheless, hybridisation and improved transmission could result in savings of around 32 per cent (Josefowitz and Köhle, 2002). Additional savings could also be achieved with a reduction in vehicle weight, reduced rolling and air resistance, and by promoting fuel-efficient driving habits.

For the coming decades, therefore, optimised combustion engines will remain the dominant engine type and are unlikely to be replaced to any great extent by electric vehicles powered either by battery or fuel cells. Hybrid vehicles could, however, gain a larger share of the market (Christidis et al., 2003; Merker, 2002).

Figure 4.5 Drive train savings potential in petrol and diesel engines compared with a passenger car with 164 g CO_2/km emissions



Source: SRU (2005)

4.3 Reduction potential from consumer behaviour

Consumers consider several characteristics of a new car before finally choosing the car that best fits their needs and their personal preferences. To reach the objectives of CO_2 emissions from new cars consumers should ideally be concerned about fuel efficiency. Characteristics that increase fuel consumption should for the same reason be of less importance, these include engine power, the size and weight of the car, auxiliary equipment like air conditioning and seat heating. A recent report from the German Advisory Council on the Environment (SRU, 2005) refers to a survey conducted by Deutsche Automobil Treuhand, which shows that factors, like safety and prestige, and more powerful engines, influence consumer behaviour more than does fuel efficiency. Despite the recent increases in fuel prices, only 10 percent of the car owners, that were surveyed, said that they would consider a smaller engine for their next car, while 29 per cent declared they want a more powerful car the next time they buy a new car (ibid, p 30).

The results of the German study suggest there is some potential to improve fuel efficiency by making consumers more concerned about energy efficiency of the cars already existing on the market. Additional regulation of consumer behaviour can to a certain point be cost effective. As long as it is less costly to re-allocate consumer choices among existing car models than introducing new technology, demand management will be cost effective. The costs associated with buying another car than the most preferred one, arises because adjusting behaviour is associated with a sacrifice: theoretically adjustment costs correspond to the value of the benefits foregone.

To make a full assessment of costs efficiency requires information about adjustment costs associated with different kinds of sacrifice, i.e. information about the value of benefits foregone when adjusting behaviour. Since adjustment costs vary between individuals (and also between other buyers, i.e. companies) a full assessment requires data from a large range of consumers. However, even though detailed information is lacking, it is still possible to make a rough estimate about whether an adjustment may give rise to high or to relatively low adjustment costs.

The potential to make cost effective reductions by re-allocating new cars among consumers corresponds approximately to adjustments that have a relatively low cost. Consider, for instance Volvo V70, which was the most popular new car model in Sweden in 2005 (10% of the total market for new passenger cars[5]). The conventional versions of this car model are available with both petrol and diesel.[6] The emissions from the different petrol versions range between 214 and 266 g CO_2/km.[7] Lower emissions correspond to a smaller engine. For the petrol versions of Volvo V70 the power of the engine ranges between 103 and 220 kWh, respectively. Diesels are available with emissions ranging from 171 to 223 g CO_2/km with associated engine powers of 96 and 120 kWh. A movement form the highest CO_2/km per kilometre value to the lowest would imply savings of 95 grams per kilometre. To achieve these savings a consumer who currently prefers the highest emitting car has to change fuel, automatic transmission and engine power. Holding gearbox and engine power constant, a consumer can reduce emissions from 234 to 223 g CO_2/km, if choosing diesel instead of petrol. Sacrificing automatic transmission would reduce emissions further, to 199 g CO_2/km. Among these three adjustments: fuel (petrol/diesel), engine power and transmission, fuel is most probably the adjustment, which is, associated with the lowest adjustment costs. Reducing engine power is probably a larger sacrifice than changing fuels because engine power influences driving characteristics in a more direct way. Also a change of the gearbox affects driving and may, therefore, also be associated with relatively high adjustment costs, at least in the case the driver is accustomed to automatic transmission.

Taking this example further, it is possible to consider other adjustments as well, such as a change to a smaller Volvo or choosing a car of another brand. These adjustments may, on average, require larger sacrifices than those discussed above. Choosing a smaller car than otherwise implies sacrificing space. There are consumers who for one or another reason need a large car, e.g. because of family size. For these consumers adjustment costs would be very high. For small families the sacrifice would probably be less costly. It is also highly probable that adjustment costs are high if consumers have to choose another brand. The driving characteristics of another car make differ in many respects from the one that the consumers prefer and are accustomed to.

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[5] Bil Sweden (2006)
[6] In addition Volvo V70 is available as Bi-Fuel CNG.
[7] Konsumentverket (2005) Bilar, Bränsleförbrukning och vår miljö

Introducing monetary regulation like taxes or tradable permits would automatically lead to cost effective adjustments, meaning that consumers whose relative cost of sacrifice is low, would choose to adjust their behaviour, and those who find it difficult to change behaviour would not adjust. On the whole, the result of cost effective regulation implies larger adjustments where sacrifices are small and smaller adjustments where consumers find the sacrifice to be large.

In a study about how Swedish buyers of company cars would respond to taxes tied to CO_2 emissions, it was assessed that the largest adjustment would stem from a change of fuel from petrol to diesel because the associated cost of sacrifice would be relatively low.[8] The costs of sacrifice associated with smaller engines and smaller cars were assessed as being higher and of approximately the same size. The impact on adjustments was assessed to being one half of the adjustment of fuel. Changing to another brand or giving up the company car was assessed to correspond to the highest adjustment costs.

The study on company car taxation assumed that taxation of company cars would become similar to the system already in use in the UK. Some adjustments were made to fit current levels of Swedish company car taxation. The associated changes and their impact on adjusting behaviour were calculated, see table below.

