Implementing of Alternative Fuels in Sweden

A report to the Governmental Commission on Transport and Communications

KFB SIKA NUTEK

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Stockholm, September 20, 1996

To the Communications Committee

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The Governmental Commission on Transport and Communications has directed KFB, NUTEK and SIKA to prepare material for a decision on the introduction on a large scale of alternative fuels.

We have carried out this task jointly and the attached report outlines three different strategies for the introduction. Strategies 1 and 2 have been designed to achieve the target of 15 per cent bio-based energy usage within the road transport sector by 2010. The third strategy extends the introduction period to 2020 and reduces the target to 10 per cent.

Strategy 3 also involves the introduction strategy being preceded by a five-year R&D programme. This should be complemented with continued tax exemption for ethanol and a broad evaluation programme to allow experiences gained from different areas of usage to be applied.

Based on the background of the R&D situation for the various alternative fuels and the high cost of beginning the introduction on a large scale of bio-based fuels today, we would recommend Strategy 3.

Stockholm, September 20, 1996

Urban Karlström Christer Heinegård Staffan Widlert

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1. Foreword

In its letter of June 28, 1996, the Governmental Commission on Transport and Communications requested KFB (Swedish Transport & Communications Research Board), Nutek(National Board for Industrial and Technical Development) and SIKA to carry out an investigation, to be completed by September 6, 1996, clarifying the potential for the introduction of 15 per cent of alternative fuels in the road transport sector by 2010. Commissions directive is included in this report as Appendix 1. The working group was later granted an extension of the time limit for the completion of its work until Friday, September 20, 1996.

The working group consists of Urban Karlström, chairman; Henrik Swahn, SIKA; Gunnar Kinbom, NUTEK; and Sören Bucksch, KFB. Nils Elam, of IEA/AFIS, also participated. Magnus Brandel of IVL (Swedish Environmental Research Institute) acted as secretary.

During the course of the work, discussions were held with various parties and their support obtained. On September 10 the report was discussed and views were put forward at a meeting at KFB. The invitation and list of participants at this meeting are enclosed with this report as Appendix 2. The views put forward have been, to a great extent, taken into consideration.

Against the background of our directive we have conducted investigations on the following basis:

Economic and public finance aspects to the introduction of alternative fuels, SIKA.

- Estimated annual costs for the supply and distribution of 1,500,000 cubic metres of bio-ethanol to the Swedish road transport sector, IEA/AFIS Nils Elam at the request of NUTEK.

- A plan for the introduction of alternative fuels, the Institute for Swedish Environmental Research Institute, Magnus Brandel, IVL at the request of KFB.

The authors of this report are responsible for its contents.

2. What we mean by alternative fuels

Alternative fuels comprise alternatives to petrol and diesel oil, which currently dominate the road transport sector. This is a relatively broad concept and alternatives can be identified which may be based on fossil fuels and renewable sources of raw materials.

A number of alternative fuels have been discussed, which have different characteristics with regard to environmental friendliness, availability, etc. *Table 1* provides an overview of which alternative fuels may be of interest in the near future. These are divided firstly into alternatives which are based on fossil fuels and renewable raw materials, and secondly into niche usage and large-scale usage (niche refers to a level of 0-10 per cent usage of an alternative fuel and large-scale can refer to usage over 10 per cent calculated over the entire fuel pool for road traffic).

Table 1 Potential for usage of different fuels and conversion techniques

Alternative	Alternatives with insufficient capacity for 10% criterion for niche use	Alternatives which can fulfil 10% criterion for large-scale use		
		Short term	Medium term	Long term
Fossil raw materials				
Reformulated petrol		X	X	X
Reformulated diesel		X	X	X
LPG			X	X
Natural gas				X
Methanol from natural gas			X	X
DME from natural gas			X	X
Methanol from coal				X
Mixture of diesel and vegetable oil esters	X			
Renewable raw materials				
Methanol from cellulose				X
Methanol from plants rich in sugar and starch	X			
Ethanol from cellulose				X
Ethanol from plants rich in sugar and starch	X			
Vegetable oils	X			
Esters from vegetable oils	X			
Biogas	X			
DME from cellulose				X
Hydrogen gas from renewable raw materials				X

Source: based on M. van Walvijk & C.T.A. Leijs (INNAS BV, Holland) Brandstoffen voor het Wegverkeer, 1994

It should be noted that the table primarily provides an assessment of the *technical* conditions for possible future usage. The economic consequences, environmental consequences and effects from an energy storage point of view of the large-scale introduction of the various

alternatives have not been analysed in detail. By short term we mean up to ten years, by medium term 10-20 years and by long term over 20 years.

It can be seen from the table that the *number of alternatives* which can in future be used on a large scale and which are based on renewable energy sources is probably very limited. This applies primarily to bioalcohols. Alternatives such as vegetable oils and biogas can be used on a limited scale, as niche fuels. Decisions within other sectors, in particular the energy sector, can influence the conditions for using natural gas and hydrogen gas in the future.

DME (dimethylether) is also listed in the table as it has proved to have favourable technical and environmental characteristics as a fuel for diesel engines. DME is similar to LPG (motor gas) in use and can in principle be manufactured from renewable raw materials.

Current demonstrations and use in Sweden and abroad

The trials, etc. which are being carried out in Sweden are described in *table 2*. As a result of these ventures, more facts are now available concerning production, distribution, usage and environmental effects of these alternatives.

Table 2 *Current demonstration and use of alternative fuels and electricity in road vehicles in Sweden 1996*

Alcohols	**Type of vehicle**
Ethanol	279 buses 4 trucks 50-100 FFV*
Combined fuels 15% ethanol	24 buses 20 trucks
Gaseous fuels	
Natural gas	approx. 180 buses 17 trucks
LPG	2 vehicles
Biogas	46 buses
Other	
Electricity	100 electric cars 9 electricity hybrid buses

Source: NUTEK, KFB, SLTF and others

* FFV = Flexible Fuel Vehicle – vehicles which can run on ethanol and/or petrol

At the moment around 10 per cent (just over 500) of Sweden's 5,000 buses in regular traffic use some form of alternative fuel. According to the Swedish Public Transport Association, the maintenance of this level of use and the possible expansion of it in the future are dependent on future decisions regarding alternative fuels, e.g. taxes. It may also be mentioned that some 300 environmental cars are to be introduced in Stockholm and elsewhere with

support from the EU (the THERMIE programme). NUTEK provides support for vehicle projects which demonstrate the use of natural gas. KFB supports various different vehicle trials involving the use of biogas and ethanol. A demonstration programme relating to electric and electricity hybrid vehicles is being carried out with support from KFB, and NUTEK is supporting a project covering the technical procurement of electric cars.

Table 3 describes the current projects within the EU on different types of alternative fuels. The statistics reflect the situation at the beginning of 1994 and have been produced by Institut Wallon, which is a member of an EU network associated with the Thermie programme. Even though the reports are not fully up-to-date, the main trend is probably be the same today. It should be noted that the figures refer to projects and not number of vehicles.

Table 3 Demonstration of biofuels in vehicles in EU countries in 1994, projects

Countries	RME	Bioethanol	Rape oil	Other or unspecified	Total
Belgium	1	0	0	0	1
Denmark	1	0	0	0	1
France	60	3	0	19	82
Germany	39	0	19	1	59
Greece	0	0	0	0	0
Ireland	1	0	1	1	3
Italy	24	0	0	2	26
Luxembourg	0	0	0	0	0
Netherlands	1	1	0	0	2
Portugal	0	0	0	0	0
Spain	2	0	0	0	2
UK	1	0	0	0	1
TOTAL	**130**	**4**	**20**	**23**	**177**

Source: Institut Wallon

It can be seen from this table that there is a distinct preponderance of projects using rape oil-methylester (RME), while there are few alternatives using, for instance, bioethanol. The tests using RME covered a total of 1,255 vehicles in France, 388 in Italy and 280 in Germany in 1994. Electricity is used in vehicles on a relatively large scale in different countries. France is one of the leading countries within the EU in the use of various alternative fuels and electricity.

Outside Europe, we have noted there extensive activities are in process in the *USA* relating to alcohols, and this includes both low admixture and combined fuels as well as use in a pure form in vehicles. Even though the use of motor alcohols is growing strongly, there is still a preponderance of gaseous fossil-based fuel alternatives, such as Liquefied Petroleum Gas (LPG). In *Brazil* the use of ethanol in light vehicles has already been introduced on a large-scale, but this programme, which was begun in the 1970s, has now stagnated and is tending to decline partly because only 5 per cent of new cars sold are E 95 vehicles. This is in turn due to a change in the relative prices of petrol and diesel fuel. Today 4.3 million private cars run on E 96 and the other 6.4 million run on E22, which is obligatory throughout the country. *Table 4* shows the use of alternative fuels and oxygenates in Brazil and the USA in 1996.

Table 4 *Use of alternative fuels, etc. in Brazil and the USA, type of fuel and percentage of vehicles run on alternative fuels*

	Fuel	Percentage of total vehicles
Vehicles run on alternative fuels, etc.		
Brazil	E 96	40%
"	E 22	60%
USA	LPG; CNG	0.2%
"	M 85, E 85	0.03%
Consumption of alternative fuels		
Brazil	E 96	37%
USA	LPG, CNG	0.2%
"	M 85, M 100, E 85	0.005%
Consumption of oxygenates in low admixture		
Brazil	E 22	12%
USA	MTBE	2%
"	E 10	0.6%

Source: Claès Pilo, SDAB, PM (see Source references)

We may therefore draw the conclusion that Sweden is more or less alone in Europe in pursuing the development of motor alcohols, while the use of motor alcohols in a pure form and as blending components is found mainly in Brazil and also the USA. The basic reason for RME's strong impact in Europe is the powerful agriculture interest and the relatively weaker impact of the CO_2 issue in the environmental debate. In the long term several different alternative fuels will probably become available on the market in Sweden and abroad, either as niche fuels or fuels for use on a larger scale.

3. Conditions for introduction on a large scale

3.1 The benefits of greater use of alternative fuels

There are several different reasons for promoting an increased use of alternative fuels based on renewable raw materials. Compared with fossil-based fuels, the fuels can help to bring about environmental improvements, increase diversity in the energy system and, when produced domestically, create jobs, which can be very significant from a regional and local perspective. If the fuels are based on domestic raw materials, they can also help to reduce the need to import fossil fuels.

One reason for introducing alternative fuels, which has been emphasised very strongly in recent times, is that a more extensive use of alternative, biobased fuels could help to reduce emissions of CO2. This assumes that the use of fossil fuels in the cultivating. Processing and distribution of the alternative fuels can be minimised. Engines developed for motor alcohols and other alternative fuels can increase the long-term benefit of introducing alternative fuels by further reducing the consumption of fossil fuels and reducing emissions from the traffic sector.

More limited use of alternative fuels in heavy vehicles can have positive effects in the short term and medium term in cities and densely-populated areas, by reducing emissions of NOx and particles. In the longer term the differences between the various different alternative fuels should even out through continued technological developments. In the case of Otto engines, the benefit from changing over to renewable alternative fuels, if carried out on a large scale, would be that CO2 emissions are reduced. The reason why the environmental benefits mainly comprise a reduction in CO2 emissions is a result of the introduction of catalytic exhaust fume filter systems, which have brought a radical reduction in emissions of various regulated pollutants.

3.2 Supply of alternative fuels

Table 5 shows the consumption of fossil fuels within the road transport sector.

Table 5 Consumption of petrol and diesel fuel in road transport in 1995, cubic metres

Fuel	Road transport*
Petrol	5,602,000
Diesel fuel	1,650,000
Total	7,252,000

*If working machines are included in the calculation, then the consumption of petrol and diesel fuels would be 146,000 and 1,425,000 m3 more respectively, according to the Swedish Environment Protection Agency (figures originate from 1987/88).

The energy content of petrol and diesel fuel differs slightly, which can mean that the oil replacement obtained when adopting the different introduction strategies could vary slightly. According to reports, the replacement varies from around 1/1.3 petrol/ethanol when used in FFV vehicles to around 1/1.7 when used in diesel vehicles. We have assumed for the remainder of this report that 1 volume unit of oil-based fuel is equivalent to approximately 1.5 volume units of ethanol.

