

# Reducing CO<sub>2</sub> Emissions from New Cars

A progress report on the car industry's  
voluntary agreement and an assessment of  
the need for policy instruments

Per Kågeson



European Federation for  
TRANSPORT and ENVIRONMENT

## **Reducing CO2 Emissions from New Cars**

A progress report on the car industry's voluntary agreement and an assessment of potential policy instruments

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Per Kågeson  
Stockholm, January 2005

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## 1. Introduction

The aim of this report is to discuss the need for policy instruments that can help Europe reduce the specific CO<sub>2</sub> emissions (per km) from new passenger cars. It includes an analysis of the results of the 1998 voluntary agreement between the European Commission and the motor industry on CO<sub>2</sub> emissions from new cars.

Europe may in future make use of high energy and carbon taxes or a cap and trade system that covers carbon emissions from all sectors of society. In such a situation it does not necessarily follow that a supplementary tool that affects the specific emissions of new cars should be introduced. The next section of this report explains why this is something that the Council and the European Parliament should nevertheless contemplate.

## 2. Background

The European Union is committed under the Kyoto Protocol of the United Nations Convention on Climate Change to reduce greenhouse gas emissions by 8 per cent by 2008-2012 compared to the 1990 level. This is a modest first step towards cutting emissions by 50 per cent or more in order to prevent the concentration of carbon dioxide (CO<sub>2</sub>) from reaching a level above 550 ppm in the longer term.

The long-term objective is an enormous undertaking that could, if carried out in an inefficient way, have a significant negative impact on economic growth and European competitiveness. It is thus essential to focus on cost-efficiency and to make use of policy instruments that encourage the use of low-cost abatement measures.

There are two broad policy instruments that have the ability to achieve a very low variability in marginal abatement cost between the different sectors of society:

- 1) an equally high carbon tax enforced on emissions from all sectors of society
- 2) a cap and trade system.

Combinations are also possible, e.g. a cap and trade system covering certain sectors and carbon taxes in the remaining sectors.

A cap and trade system means setting a cap on emissions, issuing carbon dioxide permits up to that ceiling and allowing stakeholders to trade the permits. As a result, installations and activities that can reduce emissions at low cost will have a strong incentive to make use of these opportunities in order to sell permits to stakeholders that face a higher marginal abatement cost. A system of tradable permits has the advantage over carbon taxes of ensuring that the target is actually reached.

In its directive on emissions trading, the Council and the European Parliament made it mandatory for energy-intensive industries, power plants and boilers over a certain size to participate in a common scheme for emissions trading that took effect on 1 January 2005. The scheme covers approximately 45 per cent of the carbon emissions of the EU-15 and will be extended to include emissions from the same type of installations in the ten new member states. In addition, the directive provides an opportunity to extend the trading system to emissions from other sectors of society from 2008.

If the trading scheme is extended to include emissions from all sectors, including the transport sector, there would be no need for additional general policy instruments for achieving the target. The additional instruments would only distort the trade and increase the abatement cost without reducing the emissions below the cap. How-

ever, as Kyoto is not the final target, Europe needs to make plans for the second and third commitment period whose targets have not yet been negotiated. In this context there might be a need for additional policy measures.

In a case where tradable emission permits cover emissions from all sectors of society or when carbon emissions are restrained by a common CO<sub>2</sub>-tax, specific policy instruments aimed at particular areas or problems should be used as supplements only to the extent that they facilitate the utilisation of different potentials for reducing CO<sub>2</sub> emissions at a cost that falls below the assumed marginal abatement cost for achieving the next climate target. One obvious example of a cost-efficient supplement to emissions trading are rules or subsidies that make professional drivers take lessons in "EcoDriving", another is improving the surveillance of speed limits on highways. Besides cutting CO<sub>2</sub> emissions, both measures reduce other types of cost such as those for traffic accidents, road wear and wear on the powertrain, brakes and tires of cars.

In the road transport sector one should contemplate the use of additional CO<sub>2</sub> policy instruments aimed at reducing the specific fuel consumption of new cars. There are five reasons for this:

- 1) It is, from a technological point of view, possible to substantially reduce the emissions from new cars at low cost or even negative cost<sup>1</sup>. This can be done by using lighter materials and by somewhat compromising top speed and acceleration. Downsizing the car body, engine and powertrain makes the vehicle lighter, which in turn provides an opportunity to make the engine even smaller and less powerful.
- 2) It takes 15-20 years to replace the entire car fleet of a country. Assuming a rising marginal CO<sub>2</sub> abatement cost, it might be a good idea to start adjusting the composition of the vehicle fleet at an early point in time.
- 3) Buyers generally do not consider the entire fuel cost over the life of the vehicle. This is particularly evident for company cars which are normally sold in the second-hand market within 2-3 years. Not considering the entire fuel cost could be regarded a market failure.
- 4) The annual cost of road fuel makes up a relatively large share of the transport costs of most families. Low-income households, in this context, have to buy their cars from a second-hand car market that results from the preferences of the rich. They are also much more vulnerable to steep increases in fuel prices that might result from emissions trading for reaching longer-term objectives. If voters belonging to such households find that they have become victims of the climate policy of their government, they might object to the radical targets needed to save the planet from climate change. Broad access to low-consuming cars will make it a great deal easier for politicians to gain public support for such policies.
- 5) A growing domestic market for fuel-efficient passenger cars can benefit European manufacturers with an interest in international markets. Strong policy measures are underway in California, China and Japan aimed at making vehicle fleets increasingly more fuel-efficient. To be competitive in these markets, having a strong position in a growing European low carbon segment is likely to become a strategic issue.

The problem with high fuel costs being imposed on owners of second- and third-hand cars is most evident in Member States where a large share of all new cars are bought by companies and institutions who are less sensitive to fuel costs than pri-

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<sup>1</sup> This will be discussed in later sections of this report.

vate citizens and who tend to keep their cars for only 2-3 years. This means that a large portion of the total fuel costs of a car will be borne by someone other than the person making the choice. The subsidies associated with company cars used by individual employees mean that fuel efficiency rarely plays a major part in the final purchase decision of the first user. Company cars make up 30-50 per cent of new car purchases in countries such as Germany, the Netherlands, Sweden and the United Kingdom. As they tend to be less fuel-efficient than the average new car and ultimately make up a large proportion of the second-hand fleet, there are long-term implications for the fuel efficiency of the whole national fleet.

The object of this paper is thus to discuss and analyse different policy instruments that could be used to make new cars less fuel consuming. However, the need for such instruments is conditional on the degree of success of the voluntary agreement between the automotive industry and the European Union. In a case where manufacturers deliver all of what they have promised, there would be little cause to contemplate the introduction of additional policy instruments. Therefore this report will assess the current market trends and the progress made since 1995 before returning to the issue of potential policy instruments.

### **3. The transport sector and climate policy**

Road transport CO<sub>2</sub> emissions in the EU-15 grew on average by 1.6 per cent per year between 1990 and 1995 and by 2 per cent per annum between 1995 and 2001. In total, CO<sub>2</sub> emissions from road transport grew by 22 per cent between 1990 and 2001. In the latter year road transport accounted for 24 per cent of the total man-made CO<sub>2</sub> emissions in the EU-15, and passenger car traffic was probably responsible for around 60 per cent of this.

Real emissions from passenger cars are affected by the number of cars in use, the average specific fuel consumption according to the official test cycle, driving styles, auxiliary installations and the annual average mileage. The specific fuel consumption measured according to Directive 93/116/EC does not include fuel used for powering electric equipment such as headlights, electrically warmed seats or air-conditioners. The direct effect on fuel consumption of using an air-conditioner, for instance, is between 10 and 15 per cent.

### **4. Trends in car ownership and fleet composition**

The total number of passenger cars in the European Union (EU-15) reached 187 million at the end of 2003, up 27 per cent since 1990. The growth of vehicle fleets has been considerable in most Member States. In 2003 a total of 13.8 million new cars were registered in the 15 Member States.<sup>2</sup>

Table 1 shows new passenger car registrations by market segments. It is notable that from 1990 the combined market shares of the two smallest classes, *small* and *lower medium*, has increased from 58 to close to 67 per cent. This might partly reflect a trend towards "the two car household" where the second family car tends to be smaller than the first. At the other end of the market, the combined share of *executive* and *others* has increased from 15 to 20 per cent. In the meantime, the upper medium segment has declined by 9 percentage points. The segment referred to as

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<sup>2</sup> [www.acea.be](http://www.acea.be)

*others* has in recent years been dominated by Sport Utility Vehicles (SUVs). It has trebled its share of the market since 1990.

**Table 1. New passenger car registrations in EU-15 – breakdown by segments**

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)

The weight and power rating of new passenger cars increased significantly during the 1980s and 1990s. Not only those buying large cars but also customers of small and medium-size cars were increasingly offered a variety of engine sizes and power ratings. Delsey found in a study for the ECMT (1995) that average power ratings rose by more than 9 kW between 1980 and 1990 in France, Germany, Sweden and the United Kingdom.

Table 2 provides data on some important technical features that affect specific fuel consumption. From the table it is evident that average power increased by 9 kW also in the 1990s and by an additional 7 kW in the three years between 2000 and 2003. The total increase since 1990 amounts to 30 per cent. Cylinder volume rose somewhat less (+ 10%), which means more power is now produced per unit of engine volume. The share of cars equipped with four-wheel drive (4WD) has more than doubled since 1990. Most of the increase took place after the 1998 agreement with the motor industry on specific fuel consumption. The trends towards more power, larger engines, 4WD and heavier vehicles all affect specific fuel consumption negatively. The only parameter shown in table 2 that reduces fuel consumption and specific emissions is dieselisation. The share of diesel cars rose from 14 per cent in 1990 to close to 44 per cent in 2003. As we shall see in a later chapter on “the rebound effect” the positive effect of dieselisation is, to a large extent, offset by a higher annual mileage.

**Table 2. Passenger car registrations in Western Europe (EU-15+EFTA) – breakdown by technical specifications. Per cent of new registrations.**

	1990	1995	2000	2003
Average power (kW)	61	64	72	79
Cylinder volume (CM <sup>3</sup> )	1591	1657	1703	1743
Share of 4WD	2.6	2.9	4.5	6.3
Share of diesel	13.8	22.0	32.1	43.7

Sources: ACEA and AAA (cylinder volume)

The average vehicle weight of new cars has increased dramatically despite the fact that the breakdown of registrations in different segments has not changed much in the EU-15 (table 1). Unfortunately, there is no common system for reporting vehicle weight in Europe. There seems to be a systematic difference in the reporting of the mass of vehicles between motor industry data (which report “kerb mass” of empty vehicles) and Member States data (report in accordance with Decision 1753/2000/EC). Mass has, according to ACEA data, increased by around 10 per cent.

Table 3 shows the development of service weight between 1990 and 2003 in the Swedish market. The share of new registrations weighing more than 1.5 tonnes has increased from 8 per cent in 1990 to 50 per cent in 2003, while cars weighing less than 1.3 tonnes shrunk from 53 to 13 per cent during the same period.

Sweden might be regarded as a special case, having Europe’s heaviest fleet of passenger cars. However, what happened in Sweden did also take place elsewhere. Cars in all segments became heavier. This was partly due to more stringent safety requirements, adding the weight of additional beams, airbags etc, but larger engines, 4WD, automatic gearboxes, additional volume (in all classes) and new gadgets explain most of the growth.

**Table 3. New passenger car registrations in Sweden – breakdown by service weight. Per cent.**

<b>Service weight</b>	1990	1995	2003
< 1 000 kg	10.9	2.9	1.1
1 000 – 1 299 kg	41.1	31.2	12.2
1 300 - 1 499 kg	40.2	33.1	27.0
1 500 – 1 699 kg	5.6	27.0	34.0
> 1 700 kg	2.4	5.8	16.1

Source: BIL Sweden

There is a strong trend towards tall and mighty. In Sweden, Sports Utility Vehicles (SUVs) have increased their share of new registrations from around 1 per cent in 1990 to 6.4 per cent in 2004. Minivans/Multi-purpose vehicles (MPVs) made up 8 per cent of new sales in 2004 compared to 4 per cent in 1998. Besides SUVs and minivans/MPVs the industry currently markets 35 other models with a height of 155 cm or more. Traditional passenger cars have heights in the range of 135 to 150 cm. In 1995 there was only one model higher than 155 cm in the European car market besides SUVs and minivans.

## 5. European Union policy on specific fuel consumption

In 1995, the Council approved a Community Strategy to reduce CO<sub>2</sub> emissions from passenger cars. The Council foresaw three inter-related policies, which, when taken together, would reduce CO<sub>2</sub> emissions to an average level of 120 g/km for newly-registered cars. The three elements were:

- a voluntary agreement with the car manufacturers to “commit the industry to make a major contribution” to the 120 g/km average standard and a related monitoring system for identifying the CO<sub>2</sub> emissions from newly registered cars
- a CO<sub>2</sub> information and labelling scheme directed at consumers
- an increase in the use of fiscal instruments, both applied to fuels and to the fuel efficiency of vehicles.

The Commission, however, did not manage to convince the automotive industry that 120 g/km can be reached in the foreseeable future.

## 6. The agreement with the car industry

In 1998, the European Commission and the European car industry represented by the European Automobile Manufacturers Association (ACEA) finally reached an agreement on the reduction of CO<sub>2</sub> emissions from cars. In this agreement, ACEA commits itself:

- to achieve an average CO<sub>2</sub> emissions figure of 140 g/km by 2008 for all new passenger cars classified as M1 in Council Directive 93/116/EEC<sup>3</sup>, sold in the EU with emissions measured according to the test procedure of Directive 93/116/EC
- to bring to the market individual car models with CO<sub>2</sub> emissions of 120 g/km or less by 2000
- to an indicative intermediate target in the order of 165–170 g/km in 2003 as the basis for monitoring progress
- to review the potential for additional improvements with a view to moving the new car fleet average further towards 120 g/km by 2012. This review was to be undertaken in 2003.