Table 4.3 Expected adjustments of consumer behaviour for company cars if new CO_2 related taxes would be introduced in Sweden

	Consumers changing behaviour	Reduction CO_2 g/km
Fuel	20%	6.5
Engine power	10%	2.2
Smaller car	10%	1.9
Change of brand	5%	1.2
No company car	6%	-
Total	51%	11.8

Source: Naturvårdsverket (2004) and additional calculations on impacts on g/km

Calculations based on sales top ten of company cars were made to assess the impact of the tax on emissions.[9] Assuming a starting value of 214 g CO_2/km as the average for company cars, would reduce the average with almost 12 g CO_2/km, corresponding to a reduction of 5.5 percent.[10] Since company car taxation concern about 25 percent of all new car sales, the corresponding effect on all new cars would be about 2 percent.

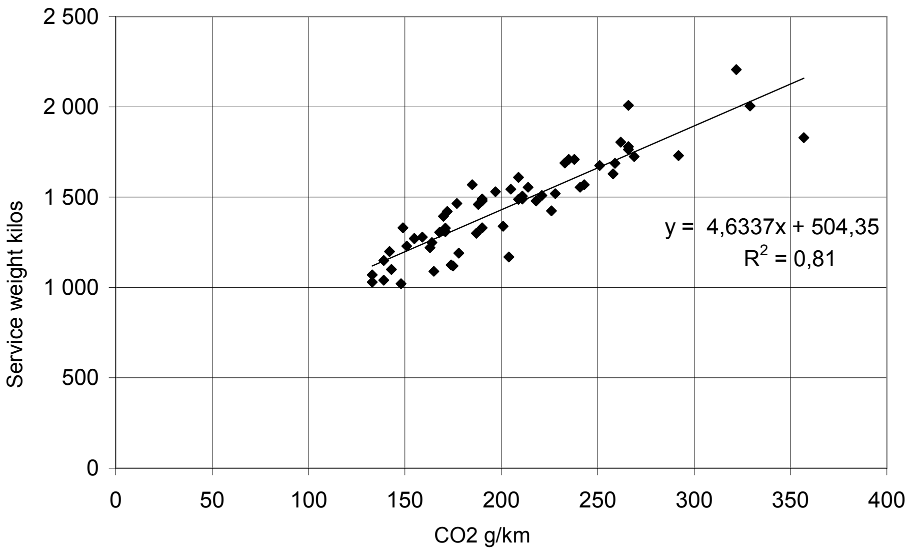
Sales top 30

To find the potential for all new passenger cars, the Swedish sales top 30 in 2005 have been investigated.[11] First we show the range of CO_2 emissions in comparison to several characteristics. After that we assess the potential for cost effective

[8] Naturvårdsverket (2004)
[9] Top ten models make up 70% of the market.
[10] A starting value of 214 assumes that minimum emissions and maximum emissions from petrol and diesel versions are distributed 50-50 for the top ten models.
[11] The top 30 models made up 70 percent of sales in 2005.

reductions. The characteristics that reduce the average emissions of CO_2/km include consumer adjustments that concern the weight of the car, engine size, fuel and auxiliary equipment. The plot between CO_2 and service weight for top 30 petrol cars is shown in figure 4.6 below. The figure shows clearly that heavier cars emit more CO_2 per kilometre than the lighter ones and that the relation is strong having a correlation coefficient of 0.9.[12] The relation for diesel cars is not shown here, but is very similar to that of petrol cars.

Figure 4.6 CO_2 emissions and service weight for petrol cars of sales top 30 in Sweden in 2005



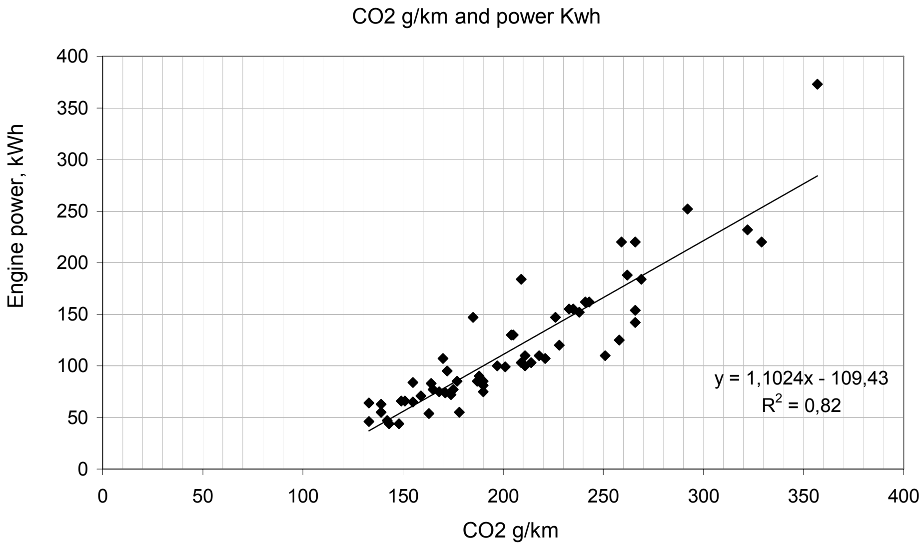
Source: Konsumentverket (2005) and BilSweden (2006)

Note. The plot shows the relation of minimum CO_2 and Service weight and maximum CO_2 and service weight for top 30 petrol cars

Similarly, the plot between emissions of CO_2 and engine power shows a strong correlation, see figure below.

