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The Drive for Less Fuel

Will the motor industry be able to honour its commitment to the European Union?

By

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Preface

To date EU efforts to stem the growth in the emissions of CO_2 from transport have only targeted one element of one part of total transport CO_2 emissions – new car fuel efficiency. This "*one club*" approach must therefore be assured of success if the transport sector is to contribute to the EU wide reductions of CO_2 emissions required by the Kyoto Protocol.

The cornerstone of the EU strategy has been a voluntary agreement with vehicle manufacturers for them to reduce the CO_2 emitted by their new cars per kilometre driven. If this element of the strategy falls short of its target, the minimal community action on transport CO_2 taken thus far will fail, preventing transport contributing to reduced EU CO_2 emissions.

This report offers a comprehensive assessment of the agreement between the manufacturers and the Commission. The Author concludes that it is unlikely that the agreement can be honoured without additional efforts on the part of regulators. As a result he recommends the EU to adopt alternatively a system of tradable CO_2 emission credits or a sales tax which is highly differentiated for specific CO_2 emissions.

Whilst the report is not an endorsement at this time by T&E of a more general system of CO_2 emissions trading, it is clear that regulators both at national Member State and EU levels will need to consider all options for additional action. The alternative is that sectors already contributing real reductions in their CO_2 emissions will have to undertake further actions if the EU is to abide by its international legal commitments. Alternatively the most equitable approach to all sectors would be a universal carbon tax.

Frazer Goodwin

Policy Officer

Author's foreword

T&E's Swedish member Gröna Bilister (The Swedish Association of Green Motorists) initiated this report.

Several people have contributed data and comments on a first draft. I particularly want to thank Malcolm Fergusson, IEEP, for both having provided valuable background information and some very useful comments. Special thanks go to Chris Bowers for having proof read the manuscript.

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Stockholm in January 2000

Per Kågeson

Executive summary

- The automotive industry will not meet its commitments to the European Union to produce cars in 2008-09 that on average emit no more than 140 g carbon dioxide (CO_2) per km without large changes in its production and marketing strategies.
- A shift to more efficient powertrains – such as common rail diesel engines, direct injection petrol engines, electric hybrids and fuel cells – will at best account for half of the reduction needed.
- Improved fuel efficiency of conventional petrol engines and reduced mass, air resistance, friction and rolling resistance of all cars (regardless of powertrain) could make up the difference provided that the current trend towards heavier and more powerful cars, including "Sport Utility Vehicles" (SUVs) and vans, is discontinued.
- The experience gained in Sweden and the UK suggests that mandatory use of CO_2 labels on cars displayed for sale and information on fuel consumption in marketing could not be expected to make much difference.
- The motor industry is not likely to be able to achieve the necessary trend towards smaller and less powerful cars on its own as manufacturers, wholesalers and dealers all earn more from concentrating on large, luxury and powerful cars.
- The conclusion is that without additional financial incentives/disincentives manufacturers will only make use of a minor part of the available potential for general fuel-efficiency improvement.
- A system of tradable emission credits or a sales tax that is differentiated for specific CO_2 emissions appears to be most useful policy instruments. The latter 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 vans and SUVs, the sales tax needs to be highly differentiated.
- Diesel fuel is less taxed than petrol in most Member States. A further shift to diesel engines will thus affect real consumption less than would have been the case under equal taxation. When petrol engines become more efficient, the extra annual mileage stimulated by the lower tax on diesel will approximately counter-balance the remaining difference in specific CO_2 emissions (per km). The conclusion is that fossil road fuels should be taxed according to their content of carbon. This means taxing diesel fuel 13 per cent above petrol as it contains more carbon per litre of fuel.
- When cars become more fuel-efficient, the lower running costs will encourage owners to drive further. To counter-balance this "rebound-effect" the tax on diesel and petrol needs to be raised annually by 20-30 per cent of the rate of fuel efficiency improvement.
- The joint monitoring of the CO_2 agreement should cover both individual manufacturers and the progress made on national markets.

- A swift introduction of low-sulphur diesel and petrol fuels is needed to provide for a shift to direct injection diesel and petrol engines. Thus it is essential that Member States be allowed to introduce tax-breaks for ultra-low sulphur fuels.
- Speed and driving behaviour are other important elements in a comprehensive CO_2 abatement strategy. Speed limits and speed control could depress fuel consumption by around 5 per cent.
- A specific CO_2 emission of 140 g/km (or even 120 g) could be achieved without a marginal loss of welfare. The abatement cost is low and in the case of engine and car downsizing even negative. When the positive side-effects on traffic safety are considered, it becomes obvious that society could achieve a net gain in welfare from reducing the specific fuel consumption of new cars. If the European Union fails to make use of this opportunity, CO_2 will have to be further reduced in other sectors of society at a considerable additional cost.

1. Introduction

Passenger car traffic accounts for around 12 per cent of total man-made CO_2 emissions in the EU.[1] Road transport CO_2 emissions grew by around 9 per cent from 1990 to 1997, and passenger cars account for much of this growth (European Commission and ACEA, 1998).

The European Commission and the Environment Council have high expectations that agreements with the motor industry will reduce CO_2 emissions from new cars by around 25 per cent by 2008 (to an average of no more than 140 g CO_2/km). This figure is for petrol-fuelled cars equivalent to a fuel consumption of approximately 5 litres per 100 km. The European Automobile Manufacturers Association (ACEA) says "this voluntary approach will allow environmental objectives to be achieved more quickly than through other means" (ACEA's president Bernd Pischetsrieder in 1998).

The veracity of ACEA's statement can only be judged by close examination of the prospects for fuel economy improvements The aim of this report is therefore to analyse the technical opportunities available and examine to what extent they can penetrate the European market by 2008. A reason for undertaking this study is a fear that the current trend towards more powerful engines and more vans and sport utility vehicles will continue. This may lead to a situation where the manufacturing industry, when approaching 2008, will say that it failed to reach an average of 140 g CO_2/km because customers wanted something other than a car that can do 100 km on five litres of fuel.

If such difficulties can be foreseen, it is essential that the European Union develops the third (and as yet unexplored) pillar in its CO_2 strategy for cars: market oriented measures to influence motorists' choice towards more fuel-efficient cars. Another objective of this study is therefore to take a close look at what governments could do in order to help the industry to honour its commitment.

2. Recent trends in car ownership and fuel consumption

The total number of cars in the EU reached 170 million at the end of 1997, up 16 per cent since 1990. The growth has been considerable during the 1990s in all EU states with the exception of Finland, Sweden and the Netherlands where car ownership has stagnated. Total car mileage has grown by an estimated 15 per cent since 1990 (homepage of DG VII). In 1998 a total of 13.9 million new cars were registered in the 15 Member States of the Union.

Data on average (sales weighted) fuel consumption is not available from all Member States of the EU. ECMT (1999), however, has calculated weighted

[1] Total road traffic accounts for 22 per cent and total transport for around 26 per cent (international aviation and shipping not included).

averages for new cars in seven Member States (including the big four) based on data from ACEA and OICA (Organisation Internationale des Constructeurs d'Automobiles). The average reduction was dramatic in the first half of the 1980s, but since 1985 fuel consumption has stayed relatively stable. Since 1995, based on the new EU test cycle (93/116/EC), fuel consumption and CO_2 emissions from newly registered cars have shown a weak tendency of decline.

The power delivered by the engine of a car is used to overcome air resistance, friction, rolling resistance and inertia (vehicle weight) during acceleration. When driving at low speed the main factor determining power requirements is vehicle weight. From the technological progress achieved since 1985 one would expect a reduction in average specific fuel consumption in the order of 15-20 per cent. However, most of this potential has been offset by a trend towards heavier and faster cars.

The average size 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 variety in terms of engine sizes and power rating. 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 1 shows the market shares for passenger cars in western Europe (EU 15, Norway and Switzerland) by segment. The statistics are somewhat distorted by the fact that commercial vehicles (CVs) are sometimes registered as passenger cars and cars as commercial vehicles. "Other" in table 1 is predominantly made up of CVs such as the Renault Kangoo and VW Transporter. In Portugal and Spain Sport Utility Vehicles (SUVs, e.g. jeeps) are registered as commercial vehicles, which means that they are not included in table 1.

Table 1. New car registrations by market segment in Western Europe 1990-1998. Per cent.

Segment	Example	1994	1998
Mini	Fiat Panda	4.3	6.4
Small	Renault Clio	28.1	26.7
Lower medium	VW Golf	31.4	30.4
Medium	Ford Mondeo	23.5	22.0
Upper medium	Opel Omega	6.6	5.5
Luxury	Mercedes-Benz S-class	0.5	0.5
Sport/Coupe	Ford Puma	1.3	2.0
Minivans	Chrysler Voyager	1.3	2.7
Sport utility vehicles	Landrover Freelander	1.8	2.5
Other		1.2	1.6
Total		100.0	100.0

Source: Financial Times Automotive Quarterly Review (Q2/1999).