The car manufacturing members of ACEA are BMW AG, Daimler-Benz AG, Fiat Auto S.p.A., Ford of Europe Inc, General Motors Europe AG, F. Porsche AG, PSA Peugeot Citroën, Renault SA, Rover and Volkswagen AG. These firms also include brands such as Audi, Opel, Saab, Seat, Skoda and Volvo. The commitment covers only passenger cars.

As summarised in table 4, 140 g/km is equivalent to a fuel consumption of 5.9 litres per 100 km for petrol-fuelled cars and 5.4 litres for diesel cars. To reach 120 g/km, petrol cars should not consume more than 5.1 litres, while diesel cars must stay below 4.6 litres per 100 km. The difference between petrol and diesel-fuelled cars is an effect of diesel fuel containing approximately 10 per cent more carbon per litre than petrol. The amount of CO<sub>2</sub> released from the combustion of 1 litre of petrol and 1 litre diesel fuel depend on the exact chemical composition of the fuels but are in table 1 assumed to be 2.36 kg and 2.60 kg respectively.

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<sup>3</sup> Passenger cars with no more than eight seats in addition to the driver's seat.

**Table 4. Maximum consumption of petrol and diesel for achieving the European Union's CO<sub>2</sub>-emission targets.**

Target	Fuel consumption per 100 kilometres	
	<i>Petrol</i>	<i>Diesel</i>
120g/km	5.1	4.6
140 g/km	5.9	5.4

It should be underlined that the agreement between the European Union and the motor industry is not legally binding. The legal status of the agreement is a Commission Recommendation. Therefore the Council and Commission have reserved the right to legislate if the motor industry fails – but have not yet made clear when, how, and by what criteria. The agreement furthermore does not change the existing EU target of 120 g/km, initially meant for 2005.

ACEA made the agreement conditional on several external factors that could have a potential impact on its ability to reach the target. ACEA assumes that its commitment “*provides complete and sufficient substitute for all new regulatory measures to limit fuel consumption or CO<sub>2</sub> emissions, and for any additional fiscal measures in pursuit of the CO<sub>2</sub> objectives of its commitment*”. The organisation underlines that its commitment is based on the assumption of an “*unhindered diffusion of CO<sub>2</sub> efficient technologies*”. Therefore, according to ACEA, it is fundamental that any measures which might hamper the diffusion process will be taken into consideration in the monitoring procedure. ACEA also declared that the industry's concentration on diesel engines and lean burn technologies must be combined with special exhaust gas after-treatment devices capable of reducing NO<sub>x</sub>. For such devices to work properly the diesel or gasoline fuel must have a very low content of sulphur. The minimum fuel quality standards of the EU have since been changed to accommodate the industry.

The European Commission has also concluded agreements on CO<sub>2</sub> emissions from cars with the Japan Automobile Manufacturers Association (JAMA) and the Korean Automobile Manufacturers Association (KAMA) for their sales in the EU. The two organisations' commitment are on behalf of members who sell cars in the EU market: Daihatsu, Fuji Heavy Industries (Subaru), Honda, Isuzu, Mazda, Nissan, Mitsubishi, Suzuki and Toyota (all of them JAMA), and Hyundai Motor Company, Daewoo Motor Co Ltd, and Kia Motor Corporation (KAMA).

The Commitments from JAMA and KAMA are modelled on the Commission's agreement with ACEA. The only deviations are with regard to the time frame (2009) and the estimated target range for 2003 (JAMA).

The European Commission originally estimated that the achievement of the automotive industry's CO<sub>2</sub> emission target for all new cars sold in the European Union would reduce specific emissions by around 25 per cent and contribute about 15 per cent of the total emission reductions required from the EU under the Kyoto Protocol. An underlying assumption was that car mileages would grow by 2 per cent per annum and that, without the agreement, average new passenger car CO<sub>2</sub> emissions would have stayed at the 1998 level (European Commission and ACEA, 1998).

## **7. Directive on the monitoring of average specific fuel consumption**

The commitments made by the producers have been endorsed by the European Commission and welcomed by the European Council. Their implementation is monitored jointly by the Commission and the three motor industry organisations in accordance with the rules set out in Monitoring Decision (1753/2000/EC). The Commission reports to the European Parliament and the Council of Ministers annually. The vehicle registration authorities in the Member States provide data for the monitoring, which is based on the Certificate of Conformity that is issued for each new vehicle model, and on sales statistics.

Currently the EC type-approval legislation only covers petrol and diesel vehicles though the Commission's intention is to include Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG) in the future. The Commission says that the inclusion of electric vehicles is problematic because of the difficulty in assessing their use in terms of their overall emissions of CO<sub>2</sub>, including power generation (European Commission, 1998d).

## **8. Progress since 1995**

According to estimates by the European Commission, cars sold in Europe in 1995 emitted on average 186 g CO<sub>2</sub>/km, based on the EU test cycle (93/116/EC).<sup>4</sup> If this figure is taken as an approximate base-line value, a reduction to 140 g means cutting emissions further by 46 g or 24.7 per cent.

Between 1995 and 2003 CO<sub>2</sub> emissions from newly registered cars fell to 164 g/km. This corresponds to an 11.8 per cent decline over eight years. With only five years left (including 2004), this means that the target can only be met if the rate of progress is improved considerably. To close the target gap, ACEA, JAMA and KAMA must reduce emissions by respectively 2.8, 3.1 and 3.6 per cent per annum.<sup>5</sup> This corresponds to 4.6, 5.3 and 6.5 g per year.

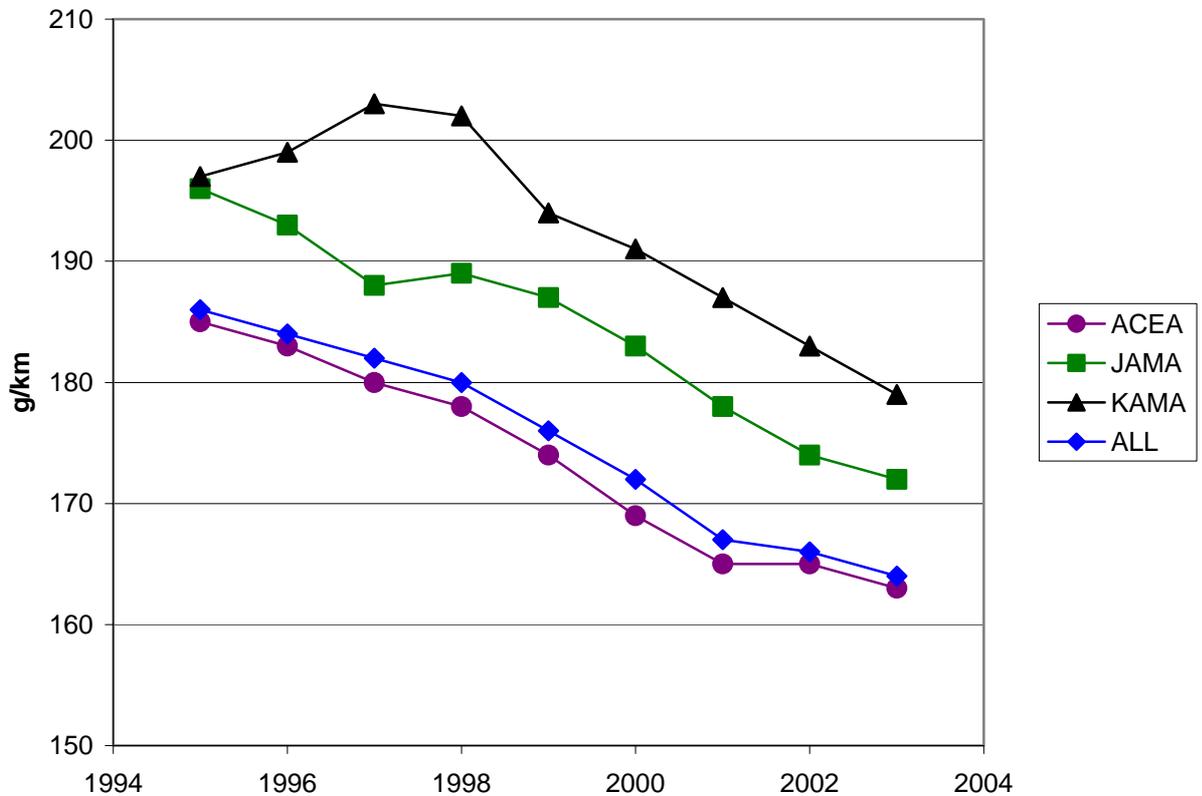
A concern in this context is that the members of ACEA, who produce 86 per cent of all cars sold in the EU-15, have been doing less well in the last two years. The average rate of annual improvement for ACEA was 1.8 per cent between 1995 and 2001, but since 2001 the average enhancement has only been 0.6 per cent per year. JAMA and KAMA, on the other hand, have reduced emissions by respectively 1.7 and 2.1 per cent per year since 2001. Figure 1 shows the trends for the three branch organisations

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<sup>4</sup> Figures from some Member States, in particular Greece and Finland, were not complete.

<sup>5</sup> ACEA's figure based on Member States' data. Based on ACEA's data the figure would be 2.6%.

Figure 1. CO<sub>2</sub> reduction trends for ACEA, JAMA and KAMA 1995-2003. g/km.



Source: European Commission

ACEA and JAMA managed to reach their indicative intermediate targets of respectively 165-170 g and 165-175 g in 2003. It seems less likely that KAMA will be able to reach its 2004 indicative target range of 165-170 g/km. It would require a reduction by 9 g/km in just one year.

ACEA and JAMA also managed to fulfil their commitments to produce a few models by 2000 that emit less than 120 g CO<sub>2</sub>/km. The number of vehicles with specific emissions below 120 g has increased considerably in recent years. First registrations of such cars in 2002 totalled over 580 000 units for ACEA. They correspond to 5 per cent of all new registrations. JAMA sold 44 000 units with emissions below 120 g, corresponding to 3 per cent of total sales. In 2002, KAMA did not sell any unit with emissions below 120 g/km.

In an early statement, ACEA declared that its CO<sub>2</sub> target would “*mainly be achieved by technological developments affecting different car characteristics and market changes linked to these developments*”. The statement goes on to say that ACEA will aim at a high share – up to 90 per cent – of new cars being equipped with direct injection gasoline or diesel engines. Diesel engines are by nature more fuel-efficient than equivalent petrol engines. The advantage tends to be greater in urban conditions as petrol engines show a much greater decline in efficiency at part-load than diesel engines. Direct injection (DI) diesel engines are more efficient than indirect

injection (IDI). DI engines have therefore replaced IDI engines in the production of most new cars.

Between 1995 and 2003 the market share of new diesel cars in Europe went from 22 to 44 per cent. For ACEA the diesel share in 2003 was 47.5 per cent of new sales. Diesel engines accounted for 28 and 26 per cent respectively for JAMA and KAMA. According to JAMA (2003), until the end of 2002, dieselisation achieved a reduction of 1.1 per cent of the specific CO<sub>2</sub> emissions from new JAMA cars and a 3.8 per cent reduction of emissions from cars marketed by ACEA. This should be compared to 8.1 and 8.3 per cent respectively for reductions from technological innovations and 0.8 and 0.3 per cent from changes in model mix. This means that the shift from petrol to diesel engines accounted for respectively 11 and 31 per cent of the progress made by JAMA and ACEA. In addition, the overall CO<sub>2</sub> reduction for diesel cars was higher than for petrol cars, 12.3 per cent compared to 9.5 per cent (based on all three groups of manufacturers). However, part of this achievement might be a result of small cars increasing their share of the diesel market as a result of faster diesel penetration of the small and medium segment after 1995.

Both ACEA and JAMA initially mentioned direct fuel injection in petrol engines as part of the solution. Direct injection petrol engines (often referred to as Gasoline Direct Injection (GDI)) use modified chamber designs and direct fuel injection into the chamber to achieve a good combustion of a comparatively weak fuel/air mixture. To alter production to direct injection does not require entirely new engines. A different fuel injection system and some minor modifications to the engine are all that is needed. From a production point of view it would thus be feasible to carry out a major shift to direct injection in a few years time. However, the share of new cars sold on the European market that have direct injection petrol engines has stagnated in recent years. JAMA reports a peak at 3 per cent in 2000 followed by a decline to just above 1 per cent in 2002.<sup>6</sup> No figures on direct injection for gasoline engines have been reported by ACEA and KAMA.

Numerous 'green' concept cars have been on display at major automotive fairs in recent years. However, only a few of them have been marketed and market penetration has been slow. In 2004 only around 8 500 new hybrid electric cars were registered in the EU-15,<sup>7</sup> a mere 0.06 per cent of total sales of new cars.<sup>8</sup> The Toyota Prius dominates the hybrid market. When driven according to the EU-test cycle the Prius emits only 104 g/km. High cost is holding back production of electric hybrid vehicles and has made it necessary for governments to subsidise sales. However, the 2003 decision by the California Air Resources Board to allow automakers to fulfil their 10 per cent ZEV (Zero Emission Vehicles) sales mandate with *partial zero emission vehicles* is expected to boost the marketing of full hybrids in California.<sup>9</sup> In Europe, mild HEVs<sup>10</sup> seem more likely to be the choice of the manufacturers.