[12] Correlation coefficient = $\sqrt{R^2}$

Figure 4.7 **CO_2 emissions and engine power for petrol cars of sales top 30 in Sweden in 2005**

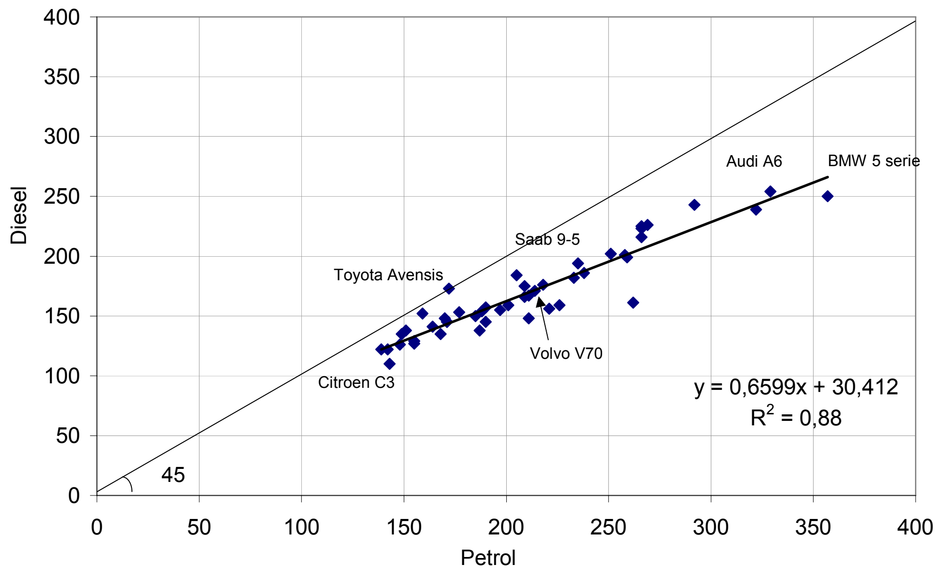


Source: Konsumentverket (2005) and BilSweden (2006)

Note. The plot shows the relation of minimum CO_2 and Engine power and maximum CO_2 and Engine power for top 30 petrol cars

It was concluded earlier that consumer adjustment costs are lower for changing fuels from petrol to diesel.[13] The next figure shows a plot between petrol and diesel models.

Figure 4.8 **CO_2 emissions of petrol and respective diesel model of sales top 30 in Sweden in 2005**



Source. Konsumentverket (2005) and BilSweden (2006)

[13] Adjustment costs from conventional fuels to alternative fuels such as ethanol or biogas are much higher because of the lower availability of alternative fuels at filling stations.

The 45-degree line depicts the position of models that have equal emissions from petrol and diesel. There is only one model on the line: Toyota Avensis. Besides fuel, the two Avensis differ with respect to engine power. The petrol version is the lowest emitting Toyota Avensis on the Swedish market and has an engine power of 95 kWh. The diesel version has an engine of 85 kWh. The other car models are, as expected, clearly below the line.

The differences due to gearbox range from zero to 20 g CO_2/km. Emissions from CVT automatic transmission do not differ from manual transmission. Auxiliary equipment is not included in the emission statements of the EU cycle. But they still affect emissions, air-conditioning, for instance, affects emissions by 3-8 percent.[14]

Potential for cost effective adjustments

To assess the potential to reduce CO_2 emissions, several calculations have been carried out based on sales top 30 in 2005. The first calculation was made to find out the maximum potential to reduce CO_2 emissions from new cars. It was assumed that all buyers of new cars continue to buy their most preferred model, but instead of their current version they choose the minimum-emitting one. Unless additional regulation was introduced, it was assumed as a starting point that emissions were on average 197 g CO_2/km and that the share of diesel cars was 10 percent. Supposing adjustments would result in 100 percent diesel penetration and that all buyers buy the lowest possible emitting diesel version of their most preferred model reduces average emissions to 167 g CO_2/km.

Assuming a more realistic scenario, the next calculation assumed that only an adjustment of fuel was possible. Supposing the share of diesels would rise to 50 percent of new cars, which is equivalent to current market penetration of many EU countries, average emissions would go down from 197 to 184 g CO_2/km. Following the company car taxation study, it was then assumed that additional adjustments towards a smaller engine (within the same car model) would be only half of the size of the impact on fuel shifts. This calculation showed a potential to reduce emission further from 184 to 175 g CO_2/km.

Based on current information, it is not possible to say what the exact size is of the potential for cost effective reductions by re-allocating among new cars. We need to know the value of benefits foregone and we need information about the costs for introducing new technology. However, what these calculations show is that there is potential to reduce CO_2 emissions from new cars with 13-30 g CO_2/km within the same car model - and it is possible to argue that these re-allocations do not represent very large sacrifices for consumers. The potential to reduce emissions related to small sacrifices is somewhat larger in Sweden than in other European countries, due to low diesel penetration. In the rest of the European Union the potential most probably lies in the lower end of the interval.

[14] Konsumentverket (2005)

4.4 Cost of reducing emissions from new cars

In IEEP (2005) an assessment is presented of the economic, business and environmental impacts of different schemes leading to the target level of 120 g CO_2/km emissions from new registrations of passenger cars by 2012. Since the reduction potential as well as the abatement costs vary depending on engine technology (diesel or petrol) and vehicle size, separate abatement cost curves have been estimated for six representative car types; small, medium and large sized petrol and diesel cars respectively. Included in the study is a prognosis of the development of the structure of the new car fleet, e.g. the share of small, medium and large scale cars as well as the share of petrol and diesel cars.

To assess the cost impacts of a 120 g CO_2/km target, the following cost data have been used by IEEP (2005):

- Ricardo: Update of the "Carbon to hydrogen" roadmaps for passenger cars (2003)
- Arthur D. Little (ADL): Investigation of the Consequences of Meeting a New Car Fleet Target of 120 g/km CO_2 by 2012 (2003)
- German Aerospace Centre (DLR): Preparation of the 2003 review of the commitment of car manufacturers to reduce CO_2 emissions from M1 vehicles (2004)
- JRC/CONCAWE/EUCAR: Well to wheels analysis of future automotive fuels and powertrains in the European context, Tank to wheel report (2003)

Cost curves

The baseline cars used by IEEP (2005) to develop cost curves for the various car types are presented in Table 4.4.