The average European fuel consumption probably would not have stayed stable since 1985 had sales of diesel-engined cars not risen considerably in several European markets over the past 15 years. Diesel engines used to be more expensive than petrol engines but much of the price differential has disappeared. Dramatically improved performance, cheaper fuel (much less taxed than petrol in most Member States) and relatively low fuel consumption have contributed to making diesel more popular. Diesel engines, however, emit three times more nitrogen oxides and at least 10 times more particles than equivalent petrol-fuelled engines.

Tables 2 and 3 show newly registered cars in the Netherlands and Sweden by weight classes in 1985, 1990 and 1997. When comparing the figures of these two tables with new registrations by market segments (as in table 1) it is evident that the fast increase in vehicle weight cannot be explained primarily by a shift to larger cars. Most of the increase is instead due to factors such as larger engines, improved safety and new types of equipment and gadgets.

Table 2. Newly registered passenger cars by weight in the Netherlands. Per cent.

Service weight kg	1985	1990	1997
- 950	67.5	48.2	28.3
951-1350	30.8	47.2	61.4
1351-1750	1.5	4.1	9.4
1751	0.2	0.5	0.9
Sum	100.0	100.0	100.0

Source: Central Bureau of Statistics.

Table 3. Newly registered passenger cars by weight in Sweden. Per cent.

Service weight kg	1984	1990	1997
-899	8.0	6.0	0.6
900-1099	30.3	19.8	8.8
1100-1299	29.6	26.2	23.7
1300-1499	29.7	40.2	33.6
1500-1699	1.8	5.6	25.1
1700-	0.7	2.4	8.2
Sum	100.1	100.2	100.0

Source: Statistics Sweden

Table 4 shows the development between 1984 and 1996 in terms of average service weight, engine power, top speed, acceleration and fuel consumption for 18 volume models in the Swedish market (or in some cases models and their successors). [2]

Table 4. Volume models in the Swedish market. Average figures for new models in 1984 and 1996.

	1984	1996	Change	Change in %
Service weight kg	1099	1278	+ 179	+ 16
Engine power hp	92	122	+ 30	+ 32
Top speed km/h	172	195	+ 23	+ 14
Acceleration 0-100 km/h seconds	12.3	10.9	-1.4	- 10
Fuel consumption litre/100 km	8.2	8.1	-0.1	- 1

Source: Kågeson (1999), based on data in Autograph-Bilfakta (1984 and 1995).

[2] The Audi 80/A4, Audi 100/A6, Citroën CX/XM, Fiat Uno/Punto, Ford Fiesta, Ford Sierra/Mondeo, Honda Accord, Mazda 323, Mazda 626, Nissan Sunny, Opel Corsa, Opel Kadett/Astra, Saab 900/9-3, Toyota Camry, VW Golf, VW Passat, Volvo 340/440/S40 and Volvo 240/850/S70.

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 1000 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 not weight, engine size and power rating increased from their 1985 levels. Van den Brink and Van Wee conclude that in the period from 1985 there must have been large improvements in engine efficiency, air-drag coefficient and rolling resistance to compensate for the increase 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.

3. The European Union and the Kyoto Protocol

In December 1997 in Kyoto, the parties to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) agreed upon a Protocol, which is now open for ratification. The industrialised countries agreed at Kyoto to legally binding commitments to reduce greenhouse gas emissions. The European Union committed itself and its Member States to reduce greenhouse gas emissions (including emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6) by 8 per cent by 2008-2012 compared to 1990 levels and to be on track for further reductions after 2012.

Without additional policy measures, EU total greenhouse gas emissions are expected to increase by some 6 per cent in 2010 from 1990 levels. Comparing this "business as usual" (BAU) scenario with the Community's Kyoto commitment therefore implies a reduction effort of 14 per cent. According to the Commission, this amount can become significantly higher in the case of a long period of high economic growth combined with historically low energy prices. The transport sector is expected in the BAU scenario to increase its CO_2 emissions by 22 per cent by 2000 and 39 per cent by 2010 from the 1990 level (the effect of the agreements with the car industry not included) (European Commission, 1999).

In June 1998, the 15 Member States reached an agreement on how to share the burden of fulfilling the Community's Kyoto commitment (Council conclusions of 17.6.1998). Table 5 shows how this burden sharing agreement affects different Member States. From the right hand column of the table it is evident that some Member States will face real problems unless they take additional measures. For countries such as Austria, Belgium, Denmark, Italy and the Netherlands the outcome of the car industry's effort to reduce CO_2 emissions from new cars is crucial.

Table 5. The European Council's agreement on greenhouse gas emission burden sharing. Percentage reduction of emissions calculated as CO_2 equivalents and the situation in 1995.

	Burden sharing	Evolution from 1990 to 1995
Austria	- 13%	+0.6
Belgium	- 7.5%	+4.4
Denmark	- 21%	+10.0
Finland	0%	-0.5
France	0%	-1.1
Germany	- 21%	-12.3
Greece	+ 25%	+4.6
Ireland	+ 13%	+4.3
Italy	- 6.5%	+1.7
Luxembourg	- 28%	-45.0
Netherlands	- 6%	+7.5
Portugal	+ 27%	
Spain	+ 15%	+8.0
Sweden	+ 4%	-3.3
United Kingdom	- 12.5%	-8.4
Total EU	- 8%	

In 1995, the Council approved a Community Strategy to reduce CO_2 emissions from passenger cars (Council Conclusions 25/06/95). The Council foresees three inter-related policies which when taken together would reduce CO_2 emissions to an average level of 120 g/km for newly registered cars. The three elements are:

- a voluntary agreement with the car manufacturers to "commit the industry to make the major contribution" to the 120 g/km average standard and a related monitoring system for identifying the CO_2 emissions from newly registered cars;
- a CO_2 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, failed to convince the automotive industry that 120 g/km can be reached in the foreseeable future.

4. The European Union's agreement with the car industry

In July 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_2 emissions from cars. In this agreement, ACEA commits itself:

- to achieve an average CO_2 emissions figure of 140 g/km by 2008 for all its new cars sold in the EU, as measured according to the EU's test procedure (Directive 93/116/EC);
- to bring to the market individual car models with CO_2 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. ACEA underlines that this "does not constitute a commitment of any kind";
- 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 will 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 and Volkswagen AG. These firms also include brands such as Audi, Opel, Rover, Saab, Seat, Skoda and Volvo.

These commitments have been endorsed by the European Commission and welcomed by the European Council. Their implementation will be monitored jointly by the Commission and ACEA, and the Commission will report to the European Parliament and the Council of Ministers annually. The vehicle registration authorities in the Member States will provide data for the monitoring.

It should be underlined that the agreement 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 ACEA fails – but have not 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.

4.1 Special conditions for ACEA's commitment

ACEA has made the agreement conditional on a number of external factors that, according to the association, could impact on its ability to honour its commitments. ACEA's commitments are therefore linked to a number of assumptions or demands:

- The commitment covers only passenger cars classified as M1 in Council Directive 93/116/EEC.[3] However, the Commission has decided to study, in consultation with manufacturers, the possibility of extending to light commercial vehicles the scope of Directive 93/116/EC on the determination of CO_2 emissions from motor vehicles as a first step to trying to include light commercial vehicles in comparable commitments by manufacturers.
- ACEA assumes that its commitment "provides complete and sufficient substitute for all new regulatory measures to limit fuel consumption or CO_2 emissions, and for any additional fiscal measures in pursuit of the CO_2 objectives of its commitment". Any fiscal measures, including their added value to ACEA's commitment, will be taken into account in ACEA's and the Commission's joint monitoring process.
- ACEA underlines that its commitment is based on the assumption of an "unhampered diffusion of CO_2 efficient technologies". Therefore, according to ACEA, it is fundamental that any measures which might hamper the

[3] Passenger cars with no more than eight seats in addition to the driver.

diffusion process will be taken into consideration in the monitoring procedure.

- ACEA declares 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 NOx. For such devices to work properly the diesel or gasoline fuel must not contain more than 30 ppm sulphur. ACEA also demands a maximum aromatic content of 30 per cent in gasoline and for diesel a cetane number of minimum 58. These demands go beyond the new EU minimum fuel quality standards set out for 2005.
- ACEA also makes it clear that its commitment is conditional on equivalent commitments by the Japanese, Korean and American car producers.

4.2 ACEA on monitoring

ACEA says that the joint monitoring procedure should cover:

1. The development of CO_2 emissions based on the collective achievement of reductions of the average EU fleet of new car sales represented by ACEA.