In order to replace 15 per cent of the current oil consumption, in line with our directive, it is necessary to replace 1.0 million m3 of fossil fuel with other alternatives. In our calculations of consumption in 2010, we have assumed that it will be unchanged compared with today. We have assumed in this estimate a slight increase in the total transport activities in the country, which is offset by improvements in energy efficiency in the transport sector. This means that if consumption in total exceeds today's level, it will be necessary to use more alternative fuels in order to achieve the 15 per cent introduction.

We have based our calculations on the large-scale introduction of ethanol, as extensive information is available for making this type of assessment. We wish to point out, however, that this assessment is based on current know-how and new know-how could mean that other alternatives might also become of interest in the medium term or long term. This is particularly the case with methanol based on renewable raw materials and DME. We regard biogas and RME as more marginal elements in an introduction strategy, as is electricity in the short-term perspective. The programme for ethanol introduction, which we will develop in more detail in the following pages, should therefore apply to methanol as well, which makes it more logical to refer to a motor alcohol programme. As the technical conditions are slightly different for ethanol and methanol, however, we have chosen to describe and specify the consequences of the introduction of ethanol.

Ethanol production in Sweden currently amounts to around 15,000 m3 (per year). Imports of ethanol amount to 50,000-100,000 m3, corresponding to 0.35-0.7 TWh. At present, around 5,000 m3 of ethanol are used in regular operations in ongoing vehicle projects. The use of ethanol is essentially chemical-technical.

According to NUTEK, biogas is currently being extracted from around 55 deposits with an energy value of 0.4 TWh. It is used for generating heat and power. The potential for biogas has been assessed as around 5 TWh/year from waste products. Its use as a fuel is at present limited, but this can be expected to increase. Taking into account the competing areas of use and the rate of build-up for biogas-based vehicle fleets, e.g. buses in city traffic, NUTEK estimates that biogas could contribute 0.3 TWh in 2010 and 0.5 TWh in 2020. The introduction of biogas assumes that other vehicle fleets, not only buses in city traffic, can be included, as this category of vehicle is expected mainly to use ethanol fuel.

Production of RME is limited by agricultural acreages, sequential growth consequences, and alternative uses (foodstuffs), according to NUTEK. An upper limit for its use as a fuel has been estimated at 100,000 m3, corresponding to 0.9 TWh/year. This level assumes an increased production of rape. Nitrous oxide (laughing gas) has a considerable greenhouse effect. Relatively large amounts of this gas are produced in the cultivation of rape. NUTEK therefore assumes, for environmental reasons, that 1/3 of the maximum production level will be achieved, i.e. 0.3 TWh by 2010.

Electric cars do not have the same limitations as biofuels due to availability of resources, but they are limited by the rate of technological development with regard to batteries and vehicle performance. NUTEK estimates that electric cars may account for 5 per cent of transport work by 2020. Electric vehicles, unlike biofuels, have the advantage that their fuel is cheap, while vehicles with batteries are the limiting factor here. The rate of development for electric vehicles is difficult to estimate with any certainty. Given favourable technical developments, electric vehicles can play a significant role, while problems with batteries could impede future developments. If significant progress is made within battery technology and the prices of vehicles fall from their currently high level to approximately the same as conventional cars, a spontaneous introduction cannot be ruled out, partly due to the low price of electricity (currently around SKr 1.50/10 km). Developments in this field should be watched closely.

In the case of the alternative supplies describe in the following our calculations are based on current production processes and raw materials and mainly apply to agricultural materials. We assume that they are produced in Sweden or abroad. The question of what physical constraints may exist on the production of 1.5 million m3 of raw materials by the year 2010 have not been investigated in any great detail. It would probably require a substantial effort to produce such large quantities in the form of (surplus) grain in this relatively short time-span.

The introduction of motor alcohols is expected to take place by phasing them into the existing supply system. Biogas and electricity require the build up of new distribution channels. In the following description we emphasise primarily the costs of introducing ethanol on a large scale.

The supply costs amount, depending on scenario, to between SKr 5.3 billion and SKr 9.2 billion per annum at current oil prices, in the event of an introduction of 1.5 million m3 of ethanol per annum.

The supply costs do not include any costs for new or modified vehicles and engines. It should be noted that the introduction costs are based on the use of agricultural raw materials, as we have judged that new technology based on cellulose raw materials will not be available in time for 2010.

Table 6 *Estimated total costs per annum for supply of 1.5 million m3 in different scenarios*

Supply scenario	Estimated cost	
	SKr million/year	SKr/litre
a) Domestic ethanol production from domestic raw materials	6,400-8,300	4.2-5.5
b) Purchase of ethanol on the world market		
b1) excl. import fee	5,550-7,050	3.7-4.7
b2) incl. import fee	7,650-9,150	5.1-6.1
c) Import of raw materials for domestic ethanol manufacture	7,500	5.0
d) Investments in raw materials and ethanol production in developing countries (excl. import fee)	5,300	3.5

Source: IEA/AFIS

The cost levels for supply stated in the table refer to total costs. From these the cost avoided by eliminating the need to import around 1.0 million m3 of petrol or diesel fuel should be subtracted. This cost is currently around SKr 1.05/litre or a total of SKr 1.1 billion.

The Foundation for Swedish Ethanol Development, SSEU, stated at its meeting on September 10, regarding the cost of producing 95 per cent ethanol that SKr 3.0/litre would be a more realistic level than that used by the IEA/AFIS. SSEU's concept is based on the use of industrial wheat as a raw material.

The proposed concept involves producing ethanol from two different types of raw material (starch and cellulose) in combination. The costs of producing ethanol using current technology are relatively well known. On the other hand, few facts are available to allow a calculation of the cost of hydrolysis of straw to fermentable sugar. We are therefore unable to assess the plausibility of the cost level presented by SSEU or the time required for commercialising the process.

With reference to the forced introduction of 15 per cent biofuels by 2010, which KomKom wishes to see, it was judged appropriate to use the raw materials and raw material costs used in our report as a basis. The idea put forward by SSEU, of erecting 3-5 ethanol factories on a commercial scale, applying technology which has not yet been tested outside of the laboratory and a pilot project, would seem somewhat premature in the current circumstances.

Research into enzymatic hydrolysis is carried out at Lund University. In addition to this, the USA is developing technology for more cost-effective ethanol production, based on

enzymatic hydrolysis of timber. If the American goals are achieved, the costs in accordance with supply scenario a) with "American conditions" would be reduced to SKr 1,500 million per annum and the additional costs would therefore be only SKr 500 million per annum at current oil prices.

Apart from production costs, the price of ethanol is also affected by trends in the prices of energy raw materials in a global perspective, including the interaction between different sub-markets. We have not analysed this question in detail, but would like to point out that it could affect the future price of ethanol.

A further question which affects the cost and price of ethanol is the restrictions stipulated for the introduction of alternative fuels in the *EU's mineral oil directive*. The mineral oil directive involves both a demand for a minimum level of taxation and regulations on a similar tax level for the same type of fuel. Different tax rates for different grades, such as leaded or unleaded petrol, are not permitted. Non-mineral oil based fuels, such as ethanol and other biofuels, should have the same tax rate as the mineral oil based fuels they replace. An exception to this rule has, however, been incorporated into the mineral oil directive. According to Chapter 8, section 4, countries can apply to the EU Commission for approval of a more permanent exception from these regulations. In order to be approved in accordance with Chapter 8, section 4, no member country should have any objections to the exception.

Even though proposals have been put forward within the EU for replacing the mineral oil directive and thereby creating an opening for differentiated taxation of fossil fuels and biofuels, it has not proved possible to implement these in practice. It may be concluded, however, that the rules in Chapter 8, section 2, on support for demonstrations on a large scale has been applied differently in different countries, depending on local conditions in each country. There would therefore appear to be some scope for introducing alternative fuels in member countries without this coming into conflict with the mineral oil directive.

3.3 Use of alternative fuels

The composition of the current Swedish vehicle pool

In order to replace fossil fuels with alternative fuels, primarily ethanol, it is necessary to be able to use them in different types of vehicle. Knowledge of the extent to which the fuel is used and its distribution among different categories of vehicle, age categories, owner conditions, etc. is essential for an analysis of introduction strategies. The following information is based to largely on statistics from the Association of Swedish Automobile Manufacturers and Wholesalers.

With regard to *vehicle categories*, we may note that 77 per cent of the volume of fossil fuels is used in private cars, while the remaining 23 per cent is used in diesel vehicles. Another important factor for assessing conditions for replacing vehicles is their age. At present, 66 per cent of the stock of private cars consists of vehicles younger than 10 years old, while the corresponding figure for buses is approximately 56 per cent and for trucks around 65 per cent. Probably, there is therefore a relatively great need to replace older vehicles with new ones. In this way older and more environmentally harmful vehicles can gradually be phased out from the road traffic system.

An introduction of more energy-effective and environmentally-adapted vehicles will be made easier if the number of new car sales increases. The parliamentary decision to remove purchase tax on cars should help to stimulate sales of new cars (bill 1995/96:222).

Market potential for an introduction of ethanol

The following section describes different means of introducing ethanol into the vehicle fleet in the form of pure fuel or different forms of combined fuel.

A. Low blending of ethanol in petrol

Introducing a low blend is primarily a question of negotiation between the industry and the government. Swedish standards currently allow for around 5.5 per cent ethanol to be blended in petrol. 5.5 volume per cent of ethanol (21.4 MJ/l) blended in petrol (31.5 MJ/l) corresponds in energy terms to 3.9 per cent of the energy content of the blend. If the introduction is to occur quickly throughout the entire petrol pool, it would best be done in depots. Alternatively, the addition can be blended in the refinery in the form of ETBE or MTBE (ethers which function as low blend components in petrol). The advantage with refinery blending is that the ethanol can be given a higher value, for instance as an octane raising component, but the number of petrol companies in Sweden which can add ETBE to petrol is limited. If the entire pool is to have a blend of up to 5.5 per cent, it is necessary to have a supplementary low blending of ethanol. We note that there are differing opinions on low blending and the addition of ETBE and MTBE. There is therefore no reason for us to take a stand on what method should be used to obtain a low blend, but we have assumed in our calculation example that ethanol has been blended in the depot.

The question has arisen of whether a higher blend of ethanol in petrol than that currently allowed would be one means of quickly achieving an increased element of biofuels in the road traffic sector. The figure of 10-20 per cent has been mentioned in this context. Table 4 shows that a higher blending percentage exists in both the USA (gasohol with 10 per cent ethanol) and Brazil (E 22 per cent). Swedish standards for petrol (SS-EN 228) refer to the EU's oxygenate directive. As this directive has not been implemented in Sweden, the oxygenate content is not restricted in the standard. For petrol in Environmental class II, which is defined in the Act on Chemical Products, the oxygenate content is limited to 2.0 per cent oxygen. This is equivalent to around 5.0 per cent ethanol. Of course, all blends must satisfy the other quality requirements. A proposal for a new EU directive, which is planned to come into effect in 2000, includes a maximum limit of 2.3 per cent oxygen content in petrol.

There are several reasons for limiting the oxygen content. By blending ethanol in petrol the petrol is diluted, i.e. the energy content is reduced. If the petrol is diluted too much, this will have an effect on driving capacity and will increase emissions, in particular of NOx.

Blending ethanol into petrol will also raise the steam pressure. This can mean that more hydrocarbons enter the atmosphere from storage tanks as well as from the car's petrol tank which increases emissions of hydrocarbons. A high steam pressure can also cause problems in driving, in the form of a greater risk of 'steam locks', which could prevent the engine from starting. The increase in steam pressure can be compensated for by subjecting the basic petrol to a lower steam pressure when it is produced at the refinery. This can be done by mixing less

butane into the petrol. If the steam pressure is reduced too much, however, the petrol will not satisfy the quality requirements. It should therefore be a requirement that the petrol in question is blended with ethanol at a later stage (at the depot or the petrol station). The requirements made in respect of petrol should therefore be based on whether ethanol is to be added or not.