Table 4.4 Specifications of 2002 baseline cars

Averages	LD	LP	MD	MP	SD	SP	Grand Total
Total CO_2	200.7	237.5	152.9	183.7	123.2	148.5	166.4
Vehicle mass	1689.5	1499.7	1365.0	1260.7	1028.5	957.3	1236.1
Power	100.7	129.4	81.7	85.7	54.2	52.5	77.3
Engine capacity	2326.3	2439.0	1949.6	1725.6	1606.0	1238.2	1732.5
Length	4.6	4.5	4.4	4.3	3.8	3.7	4.2
Width	1.8	1.8	1.8	1.7	1.7	1.6	1.7
Height	1.7	1.5	1.5	1.5	1.4	1.5	1.5
Volume (l*w*h)	14.1	12.4	11.4	11.0	9.1	8.9	10.7
Consumer price Euro	34 737.5	51 039.6	23 643.6	28 932.7	14 896.4	13 442.9	24 162.6

Source: developed from Polk Marketing Systems data.

Note: L=large, M=medium, S=small, D=diesel, P=petrol

The average CO_2 emissions for all of the cars included in the data set were calculated to 166 g/km.

The 2002 baseline technologies for these six baseline cars are presented in Table 4.5.

Table 4.5 2002 baseline technologies

	Petrol, Small	Petrol, Medium	Petrol, Large	Diesel, Small	Diesel, Medium	Diesel, Large
Engine layout:	4 cylinder in-line	4 cylinder in-line	4/6 cylinder in-line	4 cylinder in-line	4 cylinder in-line	4/6 cylinder in-line
Fuel system:	Multi point injection	Multi point injection	Multi point Injection	Common rail direct injection	Common rail direct injection	Common rail direct injection
Gearbox:	5 speed manual	5 speed manual	5 speed manual (automatic)	5 speed manual	5 speed manual	5 speed manual (automatic)

In order to estimate abatement cost curves for each of the six car types, 20 technology packages were identified and analysed. For both petrol and diesel cars, the CO_2 benefit and costs of each possible technology package were calculated. For petrol this meant 4800 technology packages and for diesel 1440 packages (because of the fewer engine related technology options available with diesel). See IEEP (2005) for further details.

Figure 4.9 below shows the cost curve developed for small petrol car. Figure 4.10 brings all six cost curves together for comparison. It is assumed that the cost increases be reflected in the retail price. The curve thus illustrates the relationship between CO_2 emission reduction and retail price increase, holding fixed the size of the car.

Figure 4.9 Cost curve for small petrol engine

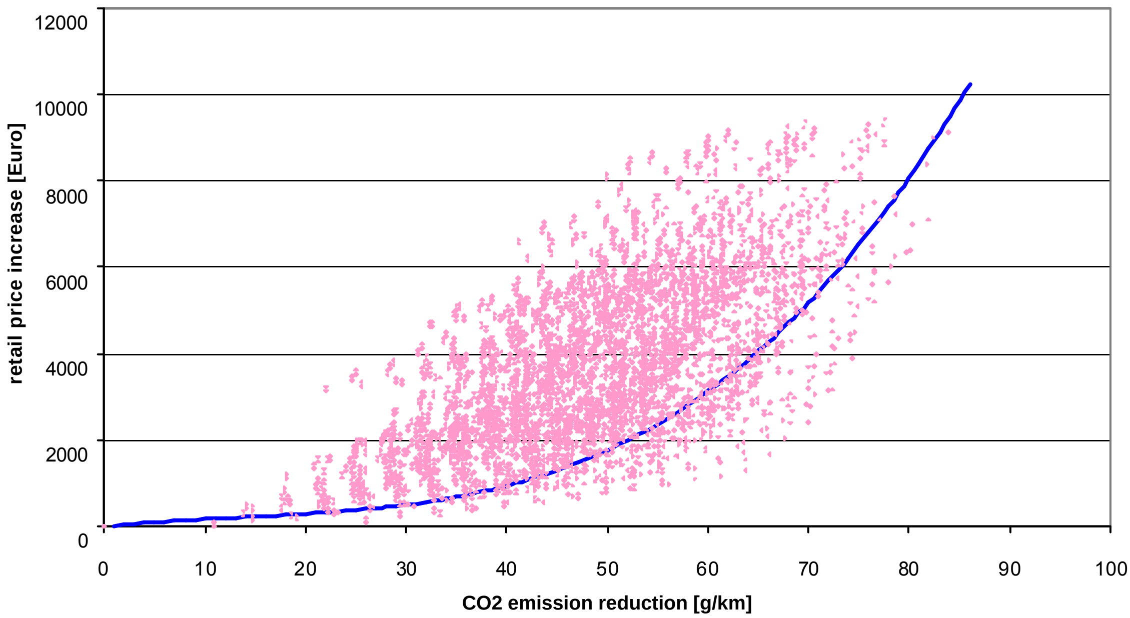
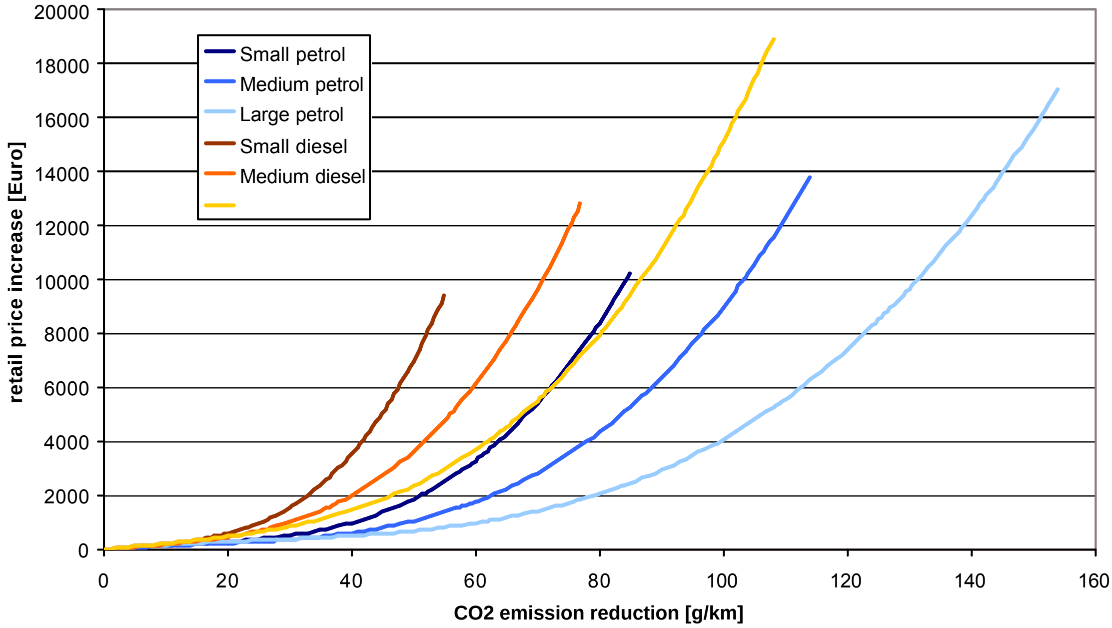