2. The development of the CO_2 emissions of non-ACEA car manufacturers for their sales in Europe.

3. Any developments regarding the underlying factors upon which ACEA's commitment is based.

4. The impact on CO_2 emissions of new regulatory measures.

5. The development of new breakthrough technologies (e.g. natural gas, hydrogen, fuel cells, electric drive), which might be available for production in the next decades, and the impact of the Community's 5th R&D framework programme, which is expected to foster research in this area.

6. The development and promotion of other measures deemed to reduce fuel consumption, i.e. telematics and optimisation of the infrastructure to reduce congestion; driver education for fuel efficient behaviour; driver information on fuel efficiency.

7. The impacts on the financial performance, competitiveness and employment within the European automotive industry associated with the commitment.

4.3 Means to achieve the target

ACEA states that its CO_2 target "will 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.

At the same time, the aim is to preserve the diversity of the product offered by the European car manufacturers and to maintain their competitiveness. Down-sizing is not an element in ACEA's strategy.

4.4 How should the agreement be interpreted?

ACEA's deal with the European Commission is not easy to judge. 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.

It makes sense that the manufacturing industry should be allowed to draw on the development of new breakthrough technologies (e.g. natural gas, hydrogen, fuel cells, and electric drive). Making the commitment provisional on equivalent commitments by non-ACEA car producers is also relevant.

ACEA demand for road fuels which meet more stringent requirements than the Community's 2005 standards is reasonable from an environmental point of view but complicated in a political context. It may be that some or most oil companies will decide for commercial or technical reasons to produce diesel and gasoline fuels with no more than 30 ppm sulphur despite the fact that the highest permissible content will be 50 ppm in 2005. But if this does not happen, the Community will have to either review the Directive on fuel standards (98/70/EC) or stimulate Member States to introduce environmentally differentiated diesel and gasoline taxes that give a premium to fuels with less than 30 ppm sulphur. Germany has already decided to introduce 10 ppm gasoline and diesel fuels by 1 January 2003 and intends to support these blends by giving them a tax break of DEM 0.03 per litre. Germany has also called for the Commission to propose that all gasoline and diesel sold in the Community should be "sulphur-free" by 2007 (i.e. <10 ppm).

ACEA says that there is no need for additional fiscal measures. The association is obviously confident that its members can achieve the CO_2 target under current fiscal conditions. ACEA nevertheless demands that the joint monitoring process should value the impact on CO_2 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.

ACEA underlines that its commitment is based on the assumption of an "unhampered diffusion of CO_2 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_2 ought to be equally taxed (i.e. the tax should be technically neutral). This implies a substantial rise in the level of the diesel tax in most Member States.[4]

The development and promotion of other measures deemed to reduce fuel consumption do not have anything to do with the specific fuel consumption of new cars when driven according to the prescribed test cycle. What conclusions does ACEA think should be drawn in the monitoring process from improved driver education or measures leading to less congestion? If such measures happen to reduce fuel consumption in real traffic by a certain percentage, why should the car manufacturers have credit for this? The development and promotion of other measures related to car traffic are important supplements to the efforts made by the car industry and both are needed if transport emissions of CO_2 are to be substantially reduced.

[4] Growing concern over negative health effects of particles is a second reason to raise the tax on diesel.

ACEA has also made its commitment conditional on the avoidance of negative impacts on the financial performance, competitiveness and employment within the European automotive industry associated with this commitment. This gives rise to several questions:

- How will ACEA and the Commission know whether competitive problems in any of the corporations belonging to ACEA are caused by the industry's collective commitment to reduce CO_2 emissions from new cars?
- Suppose that all other car manufacturers make the same provision. Does this mean that any change in market shares between, for instance the European and the Japanese producers should be taken as a ground for re-negotiating the agreement? And if so, should the target be corrected only for the loser?
- Does ACEA mean that any deviation from a business-as-usual scenario for total car sales should be used as a ground for changing its commitment? And in that event, how would it be possible to assign the deviation to the agreement with the EU when saturation or a shift in consumer preferences could just as well have been the cause?

As the Commission, the Council and the European Parliament have not deserted their 120 g objective, there is clearly a need for additional measures. A major problem might then be to know to what extent progress is due to such supplementary measures and how much of the credit should really go to ACEA.

4.5 Agreements with Japanese and Korean car manufacturers

The European Commission has recently concluded agreements on CO_2 emissions from cars with the Japan Automobile Manufacturers Association (JAMA) and the Korean Automobile Manufacturers Association (KAMA) for their sales in the EU. JAMA's and KAMA's 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 (JAMA and KAMA) and the estimated target range for 2003 (JAMA).

In order to take into account differences in the situations in 1995 of JAMA and ACEA, two modifications in the Commitment were found to be necessary :

- JAMA will meet the target value of 140 g CO_2 /km one year later (i.e. by 2009).
- The intermediate target range is somewhat larger (165-175 instead of 165-170 g CO_2/km).

Where KAMA is concerned, the deviations from the agreement between the Commission and ACEA are as follows:

- KAMA commits itself to achieving the 140 g CO_2/km target one year later than ACEA (i.e. by 2009).
- The same is true for the indicative intermediate target (2004 instead of 2003).

- For the availability of 120 g CO_2/km models, KAMA commits itself to a make its best efforts to introduce such cars "at the earliest possible date after the year 2000".
- In 2004 (instead of 2003), KAMA will review the potential for additional CO_2 reduction, with a view to moving further towards the Community's objective of 120 g CO_2/km by 2012.

In its evaluation of the commitments by JAMA and KAMA, the Commission says that in order to understand the necessity to deviate in these respects from ACEA's commitment it should be recalled that their 1995 starting point is somewhat higher than ACEA's (in the range of 193-202 g CO_2/km for JAMA and 194-197 g for KAMA compared to 186 g for ACEA). According to the Commission, KAMA's CO_2 target represents a significant effort even with a one-year delay compared to ACEA, given KAMA's higher 1995 starting point and the fact that Korean manufacturers are technologically behind both ACEA and JAMA. The Commission goes on to say that ACEA, JAMA and KAMA will have to make equivalent CO_2 reduction efforts of about 4 g CO_2/km per year in order to meet the target of 140 g CO_2/km. Against this background, the Commission considers JAMA's and KAMA's commitments represent a CO_2 reduction effort equivalent to that of ACEA (EC Commission, 1999b).

Like ACEA, JAMA and KAMA declare that the target will mainly be achieved by technological developments affecting different car characteristics and market changes linked to these developments. The Japanese car manufacturers have high expectations for certain technologies, in particular those associated with direct injection engines and hybrid-electric vehicles, which they consider to be the most promising routes to low specific fuel consumption (JAMA, 1999). KAMA says regarding technological developments that it will "aim at a high share of new cars equipped with CO_2 efficient technologies" (KAMA, 1999).

The Environment Council on 12.10.1999 supported the Commission's intention to accept the agreements by JAMA and KAMA. Similarly to the agreement concluded with ACEA, the agreements with JAMA and will take the form of commitments and an exchange of letters between the Commission and JAMA and KAMA respectively and a Recommendation to be adopted subsequently by the Commission.

The detailed assessment given above with respect to the ACEA agreement is also valid with regard to these commitments.

4.6 The Commission's analysis

The Commission estimates that the achievement of the automotive industry's CO_2 emission target for all new cars sold in the EU will contribute about 15 per cent of the total emission reductions required from the EU under the Kyoto Protocol. An underlying assumption is that car mileages will grow by 2 per cent per annum and that without the agreement average new passenger car CO_2 emissions would have stayed at the 1998 level (European Commission and ACEA, 1998).

Due to the lack of measured data the starting point has to be indicated as a range.[5] The target range does not represent an additional commitment by the industry, and the Commission recognises its indicative nature. It nevertheless attaches special importance to these intermediate objectives as a basis

[5] According to ACEA, European-made cars produce an average of 171 grams per kilometre of CO_2, compared with about 260 grams in the U.S. and 175 grams in Japan (www.acea.be).

for verifying whether the agreements are effective. This arises in particular from concerns expressed by the European Parliament. Against this background, the Commission would thoroughly review the agreements should the manufacturing industries fail to achieve their target range in 2003 (European Commission, 1998a).

The agreements with the manufacturing industry foresee the introduction of innovative vehicle concepts as well as cars using alternative fuels or radically new propulsion systems. The Commission recognises that this requires that the CO_2 emissions of such vehicles and fuels "be measured and/or calculated according to a standardised procedure". Directive 93/116/EC will therefore have to be amended accordingly (European Commission, 1998a).

The Commission notes 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).

4.7 Will the commitments by the industry provide any added value?

The added value of the agreement between the manufacturing industry and the European Commission is difficult to assess. ACEA has not and will not decide on how the burden is to be shared among its seven car producing members. Instead, ACEA will rely on the competition between members and with non-EU producers (personal communication, Stephen Wallman, Volvo). It is true that the challenge from the Japanese car producers, concentrating on direct injection and electric-hybrids, will presumably force members of ACEA to respond by producing more fuel-efficient cars. However, if fierce competition is the driving force, there is cause to question whether the agreement will bring about anything that would not have happened anyway.