This would reduce the flexibility of the transport system. Nowadays, it is not unusual for an oil tanker to leave port without a final destination having been decided. The practical consequence of this may be that separate distribution systems need to be established for petrol which is to have ethanol added and that which will not.

In cases where the amount of butane in the basic petrol is limited, surplus butane may have to be sold on other markets. As in some cases, butane could be in surplus supply, its alternative value as a refinery fuel will be lower than petrol. This raises the production cost and makes producers less willing to pay so much for ethanol. It should be pointed out that proposals have been submitted to the EU Commission to further reduce steam pressure in petrol. If these proposals are accepted, an ethanol blend could make it necessary to exclude more valuable petrol components than butane from the mixture (i-pentane, etc.). The cost of compensating for the loss of octane which this would cause might be considerable.

In the USA there is a product on the market known as 'gasohol', which contains 10 per cent ethanol. Modern petrol engines can take this diluted product without any noticeable problems in driving and even Swedish car manufacturers ship cars with standard engines to the USA, which can run on 10 per cent ethanol blends. These car are models from 1990 onwards, which are fitted with oxygen sensors that can measure the energy content of fuel. Most older car models can probably also run on a 10 per cent ethanol blend, as far as drivability is concerned. On the other hand, there is a risk that the exhaust fume standards will be exceeded, in some cases significantly.

The steam pressure problem has been dealt with through an exception in the USA, known as the 'Dupont Waiver', which means that steam pressure in excess of environmental standards will still be accepted if it is due to blending with ethanol. However, the American environmental authority, the EPA, has long been opposed to this exception.

In Brazil there is a grade of petrol which has up to 22 per cent ethanol blending. Such a high content would probably cause driving problems in the Swedish climate and lead to higher emissions.

The main problem with introducing petrol blended with more than 5.5 per cent ethanol in Sweden is that the consequences would be markedly different, depending on which year's car models are involved. Very detailed regulations would probably be required stipulating which car models from which years could be allowed to run on this kind of petrol, with reference to exhaust fumes. The guarantee requirements for emissions after several years and many kilometres which car manufacturers now have to provide would probably have to be abandoned. There is a risk of serious problems arising with regard to inspections and compliance with the environmental standards for cars. The problem could be reduced when catalytic converters and oxygen sensors are introduced into all cars; at present around 46 per cent of private cars are equipped with catalytic converters, while transport work using vehicles fitted with catalytic converters amounts to around 57 per cent. The question of the

extent to which catalytic converters would solve the problem of increased use of oxygenates in petrol is, however, a subject for discussion.

In summary, it can be said that the question of blending ethanol with petrol is a complex issue, particularly if higher blend levels are being considered. There appear to be differing opinions on what technical conditions and environmental consequences would arise with particularly high blends (>2 per cent oxygen _ 5 per cent ethanol).

B. Introduction of FFV vehicles (Flexible Fuel Vehicles)

Introduction on the large scale required to achieve the stipulated level of 15 per cent would require a broad concentration on various categories of owner, even including individual households, from the very start. Parallel with this broad introduction, further development and improvement of technology would be needed. It is important that FFV cars are not inferior to other cars with regard to other emissions than CO2.

One possibility that could be tried would be to arrange technical procurement projects for FFVs, in the same way as for electric cars, with the aim of accelerating the pace of technical development. This would mean testing these vehicles in the Swedish climate, optimising them for different fuel mixtures, etc. Give the type of market which can be foreseen for the future, this type of procurement could be attractive to the car industry. It must be assumed that the oil industry would gradually build up a distribution network for FFV fuels in line with the build up of demand for these fuels.

An important question in this context is whether the long-term aim should be to develop vehicles with engines dedicated to one fuel or whether the introduction of FFV vehicles should continue. The deciding factor for this is whether ethanol is introduced as an engine fuel in the other Nordic countries and on the Continent. For obvious reasons, it is not possible, however, to decide on this point yet. One advantage of FFV vehicles is that if, for various reasons, it turns out not to be possible to use ethanol, the vehicle can be used as a petrol-driven car. The engine technology can also be developed so that the specific characteristics of the various fuels can be used in the optimum way.

The goal of the introduction strategy referred to in the directive is very ambitious and achieving it would require a variety of instruments. Firstly, it is important that the introduction of these vehicles can be perceived as credible. This can be done by means of tax legislation, but it would also require discussions and agreement with the industry.

If the intention is to extend the use of FFV vehicles, therefore, it is important that the introduction of new cars and the scrapping of old, more energy-consuming and environmentally-harmful vehicles are accelerated.

C. Heavy vehicles

Current trials with vehicle fleets include ethanol buses which demonstrate the use of ethanol. Replacing diesel fuel with motor alcohols would appear to be appropriate in built-up areas, as it can reduce emissions of NOx and particles compared with diesel fuel, at least in the short- and medium-term perspective. Further development of engines and drive systems (hybrids) is foreseen. It would be an advantage engines could be designed which do not need to use

ethanol with the addition of 'ignition improvers', as these are currently both expensive and hazardous to health. In the long-term, DMEs may constitute an alternative as a diesel fuel replacement, as they do not require any ignition improver.

Discussions on the further development of ethanol use should be held with bus companies, local authorities and transport principals. It is important that the additional cost of using ethanol, compared with diesel, can be reduced. Further, more advanced trials are expected to be held in major cities and built-up areas which have introduced environment zones or are planning to do so. Possible principals for these activities could include the retail trade, communications, postal and telecommunications plus the public sector and other services.

Trials are currently in progress on the introduction of ethanol in blends of up to 15 per cent in diesel, with the aim of determining how much might be an optimum blend, taking into account the oil replacement and technical conditions. This type of introduction could be considered as a complement.

The distribution of ethanol introduction by 2010

In order to achieve the targets for the introduction of ethanol which KomKom has directed us to investigate, introduction on a large scale over a short period of time would be needed. We would like to point out that this should be seen more as an example of a possible introduction strategy and not as detailed appraisal of the realism in the breakdown between types of fuel and vehicle.

Table 7 Examples of the introduction of ethanol by 2010, m3

Composition	Oil replacement	Ethanol
a) 5.5 volume % ethanol blend in the petrol pool	200,000	300,000
b) Initiated phasing in of FFV vehicles	550,000	825,000
c) Heavy vehicles (E 95 and E 15)	250,000	375,000
Total	**1,000,000**	**1,500,000**

Making more efficient use of alternative fuels could, as earlier findings indicate, reduce the need for such fuels. If we estimate more effective usage (e.g. 1/1.3 against 1/1.5 oil/ethanol), the use of ethanol in FFV vehicles would falls from 820,000 m3 to around 715,000 m3. It can be concluded from this that efficiency improvements could reduce the need for fuel.

Distribution costs

The short time remaining until 2010 would require the introduction on a large scale of ethanol in the existing distribution system. This is probably the most costly introduction scenario, as it would require the introduction of several different types of fuel at the same time and in this

case the build-up of complementary distribution systems. The table below shows the distribution costs for alcohols in selected scenarios.

Table 8 *Estimated annual additional costs for absoluting and distributing 1.5 million m3 of ethanol in selected scenarios*

Usage and distribution scenarios	**Estimated cost**	
	SKr million	**SKr/litre**
1) Pure ethanol - petrol replacement, E 85*	600 - 1,365	0.4-0.9
2) Pure ethanol - diesel replacement	765	0.5
3) Low blend in petrol (5% ethanol)*	990 - 1,850	0.6-1.2
4) Blending in diesel (15% ethanol)	1,260	0.8

* Including absoluting

Source: IEA/AFIS

The cost levels stated in the table for distribution and absoluting refer to additional costs. The costs are stated as a range, depending on the cost of absoluting alcohol (removing water from alcohols to prevent phase separation). The cost of absoluting amounts to 20 to 60 öre per litre, depending on which technique is used. The costs relate to four different introduction alternatives. Table 7 showed that several different alternatives were included in the introduction foreseen. It has not been possible to specify the costs of an introduction along the lines of our example in more detail, within the framework of this report.

Vehicle costs

The additional cost for an FFV vehicle is estimated to amount to around SKr 7,000 per vehicle at current prices. The effect on running costs would depend to a great extent on the development of materials and motor oils. If a larger market can be created for FFV vehicles, the purchasing and running costs could eventually become equal to the corresponding costs for conventional vehicles.

The technology used in buses today is wholly commercial, but there are differing reports on what it actually costs to buy and run ethanol buses. One assessment made is that an ethanol bus which runs 45,000 km/year costs around SKr 30,000 more to maintain and around SKr 70,000-100,000 more in operating costs than a diesel-powered bus (spring 1996). As a rule of thumb, it is stated that an ethanol bus costs around SKr 30,000 more to buy than a conventional bus.

We have not made a detailed study of the introduction of biogas and electric vehicles, partly because the cost information is uncertain. The additional cost of a biogas bus is estimated at around SKr 400,000. In the case of electric vehicles, the cost picture is more complex.

The selling price of an electric vehicle would more than double during the initial phase of an introduction, although it would fall closer to a more normal vehicle cost if the introduction were on a larger scale.

3.4 Three introduction strategies

Our task is to illustrate and describe the consequences of an introduction of alternative fuels, in line with the Commission's directive. To arrive at this illustration and description, we have selected ethanol alone as an alternative fuel to use in our exemplificatory estimates. If alternative fuels are introduced at the pace and to the extent mentioned by Commission, then ethanol could be expected to play a dominant role. We are aware, however, that in reality several alternative fuels could be introduced parallel to each other, if the Comission's 'model' is decided on. To begin with, we would like to make it clear that our study has not shown any crucial technical obstacles to introduction on a large scale. On the other hand, our study shows that the production cost of ethanol, using currently available production technology and distribution system would be considerable, given the short introduction period assumed. We have at the same time noted that new technology may alter the costs in the future.

Conditions on the supply side are of central significance to the carrying out of our task. It is matter of being able to make practical arrangements for supplying the fuel. The analysis on the demand side covers different types of vehicle which can use fuel in one form or another and the technical conditions for this that must be satisfied. We have also examined the incentives which may be regarded as necessary for players on the supply side to make the changes required.

The two most important aspects of the demand side incentives are the price on the market (to the consumer) of alternative fuels, and the prices of the vehicles which are expected to use different quantities of alternative fuels.

Our point of departure with regard to fuel prices to the end user has been that the price per energy unit for alternative fuels should not exceed the price of fossil fuels. The consequence of this is that the scope for taxing alternative fuels is defined as the gap between the market price, including all taxes on fossil fuels, and the actual cost of the alternative fuels. Both the environmental characteristics of the alternative fuels and the energy efficiency of the vehicles must be taken into account in this context.

As far as vehicles are concerned, we have found, on the basis of the analysis reported earlier, that we must expect a high proportion of the alternative fuels used to be used in FFV vehicles. To build up demand for the fuel sufficiently quickly, it is necessary, in view of the current cost structure for FFV vehicles, to have special incentives.

A further condition on which our analysis is based is that ethanol production will not involve the use of fossil fuels in the life-cycle from cultivation, harvesting, production to distribution/use. This is an assumption which could be discussed. According to the

information we have obtained, IEA has assumed a 30-70 per cent efficiency (percentage fossil fuel in the entire production chain in the production of ethanol).

We have chosen to show calculations for two strategies which could be followed in order to perform the task given in Commission's directive. In the following section we will describe in more detail the design of these strategies and what incentive we consider to be necessary for their implementation.

Strategy 1 is based on our assuming direct that the 15 per cent target shall be achieved by 2010. This strategy would involve immediately introducing the necessary incentives and making the necessary decisions for initiating the process towards achievement of the target.

Achieving this target would require extensive adjustment, on both the supply side and the demand side. Experiences gained from projects of a similar magnitude suggests that the time available for such an extensive change-over is very short.

The implication of Strategy 1 is that it cannot be assumed that new production technology involving far lower costs than those of today, would come into use to any significant extent between now and 2010. Even if some technical breakthroughs were made, it may be assumed that the accelerated introduction could cause bottlenecks which would impede the phasing in of new technology.