Figure 4.10 All cost curves



Source: IEEP (2005)

Figure 4.10 illustrates that, at a given cost, larger reductions are generally available from large cars than from smaller ones, and from petrol cars than from diesel ones. The information in the figure can also be used for estimating abatement costs. A simple exercise helps to show the approximate abatement costs for reaching an average of about 120 grams per kilometre. First we need to estimate the market shares of the different car types. Data in the beginning of this chapter in table 4.2 gives some guidance on possible market shares of the car types in the IEEP study. According to table 4.2 large cars made up about 20 percent of new registrations (in table 4.2 the sum of executive and others is 19.5). Small cars have a share of 34 percent and medium sized cars 46 percent. Assuming diesels make up 50 percent of each car type, the share of small cars need to increase somewhat in order to replicate the starting value of an average of 166 gram CO_2 per kilometre, see table 4.6.

Table 4.6 Approximate abatement costs

Car type	CO_2 (g/km)	Market share	Increase in retail price	Reduction in g/km	CO_2 (g/km)
LD	200,7	0,1	2 000	45	155,7
LP	237,5	0,1	2 000	80	157,5
MD	152,9	0,21	2 000	40	112,9
MP	183,7	0,21	2 000	60	123,7
SD	123,2	0,19	2 000	30	93,2
SP	148,5	0,19	2 000	55	93,5
Average	166,1	1,0		49,6	116,5

In order to reach cost effective abatement, the increase in retail prices has to be equal for all car types (the assumption is that increased retail price directly reflects marginal abatement cost, where equalised marginal abatement costs is a condition for cost efficiency). For carrying out the calculations we also need to make an assumption about future market shares of the six car types. Typically buyers of small cars are more price sensitive than buyers of large cars, which implies that the market share of small cars may decrease due to the (equal) price increases. On the other hand, additional measures, such as a cap-and trade or a credit system for new cars will reallocate the cost burden to high emitting cars. In addition, current trends show increasing shares of large cars. In order to keep calculations simple, we therefore assume market shares stay constant. This exercise should thus give an approximate range of abatement costs. The calculations show that with constant market shares, an increase in retail prices of about 2 000 euro per car corresponds to a reduction of almost 50 grams per kilometre of an average car, bringing the average emissions from new cars to about 117 g/km. By similar reasoning, an increase in retail prices of 6 000 euro would reduce average emissions to approximately 95 grams per kilometre. Assuming the prices increase to 2 000 euro and the average emissions will be reduced by 50 g/km per kilometre implies a cost per allowance of about 40 euro. (Assuming one allowance corresponds to one gram per kilometre).

It is possible to arrive at a more exact estimate for reaching different targets by using the actual cost equations. Table 4.7 shows the estimated cost equations as well as the starting CO_2 emission level for each car type.

Table 4.7 Total abatement costs

Car type	CO_2 (g/km)	consumer price	Retail price increase (marginal abatement cost)
LD	200.7	34 738	$0.0165x^3 – 0.4x^2 + 26x$
LP	237.5	51 040	$0.0072x^3 – 0.54x^2 + 23x$
MD	152.9	23 644	$0.032x^3 – 0.6x^2 + 23x$
MP	183.7	28 933	$0.0135x^3 – 0.65x^2 + 20x$
SD	123.2	14 896	$0.074x^3 – 1.5x^2 + 30x$
SP	148.5	13 443	$0.025x^3 – x^2 + 25x$

Source: IEEP (2005)

Each equation gives the mathematical form for the curves illustrated in Figure 4.10 above. Cost effective abatement implies that marginal abatement costs should be equalised. With information about the number of cars of each type (currently and if possible a prognosis for future development), one can thus from the equations in the table calculate the minimum cost of reducing the average emissions from all cars to target levels such as 120 g CO_2/km or 100 g CO_2/km.

5 Design of a system for new cars

This section analyses the design of a possible trading system for new cars. Subsection 5.1 discusses the possibilities of including new cars in the current emission trading system of the European Union. Due to the difficulties in reaching policy goals for new cars, if included in the EU-ETS, we suggest a separate system designed as a baseline and credit system, which is further developed in subsections 5.2-5.4. Subsection 5.5 considers the need for complementary measures.