Cars that can run on alternative fuels made up less than 0.2 per cent of ACEA's new registrations in 2002. JAMA and KAMA did not report on alternatively fuelled vehicles.

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<sup>6</sup> *Monitoring of JAMA's Commitment on CO<sub>2</sub> Emission Reductions from Passenger Cars* (2002). Final Report 5 September 2003. Joint Report of the Japan Automobile Manufacturers Association and the Commission Services.

<sup>7</sup> Low Carbon Vehicle Partnership ([www.cvp.org.uk](http://www.cvp.org.uk))

<sup>8</sup> Based on an assumption of the 2004 sales being 14 million.

<sup>9</sup> Full hybrid means load-sharing between a combustion engine and an electric drive.

<sup>10</sup> Mild hybrid means integrated starter-alternator with motor assist (>100V).

Five years ago several car manufacturers had already announced the commercialisation of fuel cell cars. Honda, Toyota and Daimler-Chrysler all pledged to have fuel cell cars for sale in 2004, Mitsubishi in 2005. However, none of these plans have materialised. The main barrier to market introduction is the high cost, and nothing is yet known about the price range for mass-produced fuel cell vehicles.

Progress by individual manufacturer?

To put maximum attention on the performance of individual car manufacturers it is essential to monitor each corporation separately and publish annual figures on the progress that they make. The European Commission originally said that its intention was to use its monitoring scheme to demonstrate the contributions of each manufacturer to their common commitment (European Commission, 1998d). This would require establishing the current average fuel consumption (weighted for actual sales) of each manufacturer. Considering the fact that producers of small cars will easily reach much lower consumption levels than those producing larger cars, it would be necessary for the Commission to demonstrate progress as percentage reductions on the average specific fuel consumption of the base year for each manufacturer. However, the Commission has not yet publicised any data on the progress or lack of progress of individual manufacturers.

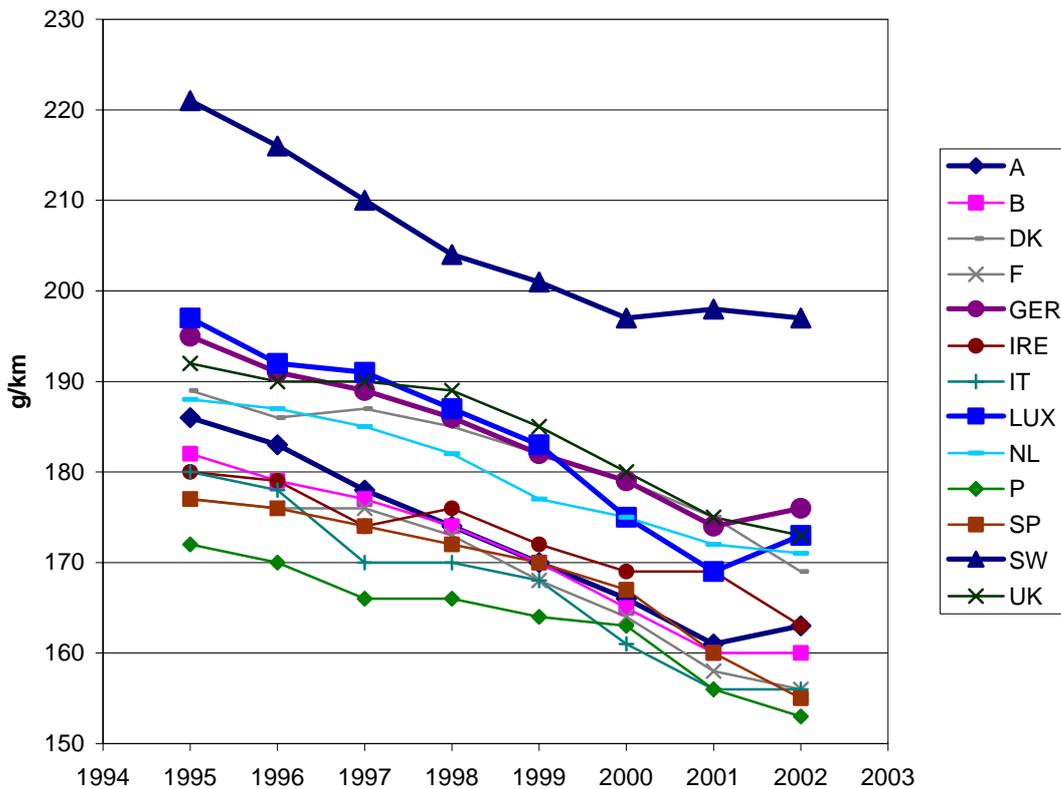
## **9. Progress by member state**

Figure 2 shows the development of average specific emissions of CO<sub>2</sub> in the different Member States between 1995 and 2002.<sup>11</sup> The recent upward trend in some Member States (Austria, Germany and Luxemburg) is of particular concern. Sweden's lack of progress is even more worrisome. Emissions from new registration in Sweden continue to stay far above those of all other Member States and have not declined since 2000. Sweden's figure for 2003 (not covered by Figure 2) was 198 g/km.

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<sup>11</sup> The figures for 2003 are not yet available from the Commission.

**Figure 2. Progress in different Member States 1995-2002**



Source: Own calculations based on data in the annual monitoring reports of the European Commission

No historic figures can be given for Greece and Finland since data for most of the years are not available. However, in 2002 Greece finally reported an average emission of 166 g/km and Finland reported 176 g (down 2 g from 2001).

### 10. Will the motor industry be able to honour its commitment?

From the relative modest progress made in the last two years, in particular by ACEA, it is evident that the motor industry is unlikely to be able to honour its commitment to reach an average of 140 g for new cars in 2008 unless Member States introduce economic incentives that strongly influence market preferences. Only a dramatic change in consumer preferences or a major technological break-through could significantly change the outcome. The progress made by technological development is likely to continue. It is, however, used to a large extent by the industry and its customers to achieve more power and to increase comfort and vehicle weight.

Current trends suggest that ACEA will at best achieve 80 per cent of the gap between 1995 emissions and the 2008 target. JAMA, which started from a higher specific emission, may only achieve three quarters of its task, and KAMA looks designated to end up achieving even less. On average, new registrations in 2008-09 will

probably emit around 150 g/km. If ACEA's poor performance in 2002 and 2003 marks the beginning of a new trend, the outcome could become even worse.

The likelihood that electric-hybrids and fuel cell cars will make a significant contribution in the few years that remain to 2008-09 is extremely small. Hybrid electric cars currently cost 20-30 per cent more than a comparable internal combustion car. Acceptance will, of course, also depend on real-world performance, reliability and status. To be competitive, the cost of producing fuel cell engines versus internal combustion engines would have to drop tenfold. Mass production would presumably narrow the gap, but buyers will nevertheless have to pay a considerable premium, at least initially.

For sales of battery cars to reach beyond a few thousand vehicles, a battery-efficiency revolution is needed. No such development is yet in sight even though battery efficiency has improved significantly in recent years, partly as a spillover from the development of batteries for laptop computers and cell-phones. Some observers believe that this development will eventually lead to a revival of the battery car, which would in such circumstances have a better well-to-wheel efficiency than fuel cell vehicles and probably at lower cost (Duleep, 2003, and MacCready, 2004). However, it should be underlined that the effect on overall carbon emissions from using battery vehicles (if they become a feasible alternative) would not be significant as the marginal power production takes place in coal-fired condensing power stations in most of Europe. The same, of course, is true for hydrogen produced by electrolysis.

Due to high cost, the contribution from new power-train technologies in 2008-2009 is likely to be almost negligible. Mild hybrids may start penetrating the market well ahead of 2008 but, if so, mainly in the upper segments.

Where alternatively fuelled vehicles are concerned, it could be questioned whether cars that can run on a bio-fuel and on a conventional fuel such as diesel or petrol (bi-fuel and flexible-fuel vehicles) should be accounted for according to their emission of fossil carbon when driven on the alternative fuel. As bio-fuels are in scarce supply it is essential that alternatively fuelled vehicles are as fuel efficient as cars that run on conventional fuels. In addition, there is no guarantee that owners will rely 100 per cent on the alternative fuel.

How should the agreement be interpreted?

ACEA's deal with the European Commission is not easy to assess. There are many conditions and some of them do not refer at all to the average specific fuel consumption of new cars driven according to the EU test cycle. It is therefore necessary to consider how reasonable these conditions are, and how likely they are to be fulfilled. Otherwise there is an obvious danger that the agreement may be declared void by the manufacturers for reasons beyond their control.

ACEA underlines that its commitment is based on the assumption of an "*unhindered diffusion of CO<sub>2</sub> efficient technologies*". This generally-worded assumption serves to replace ACEA's condition in an earlier outline proposal (of March 1998) that "*no negative measures against diesel fuelled cars*" should be taken. What ACEA is obviously thinking of is a possible situation in which the Community or individual Member States decide to raise the diesel tax to make it come closer to the tax on petrol. Diesel is – with the noticeable exception of the UK – taxed at around 65 per cent of the level of the tax on petrol. From a cost-effectiveness point of view all emissions of CO<sub>2</sub> ought to be equally taxed (i.e. the tax should be technically neu-

tral). This implies a substantial rise in the level of the diesel tax in most Member States.<sup>12</sup>

Another reason for making the agreement conditional on an unhampered diffusion of CO<sub>2</sub> efficient technologies may be a fear that future exhaust emission limits for diesel cars may add substantially to the cost of the vehicles.

Considering that improvement within each category of engine and vehicle type has proven more important than the shift from petrol to diesel engines, there is little cause to compromise between fuel efficiency and clean exhausts. The current revision of the exhaust emission limits should aim at making Euro 5 technically neutral, i.e. the same emission limits should apply to all engines regardless of type and fuel supply. It should also be noted that the current difference in efficiency between the petrol engine and the diesel engine may diminish as a result of technological development. New engine concepts such as the HCCI engine (Homogeneous Charge Compression Ignition), that combines some of the best properties of the petrol and the diesel engine, may also make it to the market place.

## 11. The technical potential for reducing fuel consumption

Reducing specific fuel consumption from new cars implies more than a shift to diesel and direct injection gasoline cars and more than looking for new powertrains. Manufacturers also try to improve the efficiency of all cars, regardless of engine type. Several well-placed observers believe that advanced forms of fossil-fuelled spark ignition or diesel engines combined with advanced automatic transmissions will dominate the market well beyond 2020.<sup>13</sup> For several decades the most cost-effective method of reducing CO<sub>2</sub> emissions from cars will be to improve fuel efficiency. There are many ways of further improving the fuel efficiency of conventional engines and cars, among them:

- High-powered ignition systems that ensure complete combustion of the fuel available
- Improved fuel injectors
- Computer controlled engine management
- Improved compression at low engine loads
- Engine friction reduction
- Variable valve timing
- Variable geometry turbocharger
- Cooled Exhaust Gas Recirculation (EGR)
- Six-speed manual transmission
- Electric-motor-driven power steering
- Stop-go systems
- Cylinder deactivation
- Continuously-variable transmission (CVT) to improve gearing efficiency
- Mild hybrid<sup>14</sup>

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<sup>12</sup> Growing concern over negative health effects of particles is a second reason to raise the tax on diesel.

<sup>13</sup> Keith, D. and Farell, A., *Rethinking Hydrogen Cars*, Science vol 301, 18 July 2003. *Future Powertrain Technologies*, DRI-WEFA and Arthur D, Little, Transport Research Board of the National Academies of Sciences, *The hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*, Washington D.C., 2004.

<sup>14</sup> Mild hybrid means integrated starter-alternator with motor assist.

- Reduced mass
- Reduced mechanical friction
- Reduced air drag and rolling resistance

#### Ricardo's study

In a report for the British Department for Transport, Ricardo (2003) has analysed the efficiency and costs of different measures for reducing carbon emissions from a mid-size diesel reference car which currently emits 152 g/km. No compromise was made with driveability, performance or size. The vehicle weight remained approximately the same over the various improvement steps. Most of the measures undertaken have to do with the efficiency of the powertrain. Downsizing of the engine is a major element of Ricardo's strategy.

Ricardo's reference vehicle is presumed to cost £15 157 (€21 400). Table 5 shows some of the results of Ricardo's study. From the table it is evident that emissions can be cut in half by utilising technologies that already exist or could make it to the market place within a few years. The cost of taking Ricardo's first step is equal to €46 per gram/km. The second step increases the consumer price of the car by €35 per gram (compared to the price of the 2003 reference car), and the third by €55 per gram of CO<sub>2</sub>. Assuming that 85 per cent of the retail price is tax (the UK VAT is 17.5% of the pre-tax price), the social costs of the first three steps are respectively €39, €30 and €47 per gram.

If emissions trading were to replace all taxes on energy, the equilibrium price on the permit market for reaching Europe's target under the Kyoto Protocol would be around €70 per ton (Kågeson, 2001). Assuming that the average car is driven 200 000 km during its life, each reduction of one gram per km should from this point of view not cost more than €14. However, in a socio-economic valuation one should also consider that the pre-tax cost of fuelling the vehicle is reduced when it starts to consume less diesel per km. At today's crude oil prices and production costs, the price of diesel is approximately €0.29 per litre, which means that for each reduction of one gram of CO<sub>2</sub>/km there is, over the life of the vehicle, a fuel saving worth €22.30 (taxes not included).