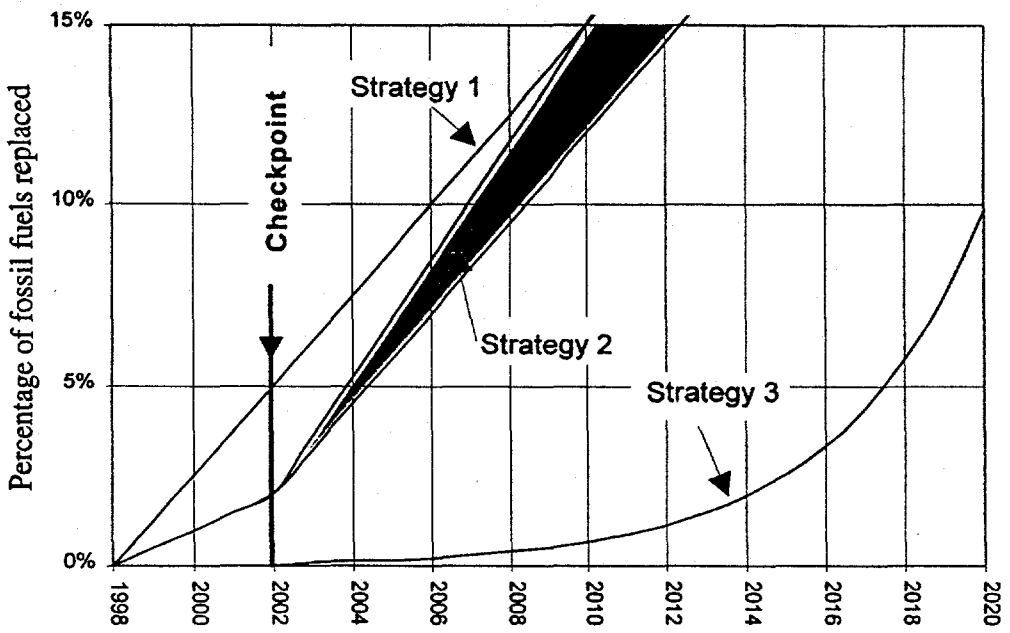
It is also assumed that the state would become more actively involved in building up ethanol production capacity. We also assume that industry will take an active role in implementing this strategy in the form of production of fuels and supply of vehicles.

Strategy 2 involves introducing a checkpoint, to check progress, in 2002. As Strategy 2 involves delaying the start-up phase, there is a risk that the introduction target could not be achieved by 2010. On the other hand, this strategy does make it possible to keep economic costs and the effects on public finances under closer control. More information should be available for evaluating the cost of ethanol production by the time the checkpoint is reached. Strategy 2 also assumes that the introduction is in principle started immediately, but that it will be on a smaller scale than Strategy 1 between now and the checkpoint.

Strategy 2 does not involve any assumption that the state will take an active part in the short-term build-up of ethanol production plants, since the state might wish to retain its freedom of action until the checkpoint. During the period between now and 2002, the bulk of the ethanol consumption can be covered by imports on short-term supply agreements, etc. This would make us more dependent on the world market price of ethanol, but it would limit the consequences of possible faulty investments in production plants.

Strategy 3 assumes a slower rate of introduction, by limiting the investments to R&D between now and the checkpoint in 2002. In this context, as no introduction in accordance with Strategies 1 and 2 is involved, it would not be possible to achieve the introduction target by 2010. This would delay the decision on an introduction to the checkpoint, with the object of reducing the total costs and making it possible to take a more unconditional decision on the mix of alternative fuels and consequently the different production and introduction alternatives. We call this Strategy 3. We have summarised our strategies in *figure 1*.

Figure 1: Different introduction strategies



The goal for Strategy 2 is the same as for Strategy 1, but it should be noted that there is still some uncertainty over whether this is realistic. Strategy 3 differs from Strategies 1 and 2 in that the target is assumed to be lower and to be achieved later. It is assumed that a decision on this will be taken in stages, primarily in the context of the checkpoint.

Common to both Strategy 1 and Strategy 2 is that they require extensive means of control if they are to be implemented. We assume that initially ethanol will not be subject with energy tax and CO2 tax, and that ethanol will be exempted from VAT until 2002. Both alternatives assume that the introduction of FFV vehicles will be subsidised.

Strategy 2 assumes that R&D work to develop new production technology will take place parallel to the introduction. Strategy 1 also assumes that R&D will take place parallel to an introduction, but that this would be slightly different in character than in Strategy 2. The new information and practical experience that would be generated are assumed to be included in the fact base used for decision-making when the checkpoint is reached in Strategy 2. In view of the initial time delay in Strategy 2, it would be necessary to use the time between now and the checkpoint to make detailed preparations for coming introduction process, should it materialise. These preparations could involve further work on following up current research projects of various kinds and building up experiences from production and the user side. It is also important to expand our knowledge of how different incentives will function in practice, of institutional arrangements on the supply side, etc. The R&D programme is aimed at supporting the special introduction programmes that would permit a 15 per cent introduction, mainly in the form of ethanol, by 2010. Strategy 3 covers, as has already been described, only the R&D programme and follow up of the experiences gained over five years.

Views on the introduction Strategies 1 and 2 investigated by us have been expressed in various contexts. At a meeting at KFB, the view was put forward that the introduction we have examined on the basis of our directive is too rapid and large scale, and over a far too

short period. The Swedish Environment Protection Agency has stated that the time horizon should extend far longer than to 2010. The Agency maintains that an introduction by this point in time could make a longer term introduction more difficult. It comments that if CO2 emissions are to be reduced even further in the transport sector, then other alternative fuels, apart from ethanol, could become appropriate.

We would also like to draw attention to the need for international harmonisation that would arise in connection with an introduction. An introduction in line with the alternatives discussed above assumes an exemption in accordance with Chapter 8, section 2, or possibly Chapter 8, section 4. We believe that, in this light, the following measures should be considered:

- to clarify the conditions for reducing tariffs on alcohols or alternatively to investigate the possibilities for obtaining special import quotas for ethanol for use as fuel.

- to prepare an overall strategy for further R&D collaboration with the EU and other international fora, such as IEA in Paris.

The arrangement of the calculations

Based on the discussion mentioned above, we have made estimates for the introduction on a large scale of alternative fuels to the level of 15 per cent, in accordance with two different strategies.

Strategy 1 assumes that very little time is left between now and 2010 if the target of 15 per cent is to be achieved. Strategy 1 therefore involves, bearing in mind the time limit, immediately beginning a process of introduction based on current conditions. This means that different types of control system and other measures, e.g. to build up supply, should be introduced almost immediately.

Strategy 2 involves an attempt to deal with the economic risks associated with an immediate introduction by postponing the decision on a possible large-scale introduction to a checkpoint (in 2002), at which point the production costs of ethanol will be re-examined. If the production costs are judged to be competitive, in a comparison with fossil fuels, a decision can be made on a large-scale introduction and on the control system required to reach the target. It is likely that this control system will need to be rather more stringent than that in Strategy 1 as the time remaining until the target year, 2010, is that much shorter.

Strategy 3 does not assume any special control system, apart from the retention of the current tax exemption on alternative fuels which are based on renewable raw materials. We will return to this issue in section 3.7.

3.5 Strategy 1 - rapid introduction

Control system and other measures included in Strategy 1

As mentioned above, Strategy 1 assumes that certain means of control and measures will be brought into effect within the very near future. In our calculations we have assumed that the following means of control will be decided on and come into effect from 1998 until the year 2010.

1. Ethanol will be exempted from CO2 taxation for the entire period 1997-2010.

2. VAT exemption for ethanol as a fuel for the entire period 1997-2010.

3. The energy tax on ethanol will be gradually raised from SKr 0/litre in 1997 to SKr 1.50/litre in 2010.

4. Subsidies for purchasing new flexible fuel vehicles, which will compensate the buyer of such a vehicle for the entire additional cost of an FFV. It is estimated that in the year 1998 this subsidy would amount to SKr 7,000 per purchased FFV, to be gradually phased out by 2010. It is assumed that such a subsidy would be allowed by the EU regulations.

5. Subsidies for purchasing new heavy vehicles, which will compensate buyers for the entire additional cost. This subsidy is expected to amount on average to SKr 30,000 per vehicle in 1998, reducing to around SKr 15,000 per vehicle in 2010.

The resulting tax on ethanol, equivalent to the price of ethanol and the loss of tax on a quantity of energy corresponding to one litre of petrol, is summarised in the following table;

Table 9 Taxation of ethanol in Strategy 1

	Energy tax on ethanol	CO2 tax	VAT rate	VAT ethanol	Total tax ethanol	Price of quantity of ethanol equivalent to 1 lit. petrol	Price/- litre ethanol	Loss of tax revenue
1995	-0.21	0	0	0	-0.21	7.65	4.97	5.75
1996	0.19	0	0	0	0.19	8.05	5.23	5.58
1997	0.19	0	0	0	0.19	8.05	5.23	5.58
1998	0.29	0	0	0	0.29	8.15	5.29	5.58
1999	0.39	0	0	0	0.39	8.25	5.36	5.58
2000	0.49	0	0	0	0.49	8.35	5.42	5.58
2001	0.59	0	0	0	0.59	8.45	5.49	5.58
2002	0.69	0	0	0	0.69	8.55	5.55	5.58
2003	0.79	0	0	0	0.79	8.65	5.62	5.58
2004	0.89	0	0	0	0.89	8.75	5.68	5.58
2005	0.99	0	0	0	0.99	8.85	5.75	5.58
2006	1.09	0	0	0	1.09	8.95	5.81	5.58
2007	1.19	0	0	0	1.19	9.05	5.88	5.58
2008	1.29	0	0	0	1.29	9.15	5.94	5.58
2009	1.39	0	0	0	1.39	9.25	6.01	5.58
2010	1.49	0	0	0	1.49	9.35	6.07	5,58

Estimate for Strategy 1 - immediate implementation

The economic valuation of changes in CO2 emissions has a significant effect on the result of the estimate. We have chosen to look at two valuation alternatives for CO2 emissions.

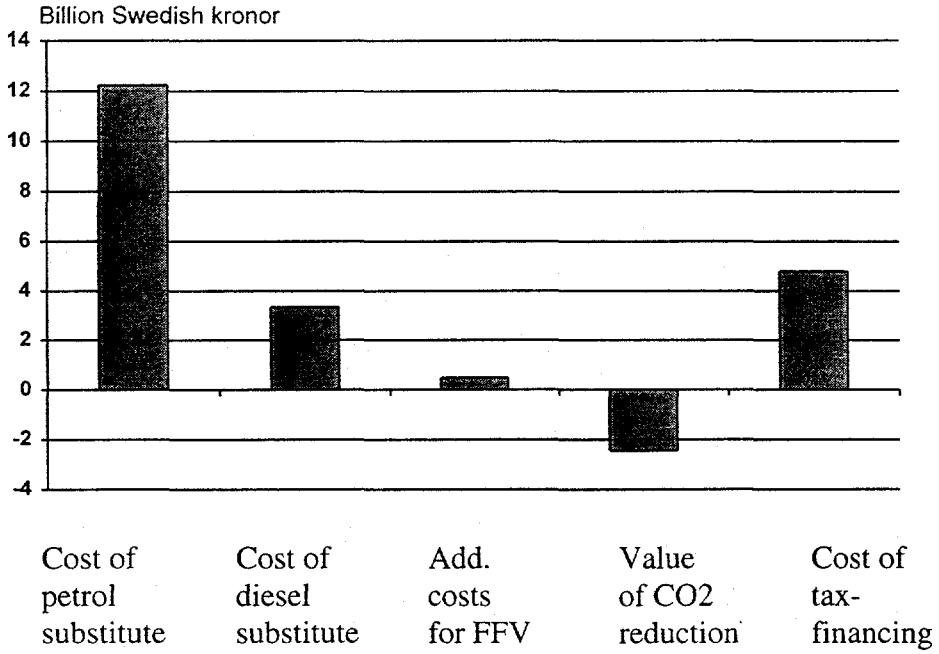
a) The valuation of CO2 corresponding to the CO2 tax level today. We assume that today's CO2 tax in the transport sector constitutes a reasonable assessment of a long-term CO2 tax rate in an intersectoral perspective. This alternative would give a CO2 tax per litre of petrol of SKr 0.86 and a tax of SKr 1.05 per litre of diesel.

b) Valuation of CO2 at the time of the checkpoint which amounts to the tax used by KomKom in its calculation assumptions for 2020. This alternative would give a CO2 tax of SKr 2.70 per litre of petrol, and of SKr 3.11 per litre of diesel.