5.1 Linking or a separate system?

Currently, member states of the European Union are preparing allocation of emission allowances for the second period of the EU-ETS. The first chance for transports to opt-in would be in 2008. Although emission trading for transports is gaining support, a more realistic time frame may be inclusion of transports into the renegotiated scheme from 2012. The main discussions about including transports concern emissions, not specifically emission standards for new cars. However, emissions trading for new cars may be seen as a possible replacement measure after 2008 when the producer commitments run out.

If linking new cars to the EU-ETS a trading unit needs to be worked out. The EU-ETS, being a cap-and-trade system based on total emissions requires that the emission intensity of new cars can be translated into emissions. The German Advisory Council for the Environment (SRU, 2005, p. 33) suggests a system that considers lifetime mileage of new cars and where car manufacturers are the trading entity. Below we assume an application of their suggestion for linking to the EU-ETS.

Advantages if linking

There are several advantages of linking a system of tradable permits for new cars to the current system of the EU-ETS. Since one of the main advantages of an emission trading system is that reductions takes place where abatement costs are the lowest, linking to the EU-ETS will imply cost savings for society as a whole. The costs for reducing emissions will, therefore, be lower than if setting up a separate system for new cars.

Another advantage of linking to EU-ETS is that there is already a functioning market. Transaction costs will be lower than for a separate system, and this holds for both traders and for initial administration because institutions are already in place.

The EU-ETS covers over 11.500 installations across the EU. Having such a large number of traders helps ensuring that markets will not be too thin, i.e. there is sufficient interest in buying and selling allowances, certifying that lowest cost for society can be achieved. In addition, having a large number of traders reduces the risk for strategic behaviour.

Disadvantages of linking

One disadvantage of linking to the EU-ETS was mentioned in chapter three, and that is that there is no guarantee to what extent total emissions from transports or from new cars will be reduced. It is, therefore, uncertain whether politically set objectives for reducing CO_2 from the transport sector can be achieved. Transports would pay the same unit price for emissions as other sectors. Sectors with the lowest abatement costs would reduce their emissions more than other sectors. It is generally more difficult to reduce carbon dioxide from transports than from e.g. the energy sector, because there are fewer low carbon alternatives to substitute for conventional technologies in the transport sector. The so far limited availability of alternative fuels further impairs market penetration of environmentally friendly vehicles. Greater difficulties to reduce CO_2 from transports than from the energy sector implies that abatement costs for reducing CO_2 emissions from transports are generally higher than in the sectors already participating in EU-ETS. Linking to the EU-ETS may, therefore, result in reductions mainly in the other sectors, and sales of additional permits to the transport sector. This discussion holds both for the case when linking total emissions from transports and for the case linking new cars. It will, therefore, not be possible to enforce a cap on emissions from transports by linking to the EU-ETS.

Still, however, the incentives will work in the right direction. If all new cars must present a certain amount of tradable permits, the price of new cars will increase, and these price increases will be larger for high emitting vehicles, implying that there will be incentives towards low emitting cars. But it will still not be possible to ensure that specified target levels such as 120 or 100 g CO_2/km be reached, since a cap-and-trade system concerns total rather than average emissions.

The German Advisory Council for the Environment (SRU, 2005, p. 33) notes that price incentives from including new cars to the EU-ETS according to their suggestion will have only very limited impact. A car having an average of 200 grams would need 16 tradable permits to cover lifetime emissions exceeding an average of 120 g CO_2/km.[15] With a permit price of 20 euro, the additional cost of a new car would be 320 euro. The German Advisory Council for the Environment notes that the additional costs may be too small to have any significant effect on demand for high emitting vehicles (ibid). Note, also, that the calculations in Section 4.4 suggested that retail price needs to increase by about 2000 euro in order for the target level of 120 g CO_2/km to be reached.

The conclusion that specific objectives for the transport sector cannot be achieved if linking the system to current EU-ETS, suggests that one may instead design a separate system for the transport sector. If the primary objective is to reduce the average emissions from new cars, then a cap should be placed on average, rather than total, emissions. Suppose, for example, that the current average is 160 g CO_2/km and that the objective is to reduce the average by 38 % (to 100 g CO_2/km) by 2018. Would this be achieved if the total permits were reduced by 38 %? Yes if the introduction of the trading system had no impact on the number of cars sold

15 Life time emissions exceeding the target level are: (200-120)*200,000=16,000,000 grams=16 tons

and if the number were the same 2018 as in the starting year. No if the number of cars was different. The problem is that the objective is specified with respect to average emissions, all cars included, while the units of trade are with respect to total emissions.

Conclusion

The disadvantages of linking an emission trading system for new cars to the EU-ETS are possibly larger than the advantages. In addition, other measures may be more efficient. Given the goals to reduce average emissions, taxing new cars, with a sales tax differentiated by emission values would perform better than linking to the EU-ETS. A separate cap-and-trade system for new cars is better than linking, but neither in this case, will it be possible to enforce the target level for new cars. The conclusion is, therefore, that an emission trading system for new cars should be separated from the EU-ETS and designed as a baseline and credit system, based on emission intensity.

5.2 Baseline reduced over time

Setting up a separate emission trading system for new cars as a baseline and credit system involves defining a baseline. It is natural to tie the baseline to the goals that are under discussion in the European Union i.e. 140 and 120 g CO_2/km. The voluntary agreements between automobile producers and the European Union have set 140 CO_2/km to 2008/2009. Different time frames have been discussed for reaching 120 g CO_2/km. One possibility is 2012. Referring to the earlier discussions about technological development shows that even a stricter baseline is within the range of known technology. Currently available technologies for conventional cars have the potential to reach 100 g/km. The costs for reaching an average of 120 g CO_2/km have been calculated to approximately 2 000 euro, measured in retail price increase. Reaching stricter targets, such as 100 grams will in the short term imply much higher costs.