The fact that ACEA has failed to agree on burden-sharing means that each company is in effect committed to the same target – but in absolute or percentage terms? If the first is true it is obviously far easier for some manufacturers than for others. It appears reasonable to think that the pledge should be interpreted as commitment by each ACEA member to reduce the average specific fuel consumption of its vehicles by around 25 per cent. ACEA, however, has no effective way of dealing with possible "free riders".

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 says that its intention is to use its monitoring scheme (see below) to demonstrate the contributions of each manufacturer to their common commitment (European Commission, 1998d). This will 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 will be necessary for the Commission to demonstrate progress as percentage reductions on the average specific fuel consumption of the base year for each manufacturer.

5. EU Directive on the monitoring of average specific fuel consumption

The European Union is about to establish a scheme for monitoring the average specific emissions of carbon dioxide from new passenger cars (European Commission, 1998d). Monitoring will be based on the Certificate of Conformity that is issued for each new vehicle model and on sales statistics. Today manufacturers often choose to type-approve several variants or versions together on the basis of the "worst case". This will somewhat over-estimate the CO_2 emission of some versions. The Commission therefore wants as much as possible to utilise "version specific data". This may require additional Certificates of Conformity from the manufacturers.

The new Directive on exhaust emissions from passenger cars is based on new reference fuels and a modified test cycle. The test cycle specified for the measurement of CO_2 emissions, however, remains unchanged. The Commission therefore intends to bring forward amending legislation to ensure that post January 2000 specific CO_2 emissions and exhaust emissions are measured according to the same test procedures (European Commission, 1998d).

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_2, including power generation (European Commission, 1998d). However, excluding battery-driven vehicles might be of little importance for monitoring average European fuel consumption. Currently there are fewer than 20 000 such vehicles in the 15 Member States and annual sales cannot be expected to reach more than 0.05 per cent of total sales as electric vehicles will face fierce competition from electric-hybrids and fuel cell cars.

The Commission's proposal for the Fuel Monitoring Directive does not mention alternative fuels such as RME, biogas and ethanol. Such fuels 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 CNG, on the other hand, are bought by people who want to use gas as their primary fuel. However, in some Member States 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. The only way of overcoming these problems is probably to monitor sales of the different bio-fuels and try to establish the approximate number of cars using them and take account of this information when calculating the average specific emission of carbon dioxide. New Flexible-Fuel Vehicles and Bi-Fuel Vehicles will then be registered as running on petrol or diesel until the number of actual (full time) users of ethanol, RME and biogas have been established. RME and bio-alcohols blended with diesel or petrol (usually 5%) can be accounted for in a similar way. In both cases it will be necessary to take account of the fact that cars registered during the last 12 months are responsible for only a part of the total consumption.

6. EU Directive on fuel consumption and information

As part of its policy package on CO_2 emissions from cars, the Commission proposed a European scheme for consumer information on the fuel economy of new passenger cars (European Commission, 1998b). The idea is to make it mandatory for all car dealers to provide this information in showrooms and advertising. The proposed 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.

The fuel economy label must provide figures on fuel consumption (93/116/EC), CO_2 emissions and a fuel cost estimate associated with 10 000 km of driving as well as a message explaining the relevance of CO_2 to global warming and the importance of driver behaviour on fuel economy.

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 modelled on the Swedish labelling system, the only important difference being the requirement in the Commission´s proposal to explain the relevance of CO_2 to global warming and the importance of driver behaviour. The British system is less demanding and restricted to the economy label. The British label, however, is mandatory and dealers can be fined up to GBP 5 000 for not complying. The Swedish system is based on an agreement between the Board for Consumer Affairs and the motor manufacturers. Frequent cases of non-compliance or only partial compliance have not resulted in any action from the Board (Trafik & Miljö 1999/3).

There appears to be 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.

7. What will manufacturers do to honour their commitment?

ACEA and JAMA have promised to bring to the market individual car models with CO_2 emissions of 120 g/km or less by 2000. This they will accomplish. The Toyota Prius and VW Lupo 3L TDI will both start selling in the spring of 2000. This means that some – but far from all – car producers will market such cars.

The main objective, however, is to reach an average of no more than 140 g CO_2 in cars sold in 2008. According to estimates by the European Commission, cars sold in Europe by ACEA members in 1995 emitted on average 186 g CO_2/km. No exact figures are available for non-EU makes. The ECMT (1999), however, found that the average specific CO_2 emission from new cars in 1997, weighted by registrations, was 183 g in a market consisting of 13 EU Member States (Finland and Greece missing) plus Norway and Switzerland (based on 93/116/EC). If this figure is taken as an approximate baseline value, a reduction to 140 g means cutting emissions further by 43 g or 23.5 per cent. This value will be used for the evaluation below.

ACEA states that its CO_2 target will mainly be achieved by equipping new cars with direct injection gasoline or diesel engines. At present diesel cars make up about 22 per cent of new sales in EU 15 and the share of direct injection engines is well below 1 per cent. The Japanese car manufacturers take less interest in diesel technologies. Instead they are aiming for direct injected petrol engines and hybrid-electric vehicles.

To get an idea of how much one can expect from these technologies by 2003 and 2008 respectively it is necessary to analyse their CO_2 benefits (over conventional petrol fuelled cars) and the potential rate of market penetration for each of them.

7.1 Diesel cars

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 are therefore increasingly replacing IDI engines in the production of new cars.

Comparing CO_2 emissions from diesel cars with those of identical petrol fuelled cars (with the same power rating) will give us an idea of how close to the target a further shift to diesel could bring the European car industry. As shown in table 6, the difference based on 10 volume models is currently (model year 1998) 24 g/km or 12 per cent.

Table 6. Difference in CO_2 emissions between diesel and petrol versions of the same car model with manual gearboxes.

Model	Diesel					Petrol					CO_2 ratio diesel/ petrol
	Version	kW	Top speed km/h	Acceleration 0-100 km/h	CO_2 g/km	Version	kW	Top speed km/h	Acceleration 0-100 km/h	CO_2 g/km	
VW Golf	GL TDI	66	178	12.8	132	1.4i	55	171	13.5	154	0.86
Peugot 306	XR 1.9	66	180	13.9	175	XS 1.6	65	179	13.5	188	0.93
Opel Astra	1.7 TD	60	168	14.5	158	1.4 16V	66	173	13.5	189	0.84
VW Passat	TDI	81	196	11.7	143	1.6	74	192	12.3	192	0.75
Ford Mondeo	1.8 TDI	65	181	13.4	179	2.0i 16V	97	209	9.6	193	0.93
Audi A4	1.9 TDI	81	196	11.3	142	1.6	74	191	11.9	188	0.76
Mercedes-Benz	C 250D	110	200	10.5	212	C 200	100	200	11.3	222	0.96
BMW	525 tds	105	211	10.4	207	520i	110	220	10.2	216	0.96
Audi A6	2.5 TDI	110	216	9.7	186	1.8 T	110	217	9.4	197	0.94
Mercedes-Benz	E 290 TD	95	200	11.5	180	E 200	100	205	11.4	215	0.84
Averages		84	193	12.0	171		85	196	11.7	195	0.88

Sources: Vägverket and Konsumentverket 1998, and Autograph Bilfakta, 1997.

The difference in fuel consumption, though, is bigger as petrol contains about 13 per cent less carbon (and energy) per litre. Spokesmen for the motor industry often say that the difference in CO_2 emissions is around 25 per cent, but this is only true for some models with DI "common rail" engines. In other cases comparison may have been made with petrol-fuelled variants having power ratings and performance far above those of the diesel versions. However, people who are willing to sacrifice performance to achieve low fuel costs are likely to have chosen a relatively "low-performing" petrol version, had there not been a major difference in fuel tax. Therefore it is wrong to compare diesel cars with their most high-performing petrol-fuelled opposite numbers.

Between 1988 and 1998 the market share of new diesel cars in Europe went from 15 to 22 per cent (ECMT, 1999). For members of ACEA the diesel share is currently 27 per cent of new sales. Assuming that the diesel engine can realistically increase its total share to 35 per cent by 2008, the contribution to the car industry's commitment would be around 3.1 g CO_2/km if the reduction is evenly split on all new cars (all else equal). This is equivalent to 7.2 per cent of the 43 g needed. However, at the same time a further shift to common rail diesel engines is likely to take place. This may improve the average efficiency (of all new diesel cars) by something like 8 per cent or minus 4.8 g if the reduction is split on all new cars. The total contribution of diesel technologies to the specific average CO_2 target would then be around 7.9 g or 18.4 per cent of the reduction needed.