**Table 5. Technologies for reducing carbon dioxide emissions from a mid-size diesel car.**

Step, year	Technologies	CO <sub>2</sub> g/km	Improvement	Cost, relative to Step 0
0	2003 ref. car (1.9 L, 82 kW, 1 351 kg)	152	–	–
1 2004	12 volt alternator (stop-start), 6 gear manual gearbox, 1.8 litre engine, Euro 4	145	4.6 %	1.5 %
2 2007	42 volt belt hybrid, automated "dual-clutch" gearbox, 1.6 litre engine, Euro 4	117	23.0 %	5.8 %
3 2010	42 v mild hybrid, NiMH battery, regenerative braking, 1.2 L (63kW/l), Euro 5	100	34.2 %	13.3 %
4 2012	Parallel hybrid, advanced engine (1.0 L), Li-ion batteries, lightweight materials, Euro 5	83	45.4 %	23.5 %
5 2017	Parallel hybrid, exhaust heat recovery, higher voltage, improved supervisor control system, light materials, Euro 5	77	49.3 %	24.3 %

Source: Ricardo (2003)

Based on these values, Ricardo's first three steps are either socio-economically cost-efficient (step 2) or close to cost-efficient (step 1 and 3). One should also recall that the marginal cost of achieving the European Union's, not yet negotiated, commitment under the next abatement period is likely to be higher than that of the Kyoto target. The cost per gram of achieving the fourth and fifth step is considerably higher and not socio-economically cost-efficient in the short term. And, what is more problematic, going from step 3 to step 4, implies a very high marginal cost, €128 per gram.

It should be noted that Ricardo's steps do not include downsizing of the vehicle or any compromise of today's customer demands for power, acceleration or top speed. Accepting a somewhat slower acceleration (e.g. equivalent to 1995 standards) or lowering top speed to, say, 150 km/h would save additional fuel at negative cost.

Ricardo believes that progressive electrification and hybridisation of downsized internal combustion engines offers significant CO<sub>2</sub> benefits regardless of the fuel or its source, at a risk level more manageable than those of more radical alternatives involving fuel cells and a major change of the fuel infrastructure. The 80 items of feedback received by Ricardo on a first version of its analysis show a general agreement with the principle of step-wise evolution.

#### The importance of reducing mass

Manufacturers generally focus more on powertrain efficiency than on reducing mass, air-drag and rolling resistance. Mass is the most important of these parameters and also the one offering the highest potential for improvement. Reducing mass is also essential for making fuel cells an economically viable option. Halved mass means halved fuel cell size and halved fuel cell cost. This is an effect of mass being decisive for the power needed for accelerating the vehicle and for driving uphill. The power required at constant speed to overcome rolling resistance and air-drag falls well below the power required for acceleration.

Being threatened by new materials such as aluminium, magnesium and composite materials, the steel industry has responded by investing in a research programme called the Ultra-Light Steel Auto Body. The objective is to develop a new steel body-shell that is around 25 per cent lighter than conventional bodies and offers an improvement of fuel efficiency of up to 12 per cent.

Many engine, transmission and suspension components can be manufactured from aluminium rather than steel. Aluminium is a great deal lighter. An all-aluminium frame, for instance, is around 30-45 per cent lighter than its current steel equivalent. The primary disadvantage of aluminium and magnesium is that they are considerably more expensive than steel.

Reducing the mass of the frame and the body makes it possible to reduce the size of the engine, which in turn contributes towards a lighter vehicle. The full size concept cars produced within the American Partnership for a New Generation of Vehicles (PNGV) had body systems weighing 30-45 per cent less than a comparable conventional car.

Amory Lovins of the Rocky Mountain Institute has taken the idea one step further by launching the concept of the Hypercar, an extreme light weight mid-size sedan, whose entire body is to be made of composite plastics. The transmission and steering are entirely electronic, which removes the need for heavy mechanical parts. In-

stead of a steering column and wheel, there are joysticks as in the cockpit of a modern aircraft. Powered by a fuel cell, *The Revolution* would achieve a fuel economy almost twice that of today's most economic diesel cars.

Volvo's concept car, the 3CC, highlights the opportunities that lie in downsizing, lightweight materials and improved aerodynamics. The car has dimensions similar to a classic 2-seater sports car but with a unique rear seat solution for an additional adult or two children. The 3CC is propelled by an electric battery powertrain, has a top speed of over 135 km/h, a range of 300 km and delivers 0-100 km/h in ten seconds. Its aerodynamic efficiency is 30 per cent better than for the Volvo S40 sedan. The electric power is delivered by lithium-ion cells identical to those used in modern laptop computers. When tested on a difficult F1 course, the 3CC consumed 0.13 kWh per km. This equals the energy content of 1.3 litre petrol per 100 km. The well-to-wheel efficiency, however, depends on where the marginal electricity production takes place. If produced in a coal-fired condensing power station, the emission from the power plant equals 105 g CO<sub>2</sub>/km. When produced in a power plant using natural gas, the emission would only be 45 g/km.

Using the 3CC concept for a 4-seater of the same length would, according to Volvo, raise energy demand by 5 per cent due to poorer aerodynamics.<sup>15</sup> To this should be added the effect on fuel consumption of slightly higher weight. Enlarging the vehicle to the proportions of a mid-size sedan would, of course, require additional weight and probably a somewhat larger engine. Nevertheless, the 3CC concept provides an idea of what is technically feasible.

#### Returning to normal

Considering powertrain improvement and rolling resistance as well as vehicle mass there appears to be excellent opportunities for reducing specific fuel consumption by 20 per cent or more in the short to medium term. This implies that an average figure of around 130 g/km should be reachable within the next 8-10 years without relying on new powertrain technologies such as full hybrids or fuel cells, and without any compromise where comfort, vehicle size, acceleration and top speed are concerned.

Downsizing offers additional opportunities but has not been an element in the strategies of the manufacturers. ACEA leaves out of consideration what slightly smaller engines, abstaining from 4WD and traditional automatic gearboxes (when they are not essential) could achieve. This kind of downsizing would not result in the European car industry selling fewer cars.

Van den Brink and Van Wee (1999) found that fuel consumption in cars with the same engine but with differing weight is equivalent to an increase of 7 per cent per 100 kg (based on 1 000 kg vehicle weight). Without the weight increase since 1985 the average new passenger car in the Netherlands in 1997 would have been 13 per cent more fuel efficient. Based on ECMT data they calculate the effect of the increased engine size and power rating since 1985 to correspond to another 6 per cent. This means that the average new passenger car in 1997 would have been approximately 20 per cent more fuel efficient had weight, engine size and power rating not increased from their 1985 levels. Van den Brink and Van Wee conclude that in the period since 1985 there must have been large improvements in engine efficiency, air-drag coefficient and rolling resistance to compensate for the increase

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<sup>15</sup> Information from Jeanette Carlsson, Volvo Cars.

in fuel consumption resulting from the increase in weight, engine volume and power rating.

Another way of demonstrating the trade-off is to calculate the fuel saving from restricting top speeds and thereby engine power (and indirectly engine volume and weight). An average saving of 1.5 to 2.0 litres per 100 km for petrol-fuelled cars under town driving conditions would be feasible, if maximum top speeds were restricted to 180 km/h (ECMT, 1995). This is equal to a reduction of around 20 per cent at zero or negative cost.

From the technological progress achieved since 1995 one would expect a reduction in average specific fuel consumption in the order of 20 per cent by 2002. However, a large part of this potential was offset by a trend towards heavier and faster cars. Table 6 shows the average growth in engine power, engine volume, vehicle mass and four-wheel drive share between 1995 and 2003.

**Table 6. Average increase in engine power, engine volume, vehicle mass and the share of cars with four-wheel drive between 1995 and 2003. Per cent.**

Engine power	23
Engine volume	5
Vehicle mass (1995-2002)	10
Four wheel drive	142

Source: Own calculation based on data from ACEA and AAA (cylinder volume)

ACEA understands the problem

The manufacturing industry appears to be aware of the problems. A study by ACEA about five years ago (no exact reference available) concluded that nearly half of the total potential gains in CO<sub>2</sub> reduction that are feasible by 2005 will be offset by regulations on safety, emissions and noise and anticipated customer demands ([www.acea.be](http://www.acea.be)). The European Commission, however, “believes that the increases in vehicle weight that might have been an effect of new legislation are, if at all, potentially small and would therefore be negligible for the average CO<sub>2</sub> emissions”.<sup>16</sup> In the view of the Commission, it is obviously manufacturer priorities and customer demands that add vehicle weight.

If ACEA is right in assuming that half of the technological gains are offset, then the specific CO<sub>2</sub> emissions could have been reduced by close to 25 per cent between 1995 and 2005 had they not been offset by higher requirements. This must be interpreted to mean that a return to the demand for acceleration, top speed etc that pleased customers in 1995, only ten years ago, could potentially reduce specific fuel consumption by at least another 15 g/km, in addition to the technical potential recognised above. This could bring the average emission of new cars below 115 g/km within eight to ten years. In this context 120 g/km in 2012 seems perfectly feasible.

However, ACEA says that “while it is technically possible to produce very low consumption models, it is unrealistic from a consumer and industrial standpoint to expect the entire European fleet to average, for example, 5 litres per 100 km” ([www.acea.be](http://www.acea.be)). This statement must be taken to mean that ACEA thinks that no manufacturer can afford not to adjust its production and marketing to what it be-

<sup>16</sup> COM(2004) 78 final.

lieves will be the priorities of its customers. And indeed, the fact that the number of European manufacturers producing SUVs has expanded from two in 1995 to seven in 2004 clearly reveals that individual producers cannot abstain from participating in promising markets.

## 12. How to reverse the trend towards tall and mighty?

It is technically feasible to reduce the average specific fuel consumption to well below 120 g/km but it will require the full participation of all brands and models as well as a halt to the existing trend towards higher performance, four-wheel-drive and additional accessories.<sup>17</sup> An obstacle in this context is the fact that wholesalers and car dealers are inclined to continue to promote this trend as it earns them more money than the promotion of less luxurious and high-performance vehicles.

Higher net incomes will make cars relatively less expensive in years to come. High-income households buy larger cars and travel more than low income households. In the United States, the shift towards vehicles classified as light trucks began in the 1970s with pickup trucks. The minivan wave began in 1984 and the SUV trend took off around 1990. A fourth wave is now underway, constituted of *crossover vehicles*, with body styles similar to traditional passenger cars but higher than normal and with 4WD.

The figures in table 1 (above) on new car registrations by market segment can be taken to illustrate this dilemma. In table 7 these segments have been aggregated into three segments by approximate price. Two trends are visible: the medium price range is losing ground both to the inexpensive and the more expensive segments. The stronger of the two tendencies is towards the highest price range. The increasing market share of small cars can probably be explained by the fact that women are increasingly becoming car owners and that many families buy a second car.

**Table 7. New passenger car registrations in the EU-15 – breakdown by price segments.**

	<b>Inexpensive</b>	<b>Medium</b>	<b>Expensive</b>
1990	58.1	22.9	15.4
1995	64.3	18.7	16.9
2000	66.9	15.7	17.3
2003	66.6	13.7	19.5

Source: Own calculation based on data from Association Auxiliaire de l'Automobile (AAA)

From an environmental point of view it is essential to ensure that Europe avoids taking the American route. Vans, SUVs and pickup trucks have increased their combined share of the US market for new cars and light trucks at an average rate of 1.1 percentage points per year since 1975 and now account for about 50 per cent of the light vehicle market. In some European markets there is now a fast trend towards minivans and SUVs though the combined market shares are generally still in the range of 8 to 14 per cent.

<sup>17</sup> The Toyota Prius, a mid-size sedan powered by an electric hybrid engine, shows that 104 g/km can already be achieved.

ACEA initially said that there was no need for additional fiscal measures. The association was obviously confident that its members could achieve the CO<sub>2</sub> target under existing fiscal conditions. ACEA nevertheless demands that the joint monitoring process should value the impact on CO<sub>2</sub> emissions of new fiscal measures. Does ACEA mean that a general increase in the taxation of road fuels or a sales tax differentiated for specific fuel consumption – which would make it easier for the industry to fulfil its commitment – should result in a more far-reaching target (such as 130 or 120 g/km)? ACEA has after all stated very clearly that its intention is to reach the 140 g/km target by technical means and not by downsizing.

### **13. Where should manufacturers' responsibility begin and end?**

Before going on to discuss potential policy instruments that can help the motor industry honour its commitment to the 2008-2009 target it is necessary to draw a line between the responsibilities of the motor industry and those of other stakeholders.

Challenged by the Community's objective of reaching 120 g CO<sub>2</sub>/km by 2012, ACEA has proposed a more *integrated approach*. The association says a cost-effective strategy for reducing CO<sub>2</sub> from cars needs to integrate activities including fuels, infrastructure, driver behaviour etc.<sup>18</sup> With reference to a report by ADL (2003), that expects 4 000€ per car to be the additional cost for achieving 120 g, ACEA claims that aiming for this target would be too costly and not cost-efficient. ACEA says that the maximum technological potential to reduce specific CO<sub>2</sub> emissions from new cars between 2008 and 2012 is 5 per cent. This is equal to 133 g/km provided that the 140 g voluntary target is met on time.

Infrastructure, driving behaviour, new fuels, public transport, physical planning etc are important parameters in any strategy for reducing greenhouse gas emissions from road transport, and the Council and the Commission should make all relevant stakeholders participate in an effort to stop climate change. However, the fact that others should also contribute is no reason to let the motor industry off the hook. It is rather a reason to define clearly what the obligations of the manufacturing industry are. The motor industry is clearly the only stakeholder that the Community can make responsible for the fuel efficiency of vehicles and for any onboard instruments that may be needed for assisting drivers who want to improve their driving behaviour.