The value according to b) above is interesting because it expresses a possible long-term political evaluation of a reduction in CO2 emissions. It could be claimed that this long-term valuation should form the basis for decisions on such long-term measures as the introduction of bio-fuel on a large scale would involve.

The calculations show that the economic costs of the "immediate implementation" strategy are considerable. The current assessment of the additional cost to the economy between now and 2010 is almost SKr 19 billion, using a tax-based value for CO2 emissions. This cost includes the additional cost of alternative fuels, the additional costs of FFVs and the cost of the distorting effects on resource allocation due to the loss of tax revenue and the need to cover the cost of state subsidies in other ways. The sub-itemised breakdown of the current assessment of the economic costs is shown in *Figure 2* below:

Figure 2 *Current assessment of economic costs and income for Strategy 1, sub-itemised. Current valuation of CO2*



Different valuations of CO2 have different effects on the economy. If a reduction in CO2 emissions is valued highly, the economic benefits would be greater. *Table 10* shows the aggregate economic effect of Strategy 1, on the basis of two alternative evaluations of CO2.

Table 10 *Summary of economic and public finance effects of the "immediate introduction" strategy for two different methods of valuing changes in CO2 emissions. Billion Swedish kronor*

Valuation basis for CO2	Total economic effect, current valuation 1996-2010	Of which value of reduction in CO2 emissions; current valuation, 1996-2010	Aggregate effect on public finances for 1996-2010
Current evaluation	-19	+2.5	-26
According to KomKom's estimate for 2020	-13	+7.6	-26

The large difference in the valuation of lower CO2 emissions will, as shown, have a strong impact on the current value of the total economic effect, while the effects on public finances are not influenced.

The economic effect includes the cost of alternative funding of the reduction in tax revenues due to lower energy tax, CO2 tax and VAT. It may be justified to not include the loss of VAT in such a calculation, and the inclusion of CO2 tax could also be discussed. If the loss of this tax revenue is excluded, the economic effects would improve by some SKr 2 billion, while the effect on public finances would remain unchanged.

In conclusion, our calculations show that the effect of Strategy 1 on public finances will be strongly negative. The economic effects will also be negative regardless of which method is used for valuing the effect of a reduction in CO2 emissions.

3.6 *Strategy 2 – fast introduction with checkpoint*

An alternative strategy, which is reasonably balanced in economic terms and with regard to its effect on public finances, could be based on how the effects are influenced by production costs and CO2 valuation. We have chosen to define a strategy which includes a checkpoint. Primarily, this checkpoint is defined in terms of a condition for the production cost of the alternative fuel, which should be satisfied before a decision can be made to expand production to the 15% level. The objective is that large-scale production should be possible without any serious adverse effects on public finances or the economy. As in Strategy 1, two alternative ways of valuing CO2 emissions are discussed, namely:

a) Valuation of CO2 which corresponds to the current CO2 tax level. We assume that the current CO2 tax paid by the transport sector provides a reasonable base for assessing the long-term CO2 tax level in an inter-sectoral perspective.

b) Valuation of CO2 at the time of the checkpoint which amounts to the figure states by KomKom in the assumptions underlying its estimate of tax revenues in 2020.

Formulating conditions for the checkpoint

The cost condition entails that the cost of producing alternative fuels with a certain energy content shall not exceed the production cost for fossil fuel with the same energy content, taking into account the engine effect with each fuel, the difference between the external effects of fossil fuels and alternative fuels respectively, etc., and the difference in distribution costs.

The condition formulated does not ensure that an introduction would satisfy demands in the future for overall economic profitability, since the economic cost of financing taxes and real cost differences on the demand side have not been considered (e.g. more expensive vehicles, other costs for traffic adjustments, such as more frequent fuel stops). See also SIKA's background report to KomKom.

Control system and other measures included in Strategy 2

Strategy 2 also requires certain means of control and measures to be introduced in the immediate future. We have based our calculations on the control system which is assumed in SIKA's report. According to this plan, the following control system would be required at various periods:

1. Exemption from CO2 tax for the entire period 1997-2010.

2. Exemption from VAT on ethanol as fuel for the period 1997-2001, after which normal VAT would be charged.

3. Energy tax on ethanol successively raised from SKr 0/litre in 1997 to SKr 2.50/litre in 2010.

4. Subsidies for new FFVs to compensate buyers of such vehicles for the entire additional cost. In 1998 this subsidy is estimated to amount to SKr 7,000 per FFV car purchased, to be successively lowered to SKr 5,000 in 2010.

5. Subsidies on purchases of heavy vehicles, to compensate buyers for the entire additional cost. This subsidy is estimated to amount to SKr 30,000/vehicle in 1998, to be lowered to SKr 15,000/vehicle by 2010.

The proposed tax structure means that the relative price of petrol compared with ethanol would remain constant throughout the period.

The resulting tax on ethanol, corresponding to the ethanol price and the loss of tax revenue for the quantity of energy corresponding to a litre of petrol, is summarised in *Table 11*:

Table 11 Taxation of ethanol in Strategy 2

	Energy tax on ethanol	CO2 tax	VAT rate	VAT ethanol	Total tax ethanol	Price of quantity of ethanol equivalent to 1 lit. petrol	Price/- litre ethanol	Loss of tax revenue
1995	-0.21	0	0	0	-0.21	7.65	4.97	5.75
1996	0.19	0	0	0	0.19	8.05	5.23	5.58
1997	0.19	0	0	0	0.19	8.05	5.23	5.58
1998	0.29	0	0	0	0.29	8.15	5.29	5.58
1999	0.39	0	0	0	0.39	8.25	5.36	5.58
2000	0.49	0	0	0	0.49	8.35	5.42	5.58
2001	0.59	0	0	0	0.59	8.45	5.49	5.58
2002	1.86	0	0.25	1.71	3.57	8.55	5.55	2.70
2003	1.94	0	0.25	1.73	3.67	8.65	5.62	2.70
2004	2.02	0	0.25	1.75	3.77	8.75	5.68	2.70
2005	2.10	0	0.25	1.77	3.87	8.85	5.75	2.70
2006	2.18	0	0.25	1.79	3.97	8.95	5.81	2.70
2007	2.26	0	0.25	1.81	4.07	9.05	5.88	2.70
2008	2.34	0	0.25	1.83	4.17	9.15	5.94	2.70
2009	2.42	0	0.25	1.85	4.27	9.25	6.01	2.70
2010	2.50	0	0.25	1.87	4.37	9.35	6.07	2.70

Other conditions underlying calculations

The other conditions underlying the calculation are more or less the same as those stated for Strategy 1. The main difference is that the price of alternative fuels is assumed to satisfy the cost condition at the latest by the date for achieving 15% substitution, and by the latest date for satisfying the conditions set for public finances, namely 2002. In practice, the checkpoint must be introduced ahead of this date. When the checkpoint is reached the production costs for ethanol will be compared with a threshold value, and large-scale production will only begin if the costs do not exceed this threshold value.

The cost conditions mentioned above can be formulated for two alternative valuations of CO2 according to the method shown in *Table 12* below.

Table 12 Threshold value for production cost per litre of ethanol at the time of the checkpoint. Two alternative valuations of CO2

Principle for valuation of CO2	CO2 value SKr/litre petrol	Threshold value for production cost per litre of ethanol
1) CO2 value in accordance with current CO2 tax	0.86	0.64
2) CO2 value in accordance with CO2 tax according to KomKom's assumptions for 2020	2.70	1.83

As noted above, the threshold value for the production cost per litre of ethanol is determined by several factors. As shown in *Table 13*, these factors together lead to two threshold values as shown in *Table 12* above. The table also shows the effect of a doubling in the petrol price.

Table 13 *Cost components which determine the threshold value for production costs per litre of ethanol at a checkpoint. Two alternative valuations of CO2.*

Cost components	Current petrol price		Assumption of doubled petrol price	
	Lower CO2 value	Higher CO2 value	Lower CO2 value	Higher CO2 value
Supply cost of petrol	1.00	1.00	2.00	2.00
Distribution cost of petrol	1.28	1.28	1.28	1.28
Cost of CO2 (valuation CO2)	0.86	2.70	0.86	2.70
Cost of other emissions	0.00	0.00	0.00	0.00
Total real cost per litre petrol	3.14	4.98	4.14	5.98
Total real cost*	2.04	3.23	2.69	3.89
- distribution cost per litre ethanol	-1.40	-1.40	-1.40	-1.40
= production cost per litre ethanol	0.69	1.83	1.29	2.49

* Adjusted for the energy content of ethanol: 0.67 litres of petrol contain the same amount of energy as one litre of ethanol.

At the meeting of the parties involved additional information was provided. These limited findings indicate a higher efficiency when ethanol is used in FFVs. This substitution relationship is an important issue and must be studied in greater detail prior to the checkpoint.

Calculation results for Strategy 2 – introduction after checkpoint

The current value of the economic costs of Strategy 2, "Incl. checkpoint" up until 2010 is shown for two alternative valuations of CO2 in *Table 14.*

Table 14 *Economic results and effect on public finances of an introduction after the checkpoint for two alternative CO2 valuations*

Principle for valuation of CO2	Assumed production cost for ethanol	Economic current value (SKr billion)	Annual cost to the economy (SKr billion/year)	Aggregate effect on public finances (SKr billion)
1) CO2 value in accordance with current CO2 tax	0.64	-3.0	-0.32	-6
2) CO2 value in accordance with CO2 tax according to KomKom's assumptions for 2020	1.83	-4.0	-0.43	-14

The reason why a net economic cost arises even though the cost condition for the production cost of ethanol is assumed to be satisfied is, as noted above, that the cost conditions do not include all economic costs, such as the additional cost of vehicles, and the real costs for covering loss of tax revenues.

The latter types of cost arises so long as the total real cost of biofuels to the end user exceeds the equivalent cost of the fossil fuel alternative.