Real CO_2 emissions, however, would not diminish to the same extent unless the taxation of diesel fuel is changed in most Member States. Currently diesel is taxed around 30 per cent below petrol in most Member States and the average price at the pump is 23 per cent below that of petrol (The Oil Bulletin, DG XI 27-09-1999). Based on a long-term fuel price elasticity of –0.7 (EU Commission, 1995b), a privately owned diesel car is presumably on average driven approximately 15 per cent more distance per year compared with the identical petrol car. This means that today the average diesel car probably emits as much carbon as the average petrol car (of the same size and with the same performance).

Diesel cars would be a good partial solution to the CO_2 problem if CO_2 emitted from diesel fuel was taxed on par with CO_2 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 EU 15 is recalculated into Euro per kg of CO_2, it becomes clear that a kg emitted from petrol is taxed 65 per cent more than a kg from diesel (Euro 0.206 vs 0.125). This policy is clearly in conflict with economic theory, which suggests that taxation of emissions should be technically neutral in order to be efficient. Where NOx and particulate matter are concerned, new diesel engines still emit around 3 and 10 times as much per vehicle kilometre. The emission limits that enter into force in 2005 will narrow the gap for particles. For NOx, however, the permissible ratio of 1/3 will remain.

7.2 Direct injection petrol engines

Both ACEA and JAMA mention 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.

Mitsubishi was the first manufacturer to introduce such engines in cars marketed in Europe. Based on type approval values Mitsubishi's Carisma S 1.8 LX GDI emits 18 per cent less CO_2 than the Carisma 1.8 GLX. However, a comparative test of the two versions of the Carisma performed by Swedish MTC according to the European test cycle (NEDC) resulted in only 10 per cent fuel reduction and when driven according to the American FTP-75 test cycle, the difference was only 8 per cent (Ahlvik, 1998).

The difference becomes even smaller when the cars are driven in a style which is closer to real driving. A Dutch test shows that under "real-world circumstances" the difference shrank to a mere 2 per cent. (Huigen, 1998, cited in Van den Brink and Van Wee, 1999).

The reason why the direct injection engine performs less well under real driving conditions is that the present generation uses a NOx-storage catalyst in combination with a three-way catalytic converter. The latter is needed to bring the engine's high emissions of NOx into line with the EU emission limit value for petrol cars. The NOx-storage catalyst stores NOx during lean-burn engine operation, when fuel consumption is relatively low. The reduction can only take place in the three-way catalyst under stoichiometric conditions.[6] Therefore, Mitsubishi has made the engine operate stoichiometrically above 30 per cent of maximum engine torque. However, under such conditions the direct injection engine uses as much fuel as an indirect injection engine. This explains why the overall fuel consumption under real driving conditions comes closer to that of a petrol engine with indirect injection. Many industry experts believe that GDI in future is likely to offer an improvement of 10-15 per cent during typical mixed cycle operation. GDI engines rely on low sulphur levels in petrol (50ppm) and could only become widespread in Europe when fuel quality has been improved to this level.

[6] A stoichiometric engine is one in which the ratio of air to fuel in the combustion mixture is chemically correct for complete combustion. Such conditions are necessary for the satisfactory operation of three-way catalytic converters.

Renault has recently developed its own direct injection petrol engine. Unlike Mitsubishi, Renault uses massive EGR (Exhaust Gas Recirculation) to achieve low NOx emissions (FT Automotive Environment Analyst, December 1999).

Currently less than 1 per cent of new cars sold on the European market have direct injection petrol engines. To alter production to direct injection does not require entirely new engines. A different fuel injection system and some minor modifications of 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, if the direct injection petrol engine is to make a substantial contribution to the CO_2 target, the motor industry has to find a new way of reducing its high emissions of nitrogen oxides. A de-NOx catalyst that can replace the current arrangement for NOx-reduction requires access to low-sulphur petrol. Petrol with less than 30 ppm sulphur might be available in some Member States by 2005, which would make a shift to direct injection possible on those markets. If this happens, one can envisage a situation in which up to 20 per cent of all cars (corresponding to 30% of all new petrol cars) produced for the European market in 2008 are equipped with these engines. This would reduce the average CO_2 emission of <u>all new cars</u> by something like 5.5 g (all else equal). This is equal to 12.8 per cent of the average reduction needed.

The low-sulphur fuels needed for the introduction of new exhaust cleaning systems for direct injection engines (diesel and petrol) appear to be on their way to the market. An agreement between the Swedish Environmental Protection Agency and the oil industry brought Sweden petrol with a sulphur content of less 50 ppm from 1 January 2000. Low-sulphur city diesel (30-50 ppm) is already dominating the diesel markets of Finland, Sweden and the UK and has started to penetrate Germany and Denmark. The German government has announced an agreement with the car and oil industries to launch diesel and petrol with less than 50 ppm in all pumps on 1 November 2001. On 1 January 2003, 10 ppm fuels will be offered (Car Lines, September 1999). Germany has asked the ECOFIN Council for permission to use tax incentives for the introduction of these fuels.

7.3 New concepts

Numerous concept cars have been on display at major automotive fairs in recent years. A few of them are now about to be introduced onto the European market. Several Japanese manufacturers are preparing for the introduction of hybrid electric cars. Such cars are powered by a combination of a conventional engine and a large battery. The latter is charged by the engine. Hybrid cars can provide large savings in particular in urban driving where the efficiency of the internal combustion engine is particularly low.

Toyota's hybrid car, the Prius, has been on sale in Japan since late 1997 and will be introduced in Europe in mid-2000. According to Toyota, the Prius consumes only half as much petrol as a conventional car of the same size (based on the Japanese test cycle). The Prius performance is almost comparable to conventional cars (top speed 160 km/h).

Honda has recently introduced its first hybrid-powered vehicle. Honda says the Insight (a two-seater that combines a petrol engine with an electric motor) will achieve 35 km per litre (2.9 litres/100 km). Starting from the end of 1999, the Insight will be gradually introduced overseas, including Europe and the United States. Honda, however, is only planning for a monthly production of 300 vehicles (Car Lines, September 1999).

Mitsubishi is expected to introduce a hybrid version of one of its models in 2000. It is not yet known when this model will be marketed in Europe.

Both the Prius and the Insight will sell in the Euro 20 000 range, a figure that may represent some subsidy by the manufacturers (Tomorrow, September/October, 1999). Toyota aims to make the car profitable, excluding R&D costs, within the next two to three years (Car Lines, September 1999).

Several car manufacturers are already announcing the commercialisation of fuel cell cars. Honda, Toyota and Daimler-Chrysler have all pledged to have fuel cell cars for sale in 2004, Mitsubishi in 2005. The main barrier to a market introduction is the high cost, and nothing is yet known about the price range for mass-produced fuel cell vehicles.

Virtually any hydrogen-rich fuel can be reformed and used in PEM (proton exchange membrane) fuel cells, including methanol, propane, CNG and petrol. However, fuel cells using reformers for onboard extraction of hydrogen are more costly and complex than fuel cells using pure hydrogen. A fossil-fuelled PEM cell driven car will at best cut fuel consumption by 40-45 per cent compared with the same car using a petrol-fuelled internal combustion (IC) engine. Fuel cells using pure hydrogen will require their own refuelling infrastructure which makes them more suitable for concentrated fleets of city buses and distribution trucks than for passenger cars, at least in the short to medium term.

The contribution from hybrids and fuel cell cars to the CO_2 target depends on production capacity, price and market acceptance. Hybrid electric cars are expected to cost 20-30 per cent more to buy than a comparable IC 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 will have to drop tenfold. Mass production will narrow the gap, but buyers will probably have to pay a considerable premium, at least initially.

Toyota's capacity to produce the Prius for overseas markets is restricted to 15 000 cars in the year 2000, mainly resulting from a limited capacity to produce its special battery. This restriction will be overcome in 2001, when the Prius will be produced and sold as a "conventional" car. Additional hybrid models are planned for introduction in 2000 and 2001, among them a limousine, an upper medium car and a mini van for nine occupants (personal communication, Bengt Dahlström, Toyota Autoimport AB, Sweden).

Most experts agree that electric hybrid and fuel cell cars will gain considerable market shares in the long term, i.e. beyond 2010 or 2015. It is not possible, however, to give a well-based forecast for the short to medium term. Assuming that the entire industry will manage to sell 30 000 hybrids in Europe in 2001 (most of which will be Toyotas) and will be able to increase the combined output of hybrid and fuel cell cars by 50 per cent per year up to 2008, the total production that year will be just above 1 million. This is equal to close to 5 per cent of an estimated 20 million new registrations in 2008 (up close to 4% per year compared to an average 5% increase 1994-99). If the average fuel consumption of these cars is 55 per cent of today´s conventional petrol-fuelled cars, their contribution to the average CO_2 emission target for all new cars will be around 4.5 g or 10.5 per cent of the reduction needed (all else equal).