Alternative fuels such as Rapeseed Methyl Ester (RME), biogas and ethanol are mostly used in cars that can also run on petrol or diesel as an alternative (Flexible Fuel Vehicles and Bi-Fuel Vehicles). Most new diesel cars are able to run on RME but few customers buy them with the intention to use this fuel. Cars equipped with an extra tank for biogas or Compressed Natural Gas (CNG), on the other hand, are bought by people who want to use gas as their primary fuel. However there is no easy way of knowing whether such cars will primarily use biogas or CNG rather than petrol. Second owners of such cars might even choose to remove the gas tank and use only petrol as the tank is rather bulky and fills up part of the luggage boot. It should therefore be made clear that the all cars that can run on fossil fuels should be part of the motor industry's specific fuel efficiency task.

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<sup>18</sup> ACEA's *Statement on the potential for additional CO<sub>2</sub> reduction, with a view to moving further towards the Community's objective of 120g CO<sub>2</sub>/km by 2012*, Brussels 27.11.2003.

#### 14. Policy instruments currently in use

All Member States (EU-15) tax fossil road fuels and cars in use, and a majority in addition enforce a sales and registration tax. Some of these taxes provide incentives to buyers to choose low consuming vehicles. Taxation of company cars is also essential in this context.

##### Fuel taxes

Fuel taxes provide a broad incentive to improved fuel efficiency as they affect choices of vehicle, driving behaviour and annual mileage. If Europe chooses not to include the emissions of the transport sector in its common scheme for CO<sub>2</sub> emissions trading, it will be necessary in most Member States to raise fuel taxes further in order to make overall emissions stay at or below the agreed target. Fuel taxes are also a means of internalising the social costs of road transport while waiting for the introduction of km taxation for all types of road vehicles.

However, in a case where Europe decides to include transport emissions in its common scheme for CO<sub>2</sub> emissions trading, it does not make sense to raise fuel taxes for the abatement of greenhouse gases as the rise would not reduce emissions below the cap. It would only shift some of the burden from other sectors (where abatement is cheaper) to the transport sector. Using high fuel taxes for reducing emissions from cars would in such a case have negative and rather costly side-effects. The price of purchasing CO<sub>2</sub> permits, however, would affect the price of petrol and diesel to a small extent. €10 per ton CO<sub>2</sub> would make the price of diesel increase by 2.7 eurocents per litre.

##### Annual circulation taxes

Several Member States base their annual circulation tax (ACT) on power rating, cylinder capacity, vehicle weight or even fuel consumption. However, the rates are generally too low to allow for a differentiation that would influence market preferences significantly. In addition buyers of new cars do not always consider the longer-term cost of owning the vehicle. This is particularly true for company cars that in some Member States make up half of first registrations.

However, in a recent consultation document, the European Commission (2004) says that the level of potential CO<sub>2</sub> reductions does not depend on the type of taxes, e.g. registration or circulation tax. This is a surprising statement. Should, by coincidence, all potential instruments be equally effective? As a matter of fact, in the same report, the Commission refers to results from a TIS study, which indicates a significant difference between the effect of registration and circulation taxes. According to this report, reducing the registration tax by 10 per cent (in relation to pre-tax car prices) would make manufacturers and retailers raise the pre-tax price by 1.1 per cent, while raising the annual circulation tax by 10 per cent would hardly affect the pre-tax price at all (-0.1%). Such a difference makes sense as first buyers are unlikely to be able pass on all of the (remaining) registration tax to second owners. A detailed survey of second- and third-hand market prices would probably reveal that a large part of the additional cost associated with high registration taxes are in practice written off during the first few years of the vehicle's life. A reasonable assumption, therefore, is that the effect on specific CO<sub>2</sub> emissions from a registration tax is larger than the impact from an equally-burdensome circulation tax.

Shifting from registration taxes to increased levels of circulation tax is also problematic from a social point of view as a high circulation tax will make it more expensive

to own a car. This problem cannot be solved to more than a minor degree by allowing part of the revenues to be returned to owners of low-emitting cars. Making the effective tax on such cars negative (i.e. giving the owner back a sum of money), would provide a strong incentive to keep low-consuming vehicles in circulation longer than what is socio-economically optimal given that elderly vehicles are dirtier and less safe than younger ones.

Annual vehicle taxes might also have to be used for purposes other than improved fuel efficiency. When differentiated for exhaust emissions, annual vehicle tax has the advantage over registration tax of giving last owners a signal about old cars being dirtier than newer models. Thus it provides a better incentive for the early scrapping of dirty vehicles.<sup>19</sup>

### Sales and registration taxes

Table 8 shows the current sales or registration taxes in the Member States of the EU-15. Five Member States do not enforce any tax on car sales other than value added tax (VAT). Member States that tax the acquisition of cars have very different systems of taxation. Several of them, however, have differentiated their taxes for differences in fuel consumption or factors that indirectly affect fuel consumption (such as cylinder capacity, power rating and vehicle weight). Some of them use progressive rates.

**Table 8. Taxes on acquisition of passenger cars in EU Member States (EU-15) and Norway. Sales or registration tax.**

Country	
Austria	Tax base is price excl. VAT. Rate is differentiated for fuel consumption, Maximum rate is 16%
Belgium	Cylinder capacity, e.g. 1.8 litres €124
Denmark	105% of price up to DDK 53 000, 180% on the remainder
Finland	28% on price after a reduction of €650 for petrol cars and €450 for diesel cars
France	None
Germany	None
Greece	Tax base is price excl. VAT. Differentiated for cylinder capacity. Range from 7-88%.
Ireland	Tax base is price incl. VAT. Differentiated for cylinder capacity. Range from 22.5-30.0%.
Italy	Fixed rate 2%
Luxembourg	None
Netherlands	45.2% of price excl. VAT after a reduction of € 1 540 for petrol cars and an addition of €328 for diesel cars.
Portugal	Cylinder capacity, e.g. 1.6 litres €5 161
Spain	< 1.6 litres 7%, > 1.6 litres 12%
Sweden	None
United Kingdom	None

Source: European Commission

<sup>19</sup> Germany has differentiated its annual vehicle tax for exhaust emissions with differing tax levels for cars meeting the requirements of the different existing and future emission standards.

Sales and registration taxes are, in some cases, high enough to be a useful instrument for reducing specific emissions from new registrations and they have the advantage over annual vehicle taxes of providing a stronger incentive at the time of purchase (all else equal). We will return to them in a later section of this report.

#### Taxation of company cars

Company cars tend to be larger and more powerful than the national fleet average, and consequently more CO<sub>2</sub> polluting. However, there is no single definition of what constitutes a *company car*. Definitions and tax arrangements differ from country to country. Besides vehicles used by the companies themselves, company cars offered to employees as a benefit in kind are generally included.

Encouraged by relatively favourable tax treatment the latter have steadily grown over the years. Typically, company cars remain in company ownership for a period of one to three years before being sold on to the private second-hand market. As company cars in many Member States make up 30-50 per cent of all new registrations, they have an enormous impact on the size and composition of national car fleets.

Although taxation varies considerably between Member States, the rules generally provide for corporate tax arrangements, which allow the purchase/leasing and running costs of company cars to be deducted from taxable profit. In most Member States the benefit in kind of having private access to a company car is taxed by adding to the income of the user a sum that represents a certain percentage of the value of the car. A majority of them base the tax on 15-20 per cent of the retail price. The United Kingdom has a company car tax that is highly differentiated for specific emissions of CO<sub>2</sub>. For high-emitting cars a maximum of 35 per cent of the price is subject to taxation (COWI, 2001).

#### Why is Sweden worst in class?

The Swedish case clearly illustrates what may happen when the right incentives are not in place. As shown above in Figure 2, cars registered in Sweden have average CO<sub>2</sub> emissions far above those of any other Member State. This cannot be explained by Swedes being richer than other Europeans (they are not) or by Swedish elks being a bigger threat to motorists than elks in Finland or Norway. Instead, the reason why Sweden deviates so much from the European standard is a lack of taxes that influence vehicle choice towards low emissions. Sweden has no registration tax, its annual circulation tax is modest and not differentiated for fuel consumption or CO<sub>2</sub> emissions. In addition, the excise duty on diesel and petrol is lower than in other Northern European countries. And Sweden has a regime for taxing company cars that is tailored to suite the interests of Volvo and Saab, both producers of cars in the larger segments.

#### The labelling directive

Before returning to the issue of economic policy instruments let's take a brief look at the European Union's "Labelling" Directive (1999/94/EC) that makes it mandatory for all car dealers to provide information on the fuel economy of new passenger cars in showrooms and advertising. The Directive aims to make this information available to customers in four ways:

- Via a fuel economy label attached prominently to all cars at the point of sale

- Via dissemination of a short guide containing the fuel economy data on all vehicles on sale on the new car market of the Member State
- Via display posters in showrooms, covering fuel consumption data for all models on sale
- Through the inclusion of fuel consumption data in all promotional material used to market new cars.

Two Member States, Sweden and the United Kingdom, have operated fuel economy labelling schemes since the late 1970s and early 1980s respectively. The proposal for a common European scheme is, to a large degree, modelled on the Swedish labelling system.

There appears to have been no research done on the effect on consumer preferences of fuel economy labelling. However, the development of the Swedish market is not encouraging. In 1990, after more than 10 years of fuel labelling, Swedish cars had by far the highest average power rating in Europe and the highest average weight. Sweden also experienced the sharpest rise in power rating between 1980 and 1990 (+ 14 kW), followed by the United Kingdom (+10 kW) (ECMT, 1995)! Consumer preferences are influenced by many factors such as net income, car and fuel taxes, and lifestyles that presumably are of greater importance than access to fuel economy data. This is particularly obvious in North America. The mandatory fuel labelling scheme of the United States and the voluntary labelling programme promoted by Transport Canada appear to have had an insignificant influence on consumer preferences. The conclusion is that “soft” policy instruments such as labelling will have to be supplemented by real incentives to make people consider buying less fuel consuming cars.

In Sweden, frequent cases of non-compliance or only partial compliance have not resulted in any action from the relevant authorities (Forsman, 2004). Research conducted for the UK Department for Transport (2003) suggests that the current labelling scheme, that only includes mandatory reporting of *emissions*, is ineffective and should be accompanied by fuel consumption cost figures and colour coding.

## 15. The need for additional policy instruments

As the industry seems unlikely to reach its 2008-2009 target and as the Commission, the Council and the European Parliament have not deserted their 120 g objective, there is clearly a need for additional measures. At the time when the agreement with the motor industry was reached, the Commission had already noted that the agreement does not restrict the Community’s right to use additional fiscal measures. *“The fact that ACEA assumes that it can achieve its 140 g/km target for 2008 under current fiscal conditions is furthermore compatible with the approach taken by the Council in its conclusions of 25.6.1996 according to which fiscal measures are needed to go beyond ACEA’s contribution to achieve the overall Community objective of 120 g/km”* (European Commission, 1998e). However, the third pillar in the Commission’s and the Council’s CO<sub>2</sub> strategy for cars has not yet been developed.

It is evident that economic incentives will be needed to stem the current trend towards heavier and more powerful cars and to make the market fully consider fuel-efficiency. There are several possible economic incentives to consider and in addition some regulatory measures. Those offering the highest potential, besides differentiating company car taxation for specific CO<sub>2</sub> emissions, are:

- Differentiated sales tax
- Regulating top speeds, cylinder capacity, engine power or maximum fuel consumption
- Regulating average emissions from corporate sales
- Tradable CO<sub>2</sub> emission permits for new registrations

#### Sales and registration taxes

The European debate over policy instruments for reducing specific carbon emissions from cars has raged for more than a decade now. The Commission was required under Directive 91/441 to put forward proposals for an instrument to control carbon dioxide emissions from cars, originally with a deadline in 1992. After having turned down numerous proposals, the Commission's Motor Vehicle Emissions Group (MVEG) finally agreed that a graduated sales tax based on CO<sub>2</sub> emissions would be preferable. A common tax, however, cannot be adopted and enforced unless unanimously approved by Member States, which in this case proved impossible.

A reason why some Member States refrain from levying a sales or registration tax is that they want to avoid hampering the renewal of the car fleet. In a situation when new cars are expected to become much cleaner and less fuel-consuming it is essential not to use taxes that make it more expensive to buy a new vehicle. The conflict can be avoided if the tax is constructed as a fee on high-consuming models and a rebate on low-consuming ones, a "feebate" in American jargon. If well done, this means the system would not put any tax burden on the average new car.

To really influence choice there must be a considerable differentiation of the fee and the rebate. It could be calculated as a certain fee on each gram of CO<sub>2</sub>/km that exceeds a baseline value, which is lowered year after year until it reaches 120 g/km in 2012. To do the job, the rate of the fee on emissions above the baseline would probably have to be at least €100 per g CO<sub>2</sub>/km. If the baseline is, say, 160 g in 2006, a car emitting 180 g would then be taxed €2 000. A real "gas guzzler" (emitting, say, 240 g/km) would be charged €8 000. A car emitting 120 g/km, on the other hand, would earn a rebate of €4 000.

The differentiated sales tax (non-revenue raising) has the advantage of reducing the cost of motoring for second and third owners who often belong to low or medium income households.

A few Member States (e.g. Denmark, Finland and Greece) have such high tax levels that the motor industry complains about distortions. ACEA says: "*Manufacturers' commitment to provide customers in these countries with cars at affordable prices implies that pre-tax prices must be kept artificially low, thereby creating sometimes significant price differences with other countries*" ([www.acea.be](http://www.acea.be)).

