Reducing CO_2 emissions from the transportation sector

Iben SPLIID, Danish Council for Sustainable Energy, the secretariat

1. SYNOPSIS

The paper describes the results of two analyses that highlight possibilities to reduce the CO_2 emissions from the transportation sector.

2. ABSTRACT

In 1990 the Danish Government of the day together with a broad majority in the parliament decided that the CO_2 emissions from the transportation sector by 2005 should be stabilised on the 1988 level. However, the goal is far from being fulfilled and has therefore been re-evaluated lately.

To qualify the debate on the CO_2 emissions from the transportation sector, the Danish Council for Sustainable Energy has had performed an analysis containing a series of calculations that highlights the possibilities to reduce CO_2 emission from the transportation sector by 2005 and by 2012.

This analysis included seven different means including e.g. fuel tax or road pricing. The means are combined in a number of packages each fulfilling the CO_2 reduction goals.

The results confirm the general opinion that there are no easy solutions. They show that it is neither possible to reach the original goals, nor to “bend the curve” unless the most efficient measures are put into effect, i.e. for example the fuel price and reduction of the tax deduction for transportation.

Furthermore, the Danish Council for Sustainable Energy has had an analysis made on the administrative and legal responsibilities of the policies and measures within the transportation sector. The measures were also analysed with respect to the interests and the barriers to implementation. This analysis included nine different measures. The evaluation showed that road pricing will give maximum CO_2 reduction and include minimum barriers.

Both studies were performed by COWI, a Danish consultant.

3. INTRODUCTION

The goal for the Danish energy policy is to reduce total CO_2 emissions from energy use by 20% by 2005 compared to the 1988 level. In the longer term, the goal is a halving of CO_2 emissions before 2030. In connection with the Kyoto agreement Denmark should, corresponding to the internal burden sharing in the EU, achieve a reduction of 21% compared to the 1990 level (corrected for imports of electricity).

In 1990, the Danish Government agreed on a goal for the transportation sector to stabilise emission from the sector at the 1988 level by 2005. In the longer term, the aim is that the emission should be reduced by 25% by 2030. However, CO_2 emissions from the sector are continuing to grow and in 1999 were about 19% higher than in 1988. This is partly due to the fact that the economic growth since 1993 has been higher than expected when the CO_2 goal was established, but possibly also because the effort to save energy in this sector has not been very big. One may agree that the tax levels (i.e. registration fee and fuel taxes) are high, but compared to what has been done in Denmark in the other sectors the transportation sector is falling behind - probably because personal transportation is a political very sensitive area.

In the light of actual developments, the government has re-evaluated both goals and measures for the transportation sector, and the overall goal is now to “bend the curve” for the development in the CO_2 emission from the transportation sector. More precisely, the new target is to reduce the emission in 2010 by 7% compared

to what it would have been (a baseline scenario). The long-term goal is still to reduce CO_2 emission by 25% compared with the 1988 level.

The most important measures that will be employed are: international agreement with the automobile industry about improving the energy efficiency of cars; redistribution of the annual car owner tax; information to consumers about the energy efficiency of cars (energy labelling scheme); and increased taxes on petrol and diesel (*Climate 2012,* lit. 1).

This paper will describe the results of two analyses that the Danish Council for Sustainable Energy has had performed to highlight the possibilities to reduce the CO_2 emission from the transportation sector. Focus for the analyses has been on measures influencing the CO_2 emission from passenger transportation as passenger transportation is responsible for most of the CO_2 emissions from the transportation sector in Denmark, see table 1. But other consequences deriving from them are also included in the calculations, e.g., fuel taxes on transportation of goods.

Table 1. Data for the Danish transportation sector

	Volume Mpass.km/ Mtonne-km		Energy consumption TJ		CO_2 emissions 1000 tonnes	
	1988	1999	1988	1999	1988	1999
Passenger cars (< 2 t)	47 336	60 176	73 424	90 142	5 362	6 589
Busses and trains (pass.)	14 200	16 286	9 197	11 124	638	751
Ferries	570	275	-		-	-
Flights	465	398	2 620	2 177	189	157
Trucks and Light duty vehicles (> 2 t)	9 520	11 087	47 076	56 965	3 477	4 209
Trains (goods)	661	543	1 900	1 095	141	63
Ships	1 783	1 805			-	-

Sources: Statistics Denmark and Ministry of Transport, Road Directorate and the Danish Energy Agency

Based on the results of the analyses, the Council for Sustainable Energy has written to the Danish minister of traffic recommending that the Danish Parliament takes a decision in principle about introducing road pricing as soon as possible. This would allow work to begin to solve the remaining technical and practical problems in connection to road pricing, e.g., the question of how the yield from the road pricing can best be spent to support a reduction of emissions from traffic. Lately the minister has mentioned the possibility of introducing road pricing.