There are clear advantages of moving towards the goal by reducing the baseline step by step. Too rapid reductions will lead to large price increases, which in turn could have negative side effects such as spill over to second hand markets and imports of used cars. Reaching the 100 g/km target should be seen as a long term target. The design of a step-by-step system could rest on an annual baseline that is reduced each year. Sales data and emission standards are available on annual basis, making it reasonable to carry out monitoring and revisions of the baseline yearly.

5.3 Initial allocation of credits

Before trade can take place, demand and supply of credits need to be created. In a cap-and-trade system initial allocation of permits is a very important issue, because the choice influences the allocation of income. In the baseline and credit system the allocation of credits is automatic: cars below baseline receive credits and cars above baseline need to purchase credits. In principle, this implies that no cost is imposed on the baseline car. High-emitting cars will become more expensive and low-emitting cars less expensive. The credits will work in a way similar to a system of subsidies for cars emitting below the baseline and taxes for those above.

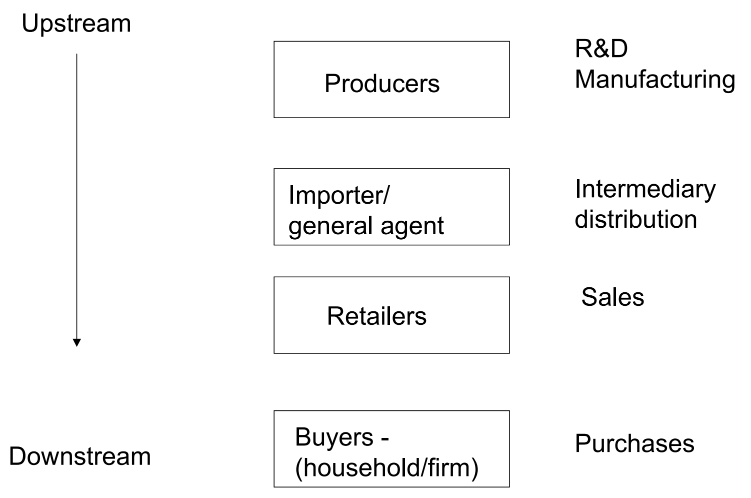
5.4 Trade market and entities trading

Trade with credits need to perform in a way that supports attainment of the baseline. A possible solution is that credits are traded in a market that is similar to a stock exchange. The offers of sellers and the bids of buyers will meet in a market that ideally clears each trading day. If, for instance, there are two sellers each of them offering 50 credits, and one buyer who needs to purchase 100 credits, the transactions can be carried out. As long as markets clear, i.e. demand meets supply, there is attainment of the baseline. To overcome imbalances, an accommodating system that handles short time excess credits or shortages will need to be worked out. There is also a need for an enforcement and compliance mechanism. Another issue to deal with is that there may be different incentives for buyers and sellers. Buyers will generally be obliged to buy credits. Sellers, on the other hand, may want to capitalise their credits later, or to bank them for coming periods. The differences in incentives can lead to shortages and an upward pressure on prices and fluctuating prices. In order to avoid major price fluctuations it will be important to make sure that credits for sale are put on the market. This can be achieved for instance by introducing strict rules regulating the time trading entities may bank credits before they are obliged to sell them.

Entities trading: Downstream or upstream?

The issue whether trade of credits should take place downstream or upstream includes several options in the production-consumption chain. The figure 5.1 below shows an overview of possible trading entities. In principle, trade can be performed at whatever level in the production-consumption chain.

Figure 5.1 Potential trading entities production-consumption chain of new cars



PRODUCERS

Choosing upstream implies that producers of cars trade with credits. Trade could take place, e.g. when the new cars leave the production line. Each car above the baseline will need to show a certificate it has acquired an amount of credits that corresponds to the grams that the car exceeds the baseline. Cars below the baseline will need to show a certificate that their credits have been put on the market. A trading system that involves producers is advantageous because it gives direct incentives to manufacturers to develop more energy efficient vehicles. This aspect is important, since only manufacturers control research and development. There are, however, some less advantageous factors. Car manufacturers generally produce cars for the global market. It may be difficult for production plants to make an advance assessment whether a specific car will be sold on the EU market and therefore is in need of credits. Another, probably a more severe problem, is that the number of car manufacturers is limited. When there is a small number of traders, strategic behaviour, may become a problem.

GENERAL AGENTS

The next potential trading entity is the importer and/or general agent. If designating trade at this level, strategic behaviour can be avoided, because there is a large number of importers and general agents across Europe. Neither will there be problems in identifying whether a car will be sold on the EU market or not. Sales or purchases of credits could take place before cars are passed on to the next level in the distribution chain. This implies that when handing over the car to the retailer, the importer/general agent supplies a certificate that trade has taken place.

CAR RETAILERS

Car retailers are the next potential trading entity in the figure. In comparison to producers, retailers as traders have similar advantage as the importer/general agent. There are even some additional advantages. Sales or purchases of credits are not required until the car finds a buyer. This may be an advantage because some cars that are on display may have to wait for a long time before finding a buyer. Engaging car dealers will help to ensure that credits are traded the same year as the car. Trade with credits in earlier stages can lead to monitoring problems because trading data and car sales statistics may concern different years. Another advantage is that car retailers have direct contact with buyers and they are in position to influence buyer decisions. Trade of credits could take place in connection with registration and be a part of the obligatory paper work.