According to the European Commission (1997a) the variation in new pre-tax car prices throughout the European Union exceeds 20 per cent for some models, mainly as a result of differences in car taxation. Another difficulty with registration taxes is that a double payment takes place when a citizen permanently moves a car registered in a Member State to another Member State that also applies a registration tax. The latter problem can be resolved by introducing a refund system for registration taxes (European Commission, 2002), and the former would disappear if the Community agreed on a common system for taxing car sales. However, a refund system becomes quite complicated in a case of a non-revenue raising system that

includes rebates, as customers who earned credits for low emissions would have to pay back part of the money when moving to a Member State that does not enforce a registration tax at all or has a different model of taxation.

Another weakness of the registration tax alternative is that only a few Member States currently have taxes of such magnitude that they are likely to have any significant impact on market preferences. Belonging to this group are Denmark, Finland, Greece, Ireland, the Netherlands and Portugal. Together they account for approximately 7 per cent of the car market of the EU-15. Of the four large Member States, representing 73 per cent of the market, France, Germany and the United Kingdom do not tax registrations at all, and Italy has an insignificant tax rate of 2 per cent.

The European Union has no power over the Member States where passenger car taxation is concerned. In order to make sales and registration taxes a potent weapon in the struggle to reduce CO<sub>2</sub> emissions, one would in particular have to convince the four large countries about the importance of introducing such taxes with rates that can effectively contribute towards lower fuel consumption.

An alternative would be to make the Union itself introduce a common scheme for taxation of new car registrations. However, such a decision is probably difficult to achieve as it requires a unanimous vote in the Council.

#### Regulatory measures

Regulating fuel consumption or CO<sub>2</sub> emissions can be made in a variety of ways, among them limits on:

- Emission per kW engine power
- Emission per cc of engine volume
- Emission per tonne vehicle weight
- Emission per unit of inner volume
- Regulating the permissible top speed
- Emission per km
- Engine power per unit of engine volume
- Engine power per tonne of vehicle weight
- Average emissions from corporate sales

For any given model of car (fitted with the same body), an increase in potential power output that raises the top speed by 10 km/h results in a real increase in fuel consumption of 0.4-0.7 litres/100 km in town driving and 0.2-0.3 litres on the highway. The European Conference of Ministers of Transport (ECMT)'s report on trends in power ratings recommended that governments consider restricting potential top speeds of passenger cars to 180 km/h (to be lowered to 160 km/h in a second stage) or restricting power-to-weight ratios to around 90 hp/tonne (66 kW), accompanied by a similar restriction of maximum power output to around 130 hp. According to the study, the latter would discourage manufacturers from producing cars weighing more than 1.5 tonnes (ECMT, 1995).

China has recently decided to introduce fuel economy standards for cars and light trucks. Each vehicle sold in the country will be required to meet the standard for its weight class. The standards will be classified into 16 weight classes. The standards differ from the federal US standard by being minimum thresholds but are on average

expected to be slightly more stringent, 5 per cent for Phase I (2005/2006) and 10 per cent for Phase II (Sauer and Wellington, 2004).

However, most of the regulatory methods listed above will not be fully effective, or can be expected to have negative side-effects. Regulating engine power, top speed or emissions per unit of engine volume is difficult as modern car engines can easily be trimmed to higher power output by replacing the original computer chip by a new one that increases the power rating. A secondary consequence of such a trend would be higher emissions, in particular of hydrocarbons and particles. On the other hand only a minority of car owners could be expected to get involved in tampering, and the marketing of trim chips could be prohibited. An alternative could be to install mandatory speed limiters on all new cars. Dings et al (1998) have shown this to be economically efficient for vans and light trucks both from a socio-economic and a private point of view.

Relating CO<sub>2</sub> emissions to vehicle weight might prove counter-productive as manufacturers would probably, in some cases, respond by increasing the weight to make room for more power.

Putting an upper limit on emissions per vehicle kilometre, on the other hand, is a feasible supplement to economic incentives. Such a limit could be set at a relatively high level and would only affect a small share of the current market. Its virtue would be in preventing the market from shifting to heavier and more fuel-consuming vehicles such as minivans and SUVs.

Regulating average CO<sub>2</sub> emissions from corporate car sales is another feasible option. This is what the United States has done through its CAFE Act. A more flexible approach combining regulation and economic incentives is tradable emission credits. These two methods will be considered in the following sections.

#### Corporate Average Fuel Economy (CAFE)

The US Corporate Average Fuel Economy (CAFE) Act sets minimum acceptable standards of fuel economy that the average vehicle sold by each manufacturer must meet. The first value set for passenger cars was 18 miles per gallon (mpg) in 1978 and this was progressively increased to 27.5 mpg by 1985. After minor fluctuations between 1985 and 1989, the value was again set at 27.5mpg in 1989 and has remained unchanged since. The values must be met separately by each firm's domestically produced cars and imported cars. Fines of \$5 per vehicle for every 0.1 mpg below the established standard are levied on manufacturers failing to meet the required level. Less stringent CAFE values are applied on light duty trucks (currently 21.0 mpg).

The CAFE system has been much debated in the United States, especially in the 1990s. There is no general agreement among experts about its effectiveness. Many observers, however, would presumably have been more positive had the mpg value been significantly increased after 1989 and had a more ambitious value been enforced on light duty trucks. The effectiveness is, of course, also dependent on the size of the fines. The current level is quite low and has not effectively stopped manufacturers from non-compliance.

It can be questioned whether a system like the CAFE would work properly in Europe. It would give a very poor incentive to manufacturers who concentrate on small cars, and small and medium size producers/wholesalers may have difficulties

balancing sales of thirsty and less thirsty models. A more flexible instrument is probably to be preferred.

#### Tradable CO<sub>2</sub> credits

A system of tradable emissions credits is neither exclusively regulatory nor truly fiscal in nature. It is included here because it regulates the average permissible fuel consumption or CO<sub>2</sub> emission and could be regarded as an extension of a CAFE-style system.

The UK's Department of Transport (1992) proposed a system of tradable credits to the European Commission's Motor Vehicle Emission Group (MVEG) in 1992. The idea was to provide each new car with official CO<sub>2</sub> emissions credits corresponding to the average permissible specific emission in that particular year. The average emission value would then be gradually tightened to reflect steps on the route to a long-term objective. If, for instance, the cap in a particular year is 150 g/km, each car sold on the European market would get 150 credits, one for each gram allowed. For cars achieving a better fuel efficiency than required, manufacturers would be free to sell their surplus credits to those who did not meet the standard. Under the trading scheme no new car could be sold or registered without delivering to the relevant government authority the number of credits that correspond to its CO<sub>2</sub> emissions per km. The initial distribution of credits (the 150 permits/vehicle in the example above) would be free of charge. However, the cap and trade system can co-exist with a sales or registration tax, if a Member States wants to maintain this form of taxation for fiscal purposes or for a specific reason other than CO<sub>2</sub> emissions.

A market place for trading CO<sub>2</sub> emission credits could be created either by the Community or by the automotive industry. To prevent manufacturers from withholding credits from sale to competitors, part of the credits would, according to the original British proposal, be reserved for an EU authority, which would auction them and return the revenue to the original owners.

A scheme for emissions trading based on permits for specific CO<sub>2</sub> emissions from new cars should not be confused with a general system for CO<sub>2</sub> emissions trading covering emissions from all kinds of sources. The former is related to specific emissions from new cars (i.e. emissions per km when driving the vehicle according to the EU test cycle), the latter to actual emissions from different types of sources. The two systems could exist in parallel.

Trying to integrate the two types of trading system is not a good idea. This could in theory be done by recalculating the specific credits into emissions released during the life of the car, based on some assumption about average annual mileage and life of cars. In such a system, the wholesaler would have to acquire emissions permits for the estimated average life emission of the model. However, it would not be possible to take into account other parameters that influence real emissions such as driving style, car maintenance and tyre pressure. And, what is more important, the current price on the market for CO<sub>2</sub> emissions permits does not reflect the long-term marginal cost of the European Union's climate change policy and, thus, would do little to prepare the automotive industry for coming commitments. An integrated approach would not contribute to any of the five objectives mentioned on page 4.

Fergusson and Holman (1992) feared that the British proposal would not work due to market resistance and that the credits reserved for auction would not be enough to prevent a market failure. Kågeson (1992) responded by suggesting that all "free" credits should be banked automatically with the EU authority when the car was first

registered. These credits would then be sold at weekly or monthly auctions, where all manufacturers/importers needing extra credits would have to compete. The revenue from the sales could be divided equally on all credits sold during a certain period in order to avoid short-term fluctuations in the revenue received by the companies who earned the credits. To prevent manufacturers from withholding credits bought at auction it would be sufficient to rule that such credits must be used within three (or four) months from the day of purchase or otherwise sold back to the authority.

In much the same way as with a regulatory system, the key advantage of a tradable credits scheme over purely fiscal measures is that an agreed target would be achieved and the uncertainty about the likely scale of improvement would be removed. As underlined by the UK Department of Transport (1992), overall improvements would in theory be achieved at the least possible cost.

A tradable credits scheme might result in administrative and control costs higher than those of other regulatory measures or economic policy levers. Another possible drawback of the system would be difficulties for manufacturers in predicting the future price of emission credits and thus the total cost of cars requiring extra credits. This, however, is likely to be a problem only initially.

A system of tradable credits nevertheless offers an attractive blend of fiscal and regulatory instruments. Current experience of tradable credits rests largely in the USA, and relates mainly to stationary emissions sources. Those systems have worked well, and sulphur emissions permits are regularly traded at the Chicago stock exchange. In Europe, as mentioned above, a scheme for CO<sub>2</sub> emissions trading, restricted to certain sectors of society, started operating on 1 January 2005.

An EU-wide cap and trade scheme for specific CO<sub>2</sub> emissions from new cars would provide equal treatment to all manufacturers and all Member States. It has the advantage over national sales and registration taxes of not distorting the market and not requiring a refund system to avoid double-taxation of car owners who move from one Member State to another.

It is extremely difficult to predict the equilibrium price of a CO<sub>2</sub> permit market. The outcome depends to a great deal on to what degree customers will prefer smaller engines and downsizing to expensive measures such as electric-hybrid engines. In order to reach 120 g by 2012, the cap should be lowered by 5.6 g per year from 2005. This would require an extra effort from the industry or additional adjustment among customers as the best achievements from one year to another under the voluntary agreement so far have been 5 g in 2001 and 4 g in 1999.

One way of moving gently from the current commitment by the industry to a cap and trade scheme could be to begin with a reduction of 4 g in the first year under the new regime, and to gradually raise the requirement in the following years. This would be a way of learning by doing and could even allow the Community to await the equilibrium price of the first year trade before definitely deciding on the caps for year 2, 3 and 4.

A scheme for tradable emission credits can be introduced by the Council by qualified majority. As it does not involve any element of taxation, a unanimous vote is not required.

### California is leading the way

In 2002, the state of California passed a law that demands sharp reductions in the emission of greenhouse gases from cars and light duty vehicles. Based on this law, the California Air Resources Board (CARB), in Autumn 2004, proposed that car makers should, in a first phase, be forced to reduce specific emissions from new cars and light commercial vehicles by respectively 25 and 18 per cent in 2012 and in a second phase with a total of 34 and 25 percent in 2016. The idea is to make the manufacturers comply with CO<sub>2</sub> emission limits, which are gradually lowered. Under these caps individual producers will be allowed to trade emission permits with each other.

According to estimates by CARB the purchase price of new vehicles is likely to rise as a consequence of the new standards by an average of \$325 during the first phase and \$1 050 in the second phase (lower for cars and higher for light commercial vehicles). The added cost, however, will be saved over the life of the vehicle due to reduced running costs.<sup>20</sup>

The Environmental Protection Agency, however, says carbon dioxide is not a pollutant under the Clean Air Act. The Bush administration thus argues that California's new rules are really fuel-economy standards and that only the federal government has the power to set such standards. The car industry insists that the technology required to meet the new rules is either unavailable or hugely expensive. In December 2004, the industry filed a lawsuit against CARB, claiming that a law limiting CO<sub>2</sub> emissions from new vehicles pre-empts federal law setting fuel-economy standards.

### Maybe Europe too?

Tradable credits were among five different options presented by the European Commission at a workshop held in 1998 in Strasbourg. The Commission presented fee-bates and tradable credits as having the potential to significantly improve the cost effectiveness of regulation compared to binding limit values without any flexibility (European Commission, 1998). A few months later the Commission's DG2 presented a discussion paper which showed that a system of tradable credits compared with the second-best alternative option would save between €300 and €800 million annually.<sup>21</sup>

In Europe, the Dutch government (along with Germany and France) think it should be possible for the industry to reach 120 g CO<sub>2</sub> /km in 2012. The path preferred by the Member States is a new series of voluntary agreements. If the industry declines a voluntary agreement in this respect, or if the current agreement does not prove to be effective enough, the Netherlands believes that the only remaining option will be to set standards for the specific emissions of CO<sub>2</sub> which are gradually tightened. The Dutch government want such standards to be established in such a way that it allows for trading (VROM, 2004).

### Many adjustment mechanisms

As noted above, ACEA, based on a study by ADL, claims that reducing CO<sub>2</sub> emissions to an average of 120 g/km would increase average production cost by €4 000. In order to arrive at this figure ACEA's consultant assumed that there would be no

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<sup>20</sup> News Release 24 September 2004, California Air Resources Board ( [www.arb.ca.gov](http://www.arb.ca.gov))

<sup>21</sup> European Commission, DG2, Flexibility for efficiency. Achieving a fuel-efficient car fleet in Europe: the potential for a tradable credit system, presented at an ENVECO meeting, 23-24 April 1998 in Brussels.

downsizing either in terms of the size of the car itself or with regard to engine volume.