7.4 Bio-fuels and electric cars

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. The contribution of battery-electric vehicles is therefore neglected in this analysis. However, it should be underlined that the effect on overall carbon emissions from concentrating on such vehicles (if it was 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.

Bio-fuels can make a somewhat larger contribution to the motor industry's CO_2 target. Heavily subsidised RME and ethanol have been introduced in small quantities in some markets. The total contribution, including low-blend mixes with petrol and diesel, will hardly amount to more than 0.5-1.0 per cent of Europe's consumption of car fuels in 2008. Let us assume that it is 0.7 per cent. This is equal to 3.0 per cent of the required CO_2 reduction in 2008.

7.5 Summary: New engines and fuels

"Dieselisation", increased use of direct injection, the introduction of new powertrain technologies and alternative fuels will under the assumptions made above together reduce the specific CO_2 emissions from the average new car in 2008 by around 19.2 g/km (when driven according to the test cycle). This leaves 23.8 g or 55.3 per cent to be achieved by other measures (see table 7).

Table 7. Contributions from alternative powertrains and new fuels to attaining the 2008-09 target when the improvement is distributed over the entire new fleet. Comparison with a 1997 average emission of 183 g/km.

Measure	Reduction in average CO_2 emission of all new cars	Contribution in per cent
Shift to diesel + more common rail diesel engines	7.9	18.4
Shift to direct injection petrol engines	5.5	12.8
Shift to electric hybrids	4.5	10.5
Shift to alternative fuels	1.3	3.0
Total average	19.2	44.7
To be achieved by other measures	23.8	55.3

7.6 General improvements

Manufacturers will also try to improve the efficiency of the traditional indirect injection petrol car, which would under the above assumptions still account for about 45 per cent of the market in 2008. There are many ways of further improving the fuel efficiency of conventional petrol engines, 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

- Variable valve timing
- Continuously-variable transmission to improve gearing efficiency
- Reduced mechanical friction
- Reduced air drag and rolling resistance

The manufacturers will make an effort to reduce mass, air resistance, friction and rolling resistance. Mass is the most important of these parameters and also the one offering the highest potential for improvement.

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 (ULSAB). The objective is to develop a new steel bodyshell which 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.

The shift to lighter materials has already begun. Audi produces the A8 in an aluminium version (currently >10 000 cars/year) and aims to produce 50 000 aluminium versions of the A2. The latter will consume only 3 litres per 100 km. Audi A2 and VW Lupo 3L are low consuming not only because they are powered by a diesel engine but also as a result of low weight and air resistance.

Based on experiences from the 1990s it is reasonable to believe that general improvements and an increased use of light materials could reduce the average fuel consumption of new cars by in the range of 10 per cent in 2008 (compared with 1997). This would be additional to the 44.7 per cent mentioned above and bring the average CO_2 emission from new cars to a level approaching 145 g/100 km. The industry, however, would still be more than 5 g off the 2008 target.

To be on the safe side of 140 g/km would take a yearly improvement of 1.2 per cent (on top of dieselisation and new engines). This is technically feasible but requires 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. 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 luxury and high-performing 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. The figures in table 1 on new car registrations by market segment can be taken to illustrate this dilemma. In table 8 these segments have been aggregated into three 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 8. New car registrations by approximate price segments in Western Europe 1990-1998. Per cent.

Price class	1994	1998
Low	32.4	33.1
Medium	54.9	52.4
High	12.7	14.5

Low is Mini and Small, Medium is Lower medium and Medium, and High consists of Upper medium, Luxury, Sport/Coupe, Minivans, SUVs and Other (based on table 1).

It is essential to avoid the kind of development that has happened in America. Vans, sport utility vehicles, pickups and "other" increased their combined share of the US market for new cars and light trucks from 40 per cent in 1994 to 47 per cent in 1998 and their market share is expected to continue to grow (FT Automotive Quarterly Review, 1999). In some European markets there is now a fast trend towards minivans and sport utility vehicles though market shares are generally still in the range of 6 to 10 per cent.

The manufacturing industry appears to be aware of the problems. A study by ACEA (no exact reference made) has concluded that nearly half of the total potential gains in CO_2 reduction that are feasible by 2005 will be offset by regulations on safety, emissions and noise and anticipated customer demands (www.acea.be). The average annual reduction would then have to be in the order of 3.5 per cent to counter-balance this trend. 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." According to ACEA, "such a target would force a radical downsizing of the available range of vehicles, cause a severe loss of competitiveness, in particular in export markets, and lead to a drastic restructuring of the entire industry" (www.acea.be).

What ACEA leaves out of consideration is the fact that slightly smaller engines, abstaining from 4WD (when it is not essential) and a halt to further increase of the average vehicle size could do the job in combination with lighter materials, lower air and rolling resistance and a shift to new powertrains. This would not make the European car industry sell fewer cars in Europe.

7.7 Summary: Technical potential

1. The manufacturing industry will no doubt produce a few models in 2000 that consume less than 120 g CO_2/km.

2. The industry is not likely 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.

3. The industry will not reach the indicative intermediate target in the order of 165-170 g in 2003-04 unless economic incentives are introduced very soon. 170 g is equal to a 7 per cent decrease from an average value of 183 g in 1997 (ECMT, 1999, based on 13 Member States, Norway and Switzerland).

4. It should also be remembered that a shift to more diesel cars would not substantially reduce total CO_2 emissions as long as diesel fuel is taxed well below petrol.

8. Economic incentives and/or additional regulatory measures

The third pillar in the Commission's and the Council's CO_2 strategy for cars has not yet been developed. However, 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. The Commission is aware that the commitments by ACEA, JAMA and KAMA will at best achieve the 140 g target by 2008-09. To approach the Council's 120 g objective would require measures that promote downsizing and affect the structure of the car market (European Commission, 1998e).

There are several possible economic incentives to consider and in addition some regulatory measures:

- Tradable CO_2 emission permits (for all sectors of society)
- CO_2 tax supplementing existing fuel taxes
- Higher taxes on road fuels
- Differentiated sales tax
- Differentiated annual vehicle tax
- Tradable CO_2 emission permits for new registrations
- Taxes on company cars
- Regulating top speeds, cylinder capacity, engine power or maximum fuel consumption
- Combinations of the above

The idea of tradable CO_2 emission permits for all sectors of society will not be explored in this study. It is a potentially very effective and cost-efficient measure that treats CO_2 emissions from all sources alike. However, if introduced, there would still be need for some kind of road tax that internalises other social costs of road transport. While waiting for an electronically based km-charge (which will first be used on heavy goods vehicles), fuel tax is the second best way of internalising these costs.

8.1 Fuel taxes

Table 9 shows the current excise duties on petrol and diesel in the 15 Member States as well as the EU minimum rate. The table shows a large variation. The United Kingdom is the only Member State that taxes diesel on a level with petrol. The United Kingdom has enforced a fuel tax "escalator", currently 6 per cent per year in real terms, for some years. The British finance minister, however, recently announced that the escalator will be scrapped. From next year decisions on fuel taxes will be made on a "budget by budget basis" (ENDS Daily, 09.11.1999). The reason is probably that the UK is now so far ahead of all other Member States that further increases would potentially have negative consequences for Britain's competitiveness.

The British tax on diesel is currently 77 per cent above that of Italy who is second in rank among the Member States of the Union.

In 1997, the Commission presented a proposal for a new Directive on energy product taxes which included a step-wise increase in the minimum excise duties. The taxes on petrol and diesel would according to the proposal reach Euro 500 and 393 per 1 000 litres respectively in 2002 (European Commission, 1997b). However, the ECOFIN Council has not been able to come to an agreement on this Directive, Spain and Ireland being the two Member States who oppose a compromise. The Netherlands has proposed that those countries that are in favour of a common minimum level would continue negotiations within the EU, but come to a special agreement among themselves if it should appear impossible to reach unanimity (ENDS Daily, July 13, 1999).

Table 9. Current excise duties on road fuels in Member States of the EU. Euro per 1 000 litres.

Country	Petrol		Diesel	
	Excise duty	Rank	Excise duty	Rank
Austria	414	11	290	11
Belgium	507	6	290	11
Denmark	507	6	308	7
Finland	560	4	305	8
France	590	3	382	3
Germany	501	8	317	6
Greece	319	15	257	14
Ireland	379	12	330	5
Italy	542	5	403	2
Luxembourg	372	13	253	15
Netherlands	587	2	346	4
Portugal	499	9	295	9
Spain	372	13	270	13
Sweden	487	10	291	10
United Kingdom	670	1	713	1
EU minimum rate	287		245	

Source: ACEA (status March 1999).

Fuel taxes are generally believed to provide the broadest incentive to improved fuel efficiency as they affect choices of vehicle, driving behaviour and annual mileage. However, a market imperfection occurs if the preferences of first buyers differ greatly from those of second and third owners.