The sub-itemised breakdown of the current value of the economic cost of Strategy 2 is shown in *figure 3 and 4* below:

Figure 3 *Current value of economic costs and income from an alternative fuel strategy, by sub-item. CO2 value SKr 0.86/litre petrol.*

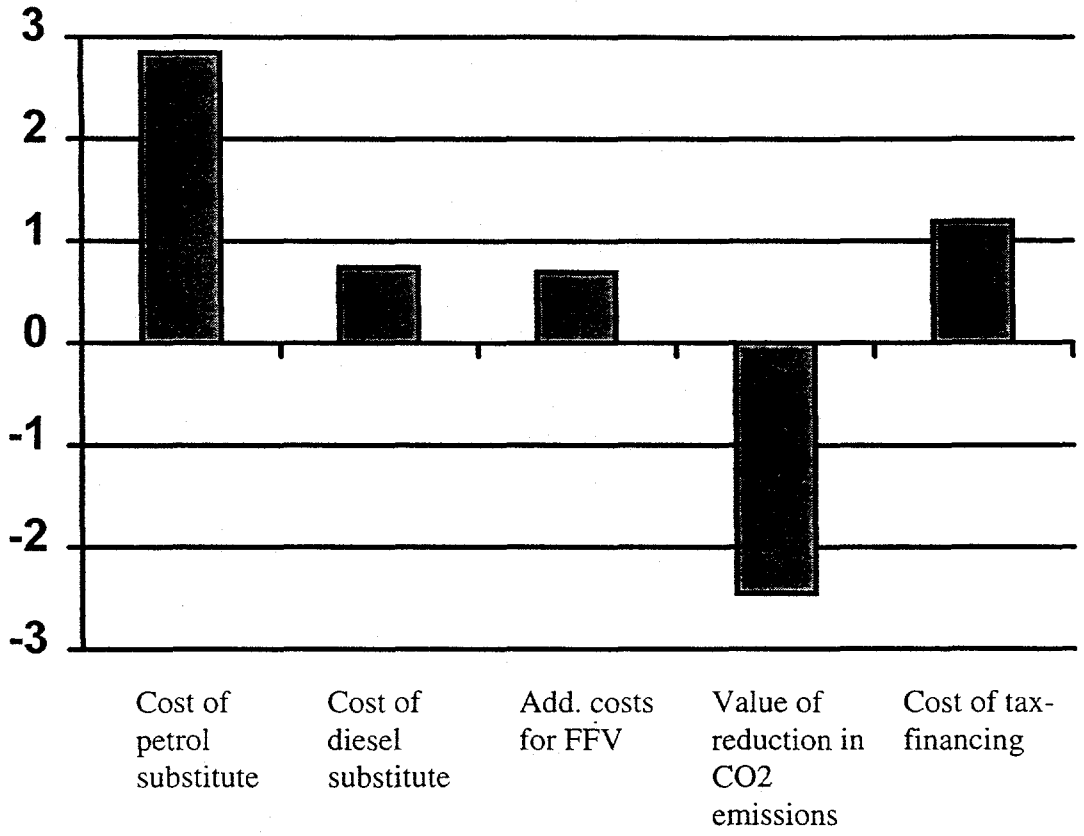
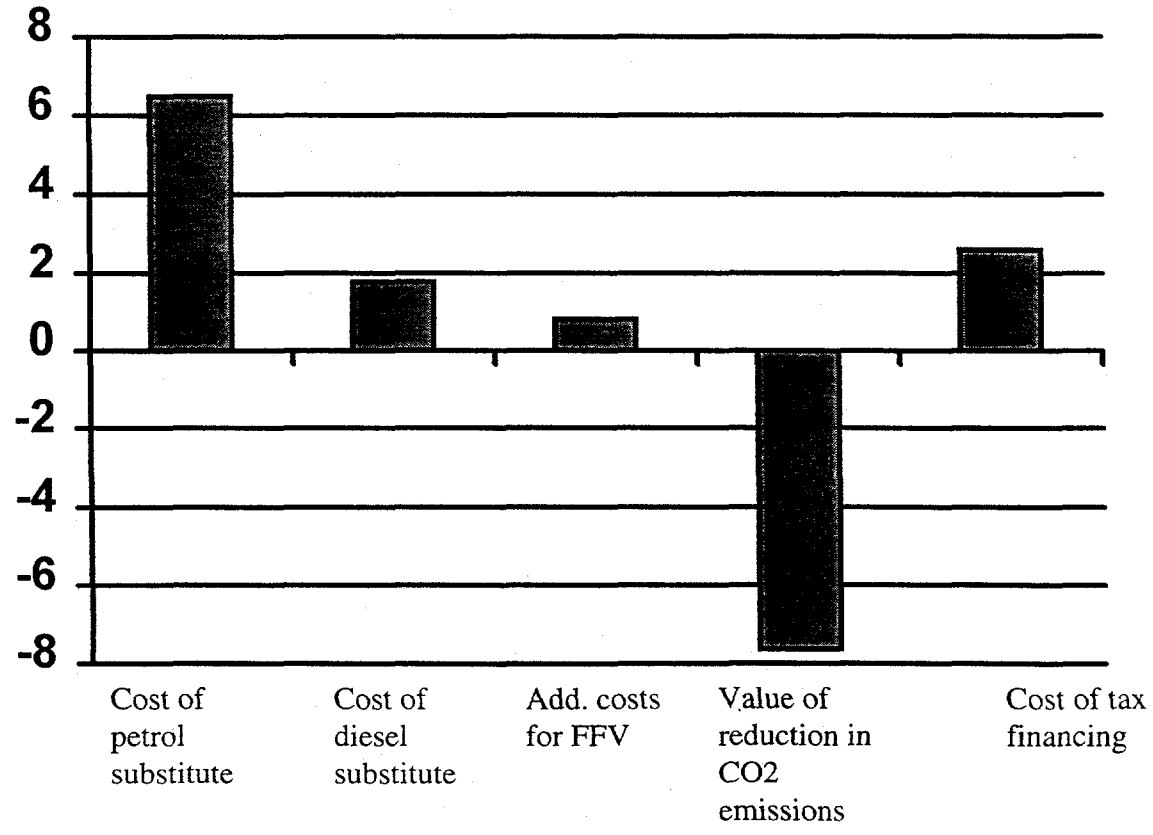


Figure 4 *Current value of economic costs and income from an alternative fuel strategy, by sub-item. CO2 value SKr 2.70/litre petrol*



Cost and net effect on public finances until the checkpoint in 2002

The current value of the economic costs between 1998 and 2001 amounts to SKr 2.1 billion. The cost in terms of public finances is SKr 2.0 billion. In addition to this, a large-scale demonstration prior to 2002 would cost up to SKr 500 million, according to this alternative.

If it is decided at the checkpoint that an introduction on a large scale should not be launched, certain costs for phasing out the project would also arise, in the distribution sector, for example, where measures of adjustment will have to be written off with immediate effect.

Conclusions

An analysis of Strategy 2 shows that there is an acute need to reduce the cost of producing ethanol in order to satisfy the cost condition. The production cost for ethanol has to be down to between SKr 0.64 and 1.83/litre by 2002, depending on the valuation of CO2. The current production cost of ethanol is shown above in Table 6.

Even if the cost condition is satisfied, the introduction of alternative fuels at the target level of 15% would entail a total net economic cost of SKr 2-4 billion for the period 1996-2010.

Given the assumptions made for Strategy 2, the aggregate effect on public finances for alternative fuel production would amount to SKr 6-14 billion, depending on the valuation of CO2. Our conclusions are summarised in *Table 15*.

Table 15 Summary of costs for Strategies 1 and 2, billion Swedish kronor

Strategy	CO2 valuation: SKr 0.86/litre petrol	CO2 valuation: SKr 2.70/litre petrol
Strategy 1		
Economic costs	19	13
Net effect on public finances	-26	-26
Strategy 2		
Economic costs	3	4
Net effect on public finances	-6	-14

At the meeting on September 10 (see appendix 2), some criticism was expressed regarding the economic estimates that we had previously presented for Strategies 1 and 2. The criticism referred, among other points, to our method of evaluating such factors as employment and other positive environmental effects such as reduced emissions in connection with the use of ethanol in diesel motors. We have concluded that these aspects may be more important, and may generate benefits, not least locally, in the form of job opportunities and reduced emissions. However, we do not consider that the inclusion of these factors would lead to any significant change in the costs we have estimated for Strategies 1 and 2. Moreover, we have noted that several of the parties involved were of the opinion that the proposed introduction plan was too ambitious and that it would therefore be impossible to implement it.

3.7 *Strategy 3 – delayed introduction*

In view of the R&D situation for the various alternative fuels, and the current high cost of beginning to introduce bio-based fuels on a large scale, we recommend Strategy 3. A detailed planning report is required, however, in order to define more precisely the scope and focus of an R&D programme. In the following section we will list some general points of departure for how such a strategy could be formulated.

Strategy 3 involves completing and extending current R&D activities, but not using government funds to support any introduction on a large scale prior to the checkpoint in 2002.

According to the current government decision, the special exemption from tax on ethanol will be discontinued at the end of 1996. This will mean that the current use of vehicles powered with alcohol will become more expensive, since ethanol will be taxed.

We consider that there are reasons for maintaining tax exemption on alternative fuels based on renewable raw materials. In our opinion, this tax exemption is important to the credibility of the government's determination to support the development and possible introduction of alternative fuels. It does not appear likely that an extension of the tax exemption would cause any harm to the country's public finances in the form of a serious loss of tax revenue, if the focus continues to be mainly on maintaining the current level of activities. Tax exemption should also apply to motor alcohols and other fuels that are used in various combinations, such as low or mixed fuel components in petrol and/or diesel, provided that they are based on renewable energy raw materials. The current level of consumption entails a loss of tax revenue of around SKr 15 million per year. As a reciprocal gesture, we expect those who benefit from an extension of the tax exemption to assist in the follow-up and evaluation of various alternatives.

The main features of this strategy are:

- A broad programme to influence international developments on the supplier and user sides.
- Further R&D leading up to a checkpoint in 2002.
- The exact features of a possible introduction on a large scale to be decided later.
- We expect the tax exemption for motor alcohols and other fuels based on renewable resources to be extended to the checkpoint in 2002.
- Further R&D into the introduction and use of alternative fuels.
- A broad programme for evaluation of all uses of alternative fuels up until 2002.

We consider that the main emphasis of the introduction should, in the longer perspective, be more on substituting for petrol, while an introduction on a smaller scale should concentrate on heavy vehicles, mainly in urban areas. A low blend would, in this context, constitute a complement. The reasons for an introduction are different for these two categories. An

introduction in FFVs or optimised vehicles would, in the long run, make it possible to reduce emissions of CO2 from the road transport sector. A more limited introduction in the heavy vehicle sector should take place in urban areas, partly to obtain environmental benefits locally and regionally, in the form of reduced emissions of NOx and particles. We wish to emphasise that these conclusions could change with the passing of time, the conditions for introducing DME on a large scale as a substitute for diesel being a case in point.

We have made a rough estimate of the economic costs and net effect on public finances of Strategy 3. It is necessary to introduce certain assumptions as a basis for these estimates. These assumptions should be regarded as factors for a calculation example whose purpose is to make it possible to determine the approximate magnitude of the economic costs and the effect on public finances of the strategy. Strategy 3 in itself involves information regarding suitable costing assumptions gradually emerging in the course of the work.

As a basis for our calculations, we have made the following assumptions:

- The production cost of ethanol is assumed to be SKr 1.80 per litre in 2003.
- The price of crude oil is expected to rise according to the assumptions made by the Energy Commission. This assumption entails that petrol and diesel prices will rise by 1% per year between now and 2020.
- The introduction of bio-based fuels will start in 2003 and continue until 2020.
- In 2020 the volume of biofuel is assumed to be equivalent to some 0.7 million m3 of fossil fuels.
- We assume that bio-based fuels will be used mainly by FFVs. Moreover, we assume that a low blend of bio-fuels with fossil fuels within the framework of current Swedish standards will be practised, and that such blends will be used widely for heavy vehicles.

The economic effects are determined by the assumptions made with regard to carbon dioxide valuation and efficiency factors for biofuels in relation to fossil fuels. For a CO2 valuation in the interval of SKr 2.70-0.86 per litre of petrol, and efficiency factors of 1-3-1.5, the current value of the economic effects varies between SKr +1.8 and -2.0 billion. The aggregate cost to public finances for the period 2003-2020 varies, given these conditions, between SKr 5 and 7 billion, which corresponds to an average of SKr 0.3-0.4 billion per year.

3.7.1 Focus of research and development

One important condition for the implementation of Strategy 3 is that R&D continues, so that the state and the parties involved are provided with the facts required for making decisions leading up to the checkpoint in 2002.

Basis for an R&D strategy

KFB and NUTEK consider that the following points should provide the basis for an R&D strategy:

- Clear objectives and principles to be defined by the state, which should enjoy international support in the long-term perspective. The objectives should be linked to both traffic and energy policies and to environmental objectives at global, regional and local levels.

- Long-term build-up of knowledge in the university sector and competence centres, by developing cooperation with industry.

- Cooperation with various sources in implementing technology, particularly on the user side.

- Government research initiatives in the fields of fuel, motors, drive systems shall be pursued in order to create a basis for future decisions on the introduction of alternative fuels on a large scale.

- It is important to pursue and develop international cooperation within the field of alternative fuels, both in terms of R&D and policy issues, in interaction with other countries, both within international organisations and fora and at a bilateral level.