Regulating CO<sub>2</sub> emissions under a cap and trade system, or reducing them by a CO<sub>2</sub> differentiated sales and registration tax, however, leaves manufacturers and customers a choice between several different adjustment mechanisms. It is not self-evident that the first choice of the customer would be to maintain top-speeds and acceleration at the levels of today. Some customers may prefer a compromise where they save a great deal of money by accepting the speeds and acceleration comparable to, for instance, those of 1995 models. The adjustment mechanisms include:

- Reducing car mass
- Reducing air drag and rolling resistance
- Improving the efficiency of the power-train
- Shifting to a new type of power-train
- Refraining from automatic gearboxes (of traditional type)
- Refraining from 4WD
- Choosing a smaller and less powerful engine
- Shifting to a smaller car (downsizing)

The last four of these measures would save the customer money, which is probably why they are not liked by the manufacturers. A Swedish study shows that if all buyers of new cars in 2003 would have chosen the least-consuming variant, without shifting model or fuel, average CO<sub>2</sub> emissions would have been cut by more than 10 per cent. The effect would have been even greater, close to 25 per cent, had all customers chosen the most fuel efficient model in each market segment, i.e. without down-sizing or shifting from petrol to diesel engines (Elvingsson, 2004).

The first four adjustment mechanisms, on the other hand, would add to the price of the car, but part or all of the increase in capital cost would be offset by lower running costs. At today's fuel price (gasoline, including taxes and VAT), a customer driving his vehicle 15 000 km per year would save €335 per year, if the specific CO<sub>2</sub> emission is reduced from 165 to 120 g/km. Over the approximately 15-year-life of the average car this accumulates to €5 000. The governments of the EU, however, would lose tax revenue from a shift to fuel-efficient cars.

Moreover, if the industry is really concerned about rising production costs, why do manufacturers make such great efforts marketing cars with high power ratings, 4WD and a lot of luxury equipment, when they could do their customers a favour by focusing on models costing less to produce and less to own? Is it not true that trends such as the current fashion for SUVs help boost the manufacturing industry's production volume (in Euros or dollars)? And who can remember having met a car dealer who tried to convince his customer to choose a less powerful engine?

#### European competitiveness

Rising costs resulting from more stringent CO<sub>2</sub> emission rules, if such costs occur, are not likely to harm the motor industry. Instead, the oil industry is the loser, when customers spend less on fuel and more on vehicles.

Another important issue for the Council and the European Parliament to consider is how a cap and trade scheme aimed at reducing specific emissions to 120 g/km, or a common sales and registration tax, would affect competition within the global auto-

motive industry. The current average emission from new registrations in the EU-15 is a good starting point for such an analysis. In this respect ACEA has an advantage over JAMA and KAMA by having the lowest current average emission. While ACEA members on average need to reduce emissions by 25 per cent, JAMA and KAMA have gaps to close of respectively 30 and 33 per cent.

Austin et.al. (2003) explored how carbon constraints in global automotive markets (the US, EU and Japanese markets) may affect value creation in ten leading automotive companies between now and 2015. They found that most European car makers and Japanese firms such as Honda and Toyota would gain from carbon constraints while BMW together with GM, Ford and Daimler-Chrysler would risk losing market shares. However, in giant corporations such as GM and Ford there would most likely be both winners and losers. European subsidiaries do not necessarily have to be among the losers.

In a similar analysis of the Chinese market, after the implementation of fuel economy standards, Sauer and Wellington (2004) found that Toyota, Ford and PSA are best positioned, requiring little or no investment over a longer period, to meet the new standards. Where Ford is concerned, this is partly explained by its models sold in China having relatively low emissions.

#### Conclusions on instruments

A cap and trade system has two advantages over registration taxes. Tradable emission credits will, by definition, achieve the objective, while sales and registration taxes may fall short of the target if rates are set at levels that later prove inadequate. The second advantage is that the Council can introduce a system of tradable emission credits by qualified majority.

The main difference between a voluntary agreement with the car industry and a cap and trade scheme is that the latter influences not only the producers but also their customers. Lack of customer acceptance is a problem that the industry itself cannot tackle. It is an issue for governments.

The current voluntary agreement has no method for dealing with free riders and no way of rewarding manufacturers who contribute actively to achieving the target. A cap and trade system as well as a common registration tax has the advantage of giving credit to proactive car producers, an incentive that may prove essential for reducing specific CO<sub>2</sub> emissions to very low levels.

#### **16. Problems that the reform will not solve**

Introducing a cap and trade system for specific CO<sub>2</sub> emissions from new cars or a harmonised scheme for registration taxes would leave a few problems unsolved.

##### The rebound effect

Improving the fuel-efficiency of cars will reduce the fuel cost of motoring. Lower fuel costs per kilometre will encourage increased driving. This indirect effect on driving and fuel consumption is sometimes referred to as *the rebound effect*. The size of the rebound effect can be roughly estimated by using the fuel price elasticity. Based on a variety of studies the European Commission (1995b) found the long-term fuel price elasticity to be around -0.7. The significance of this is that an increase of the price by, say, 10 per cent will in the longer term depress demand by 7 per cent.

However, around 60 per cent of the adjustment is in terms of improved specific fuel efficiency. Adjustment in terms of annual distance driven and car ownership accounts for only around 40 per cent of the total long-term fuel price elasticity (Netherlands Economisch Instituut, 1991, and Jansson and Wall, 1994). This implies that the rebound effect could be as high as 25 per cent. Improving the specific fuel efficiency by 25 per cent could then be expected to increase total mileage by something like 6 or 7 per cent.<sup>22</sup>

The rebound effect is particularly problematic where diesel cars are concerned. They are not only more fuel-efficient than petrol-fuelled cars, but in addition they benefit from the fuel being taxed around 30 per cent below petrol in Member States. This results in a diesel price at the pump which is typically 20 to 25 per cent below the price of petrol. The combination of a specific fuel consumption approximately 25 per cent below that of the same model equipped with a petrol engine and low fuel price results in fuelling costs being only around 60 per cent of those of petrol cars. If the rebound effect is assumed to be 20 per cent, one fifth of the difference in fuel cost per kilometre of driving a diesel car will be used for adding additional miles. That means that approximately 8 of the 25 per cent gained by better fuel efficiency are offset by higher mileage. One should also recall that diesel fuel contains 10 per cent more carbon per litre than petrol. In total, this means that on an annual basis the average diesel car probably emits only around 7 per cent less carbon than the average petrol car (of the same size and with the same performance). The United Kingdom is the only Member State that taxes diesel on a level with petrol.

Diesel cars would be a good partial solution to the CO<sub>2</sub> problem if CO<sub>2</sub> emitted from diesel fuel was taxed on a par with CO<sub>2</sub> from petrol-fuelled engines and if diesel engines did not give rise to excess emissions of nitrogen oxides and particles. However, when the average fuel taxation in the EU-15 is recalculated into Euro per kg of CO<sub>2</sub>, it becomes clear that a kg emitted from petrol is taxed around 65 per cent more than a kg from diesel. This policy is clearly in conflict with economic theory, which suggests that taxation of emissions should be technically neutral in order to be long-term efficient. Where particulate matter is concerned, new diesel engines still emit at least 10 times as much per vehicle kilometre, unless they are equipped with a particle filter. In addition, diesel cars are allowed to emit three times as much NO<sub>x</sub> as petrol cars.

The rebound effect makes car owners enlarge their annual mileage, which in turn increases the overall emissions of regulated substances such as nitrogen oxides, hydrocarbons and particles. Therefore, the emission limit values of Euro 5 (to be introduced around 2010) need to become even more stringent than in a business as usual case.

#### The test cycle

The current EU test cycle does not match real driving conditions well. The Commission should therefore contemplate bringing forward a proposal for a new cycle that includes more accelerations and de-accelerations. When changing the driving cycle, the Community should also consider the feasibility of including emissions caused by producing the onboard-electricity required for air conditioning (A/C). Most new vehicles are equipped with A/C, which may consume as much as 10-15 per cent of the overall fuel consumption of the vehicle. Having the air conditioning turned on during

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<sup>22</sup> However, in a case where specific fuel consumption is cut by half or more, one should expect the rebound effect to be smaller (in per cent) as lack of time would eventually constrain the increase in annual mileage.

the test cycle, would provide incentive to producers to reduce the electricity consumption of the device, and customers who feel that they can sacrifice the comfort of A/C would get a credit.

Introducing a cap on the CO<sub>2</sub> emissions from passenger cars or making cars more expensive by a registration tax may provide an incentive to some customers to move from cars to light trucks. In order to prevent this shift, two supplementary decisions may be needed. The first would be to introduce a similar model, cap and trade or registration tax, for light duty trucks. As the cap for light trucks would have to be more lenient than the cap for cars, some motorists would still consider shifting to trucks. A second measure to reduce the likelihood of this could be to rule that all light vehicles having more than three seats should be regarded as passenger cars and taxed accordingly.

How to reduce the negative impact on traffic safety of SUVs?

Introducing a cap on specific CO<sub>2</sub> emissions from new cars or a harmonised registration tax would make heavy passenger cars more expensive. As a result, demand for Sport Utility Vehicles (SUVs) would diminish. However, the willingness to pay for SUVs among customers is quite high. A problem in this context is that a linear system of increasing CO<sub>2</sub> taxation does not increase the price of cars linearly with fuel consumption. In essence this means that the rebate earned by a car that emits 120 g (when the baseline or the cap is 160) is equivalent to a higher share of the purchase price than the fee paid by a vehicle that emits 200 g. The net effect of this is that the tax becomes progressively less effective with increasing fuel consumption since it forms a smaller proportion of the total purchase price (DRI, 1995). For this reason one would have to expect a relatively large number of new registrations of SUVs even if the market share of these vehicles may be reduced by 50 per cent or more as a result of cap and trade or a high CO<sub>2</sub> differentiated registration tax. From a traffic safety point of view this is a concern.

According to official American data, SUVs are nearly three times as likely as mid-size cars to kill the drivers of other vehicles during collisions. The stiff frames of SUVs absorb much less energy during a crash than ordinary car frames, transferring more of the force of a crash to whatever they hit. The height of the car body is also a problem in crashes with normal cars. Occupants of SUVs, however, are much more likely than car occupants to die in a rollover or in other types of single vehicle accidents. Therefore the occupant death rate in crashes per million SUVs on the road is 6 per cent higher than the death rate per million cars. In 2000, SUVs caused approximately 1 000 more deaths among SUV occupants compared to a situation where all occupants would have travelled in cars. In addition, SUVs in America, inflicted another 1 000 unnecessary deaths among motorists who would have survived had they instead been hit by cars of the same weight as their own. At this time SUVs only made up 10 per cent of all vehicles registered in the United States, and more than half of them were less than five years old (Bradsher, 2003).

There are technical ways of limiting the death toll of SUVs. Volvo has equipped the XC90 with a reinforced roof for rollovers and a car-like unit body instead of a body-on-frame design. The XC90 also has a front end that is designed to crumble and absorb energy in a crash, and a hollow steel bar down low to reduce the risk of riding over car bumpers and door sills. Nevertheless, a test crash undertaken by the German automobile club (ADAC) showed the XC90 climbing a Volkswagen Golf in a frontal collision.<sup>23</sup> Bradsher (2003) citing experts says that the steps announced by

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<sup>23</sup> [www.adac.de](http://www.adac.de)

automakers so far will eliminate no more than a third of the extra deaths caused by SUVs.

American data indicates that full-size SUVs double the death risk for pedestrians compared to traditional passenger cars. In this case the tall hood, together with high ground clearance, is the problem.

When reflecting over what 10 per cent SUVs have done to the death rate in the United States, one should recall that European vehicle fleets include much higher percentages of small cars. If automakers begin to slim the mass of cars in response to a cap and trade system or a CO<sub>2</sub> differentiated registration tax, the difference in size and weight between cars and SUVs will increase even further.

For these reasons it is necessary to enforce much stricter safety standards on SUVs. One alternative could be to put an upper limit on the weight of vehicles classified as M1 (maximum 9 occupants). An upper limit of 1 700 or 1 800 kg service weight would probably be enough to prevent Europe from taking an American route. For improved protection of pedestrians Europe could force automakers to make the hoods of all passenger cars slope. This means that the front of an SUV can no longer look as brutal as the front of a classical Jeep, a change that might in itself reduce the fashion for SUVs. This requirement would also provide additional opportunity to insert crumbling materials in the front zone of the vehicle. An option that would reduce the risk inflicted on occupants of other cars would be to rule that SUVs must be able to automatically lower the body of the car when driven at normal highway speed or on paved streets. There are already SUVs on the market that can regulate the height of their body. When driving on a smooth highway there is no need for extra ground clearance.

#### Improve real driving

Limiting CO<sub>2</sub> emissions from road transport is not only a matter of improving the specific fuel efficiency of vehicles. Speed and driving behaviour are other important elements in any comprehensive CO<sub>2</sub> abatement strategy. According to a report from the German Environmental Protection Agency, limiting the maximum speed on the Autobahn to 100 km/h would reduce CO<sub>2</sub> emissions by 20-25 per cent, cut traffic casualties almost by half and improve traffic flow. In other Member States improved speed controls appear to be a very cost-effective abatement instrument. Speed limits and speed control could, according to the European Commission (1998c), depress overall fuel consumption by around 5 per cent.