The Danish Council for Sustainable Energy is an independent and active council, being among other things an advisory body to the government and the Parliament. The Council, in accordance with the intentions of the Danish national energy plan, *Energy 21* (lit. 2), works towards the promotion of sustainable development of the energy sector by encouraging increased use of renewable energy, as well as the promotion of energy savings and energy efficiency.

Therefore, it has been of interest to investigate if it is possible to fulfil the original goal for the emissions from the transportation sector and to analyse which measures would be required and how they could be complemented.

The analyses which have been carried out by COWI, a Danish consultant, are described in the reports *Muligheder for opfyldelse af transportsektorens CO_2-målsætning* ("Possibilities for fulfilling the CO_2 goal for the transportation sector", lit. 3) and *Forankring af de transportpolitiske virkemidler* ("Deely rooting of the political measures in the transportation sector", lit. 4. Deeply rooting or anchoring is understood as the placing of the administrative and legal responsibility for using the CO_2 measures in question.) The presentation and conclusions in this paper are fully the author's personal responsibility.

Today the most important measures to reduce CO_2 emissions from passenger transportation in use in Denmark are summarised in table 2.

Table 2. Most important measures in use today to reduce CO_2 from private transportation

Measure	Comment
Registration fee when buying a new private car	About 180% of import price plus VAT High efficient cars (e.g. the LUPO): About 60% to 150% depending on the efficiency Electrical cars are exempted
Car owner tax (paid annually)	For petrol cars: From 460 DKK to 16.920 DKK depending on the fuel economy Electrical cars are exempted
Fuel tax Energy tax CO_2 tax VAT	Petrol / Diesel 3,85 DKK/l / 2,57 DKK/l - / 0,27 DKK/l 25% - also of the energy and CO_2 taxes
Tax deduction Possibility*	0 – 24 km/day: 0 DKK/km 24 – 100 km/day: 1,58 DKK/km > 100 km/day: 0,79 DKK/km
Energy labelling	Since 2000
Others	Different measures to promote electrical cars, e.g. free parking and recharging facilities in Copenhagen

* Persons living at a longer distance from their work place get a yearly allowance against income tax, known as tax deduction for transportation. This was introduced primarily to encourage mobility in the labour market and thereby to stimulate employment.

In "Possibilities for fulfilling the CO_2 goal for the transportation sector", seven different possibilities to reach the goal in 2005 are evaluated. Furthermore, the study analyses what is needed additionally to reach a 5% reduction of the CO_2 emission from the transportation sector in 2012 (compared to the 1988 level). The analysis also includes three separate calculations for reduction of the travel time with public transportation, improved fuel efficiency in public transportation, and replacement of cars by very energy efficient cars.

Only measures that can be introduced by Denmark in isolation are included. This means, e.g., that technological improvement of the energy efficiency of cars are not included. Denmark has only very little possibility to influence this aspect, as the vehicles used for Danish road transportation are nearly all imported. There have been attempts to develop environmental benign cars in Denmark, e.g. an electrical car, but the option of a future Danish production of such cars is not included.

The analysis is restricted to measures for which the effect can be calculated. Therefore, further contributions to the CO_2 reduction could be obtained from other measures, e.g., from traffic regulation in towns, which will reduce car traffic, including the transportation of goods.

The main conclusion from the analyses is that the original goal for 2005 only could be fulfilled by use of considerable tax increases.

To illustrate the possibilities for implementing the necessary measures, the political and administrative deeply rooting of the responsibility for the implementation of different selected measures within the transportation sector has also been analysed. The analysis indicates that road pricing is the most promising measure from a combined evaluation of maximum CO_2 reduction and minimum barriers.

4. ANALYSIS

Methods and assumptions

In the calculations, the goal for the CO_2 emissions from the transportation sector was defined as:

- A stabilisation at the 1988 level in 2005
- A reduction to 95% of the 1988 level in 2012.

The reductions are for the national transportation sector. But as mentioned above the focus of the analyses is on passenger transportation.

The included measures are:
- Increases in fuel taxes/introduction of road pricing
- Increases in car owner tax for private car owners
- Bio fuels added to fuels for road transportation
- Abolition of the tax deduction possibility for transportation
- An energy labelling scheme for new private cars
- (Registration) Subsidy for electrical cars
- Decreases in ticket prices for public transportation.

In the analyses increases in car owner tax, addition of bio fuels, abolition of the tax deduction possibility for transportation, energy labelling, and subsidies for electrical cars are instruments that may or may not be introduced, while the rest of the instruments can be employed to varying degrees.

Based on the instruments, seven different possibilities – packages of instruments - have been formulated to stabilise the CO_2 emissions from the transportation sector in 2005 at the 1988 level.