- The short- and medium-term development initiatives shall be aimed at raising the level of competence in Sweden within the fields of fuel and vehicle technology.

Supply side

* Fuel technology

The total system for producing biomass needs to be further developed in order to reduce costs and environmental impact. Initiatives in the field of fuel technology should cover raw materials, process development, process systems and energy system studies, as well as cost and environmental aspects.

Activities should be focused on reducing costs and environmental consequences relating to production, refining and processing of fossil and renewable fuels, as well as storage, distribution and use of the same.

Alternative fuels

Continued support for R&D to develop cost-efficient production of ethanol from cellulose-based raw materials. It is estimated that the facts need to make a decision on a pilot plant will be available before the checkpoint is reached in 2002.

- With the emphasis on ethanol from cellulose, resources should be earmarked for studies relating to other alternative fuels.

- Initiatives for technical monitoring of production processes for alternative fuels, energy storage, etc.

- System studies relating to distribution, storage, costs, environmental consequences, etc.

*** Vehicle technology**

Continued support to R&D relating to effective vehicles and drive systems with low exhaust levels.

- R&D initiatives should focus particularly on combustion engines for renewable fuels and projects to develop fuel cells for powering vehicles. Gas- or alcohol-powered components, sub-systems and engines with a high effect and very low emission levels should be given special priority.

- International R&D cooperation and technology monitoring in the field of alternative fuels, electric hybrid power, energy storage, etc.

R&D support

NUTEK's report to the Ministry of Industry in June 1996 includes proposals for guidelines for a long-term R&D strategy for alternative fuels, etc. NUTEK estimates the funding requirement for fuel technology to be SKr 30-35 million per year during the period 1997-1999. Funding for the (preliminary) planning of a pilot plant is included in this amount, but not the cost of the actual plant.

The funding requirement for a pilot plant is hard to estimate today, but it would be at least in the tens of millions and would be influenced by the size of the plant and the time when the decision is taken.

NUTEK estimates the funding requirement for environmentally adapted vehicle technology to be around SKr 25 million per year for the period 1997-1999, plus additional funds for any prototypes.

Practical use

During the period up to the checkpoint a number of measures will be required to maintain the long-term focus of the government initiatives. Moreover, the results of completed and ongoing projects shall be put to good use by monitoring developments and applying experiences that are gained. Below are the main points that should be included in the measures up to the checkpoint.

- A follow-up and evaluation programme on a broad scale, co-ordinated between the bodies concerned, similar to that operated by KFB for its electric vehicle programme, will help to further extend the knowledge base. The programme shall cover fleet trials and other uses of various renewable fuels.

- An R&D programme focusing on the handling and use of renewable fuels in new types of vehicles. Primary issues are health and environment effects, the characteristics of the various fuels in the distribution and user stages, the need for an infrastructure for fuel supply and service, the potential for use of various fuels on a large scale, or their limitation to narrow segments ("niches"). A closer study of the planning and decision-making processes, attitudes, etc., is also required. Behavioural studies are also desirable, to clarify the need for and choice of control systems and their effects.

The environmental impact of traffic is not limited to climatic effects, but, as the work on an environmentally adapted transport system (MaTs) and other projects have shown, major local environmental problems can arise, and these form the basis for the proposal for the system-oriented R&D programme which KFB has drafted in its detailed funding application. The realisation of this programme would complement the measures that are justified by CO2 problems. The local/regional system demonstrations proposed in the R&D programme could provide further knowledge relating to the use and effects of renewable fuels, in addition to the studies of local and regional effects that are given the highest priority in the proposal.

- There is a further focus on the problems caused by traffic at an international level. Several similar programmes are in process throughout the world dealing with global climate issues and local traffic environment problems, and extensive, active exchange of experience is therefore particularly desirable, to obtain experience and knowledge, as well as to share our Swedish experiences with others.

KFB has estimated the cost of all the above points at some SKr 40-60 million per year during the period 1998-2001.

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Appendix 1: Heading for a new transport policy.
Summary from Interim report by the Government Commission on Transport and Communications

- **The focus of infrastructure**

How can we develop infrastructure for the next planning period (1998-2007) in the direction of an environmentally appropriate transport system? Proposals on the focus of investments, operations and maintenance of roads and railways.

- **Stronger political control**

How can political control of the planning of infrastructure be strengthened at both regional and national levels? Proposals on experimental activities in Skåne, Stockholm and Jämtland/Västernorrland.

- **Evaluation of traffic policy**

How successful has traffic policy been hitherto? Have utilities and authorities been able to live up to the traffic policy objectives defined, for example, in the 1988 and 1991 resolutions? Presentation of the results of an evaluation.

The Government Commission on Transport and Communications is a parliamentary committee in which all the parliamentary political parties are represented. In its final report, the Committee will be presenting proposals for a new transport policy.

We have been given the task of drawing up a national plan for communications in Sweden which will form the basis of a new resolution on traffic policy to be passed by the Government and Riksdag (parliament) in the spring of 1998. That plan will be presented in our final report in December 1996.

In this interim report we present alternative approaches and a recommended approach to infrastructure planning for the period 1998-2007. We also propose experiments in four counties for testing a planning process which strengthens political control of infrastructure planning.

In addition, we present an evaluation of the practical workings of present-day traffic policy. This evaluation has given us a basis on which to specify the traffic policy issues which we will be addressing as our work continues.

Redirection of infrastructure planning

We believe that continued infrastructure development is necessary in order to safeguard social development and national wellbeing and to improve the competitive capacity of enterprise. In addition, the infrastructure must be planned in a manner compatible with long-term sustainable development. This means that infrastructure development must be guided by fundamental considerations of the environment and human health.

Socio-economic analyses have provided an important foundation for the framing of our proposals. Not all effects, however, can be analysed by means of socio-economic calculations, and many of our calculations are based on uncertain presuppositions. Deeper studies and supplementary analyses are therefore needed in a number of respects.

Deeper studies prior to the policy decision on focus

Our proposals on the focus of infrastructure planning lack several links, of importance in a national and international perspective, for which the Riksdag and Government have previously

declared their support. Several of the sections which can be included in the Trans-European Networks (TEN) could not be included in our proposals. Proposed investments in national trunk roads are now being concentrated on the Mälaren Valley region. This is a result of the socio-economic calculations prepared in the course of our work and of the budget frames with which we started.

The socio-economic analyses indicate that the reduced scope for road investments has led to especially heavy cutbacks on investments in national trunk roads in southeast and western Sweden. This is due to the severe profitability requirements defined and to the difficulty of attaining sufficient profitability in those parts of the country, such as western Sweden, where building is expensive.

We do not take any stand at present concerning the appropriate distribution of road funds between different regions and investments. This question will be handled in the customary way as the planning process continues. Standpoints of this kind require analyses in greater depth and detail than have been undertaken in the planning focus study. Studies of alternative standards and designs may have the effect of altering the ranking order and with it the regional apportionment of funding.

It is our opinion that the distribution of trunk road investments which the socio-economic analyses have resulted in can aggravate regional imbalances. The transport system, however, must be able to go on developing nationwide, so that it will serve its purpose and be capable of contributing towards the achievement of various welfare objectives. This cannot be completely captured in the socio-economic calculations, nor is it possible in those calculations to estimate employment effects.

It is therefore urgently necessary, in our opinion, that continuing work should include analyses in greater depth of national and international links with reference to alternative budgeting and standard levels and in a wider societal perspective. This should also be capable of leading to a more equal regional distribution of investments.

Problem fields demanding special further study in a national perspective include, for example, through traffic in Skåne, traffic between Göteborg and Norway and rail traffic in central Norrland (i.e. the centre of northern Sweden).

The national links should then be reassessed by the Government prior to the Riksdag debate on the focus of planning.

Preparedness for labour market policy measures

We have analysed a large number of projects which are socio-economically profitable but which have fallen short of the socio-economic requirements we have defined for the inclusion of projects in our planning frame. These profitable projects, presented in the focus alternative which we call the basic alternative, could, however, be included in special packages for creating jobs through infrastructure investments ("employment packages").

Infrastructure planning inseparable from traffic policy

Infrastructure investments cannot be viewed in isolation from society and overarching traffic policy. Both the necessity and the focus of investments are heavily dependent on the objectives defined by society for traffic policy. Equally crucial are the decisions made concerning economic instruments, the structure of cost liability, regulations on vehicles and fuels or State procurement of traffic in various forms.

Infrastructure planning must agree with policy objectives for traffic and the environment. The actions proposed must, for example, as far as possible be environmentally appropriate and conducive to traffic safety.

Infrastructure measures, however, are of limited significance in the solution of environmental problems. The purpose of infrastructure is to provide good opportunities for the transportation of people and goods. The achievement of environmental objectives demands further measures over and above those affecting infrastructure. The same goes for traffic safety objectives.

In drawing up our proposals on the focus of infrastructure planning, therefore, we have made a general analysis of various other measures needed in order for the objectives to be met. A more concerted and cogent analysis of the traffic policy and infrastructural measures needed in order to achieve the objectives will be presented in our final report. Several of the measures to be considered are of such a kind that they may come to affect the sum total of traffic inputs and the balance between different types of transport.

Thus our standpoints on general issues of traffic policy may have an impact on the planning of infrastructure investments.

Analyses of alternative focuses

We have analysed five alternative focuses for the development and maintenance of infrastructure:

- A *basic alternative* including all measures which are judged to be socio-economically profitable.
- An alternative attaching special importance to the objective of a *good environment*.
- An alternative attaching special importance to the objective of improved *traffic safety*.
- An alternative focusing particularly on the attainment of *regional balance*.
- An alternative attaching special importance to *business enterprise issues*.

These alternatives are compared with a *comparative alternative* (zero alternative) which only includes measures which are expected to be completed or begun by the New Year 1998.

In the light of the analyses of the alternative focuses, we have drawn up a *draft focus for infrastructure planning for the period 1998-2007*.

Proposals for the development and maintenance of infrastructure during the period 1998-2007

Our proposals imply a redirection of infrastructure planning.

- Following a period of heavy expansion of the national trunk road network, operational and maintenance-related inputs will have to be increased. We propose an increase of rather more than 30 per cent for operation and maintenance of the entire national road network, compared with the present-day level (1995).
- For the rail network we propose that the allocation for operation and maintenance be raised by 6 per cent compared with the present-day level. This includes the bringing forward of re-investments to raise the permissible axle load to 25 tonnes.
- Heavy investments are recommended to increase the carrying capacity of railway lines and of the regional road network.
- Of rail and road investments totalling MSEK 58, it is proposed that 60 per cent go on railways and 40 per cent on roads.
- Investments in the enlargement of national highways are reduced by more than half compared with the existing plan. This is partly because the standard of the road network

has been elevated through enlargements in recent years and because we have now given priority to operation and maintenance within a limited budgeting frame. It is also connected with a new view of development strategy. We endorse the systematic approach and the development of a functionally integrated road network which have characterised planning, but we no longer attach any intrinsic importance to a uniform geometrical and traffic-technical standard. Every part of the national routes should be enlarged at the rate and given the standard which are justified by its own traffic conditions. The parts we have studied are relatively large and naturally demarcated. There is no question of replacing ((stretch thinking)) with spot measures, but the big national stretches can be divided up into sections with differing traffic conditions.

- Traffic safety work, for socio-economic reasons, will concentrate on implementing measures under the national traffic safety programme. Measures relating to the road system will be concentrated on spot measures for black-spot intersections and sections instead of larger road investments.
- Our proposals imply a heavy reallocation from large road investments to the operation and maintenance of the road network. Since the poorest road standard is to be found on the minor road network in the forest counties, the increased operating and maintenance allocations and load capacity investments we recommend imply an equalisation of regional imbalances in road standards. We also recommend special measures for the further encouragement to regional development and business competitive capacity.

We propose a planning frame of MSEK 190,000 for investments and road and rail operation and maintenance during the planning period 1998-2007. This fits in well with the investment cut in this field resolved on by the Riksdag for the coming budget period. We have also assessed the consequences of changing the planning frame by ±15 per cent and of a 20 per cent rise in costs.