This problem 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 private citizens and 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 user. Company cars make up 30-50 per cent of new car purchases in countries such as Germany, the Netherlands, Norway, 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.

Research has shown that most new car buyers only take account of fuel costs in the first three years of a vehicle's life in making purchasing decisions (Eriksson, 1993). There is thus a need for a supplementary policy lever even in a case where a Member State is willing to raise its fuel taxes. Espey (1996) found differentiated sales and/or annual vehicle taxes to be effective instruments for promoting a shift to more fuel efficient vehicles.

8.2 Sales and annual circulation taxes

The European debate over policy levers for reducing specific carbon emissions from cars has raged for about 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 of 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_2 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.

Table 10 shows the current sales or registration taxes in the 15 Member States plus Norway. Five Member States do not enforce any tax on car sales other than VAT (value added tax). Member States that tax the acquisition of cars have very differing 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. The Netherlands is planning to differentiate its sales tax for fuel efficiency. The aim is to introduce a relatively large difference between fuel-efficient and less efficient cars per class of car size. However, no concrete proposal has yet been

Table 10. Taxes on acquisition of passenger cars in EU Member States and Norway. Sales or registration tax.

Austria	Fuel consumption, flat rate
Belgium	Cylinder capacity + age
Denmark	105% up to DDK 50 800, 180% on the remainder
Finland	100% – FIM 4 600
France	None
Germany	None
Greece	16-128%, differentiated for exhaust emissions and cylinder capacity
Ireland	< 1.4 litres 22.5%, 1.4-2 litres 25 %, > 2 litres 30%
Italy	Fixed rate according to horse power
Luxembourg	None
Netherlands	Petrol car: 45.2% – NLG 3 394, diesel car: 45.2% – NLG 1 278
Portugal	Cylinder capacity, progressive rate
Spain	< 1.6 litres 7%, > 1.6 litres 12%
Sweden	None
United Kingdom	None
Norway	Differentiated for weight, cylinder capacity and power rating

Sources: ACEA (www.acea.be/MotorVehicleTaxation), European Commission (1997a), Toll- og Avgifts-direktoratet (1999), latest news from T&E's national member associations.

made (VROM, 1999). Finland is also planning to reform its vehicle tax to encourage the purchase of low-consuming cars (Ministry of Transport and Communications Finland, 1999).

All Member States tax cars in use. As shown in table 11, the annual vehicle tax is often based on power rating, cylinder capacity, weight or even fuel consumption (Denmark). Only Norway has a flat rate.

Table 11. Circulation taxes (annual vehicle tax) on passenger cars in Member States of the EU and Norway.

Austria	Power rating
Belgium	Cylinder capacity, progressive rate
Denmark	Fuel consumption + weight
Finland	FIM 500-700
France	Cylinder capacity + age + district
Germany	Cylinder capacity + exhaust emissions
Greece	Horsepower
Ireland	Cylinder capacity
Italy	Power rating (kW)
Luxembourg	Horsepower
Netherlands	Deadweight + province + fuel consumption
Portugal	Cylinder capacity
Spain	Horsepower
Sweden	Weight
United Kingdom	£ 155, reduced rate for cars < 1100 cc cylinder capacity
Norway	Flat rate NOK 1 965

Sources: ACEA (www.acea.be/MotorVehicleTaxation), Toll- og Avgiftsdirektoratet (1999), latest news from T&E's national member associations.

Sales and annual vehicle taxes might also have to be used for purposes other than improved fuel efficiency. Germany, for instance, has differentiated its annual vehicle tax for exhaust emissions with differing tax levels for cars meeting the requirements of the different existing and future EU emission standards. In addition, however, Germany grants cars that do 100 km on three litres of fuel a total exemption from vehicle tax up to 31 December 2005 or to the point when the accumulated exemption reaches DEM 1 000 (Bundesministerium für Verkehr, 1998).

It is a complicated task to determine the influence of different tax instruments on consumer preferences and the average specific fuel consumption of new cars. Choice is also influenced by many other factors, among them net income per capita. Ireland, Spain, Italy and Portugal all have relatively low average fuel consumption which probably reflects small car traditions and incomes below the European average rather than their use of fuel and vehicle taxes. Denmark, on the other hand, has an average specific fuel consumption below most countries with a comparable income per capita, which probably is due to its high tax on new registrations.

Sales tax has the advantage over annual vehicle taxes of providing a stronger incentive at the time of purchase (all else equal). The annual vehicle tax, on the other hand, has the advantage, when differentiated for exhaust emissions, that it gives last owners a signal about old cars being dirtier than newer models.

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 ("fee-bate" 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 gramme of CO_2/km that exceeds a baseline value, which is lowered year after year until it reaches 140 g/km in 2008. To do the job, the rate of the fee on emissions above the baseline would probably have to be in the order Euro 100-200 per g CO_2/km. If the baseline is, say, 170 g in 2003, a car emitting 180 g would then be taxed Euro 1 000- 2 000. A real "gas guzzler" (emitting, say, 240 g/km) would be charged Euro 7 000-14 000. A car doing 100 km on five litres (140 g/km), on the other hand, would earn a rebate of 3 000-6 000.

However, choosing a linear system of increasing taxation is not self-evident, the reason being that the price of cars does not increase linearly with fuel consumption. In essence this means that the rebate earned by a car that emits 160 g (when the baseline is 170) is equivalent to a higher share of the purchase price than the fee paid by a vehicle that emits 180 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). To make the scheme effective, a non-linear scale of increase is needed.

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. Its potential effects on car safety will be discussed in a later section of this report.

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). According to the European Commission (1997a) the variation in new car prices throughout the EU exceeds 20 per cent for some models. This problem would disappear if Member States agreed on a common system for taxing car sales.

8.3 Regulatory measures

Regulating fuel consumption or CO_2 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
- 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. ECMT's report on trends in power ratings recommended governments to 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).

However, most of the 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 HC and particles. One the other hand only a small minority of all car owners could be expected to get involved in tampering, and the marketing of trim chips could be prohibited. A future 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_2 emissions to vehicle weight might prove counter-productive as some manufacturers would probably 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. An alternative could be to put an upper limit on the weight of vehicles classified as M1 (maximum 9 occupants). An upper limit of 11 litres/100 km (8 for diesel cars) or 1 700 kg service weight would probably be enough to prevent Europe from taking an American route. The weight limit would also be important from a safety point of view (see further in a following section on safety).

Regulating average CO_2 emissions from corporate car sales is another feasible option. This is what the United States has done through its CAFE Act. An approach combining regulation and economic incentives is tradable emission credits. These two methods will be considered in the following sections.

8.4 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.

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 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.

8.5 Tradable CO_2 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_2 emission and could be regarded as an extension of a CAFE-style system.

The UK's Department of Transport proposed a system of tradable credits (Fendick and Taylor, 1991) to the European Commission's MVEG in 1992. The idea was to provide each new car with official CO_2 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. 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. To prevent manufacturers from withholding credits from sale to competitors, part of the credits would be reserved for an EU authority which would auction them and return the revenue to the original owners.

Critics (e.g. Fergusson and Holman, 1992) feared that the British proposal might never make it 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 Fendick and Taylor, 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 to predict the future price of emission credits and thus the total cost of cars requiring extra credits. It has also been suggested that a scheme of this kind may conflict with free trade agreements made by the World Trade Organisation.

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.

9. Performance and traffic safety

Over the lifetime of a model it is difficult to distinguish between improvements made purely in terms of safety, those made for improving performance and those made solely in terms of comfort. However, according to a report by the ECMT, there is evidence from German data that for an upper medium car model, only around a quarter of the weight increase has been due to safety features (ECMT, 1995).

Statistical data from the United States have shown that the weight of a vehicle is markedly less important in determining occupant safety in a crash than interior capacity (Khazzoom, 1994). Increased weight is only advantageous if used on impact- and strain-absorbing structures and materials which improve the ability of the car to absorb collision energy and protect the occupants. Extra weight used for other purposes is only negative from a safety point of view. A heavy car crashing into a solid object such as a tree or a rock releases more energy than a lighter car. An accident involving a heavy car and cyclists or pedestrians is more likely to injure or kill the latter than one in which a lighter car is involved. Large differences in the weight of cars is likely to cause more injuries and fatalities than a situation when most vehicles are of approximately the same weight. This is because in collisions between two cars of different weight, the lighter vehicle will suffer considerably more damage than the heavier.

Sport utility vehicles are nearly three times as likely as mid-size cars to kill the drivers of other vehicles during collisions (Thomas Hollowell, National Highway Traffic Safety Administration to New York Times, 12.12.1997). SUVs are also dangerous to their drivers and occupants by being four times as likely as cars to roll over in an accident. 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. A test undertaken by Folksam, an insurance company, and Sweden's National Society for Road Safety, showed that a Landrover Freelander crashing into the side of a Saab 9000 caused much more damage than a ordinary car would have caused. The driver of the Saab would have been killed even in a collision of only 50 km/h (Dagens Nyheter, 12.10.1999).