The packages have been composed so that in the first package the total CO_2 reduction is obtained by using the instrument that is the most effective in reducing CO_2 – increased fuel taxes. Thereafter the second most effective instrument is included in the second package etc.

Socio-economic estimations have not been made of the cost effectiveness of other measures - neither within the transportation sector nor in comparing with other possibilities for reduction, e.g., in the energy sector. Also, no economic welfare considerations have been made to support the choice between the different packages.

The focus of the analysis is on instruments that influence CO_2 emissions from passenger transport, but other consequences deriving from them are also included in the calculations, e.g., fuel taxes on transportation of goods.

The calculations are performed so that the packages analysed are neutral in terms of net public sector expenditure. This is done by assuming that increases in the total yield from the transportation sector are compensated by equal decreases of the personal taxation. Compared to previous analyses of the transportation sector, a novel feature of this study is that the CO_2 consequences of effects on other sectors are included in the analysis, as is the effect of the re-circulation of the yield in the form of increased transportation demand.

As the increases in the fuel taxes only serve environmental purposes here – and thereby no fiscal – the yield from the increases is returned to society through a reduction of the tax on personal income. Altogether, this results in changes in the composition of consumption such that demand for fuel decreases while demand for other goods and services increases. The decrease in the fuel consumption results in a reduction of CO_2 emission, while the increased use of other goods and services results in an increase in the CO_2 emission, the latter being however far less than the reduction. This effect is included in the results.

The purpose of the model has been to take advantage of a detailed partial analysis of activity changes in the transportation sector and, at the same time, to include the most important inter-sectorial effects from changes in consumption and reversal. The estimation of the macro economic interaction is however more inaccurate here than in pure macro economic analyses. In particular, the effects on economic growth from the resulting changes in the taxation – represented by the packages - is not accounted for.

Furthermore, it should be pointed out that the tax and price increases referred to, which are necessary to reach the goals, are at year 2000 prices. In the calculations the real prices of petrol and diesel are assumed constant. If there is an increase in the real price of these fuels the necessary tax increase will be accordingly less; vice versa, if the real price drops.

This also implies an assumption about the nominal taxes being adjusted yearly. As there is no built-in automatic adjustment for cost of living, this assumption will result in an overestimation of the CO_2 reduction effects unless supplementary tax increases are introduced to adjust for inflation – as is quite possible in a longer perspective.

As for fuel taxes/road pricing the two measures are treated in the same way. When road pricing is technically possible it can substitute fuel taxes, and it may be a realistic alternative to increased fuel taxes in the near future.

And road pricing will among other things not result in cross-border trading problems etc. as increased fuel taxes do. Furthermore, from a socio-economic point of view, it could be advantageous to curb other inconveniences from the traffic. For the elasticities used see Appendix A.

As for bio fuels, it should be mentioned that the point of departure here is consideration for the transportation sector in isolation. Before possible implementation, the initiative should be compared with an utilisation of the bio-mass (the crop) directly in stationary combustion plants (e.g. co-generation plants) as the conversion to liquid bio fuels requires both some process energy and includes considerable production costs. The comparison should include both CO_2 effects and socio-economic effects.

Besides the calculations mentioned above, there are made three supplementary calculations which illustrate the potential of service improvements in public transportation, energy efficiency improvements in public transportation, and introduction of very energy efficient cars that take 3 litres of fuel per 100 km (3 litre cars). The calculations have form of *If-Then* calculations, as the information about these measures is incomplete compared to the information about the other instruments.

Deeply rooting is understood as the placing of the administrative and legal responsibility for using the CO_2 measures in question. *Implementing* is understood as the actual implementation of the measure, e.g. increase of taxes, changed legislation or grant of funds.

Many different measures can contribute to reducing CO_2 emissions from the transportation sector. Therefore the rooting analysis has been concentrated on a limited number of measures, chosen with the following considerations in mind:

- Current knowledge about the effect of the measures and the socio-economic costs imposed by the implementation.
- That there should be at least one measure rooted in respectively the EU, the state, and the local governments.
- The measures can be realistically considered for application, for example, measures that have been widely debated politically.

These considerations, which are important with respect to who are responsible and thereby also who have the possibility to take action, have led to the inclusion of some other measures which are not in the above analysis.

The measures included in the deeply rooting analysis are among others[i]:

- Fuel taxes/road pricing
- Abolition or reduction of the tax deduction for transportation
- Energy standards for new cars
- Public transportation
- Environmental zones
- Information

The analysis illustrates which institutional players today have the possibility to implement the transportation political measures and which economic, legal, or political barriers could prevent implementation or cause it to fail. Also, it evaluates future possibilities for rooting and implementation.