Training drivers in *EcoDriving* can reduce specific emissions by between 5 and 15 per cent, and in some cases even more. Given the low additional cost and high cost-effectiveness of fuel-saving, in-car equipment that helps motorists adopt an economic driving style, on-board econometers that show fuel consumption per kilometre, gear shift indicators and cruise control should be fitted as standard on new cars.

## 17. Summary and conclusions

From a technological point of view the manufacturing industry should have no difficulties producing cars which on average emit 140 g CO<sub>2</sub> per km in 2008 and 120 g in 2012. However, under current rules, manufacturers, wholesalers and car dealers have no incentive to sell fuel-efficient cars. They earn more from concentrating on big, well-equipped and high performing vehicles. Such models have a higher profit margin and therefore contribute disproportionately to the economic success of the industry. Manufacturers therefore can be expected to continue to encourage the

trend towards larger vehicles such as Multi-Purpose Vehicles and Sport Utility Vehicles for use as passenger cars. No individual manufacturer can afford to take a different route without the support of incentives.

Without additional financial incentives or regulation, manufacturers will only make use of part of the available potential for a general fuel-efficiency improvement. Statements by the industry show that it is aware of this problem. From the analysis of this report it is apparent that the industry will at best achieve 75-80 per cent of the difference between the 2008-09 target and the average specific fuel consumption in 1995. The preference among customers for higher performance and bigger cars is likely to hamper the outcome of any new voluntary fuel efficiency agreement. Voluntary agreements will always fall short of what could be achieved by making use of the best available technologies. The gap is explained by the fact that voluntary agreements do not influence customer preferences. Another problem is that the current voluntary agreement has no method for dealing with free riders and no way of rewarding manufacturers who contribute actively to achieving the target.

What the Council and the Parliament need to understand is that the market is a good servant but a terrible master. To make the car market contribute fully toward sustainable transport, lawmakers need to be in command. Strong incentives or fuel efficiency regulation are needed to make the passenger car market support the climate change policy of the European Union.

Mandatory introduction and use of CO<sub>2</sub> labels on cars displayed for sale and information on fuel consumption in marketing materials could not be expected to make much difference. The experience gained in Sweden and the UK, where such schemes have been in operation for more than 20 years, is not promising.

This report shows the need for introducing an economic incentive or a regulatory measure connected to the specific fuel consumption of new cars. A system of tradable emissions credits is, in this context, an interesting option as it is a flexible instrument that can guarantee that pre-defined CO<sub>2</sub> targets are reached at the least possible cost. The European Union should contemplate the pros and cons of following California's example and introduce a common cap and trade scheme for specific CO<sub>2</sub> emissions from new cars. Such a scheme would give the European car industry a competitive advantage as it produces cars that, on average, are more fuel efficient than its competitors'.

A common European sales and registration tax that is differentiated for specific CO<sub>2</sub> emissions is the only real alternative to tradable emission credits. Such a tax should be designed as a fee and rebate system to avoid making the average new car more expensive. In order to prevent a continuing shift to minivans and sport utility vehicles, the sales tax needs to be highly differentiated. The trend towards such vehicles could alternatively be prevented by putting an upper legal limit on the service weight of passenger cars (category M1, vehicles with maximum 9 seats). To be effective this limit would then have to be in the order of 1 700 to 1 800 kg.

A cap and trade system has two advantages over registration taxes. Tradable emission credits will, by definition, achieve the objective, while sales and registration taxes may fall short of the target if rates are set at levels that later prove inadequate. The second advantage is that the Council can introduce a system of tradable emission credits by qualified majority.

Economic incentives will be of particular importance for achieving the Council's 120 g CO<sub>2</sub> target. The Commission should not wait to develop this third pillar of the Community's CO<sub>2</sub> car strategy, but start now.

The fact that most Member States (the UK being the only exemption) tax diesel fuel far less than petrol means that the current shift from petrol to diesel engines affects real emissions a great deal less than would have been the case under equal taxation. When petrol engines become more fuel efficient (e.g. indirect injection), the extra annual mileage stimulated by the lower tax on diesel will approximately counter-balance the remaining difference in specific CO<sub>2</sub> emission (per km) between modern diesel and petrol engines. A further shift to diesel will, in that situation, no longer result in lower overall emissions of CO<sub>2</sub>. An important conclusion, then, is that fossil road fuels should be taxed according to their carbon content. This means taxing diesel fuel on a par with petrol or even considering a tax around 10 per cent above that on petrol as diesel contains more carbon per litre of fuel.

Improving the fuel-efficiency of cars will reduce the fuel cost of motoring. Lower fuel costs per kilometre will encourage increased driving. This indirect effect on driving and fuel consumption is referred to as *the rebound effect*. As a result of the rebound effect the overall emissions of regulated substances such as nitrogen oxides, hydrocarbons and particles will increase. Therefore, the emission limit values of Euro 5 (to be introduced around 2010) need to become even more stringent than in a business as usual case.

It should be borne in mind that reducing the specific CO<sub>2</sub> emissions of cars to 120 g /km could be achieved without a marginal loss of welfare. The abatement cost is low to moderate and, in the case of engine and car downsizing, even negative. If the European Union fails to make use of this opportunity, CO<sub>2</sub> will have to be further reduced in other sectors of society at a considerable additional cost.

Some manufacturers will respond to emissions trading or a differentiated sales and registration tax by making new vehicles less heavy. This could increase the difference in weight between low carbon cars and SUVs. Thus there is cause to enforce much stricter safety standards on SUVs. For improved protection of pedestrians, Europe could force automakers to make the hoods of all passenger cars slope. This requirement would also provide additional opportunity to insert crumpling materials in the front zone of the vehicle. An option that would reduce the risk inflicted on occupants of other cars would be to rule that SUVs must be able to automatically lower the body of the car when driven at normal highway speed or on paved streets. There are already SUVs in the market that can regulate the height of their body.

## References

ACEA (1998), "ACEA Commitment on CO<sub>2</sub> Emission Reductions from New Passenger Cars in the Framework of an Environmental Agreement between the European Commission and ACEA", Brussels July 27<sup>th</sup>.

ACEA (2003), "ACEA's Statement on the potential for additional CO<sub>2</sub> reduction, with a view to moving further towards the Community's objective of 120g CO<sub>2</sub>/km by 2012", Brussels 27.11.2003.

ADL (2003), "Investigation of the Consequences of Meeting a New Car Fleet Target of 120g/km CO<sub>2</sub> by 2012", Arthur D. Little.

Austin, D., Rosinski, N., Sauer, A. and Le Duc, C. (2003), "Changing Drivers: The impact of climate change on competitiveness and value creation in the automotive industry", World Resources Institute and Sustainable Asset Management, Washington D.C.

Bradsher, K. (2003), "High and Mighty. The dangerous rise of the SUV." PublicAffairs, New York.

COWI A/S (2001), "Fiscal Measures to Reduce CO<sub>2</sub> Emissions from New Passenger Cars, Main Report. European Commission's Directorate-General for Environment", December 2001.

Department of Transport (1992), Fendick, M. and Taylor, S., "Tradable Credits: Variants for the Transport Sector", Transport Policy Unit, London.

Department for Transport (2003), "Comparative colour-coded labels for passenger cars", London.

Department for Transport (2004), "Powering Future Vehicles. The Government Strategy. Second Annual Report." London.

Dings, J., Dijkstra, W. and Metz, D. (1998), "Speed limiters on vans and light trucks, Environmental and economic effects", study commissioned by NOVEM, Centre for Energy Conservation and Environmental Technology, Delft, the Netherlands.

DRI Global Automotive Group (1995), "Reducing CO<sub>2</sub> Emissions from Passenger Cars in the European Union by Improved Fuel Efficiency: An Assessment of Possible Fiscal Instruments", A Report to DG XI, European Commission.

Duleep, K. G. (2003), "Alternative Paths – Comparative Cost and Performance", presentation at Asilomar 2003 IX Biennial Conference on Transportation and Energy, "The Hydrogen Transition", July 29 – August 1 2003, Pacific Grove, Cal.

ECMT (1995), "Trends in Power Ratings of Cars and Heavy Goods Vehicles", ECMT/OECD, Paris.

Elvingsson, P. (2004), "Kan vi köpa det vi vill ha?" National Road Administration Publication 2004:13.

European Commission and ACEA (1998), "CO<sub>2</sub> emissions from cars. The EU Implementing the Kyoto protocol", Brussels (pamphlet).

European Commission (1995a), "A Community Strategy to reduce CO<sub>2</sub> emissions from passenger cars and improve fuel economy", Communication from the Commission to the Council and the European Parliament (COM(95)689) (Council conclusions of 25.6.1996).

European Commission (1995b), "Towards Fair and Efficient Pricing in Transport, Policy options for internalising the external costs of transport in the European Union, Green paper" (COM(95) 691 final).

European Commission (1998a), "Communication from the Commission to the Council and the European Parliament, Implementing the Community Strategy to Reduce CO<sub>2</sub> Emissions from Cars: An Environmental Agreement with the European Automobile Industry", COM(1998) 495 final (Council conclusions of 6.10.1998).

European Commission (1998b), "Discussion Paper: Binding CO<sub>2</sub> limit values as a basis for a re-oriented CO<sub>2</sub>-cars strategy", 13 February 1998, Brussels.

European Commission (1998c), "Communication on Transport and CO<sub>2</sub> – Developing a Community Approach" (COM(1998) 204 final).

European Commission (1998d), "Proposal for a Council decision establishing a scheme to monitor the average specific emissions of carbon dioxide from new passenger cars" (COM(1998) 348 final).

European Commission (1998e), "Environmental Agreement with the European Automobile Manufacturers Association (ACEA) on the Reduction of CO<sub>2</sub> Emissions from Passenger Cars", Commission Staff Working Paper (SEC(1998) 1047).

European Commission (1999), "Communication from the Commission to the Council and the European Parliament, Implementing the Community Strategy to reduce CO<sub>2</sub> Emissions from cars: Outcome of the negotiations with the Japanese and Korean automobile industries" (COM(1999)446 final) (Council conclusions of 12.10.1999).

European Commission (2002), "Taxation of passenger cars in the European Union – options for action at national and Community levels", Communication from the Commission to the Council and the European Parliament, COM(2002) 431 final.

European Commission (2004), "Working Document to serve as the basis for the preparation of an Extended Impact Assessment for the preparation of a Proposal for a Council Directive 2004/.../EC, restructuring the tax bases of the annual circulation and registration taxes, to introduce a registration tax refund system and to gradually abolish registration taxes, in order to make passenger car taxation more CO<sub>2</sub> efficient and more consistent with the Internal Market", Brussels, 12 July 2004.

Fergusson, M. and Holman, C. (1992), "A Proposed System for Controlling New Car Carbon Dioxide Emissions", the World Wide Fund for Nature UK, Godalming.

Forsman, B. (2004), "PM om bilannonser", published in "Underlagsrapporter till klimatstrategi för vägtransportssystemet", National Road Administration, Publikation 2004:103, Borlänge, Sweden.

Greene, D.L. (1992), "Vehicle Use and Fuel Economy: How Big Is the 'Rebound' Effect?", Energy J-IAEE, vol 13, n1, p 117-143.

JAMA (2003), "JAMA Position on the Potential for Achieving the CO<sub>2</sub> Reduction Target of 120g/km in 2012". Japan Automobile Manufacturers Association.

Jansson, J.O. and Wall, R. (1994), "Bensinskattförändringars effekter", Rapport till expertgruppen för studier i offentlig ekonomi, Finansdepartementet (Ministry of Finance), Stockholm.

Kågeson, P. (1992), "Making fuel go further – a critical evaluation of different political instruments for improving the fuel efficiency of new cars and other light vehicles", European Federation for Transport and Environment, T&E 92/6, Brussels.

Kågeson, P. (2000), "The Drive for Less Fuel. Will the motor industry be able to honour its commitment to the European Union?" European Federation for Transport and Environment, T&E 00/1.

Kågeson, P. (2001), "The Impact of CO<sub>2</sub> Emissions Trading on the European Transport Sector", VINNOVA Report VR 2001:17, Stockholm.

Kågeson, P. (2004), "Varför är Sverige värst i klassen?" National Road Administration, Publication 2004:14, Borlänge, Sweden.

MacCready, P. (2004), "The Case for Battery Electric Vehicles", in "The Hydrogen Energy Transition. Moving toward the post petroleum age in transportation" (eds. Daniel Sperling and James Cannon), Elsevier Academic Press.

Nederlands Economisch Instituut (1991), "De prijselasticiteit van het energie verbruik in het wegverkeer".

Owen, N.J. and Gordon, R.L. (2003), "'Carbon to hydrogen' Roadmaps for Passenger Cars: Update of the study for the Department for Transport and the Department of Trade and Industry", Ricardo Consulting Engineers, Shoreham by Sea.

Sauer, A. and Wellington, F. (2004); "Taking the High (Fuel Economy) Road. What do the Chinese fuel economy standards mean for foreign automakers?" World Resources Institute, Washington D.C.

TNO (2004), "Measuring and preparing reduction measures for CO<sub>2</sub> -emissions from N1 vehicles - final report", Delft.

Van den Brink, R. and Van Wee, B. (1999), "Passenger car fuel consumption in the recent past, Why has passenger car fuel consumption no longer shown a decrease since 1990?", paper prepared for the workshop "Indicators of Transportation Activity, Energy and CO<sub>2</sub> emissions", May 9-11, Stockholm (also published in an earlier version in Verkeerskunde, April 1999).

VROM (2004), "Traffic Emissions Policy Document", The Netherlands Ministry of Housing, Spatial Planning and the Environment, the Hague.