Table 12 shows some of the more common sport utility vehicles sold on the European market. Comparison is made with the height and fuel consumption of the estate version of the Volkswagen Passat.

Table 12. Examples of sport utility vehicles on the European market. Comparison with a normal medium size estate passenger car.

Model	Service weight, kg	Distance from chassis to ground, cm	Height, cm	Fuel l/100 km	
				Petrol	Diesel
Ford Explorer 4.0i	2060	No info	183	13.7	
Honda CR-V	1430-1440	20.5	168-171	10.0-10.2	
Jeep Cherokee	1634-1680	14.7	170	15.5	9.0
Jeep Grand Cherokee	1810-1930	14.7	169	14.9-17.9	
Land Rover Freelander	1460-1480	19.3	170-176	10.2	7.7
Land Rover Discovery	2070-2130	21.0	193	16.4	8.9
Rang Rover	2110-2220	19.5	182	16.2	10.3
Land Rover Defender 110	2050	21.5	203		10.1
Mitsubishi Pajero Wagon	2150-2180	21.5	189-190	14.3	12.8
Mitsubishi Double Cab	1950-1970	21.5-23.5	178-180		No info
Nissan Terrano II	1705-1950	21.0	183-185	11.9-12.3	9.9
Nissan Patrol GR 2.8 TD	2330	21.5	186		11.2
Suzuki Grand Vitara	1470-1520	19.0-19.5	171-174	10.1-10.6	7.8
Toyota Rav4	1415	20.5	166	9.4	
Toyota Land Cruiser 90	1980-2060	23.0	190	13.5-14.1	10.9-11.8
Toyota Land Cruiser 100	2385-2610	22.0	192	16.6	11.1
VW Passat Variant	**1410-1650**	**No info**	**150**	**8.1-10.9**	**5.5-6.0**

Source: Autograph-Bilfakta (1999a and 199b)

From the table it is clear that most SUVs are 30-40 cm higher than the VW Passat, and their centre of gravity is also a great deal higher. Most SUVs consume 40-70 per cent more fuel than the Passat.

The current trend towards more vans and sport utility vehicles is worrying both in the context of fuel consumption and traffic safety. Between 1994 and 1998, these vehicles approximately doubled their share of the European passenger car market, reaching 5.2 per cent in the latter year (FT Automotive Quarterly Review, 1999). If this trend continues, it will be very difficult indeed for the manufacturers to honour their CO_2 commitments.

Some motorists believe that a high performing car is a prerequisite for safe overtaking of other cars. However, an analysis based on Swedish road accident data showed that the fast increase in average engine power and performance of the country´s car fleet did not reduce the risk of severe overtaking crashes when statistics were checked for differences in the number of young drivers. The risk declined by 18 per cent between 1980 and 1995 but the reduction was due to fewer drivers below the age of 24, a group that is highly over-represented in this kind of accident (Kågeson, 1997). It should also be noted that, in the case of Sweden, overtaking in 1995 accounted for only 4.6 per cent of all car occupants killed in traffic accidents (and only 3 per cent of all road traffic fatalities). It is likely that a lower power output will lead to less aggressive driving, fewer risky overtaking manoeuvres and a safer traffic environment.

10. The rebound effect

Improving the fuel-efficiency of cars will also effectively 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 (Nederlands Economisch Instituut, 1991, and Jansson and Wall, 1994). Improving the specific fuel efficiency by 25 per cent could thus be expected to increase total mileage by something like 7 per cent.

Greene (1992) employed a variety of statistical approaches to the problem and concluded that the rebound effect of the US CAFE Act had been in the range of 5 to 15 per cent. Although the rebound effect may not be large, it remains an important weakness of fuel efficiency standards that they offer encouragement for drivers to travel further. The way to counter-act this effect is, of course, to raise fuel taxes.

11. Other factors influencing real fuel consumption

Limiting CO_2 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_2 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_2 emissions by 20-25 per cent, cut traffic casualties almost by half and improve the traffic flow. The report says limiting speed on the Autobahn is a prerequisite for meeting the country's commitment to the Kyoto Protocol. 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.

Driving behaviour can be influenced by information and education. Motiva, a Finish state agency, has successfully trained professional drivers from more than 130 companies and achieved a long-term fuel reduction of more than 10 per cent (J. Donner, Motiva, personal communication).

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.

12. Conclusions and recommendations

From a technological point of view the manufacturing industry should have no insurmountable difficulties producing cars which on average emit less than 140 g CO_2 per km. Lovins et al (1996) have indeed indicated technical measures that would make it possible to reach a much lower target. Instead the real challenge lies in marketing. Manufacturers have successfully linked comfort and power. For a given model, the more comfort the buyer wants, the more power he/she is obliged to buy.

Furthermore, the average manufacturer, wholesaler and car dealer has 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 (multi-purpose vehicles and 'off-road' vehicles) for use as passenger cars.

The conclusion is that without additional financial incentives/disincentives manufacturers will only make use of a minor part of the available potential for a general fuel-efficiency improvement. Statements by the industry show that it is aware of this problem. This is also the reason why ACEA and its Japanese and Korean counterparts concentrate on "dieselisation", direct injection engines and electric hybrid technologies. However, from the analysis of this report it is apparent that these measures will at best achieve somewhat less than half of the difference between the 2008 target and the average specific fuel consumption in 1995.

Mandatory introduction and use of CO_2 labels on cars displayed for sale and information on fuel consumption in marketing could not be expected to make much difference. The experience gained in Sweden and the UK, where such schemes have been in operation for around 20 years, is not promising. The power rating of new cars has increased faster in these countries than in any other Member State. Today Sweden has the heaviest and most fuel consuming car fleet of Europe.

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 a flexible policy instrument that can guarantee that the pre-defined CO_2 target is reached. Lack of European experience should not prevent the EU from trying such a scheme (or allowing Member States to do so).

A combination of higher fuel taxes and a sales or registration tax that is differentiated for specific CO_2 emission is the obvious alternative to tradable emission credits. The sales 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 specific fuel consumption and/or service weight of passenger cars (category M1, vehicles with maximum 9 seats). Those limits would then have to be in the order of 11 litres/100 km (8 l for diesel cars) and 1 700 kg respectively.

Tax incentives will be of particular importance for achieving the Council's 120 g CO_2 target. The Commission should not wait to develop this third pillar (besides the CO_2 agreement and fuel economy information) of its CO_2 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 a further shift from petrol to diesel engines will affect real consumption a great deal less than would have been the case under equal taxation. When petrol engines become more 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_2 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_2. An important conclusion, then, is that fossil road fuels should be taxed according to their content of carbon. This means taxing diesel fuel 13 per cent above petrol as diesel contains more carbon per litre of fuel.

The rebound-effect from lower specific fuel consumption on total mileage and annual fuel demand needs also to be considered. To counter-balance this effect the tax on diesel and petrol needs to be raised annually by 20-30 per cent of the rate of fuel efficiency improvement. When the specific fuel consumption declines by 1 per cent, the tax must be raised by 0.2-0.3 per cent. A tax increase is also essential as a disincentive to an extensive use of fuel consuming equipment.

The joint monitoring of the CO_2 agreement will focus on the achievements of ACEA, JAMA and KAMA and the individual car producers belonging to these associations. However, acknowledging the importance of market incentives it is essential that the monitoring process also covers the progress made on national markets. This is the only way for Member States to know whether additional tax incentives are needed at a national level.

The car industry has rightly pointed out the importance of a swift introduction of low-sulphur diesel and petrol fuels. Without them a shift to direct injection diesel and petrol engines will be severely delayed and most of the reduction will have to be achieved by downsizing and general efficiency improvements. Thus it is essential that Member States be allowed to introduce tax-breaks for ultra-low sulphur fuels. No general derogation from the Fuel Directive should be granted.

Speed and driving behaviour are other important elements in any comprehensive CO_2 abatement strategy. Speed limits and speed control could according to the European Commission (1998c) depress overall fuel consumption by around 5 per cent.

From the above it is evident that the success of the agreements with the European, Japanese and Korean car industries is far from guaranteed. It should also be underlined that these agreements were not even intended to meet the Community's 120 g/km target.

It should be kept in mind that reducing the specific CO_2 emissions of cars to 140 g /km (or even 120 g) could be achieved without a marginal loss of welfare. The abatement cost is low and in the case of engine and car downsizing even negative. When the positive side-effects on traffic safety are considered, it becomes obvious that society could achieve a net gain in welfare from reducing the specific fuel consumption of new cars. If the European Union fails to make use of this opportunity, CO_2 will have to be further reduced in other sectors of society at a considerable additional cost.

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