Results

A reference scenario was constructed to calculate the CO_2 reducing effects of the packages. This scenario corresponds as closely as possible to the current official projections of the CO_2 emissions from the transportation sector. The scenario includes the effect of a decision to increase the tax on petrol so that in 2005 it will be 29% (_ 1 DKK or 0,13 EUR[ii]) higher than at present.

The results of the calculations show that fulfilling the CO_2 goal for the transportation sector requires extensive changes compared to the actual policies in the sector. The most important among the investigated measures are:

- Increased fuel taxes/road pricing
- Mixing bio fuels in petrol and diesel
- Abolition of the tax deduction for transportation.

The main conclusion from the analyses is that it is only possible to fulfil the original goal for 2005 by considerable tax increases. It implies an increase of more than 150% if the goal of holding CO_2 emissions at the 1988 level is to be reached solely by increased fuel taxes. This results in a petrol price of about 17 DKK pr. litre (_ 2,27 EUR) compared to about 8 DKK (_ 1,07 EUR) under present policies. If all 7 measures are included then the fuel tax should be increased by about 50%; this corresponds to a petrol price of about 11 DKK (_ 1,47 EUR).

To reduce the CO_2 emissions from the transportation sector in 2012 to 95% of the 1988 level would need even more radical tax increases. If the goal is to be reached solely by increased taxes on fuel or by road pricing the calculations point to a petrol price of about 35 DKK pr. litre (_ 4,67 EUR pr. litre), or about 4 to 5 times the price in the reference scenario. For the package with all 7 measures the result is that the tax on petrol should be about 11 DKK pr. litre (_ 1,47 EUR pr. litre), corresponding to a total price of about 17 DKK pr. litre (_ 2,27 EUR pr. litre).

The main reason why the necessary tax increase for fulfilling the goal in 2012 is so drastic is that rising income levels are expected to increase the total amount of traffic at constant tax level, so tax increases are needed just to keep the CO_2 emission on the 1988 level. Therefore, to achieve an actual reduction of 5% in CO_2 emission in 2012 would require even larger increases in tax.

It should be remarked in general that the bigger the price changes in question the more difficult is it to predict the magnitude of the behavioural changes of the road users. This holds particularly for the calculations for 2012.

The inclusion of the effect of the re-circulation of the increased yield from the transportation taxes (by reduced personal income tax) augments the need for tax increases. The reason for this is primarily that the consumers will spend part of the returned yield on transportation. On the other hand the calculations show that the CO_2 emission in other sectors are little affected by the total change in taxes. Personal tax reductions by and large offset the decrease in disposable income caused by the increasing taxes on transportation.

The analysis of the deeply rooting shows primarily that the responsibility for implementation of the selected measures is at present spread among several administrative bodies within the public administration. This suggests that better co-ordination of effort in the sector should be considered, particularly in view of the apparent difficulties in reaching the CO_2 goals. And the questions about deeply rooting and implementation are very relevant to progress in the Danish debate about regulating the CO_2 emissions from the transportation sector. Several political, legal, EU legal, administrative, and knowledge barriers complicate rooting and implementation of many known measures which have a CO_2 reduction potential. Thus, reduction of CO_2 emissions from the transportation sector has not received a sufficiently high priority compared to other sectors, that the necessary measures have been implemented. Use of some of the most efficient measures depends also to a large extent on the EU and Denmark's neighbouring countries.

Furthermore, the analysis showed that today the administrative and legal rooting of the measures lacks a clear focus within the public administration. Given the expected difficulties with respect to fulfilling the CO_2 goal in the transportation sector it could be considered if a more co-ordinated effort was necessary.

A comprehensive overview of the included measures, the players, the administrative units that are relevant with respect to rooting and implementing the different measures, and an indication of barriers and possibilities for a better rooting and implementation of the measures is shown in table 3.

At the same time, the analysis showed that a more targeted discussion of deeply rooting, implementation and barriers opens new perspectives for identifying possible actions to reduce CO_2 emission from the transportation sector. These include adjustment of existing measures, clarification of barriers (for example if these are real), legislation and increased knowledge.

In a little longer perspective, road pricing seems to be the measure with special potential for contributing to the fulfilment of the CO_2 goal. As the necessary technology is expected to be mass-produced soon, it is important that the discussions are started about introducing the system and the form it could take, as the political, administrative and technical clarification is expected to take some time.