BUYERS

If choosing the downstream alternative for trading credits, households or firms that purchase a new car will be obliged to sell or purchase credits. This will make visible the price of the credit and have a direct influence on buyer behaviour. An upstream system will affect behaviour in the same way, at least as long as we assume that agents behave rationally and that markets are working. It was, however, pointed out that there is a risk of market failure, due to strategic behaviour at producer level. Another potential problem that may occur is low transparency of credit prices. If information about credit prices for some reason is suppressed a downstream approach will be superior to upstream. A possible reason for suppressing information about credits could be that car dealers receive higher margins for cars that are more high emitting, e.g. luxurious cars. To increase transparency daily or weekly, mean credit prices could be stated publicly and on the receipt. One disadvantage of downstream is, however, is that most buyers buy new cars infrequently. Because of relatively high transaction costs for using a market that resembles the stock exchange, it is probable that there will be a need of specialised brokers. One potential group who is continuously engaged in buying and selling cars is car retailers, and they would thus have comparative advantages to develop new broker services.

RECOMMENDATION

Judging from the above discussion we recommend car retailers as the trading entity in system of tradable credits for new cars. We also suggest gradual reductions in baseline. The above discussion suggests a general framework to assign car retailers as traders. The details of a system of baseline and credits will need further analysis. The discussion above builds on following ideas.

- Credits will be tied to individual vehicles
- Credits will be traded on a market where offers of sellers will be matched with the bids of the buyers
- Mechanisms will be needed to ensure that credits for sale will be put on the marker
- After exchange, credits must be withdrawn from circulation

Important issues in a future analysis will be designing mechanisms for compliance, monitoring and penalising. Incentive problems need also to be dealt with. In the case of the suggested market, incentive problems resembling those of tax evasion may occur. Making the procedure of registering a car dependant there is a certificate that trade has taken place can curb some of these. Monitoring achievement of the goal will be easier if the trade of credits is closely related in time to the sale of the car (and first time registration). Gradual annual reductions of the baseline may otherwise make it difficult to trace to what year trade of credits and registration of specific car belongs.

5.5 Need for complementary measures

Above we have discussed a Baseline and credit system for new passenger cars. In order for such a system to optimally contribute to the global emission reduction, there are at least two reasons for introducing complementary measures:

- The system aims at controlling average emissions from new passenger cars.

- There are potential side effects of the recommended system.

Cost effective reduction of global CO_2 emissions

A Baseline and credit system for new passenger cars could be an effective way to create incentives to car manufacturers to make the introduction of new technology in new vehicles economically viable, thereby further reducing the average emissions from new cars. New cars, however, although eventually becoming used cars, constitute a rather small fraction of the total emissions from the transport sector. The transport sector, in turn, is a major contributor to the total emissions. Other sectors, e.g. the energy sector, are included in the current EU-ETS. If introducing a specific system for new passenger cars, there is a need to also introduce a system controlling the emissions from the transport sector as a whole. Such a system should not only include other new vehicles, besides passenger cars, and used vehicles of different types, but also create incentives for emission reduction through changed consumer behaviour such as fewer and shorter trips by car and a shift towards low-emitting alternatives such as walking, bicycling and public transport.

In Section 3 we discussed the possible reasons for introducing separate systems controlling CO_2 emissions from the transport sector and specific systems for new passenger cars. One reason was that political objectives may exist controlling the emissions from the transport sector or controlling the technological advances in new passenger cars specifically. Another reason was that systems aimed at reducing CO_2 emissions may give rise to side effects, effects that may differ between sectors, and that separate systems could be introduced as means to handle these side effects more effectively. In the long run, however, the objective is to reduce *global* emissions in a cost-effective manner. This means that all activities leading to emissions should be included, not only in the EU but also globally. It also means that emissions should be reduced where the abatement costs are the lowest, implying equalised marginal abatement costs in all sectors and nations. One way to achieve these conditions is to include all sectors in the same trading systems. An alternatively would be to introduce a tax-based system (in certain sectors) where the tax per unit emitted is set equal to the price of corresponding allowances.

Handling the side effects of a Baseline and Credit system for new cars

Complementary measures may also be necessary in order to handle the potential side effects occurring as the system is implemented. One possible side effect is that the manufacturers react by specialising in low-emitting cars to consumers in the EU and higher-emitting cars to consumers outside of the EU, i.e. that the manufacturers aim at a geographic redistribution of their car fleet rather than developing new technology for the markets within as well as outside of the EU. This would reduce the emissions in the EU but would have lesser effects on global emissions

Another side effect, related to the above mentioned, is that the demand for imports of high-emitting “new” used cars would increase. One could e.g. expect to see a rather big inflow of relatively new cars from countries outside of the EU. This problem may be bigger in some parts of the EU than in others. As shown above, the situation in e.g. Sweden and Portugal is rather different, Portugal having the lowest average emissions and Sweden the highest. The problems with side effects is expected to be higher in a country such as Sweden, where the consumers for various reasons have shown preferences and have become accustomed to owning high-emitting car.

One possible side effect, if the car manufacturers are the ones trading, is that incentives to engage in strategic behaviour may arise due to the relatively low numbers of traders. The Baseline and credit system implies that car manufacturers with a car fleet that on average have lower emissions than the baseline, will be the ones selling credits to manufacturers with cars emitting more than the baseline level. If the baseline is set very low, this means that the number of manufacturers selling credits will be relatively small. It also means that if these manufacturers decide to withdraw the allowances from the market, the manufacturers of the high-emitting cars will either be unable to sell their cars (due to lack of credits) or be forced to pay a rather high price. Either way a possibility for the manufacturers specialising in low-emitting cars will arise to act as a cartel earning monopoly profits and possible also trying to run other manufacturers out of the market.

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Emission Trading Systems for New Cars

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Cars could be much more fuel efficient. The impact of the transport sector on climate change could be greatly reduced if new cars emit lower levels of carbon dioxide. Market-based instruments could be used to help sellers and buyers choose more efficient models.
This comprehensive report on trading of emission permits is a valuable contribution to the important discussion on how to move forward on carbon dioxide emissions from transport. It makes useful reading for regulators and industry, as well as for an interested general public.

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