Table 3. Overview of the administrative rooting and barriers and possibilities for rooting and implementation

Measure	Players	Administrative rooting	Barriers and possibilities
Fuel taxes/ ---------- Road pricing	The state, EU ---------- The state	Ministry for taxation EU ---------- Ministry of transport Ministry for taxation*	Cross-frontier trading – disagreement on the size of the problem Others ---------- Depends primarily on a political decision Needs legal authority Technologically advanced
Abolition or reduction of the tax deduction for transportation	The state	Ministry for taxation	Labour market aspect has for the moment high priority. Need for a discussion of real effect on mobility.
Energy standards for new cars	EU, the state	Ministry of environment and energy EU Commission ACEA (Association of car producers)	Rooted in EU. Problem about increased energy use due to up-sizing and extra equipment (e.g. air condition)
Public transportation	Counties, local governments, the state	Traffic companies of the counties, counties, and local governments Ministry of transport Ministry of environment and energy	Possibility of CO_2 management (e.g. bus routes and electricity for trains) and quality development, but economic barriers. Public grants a possibility.
Environmental areas	Local governments	Local governments Ministry for transport	Bill for pilot schemes. Lack of experience
Information	The state, counties, local governments, users	Ministry for transport Ministry of environment and energy Counties and local governments	Measures exist but are relatively diversified. Change of attitudes difficult.

* Depends on the exact frame for a road pricing system.

Results of the calculations

Results of the main calculations

Table 4 shows the instruments that are included in the packages and with which effect they are included.

In package 4, e.g., the following instruments are in use: The tax deduction allowance for transportation is abolished in 2000, the car owner tax is doubled and the fuel taxes are gradually increased by 62% up to 2005. Furthermore it has been announced that compulsory addition of bio fuel to fuel for all vehicles will be introduced from 2005. From 2005 to 2012 fuel taxes will be increased by extra 128 percent points so that they in 2012 will be 190% over the reference case. Likewise, the car owner tax is increased by 50%.

The effect of rather large increases in fuel costs will always be difficult to predict, and it should be underlined that there is a big uncertainty connected to the results, especially for the big price changes. Still, the calculations illuminate the magnitude of the necessary tax increases if the goal is to be fulfilled, given certain assumptions with respect to the rest of the activities. And the calculations of the effects of last year's higher price level for petrol broadly confirm the assumptions made for the elasticity of the price of petrol.

Table 4. Instruments in the packages

	Pack. 1	Pack. 2	Pack. 3	Pack. 4	Pack. 5	Pack. 6	Pack. 7
Fuel taxes Or Road pricing	158/478	73/232	62/195	62/190	52/150	52/148	54/156
Bio fuel added to fuels (15%)	-	Yes	Yes	Yes	Yes	Yes	Yes
Abolition of the tax deduction for transportation	-	-	Yes	Yes	Yes	Yes	Yes
Green car owner tax (5 increase)	-	-	-	100/150	100/150	100/150	100/150
Electric cars (registration)subsidy	-	-	-	-	Yes	Yes	Yes
Energy labelling of new cars	-	-	-	-	-	Yes	Yes
Reduction of tariffs for public transportation	-	-	-	-	-	-	5/10

Note: The number after the "slash" indicates the percentage increase in 2012 relative to the reference development.

The nominal changes in prices for fuel corresponding to the price increase are shown in table 5 for package 1, 4, and 7.

Table 5. Changes in petrol taxes (in DKK/litre, 2000 price level)

	Without package	Package 1		Package 4		Package 7	
		2005	2012	2005	2012	2005	2012
Producer's price*	1,98	1,98	1,98	2,17	2,17	2,17	2,17
New tax	4,44	11,4	25,6	6,8	12,5	6,4	11,0
VAT	1,6	3,4	6,9	2,3	3,7	2,2	3,3
Market price	8,0	16,8	34,5	11,3	18,4	10,8	16,5

* The producer's price increases when mixing with bio fuel. At the same time the tax is reduced, so the consumer pays the same amount per unit of energy available from the fuel.

From the table it can be seen that for package 4 the above-mentioned increase in fuel tax of 62% up to 2005 corresponds to a real increase of about 2,35 DKK. And the further increase to 190% up to 2012 corresponds to a new fuel tax of 12,5 DKK in 2012 compared to 4,44 DKK in the reference case.

In connection with the adding of bio fuel, it is important that this measure is announced as early as possible so that the production capacity can be adjusted.

When calculating the total CO_2 effect for the economy, an emission rate for the re-circulation of 60 gram CO_2/DKK is used. Furthermore is it assumed that 1 DKK less spent on all other goods and services than transportation will reduce CO_2 emissions by 52 gram[iii]. It is assumed in the calculations that the yield is transferred directly back (re-circulated) to the households. Alternative the transfer could be directly to trade and industry, but further analyses of the energy content in the different types of transfer would be needed to analyse this.

The efficiency of the different instruments in 2005 can be seen from table 6. The table shows how much of the necessary CO_2 reductions the instrument causes. The row labelled "interaction" shows the reductions in the direct sum of the effects that has been used to counterbalance overlapping of the instruments.

A similar split can be made corresponding to the efficiency of the instruments in 2012.

It can be seen from table 6 that increases in fuel taxes, addition of bio fuel, and abolition of the tax deduction on transportation are the instruments with the highest CO_2 reducing effect. Furthermore it can be seen that there is a difference between the total effect on the CO_2 emissions in the economy and the partial effect in the transportation sector.

Table 6. The effectiveness of the instruments to reduce CO_2 emissions in 2005 (1988=100)

	Without Package	Pack. 1	Pack. 2	Pack. 3	Pack. 4	Pack. 5	Pack. 6	Pack. 7
Fuel taxes Or Road pricing	-	-25 (-30)	-15 (-18)	-14 (-16)	-14 (-16)	-12 (-14)	-12 (-14)	-12 (-14)
Bio fuel added to fuels (15%)	-	-	-11 (-10)	-11 (-10)	-11 (-10)	-11 (-10)	-11 (-10)	-11 (-10)
Abolition of the tax deduction for Transportation	-	-	-	-2 (-3)	-2 (-3)	-2 (-3)	-2 (-3)	-2 (-3)
Car owner tax (5 increase)	-	-	-	-	-0 (-1)	-0 (-1)	-0 (-1)	-0 (-1)
Electrical cars (registration) subsidy	-	-	-	-	-	-2 (-2)	-2 (-2)	-2 (-2)
Energy labelling of new cars	-	-	-	-	-	-	0 (0)	0 (0)
Reduction of tariffs for public Transportation	-	-	-	-	-	-	-	0 (0)
"Interaction"	-	-	1 (1)	2 (2)	2 (2)	2 (3)	2 (3)	2 (3)
Total	125	100 (95)	100 (98)	100 (98)	100 (97)	100 (98)	100 (98)	100 (98)

Note: Numbers in () are the partial CO_2 reduction in the transportation sector

A doubling of the fuel tax is rather efficient but the effect of further increases declines gradually. On the other hand, the effect of the re-circulation increases (relatively) in line with decreases in changes to people's traffic behaviour. This explains why the necessary tax increases in 2012 are much higher than in 2005. Furthermore, the big amount that is to be transferred in 2012 will make the results of the calculations very sensitive to the exact value of the emission factors. If the tax increase is combined with a differentiated VAT favouring goods and services with a small CO_2 content this effect could be restricted. The question is treated in the paper "Reducing CO_2 emissions by changing private consumption by differentiation of VAT and other taxes on consumption" (lit. 5).

Supplementary calculations

a) Reduction of the travel time with public transportation

It is often stated that improvements in service and travel time are more effective than price reductions for encouraging greater use of public transportation. Here only the CO_2 consequences of the resulting demand change from a service improvement were looked at.

The calculations made within this project show that, e.g., reduction of the average travel time in public transportation by 5% has relatively insignificant effect on the total CO_2 emissions. The reduction in travel time can be obtained by creating more bus lanes in the bigger cities, increased track capacity or the like. By using the expected elasticities the reduction will correspond to 1% of the stated reduction in both 2005 and 2012. The explanation is that new travellers rather than former car drivers account for the surplus traffic generated by the service improvements. The result does not change much by changing the elasticities. It is negative for low estimates of the elasticities and increases a little for high estimates.

b) Improved fuel efficiency in public transportation

Calculations show that if a 10% reduction in ticket price should be CO_2 neutral, busses should improve their energy efficiency by about 11% in 2005 compared with the reference scenario.

There are no incentives for the public transportation companies to improve energy efficiency with the existing legislation. E.g. are the companies exempted for fuel taxes. The incentives to improve fuel efficiency could be increased by rearranging the indirect subsidy that the tax exemption represents to a yearly subvention.

c) Replacement of cars by very energy efficient cars

Disregarding possible demand effects from the improved fuel economy, a change in the car stock where 10% of the stock is replaced by very energy efficient cars that take 3 litres of fuel per 100 km, reduce the total CO_2 emissions in the transportation sector with about 4,5 % in 2012 with the given assumptions. This corresponds to between 14 and 15% of the 4 Mton CO_2 that is the reduction goal. However, the result should not be taken for more than it is. The improved fuel economy will cause an increase in transportation volume if increased fuel prices or the like do not follow the implementation of these efficient cars. And this will pull against a final result with a smaller reduction than the above calculated.

"Results" of the deeply rooting analysis

The results are summarised in table 3 above.

Fuel taxes are one of the measures with the greatest potential for reaching the CO_2 goal. The taxes are deeply rooted in the state and in EU. In Denmark it belongs to the Ministry for taxes. The barriers often mentioned in connection with political discussions of tax increases on fuel are the consideration of the competitiveness of Danish road haulage business and consideration of cross-border trading, including consideration both of the yield and of jobs in the border region. Yet, the problem of increasing cross-border trade and reduced competitiveness will reduce if the neighbouring countries, especially Germany, increase their fuel taxes.

Road pricing will, when it is fully developed, be well suited for regulation of the transportation sector. Furthermore it has the advantage compared to fuel taxes that it does not give rise to cross-border trading. A committee headed by the Ministry of transport has evaluated taxes on driving (road pricing) as a measure in the towns. They recommended that further investigations be carried out, among others, analysis of the attitudes and reactions to taxes on driving, both by trade and industry and by the general public. They also recommended that one or more pilot and demonstration projects should be initiated. The technique is now so well developed that within a short time it will be possible to mass-produce a road pricing system. To ensure deeply rooting and speed up the process, a political decision is needed on whether the system should be introduced in Denmark. After that the necessary work should be started, including examination of how the yield from road pricing can be used to support the goal for the reduction of CO_2 emission from transportation.

Abolition or reduction of *the tax allowance for transportation* is expected to give a significant reduction in the CO_2 emissions from the transportation sector. Analyses of the allowance show that the effect of abolishing it would be concentrated on relatively few persons (who travel far). Also, a great deal of the fiscal advantage from the allowance accrues to higher salaried employees and directors from neighbouring municipalities, and their mobility is hardly affected.

Energy standards for new cars are rooted in EU, which is the central player. In July 1998 the European Commission entered into an agreement with the European Association of Car Producers, ACEA, about technical reduction of CO_2 emission from passenger cars. It is for the car industry to implement the agreement, but in 2003 the Commission will evaluate the extent to which its effect is positive. The alternative is that the EU will make a legal intervention. However, the agreement is not sufficiently far-reaching and it does not take the "up sizing" of the car stock or energy consuming extra equipment into account.

Public transportation potentially can make a contribution to CO_2 reduction, especially if focus is not only on a transfer from car transportation – which is only expected to make a small contribution – but also on reduction of the CO_2 emission from the existing public transportation. The traffic companies and the counties and municipalities who themselves organise the bus service, have the possibility to set up environmental and energy conditions when they invite tenders for bus services. This is already done to a certain extend but it can be complicated due to economic aspects, as tariffs are already under pressure. Public grants might also be a possibility. In the same way the quality improvements that are necessary to attract car drivers are made complicated by economic aspects. Specifications of CO_2 content could also be considered when DSB (the national Danish railway system) buys electricity.

Environmental zones are a rather new measure and are therefore restricted by limited legal funding and knowledge for the municipalities to establish these zones. However, a bill will make it possible for municipalities to make time and geographically restricted demonstration projects with traffic regulating

measures, even they are only due to environmental considerations. The bill will also open for environmental zones.

Information as a measure is already in use, e.g. in connection with purchasing a new car. There is established an energy labelling and consumer information system. Another example is that the Danish Environmental Protection Agency in 2000 arranged an "Environmental traffic week" in connection with the European initiative "In town without my car". The purpose was to demonstrate possibilities for reducing environmental problems from traffic. The campaign took place in a close co-operation between authorities, organisations, and enterprises. It has been decided to continue the activity in 2001

However, no total strategy seems to be established, including placing of responsibility for using information as a measure to reduce CO_2 in the transportation sector. At the same time it should be noted that changes in attitude are very difficult in the traffic area.

5. CONCLUSION

The results confirm the general opinion that there are no easy solutions. They show - with the assumptions used - that it is neither possible to reach the original goals, nor to "bend the curve" unless the most efficient measures are put into effect, i.e. for example the fuel price (fuel taxes) and reduction of the tax deduction for transportation. The author acknowledges that the list of measures is not complete, e.g. are "soft" measures not considered. However, it is the author's conviction that the willingness in the population to respond to "soft" measures as e.g. avoiding short car rides, and perhaps also driver training, is so little that the conclusions reflect the necessary instruments to be used.

It is technically possible to fulfil the goals for reduction of the CO_2 emissions from the transportation sector but the political willingness to use the necessary measure is lacking. Perhaps it is not possible to solve the problem within the narrow transport political framework. A possibility might be to include utilisation of the yield from tax increases on fuel. If this yield is used for general welfare political goals and/or to reduce of other taxes or dues, the political barriers against fuel taxes might be reduced.

In a little longer perspective, road pricing seems to be the measure with special potential for contributing to the fulfilment of the CO_2 goal. As the necessary technology is expected to be mass-produced soon, it is important that the discussions are started about introducing the system and the form it could take, as the political, administrative and technical clarification is expected to take some time.

6. REFERENCES

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7. END NOTES

[i] The analysis also includes differentiated and progressive kilometre taxes and transportation agreements

[ii] Rate of exchange: 7,5 DKK

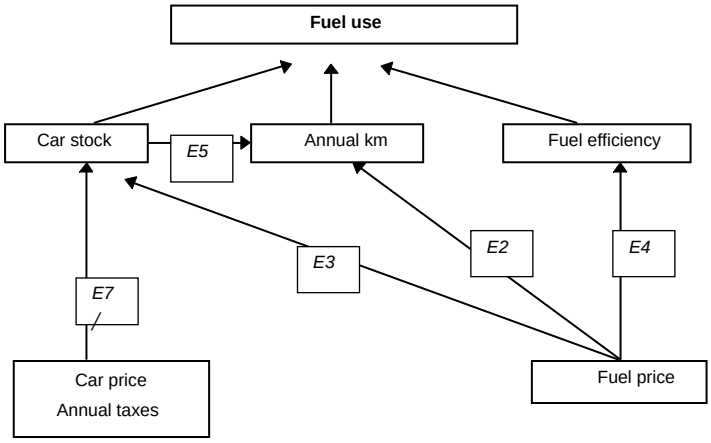
[iii] The issued input-output analyses do not describe the factor use in the production. Therefore it has not been possible to calculate a special CO_2 emission rate for the effect of changed factor prices for trade and industry. In lack of better is used 52 gram/DKK, but there are performed sensibility calculations with 22 and 82 gram/DKK.

1. APPENDIX A

Parameters

The interference between prices and fuel use for car transportation is illustrated in figure A.1.

Figure A.1. Relation between prices and fuel use for car transportation



The following restriction on the elasticities has been used in the calculations to reflect this relation:

$E1 = E2 + E3 - E4 + E3*E5$

where:
E1 is the elasticity between fuel price and fuel demand
E2 is the elasticity between fuel price and annual km per car
E3 is the elasticity between fuel price and the number of new registrations
E4 is the elasticity between fuel price and fuel efficiency
E5 is the elasticity between the total number of cars and the annual km per car.

Increases in the registration fee and the annual car owner tax are assumed to have equivalent effects on the fuel use by their influence on the number of new registrations per year. Both taxes represent fix costs for the owner and therefore should be treated the same way. And it is assumed that the consumers look at the present value of the total expenditures when buying a new car.

Table A.1 shows the main parameters. The elasticities are derived from Danish econometric studies and some Nordic studies. Effects on demand between private cars with petrol and diesel are not considered. Thus, it is assumed that changes in the price relation between petrol and diesel are so small that they will have no effect on the distribution between petrol and diesel cars.

Table A.1. Main parameters

Parameter	**Value**		
	Low	*Expected*	*High*
E1P: Elasticity, fuel price_fuel demand, passenger car	-0,50	-0,60	-0,75
E1L: Elasticity, fuel price_fuel demand, vans etc.	-0,17	-0,20	-0,25
E2P: Elasticity, fuel price_annual km per car	-0,22	-0,27	-0,37
E2L: Elasticity, fuel price_annual km per car	0,08	-0,09	-0,12
E3P: Elasticity fuel price_car stock, passenger car	-0,30	-0,30	-0,30
E3L: Elasticity fuel price_car stock, vans etc.	-0,10	-0,10	-0,10
E4P: Elasticity fuel price_fuel efficiency, passenger cars	0,10	0,15	0,20
E4L: Elasticity fuel price_fuel efficiency, vans etc.	0,03	0,05	0,07
E5: Elasticity car stock_km per car	-0,40	-0,40	-0,40
E6: Cross elasticity fuel price_ public transportation	0,07	0,08	0,10
E7: Elasticity price of a new car_car stock	-0,50	-0,50	-0,50
	2000	*2005*	*2012*
Producers price – petrol, DKK per litre	1,98	1,98	1,98
Producers price – diesel, DKK per litre	2,11	2,11	2,11
Fuel tax - petrol, DKK per litre	4,060	4,4352,365	4,435
Fuel tax – diesel, DKK per litre	2,365	70.000	2,365
Average production price, petrol car, DKK	70.000	75.000	70.000
Average production price, diesel car, DKK	75.000	2.400	75.000
Average car owner tax, petrol car, DKK per year	2.400	4.700	2.400
Average car owner tax, diesel car, DKK per year	4.700	138.400	4.700
Average registration fee, petrol car, DKK	138.400	105.720	138.400
Average registration fee, diesel car, DKK	105.720		105.720

Note: The bigger the changes in prices, the bigger uncertainty on the elasticities. The elasticity from the price of a new car to the car stock is a long term elasticity. The figures for the registration fees are incl. VAT for petrol cars and excl. for diesel cars.