Other measures to meet the carbon dioxide target

Our analyses have shown that, of the environmental targets we have defined, the carbon dioxide target is the most difficult to achieve. As an intermediate target, we have assumed that carbon dioxide emissions in the road sector will decline by 20 per cent between 1990 and 2020.

Measures of several different kinds are needed in order to achieve the carbon dioxide targets. We have assumed heavier carbon dioxide taxation, regulation of the specific fuel consumption of vehicles and the rapid introduction of biofuels.

Increased carbon dioxide tax

In our calculations we have assumed that carbon dioxide tax will be raised in such a way that the price of petrol, in real terms, will rise by 10 öre (SEK 0.1) per litre and year between 1990 and 2020. The real price rise for the period ending 2020 will then be SEK 2.30 per litre of petrol. A corresponding increase is assumed in the price of diesel fuel.

A large part of the scope created by this taxation revenue ought, in our opinion, to be applied to State support for environmental measures in the transport sector. Some form of compensation will probably also be needed for persons travelling long distances to work. If the rise in fuel prices should prove to have unacceptable distributive effects to the detriment of rural areas, those effects should be offset by means of regional policy measures in the broad sense.

We will be analysing the question of carbon dioxide tax and related supportive measures in closer detail in our final report.

Regulation of vehicle fuel consumption

In order for carbon dioxide emissions from car traffic to be substantially reduced, cars will have to be made more fuel-efficient. There are several conceivable ways of inducing improvements in the fuel economics of new cars, e.g. regulations or differentiated taxes. It is difficult, however, for Sweden to introduce such instruments on its own. International agreements are needed.

In a specimen calculation we have shown how fuel efficiency will have to be improved in order for our carbon dioxide target to be attainable. We assume that the specific fuel consumption of new cars will gradually decline until 2005. As from that year, new cars are on average to have a fuel consumption of not more than 0.63 l/10 km (the average fuel consumption of new cards today is 0.92). Technically this is quite feasible, but it will make heavy demands on international co-operation.

Support for the introduction of bio-based fuels

In our calculations we have assumed that from 2010 onwards, bio-based fuels will on average provide 15 per cent of the energy content of fuel. This can be achieved through a combination of measures, including both the development of vehicles running on bio-based fuels only, e.g. ethanol or methanol, and low admixture of bio-based fuel to the fossil fuel.

In order for this to be possible, both technical development and some form of public support for the introduction of bio-based fuels will probably be needed. We intend to return with proposals on this subject in our final report.

It is also necessary for Sweden to make active efforts to secure amendments to the EU mineral oil directive, so as to facilitate the introduction of bio-based fuels.

Consequences of our proposals and assumptions

Infrastructure measures in the national road network outside urban communities have only a marginal bearing on traffic generation and choice of transport. Our proposals, therefore, will have hardly any effect at all on the development of road traffic. The presumed increase in carbon dioxide tax and regulation of fuel consumption will between them make motoring cheaper in real terms per kilometre. Traffic growth between 1993 and 2010 is estimated at roughly 30 per cent.

As a result of heavy investments in railways, passenger rail traffic is expected to increase by about 80 per cent during the same period.

Summing up, our proposals have the following consequences:

- **Substantial travel time savings on certain stretches.**

Our proposals confer travel time savings both by road and by rail. On the Stockholm-Göteborg and Stockholm-Malmö routes, using the fastest trains, journey times can be reduced to 2½ and 3½ hours respectively.

- **Reduced emissions of air pollutants and carbon dioxide.**

The focus of infrastructure planning makes little difference to emissions of air pollution and carbon dioxide.

The possibility of achieving the carbon dioxide target with a 20 per cent reduction between 1990 and 2020 will depend entirely on the possibility of reducing specific fuel consumption in motor vehicles and increasing the proportion of bio-based fuels to the extent which we have assumed.

Stricter exhaust rules are needed in order to achieve the aim of an 82 per cent reduction in nitrogen oxide emissions between 1980 and 2020. Failing this, the reduction is expected to be about 65 per cent. The aim of reducing emissions of volatile hydrocarbons will be achieved in the short term, but in the longer term the growth of traffic will necessitate stricter exhaust regulations.

- **Reduced noise problems on national roads**

Targeted measures in the form of noise protection will remedy the noise problems of the 25,000 persons living alongside national highways and exposed to noise levels exceeding 65 dBA. The long-term target of 55 dBA will not be achieved, however, and serious noise problems will persist on the municipal road network.

- **Improved traffic safety**

By the end of the planning period (2007), the number of persons killed in road traffic is expected to have fallen to about 370, as against 589 in 1994. The number seriously injured is expected to decline from 4,221 in 1994 to about 3,600 in 2007.

- **Equalisation of regional imbalances**

The investments in operations and maintenance have a strong regional profile. Nearly half the increase will be in northern Sweden. Roughly 20 per cent of all frost-damaged roads can be remedied (4,000 km out of 19,000).

- **Improved opportunities for enterprise**

The investments in operation and maintenance and in load capacity improvements will mean a great deal to business enterprise, since they will improve the scope for heavy goods transport both by road and by rail. Special investments totalling MSEK 5,350 are recommended for rail freight traffic.

Experiment in stronger political control

We recommend experiments in Skåne whereby responsibility for drawing up and finalising plans for county traffic facilities (LTA) for the period 1998-2007 is transferred from the County Administration to the Skåne Administration.

We also recommend that the Stockholm County Council be made responsible for LTA planning in the County of Stockholm.

Both in Skåne and in the County of Stockholm, the planning process will be constructed in such a way as to strengthen political control and improve co-ordination between different types of traffic, between traffic and infrastructure and between infrastructure and other physical planning.

In the Stockholm County experiment, special importance will be attached to developing and testing a planning process in which urban planning and infrastructure planning are integrated with the planning of mass transit, goods transport and motor traffic. There should be good opportunities for this type of integration in the County of Stockholm, where the County Council is responsible both for regional planning and for public transport.

The experimental activities in Skåne and the County of Stockholm must be co-ordinated with the Government's response to the proposals of the Regional Government Commission and with the experimentation which those proposals may lead to. A Government Bill is expected in May 1996.

In the Counties of Västernorrland and Jämtland we propose experiments aimed at strengthening regional influence on the maintenance of county roads. Certain measures at present classed as maintenance and funded out of the operations and maintenance allocation of the National Road Administration or the special load capacity plan, e.g. frost-proofing and road capacity reinforcement, are instead to be regarded as investments and transferred to the LTA allocations. The corresponding moneys are also to be transferred to the LTA allocations. In this way the counties will have more to say concerning which measures are to be taken and in what order.

The experimental activities are to be followed up and evaluated in 1998, after which it will be considered whether the experiments are to continue, to be changed or to be concluded.

We have only proposed experiments in four counties, but we see no objection to additional experiments being conducted if further preparation for the experimental activities should reveal any such interest.

We have asked the county administrations to concretise our proposals on the focus of infrastructure planning at regional level. They are to report back to us not later than 1st September 1996.

We will also be instructing the National Rail Administration and the National Road Administration to describe how political control of national investment plans for the period 1998-2007 is to be established.

Evaluation of traffic policy

Our terms of reference require us to analyse whether the traffic policy aims in the resolutions passed by the Riksdag between 1988 and 1991 have been achieved.

The 1988 Traffic Policy Resolution indicates five partial objectives:

- availability,
- efficiency,
- safety,
- environmental quality,
- regional balance.

The efficiency target has been evaluated on our behalf by the Agency for Administrative Development.

The National Road Administration has evaluated achievement of the availability and safety targets in the road sector.

The National Environmental Protection Agency has evaluated the extent to which the environmental targets have been achieved, while NUTEK (the National Board for Industrial and Technical Development) and the National Rural Area Development Agency have together evaluated achievement of the regional balance target.

We have received further supportive documentation from the Civil Aviation Administration, the Central Board of National Antiquities, the Swedish State Railways and the Swedish Association of Local Authorities. In addition, the Royal Institute of Technology (KTH), acting on our behalf, has analysed the effects of a number of new train investments.

Our conclusions on the traffic policy pursued

Much has been done since 1988 for the development of transport systems.

Traffic safety has improved and emissions of pollutants have diminished considerably, at the same time as traffic volumes have grown. Carbon dioxide emissions, however, have increased.

Much has been done to expand the national railways and roads. Air traffic has been deregulated and shipping still plays a crucial part in our foreign trade.

SJ (the Swedish State Railways) has developed into an efficient and highly competitive traffic enterprise. High-speed trains have proved to be a successful venture, competing very effectively with air transport and motorism.

The organisation of the traffic utilities has been developed and adapted to new requirements of efficiency and market adjustment. The utilities have been given closely defined sectorial responsibilities for the environment, safety, research etc., at the same time as a co-ordinated and integrated structure of transport planning is being realised for all types of transport.

Traffic policy, then, is steadily developing, but there are problems involved in our way of controlling, organising and financing the transport system. Some of the targets set by the Riksdag for transport and the environment have proved difficult to achieve.

The following are some of the important conclusions resulting from the traffic policy evaluation conducted on our behalf.

- **Input data need to be improved**

In our view, the input data for investment planning must be improved and clearer guidelines are needed concerning the input data required for different planning situations.

- **Decisions must be followed up**

In our view, clear rules and distinct responsibility are needed for follow-up at both national and regional levels. The results of infrastructure investments should be followed up in relation to the targets defined for traffic policy and for individual projects. It is important to make clear whether costs and effects agree with those indicated in the input data.

- **Financial responsibility must be reviewed**

The principles of financial responsibility need to be reviewed and ways of improving calculations of the marginal socio-economic costs analysed, because at present these calculations are surrounded by a great deal of uncertainty.

- **The balance between public planning and free competition in different types of traffic should be analysed**

The evaluations show that the deregulations of air traffic and taxi services have had both positive and negative effects, although it is too early yet to pronounce on the long-term outcome. The deregulations appear to have favoured densely populated areas but to have had a number of negative effects on regions with lower traffic densities.

It is essential to analyse whether measures are needed to compensate rural areas for the effects of deregulation, and to study what may be an appropriate balance between public planning and free competition.

- **The target of regional balance needs to be defined more closely**

Our evaluation points to the difficulties of operationalising the target of regional balance and, accordingly, of analysing the degree of its achievement. An attempt must therefore be made to clarify the regional balance target.

- **The environmental targets must be defined**

The National Environmental Protection Agency points to many positive aspects of progress towards a better environment in the transport sector. Through the MaTs co-operation there also exists an established network which is compiling supportive documentation for an action plan, aimed at achieving an environmentally appropriate system of transport in the next 25-30 years. At the same time, the National Environmental Protection Agency notes that many of the environmental targets set by the Riksdag have not been achieved. Achievement of the stabilisation target for carbon dioxide emissions is especially difficult.

It is urgently necessary to develop both long-term targets concerning the prerequisites of sustainable development and interim targets showing the rate at which the long-term targets are to be achieved.

- **Traffic safety work needs to be broadened**

The National Road Administration reports a continuous improvement in traffic safety. The target set previously for reducing the number of deaths (to a maximum of 600) has already been achieved. Developments are less positive, however, concerning the numbers injured, although the number of persons severely injured has declined.

It is imperative to develop the "zero vision", i.e. to show how the aim of eliminating fatal road accidents altogether can be achieved.

- **Co-ordination of infrastructure development decisions and traffic use needs to be improved**

The Swedish State Railways report a positive development of rail passenger traffic. Traffic on county lines has also increased, except in the northern part of the country, where passenger services have been discontinued on several lines. In many places, however, there is uncertainty regarding the future when the ten-year State funding allocation for services on county lines expires. Another problem observed by SJ and others is the risk of insufficient co-ordination between those deciding the infrastructure of the rail network and those who will be using the lines. Studies are needed to show how this co-ordination can be improved.

- **Bi-modal traffic needs to be developed**

SJ reports that bi-modal railroader traffic has not developed in accordance with the Riksdag target, and the need for special measures to strengthen the development of this traffic must therefore be analysed. In this connection, attention should also be paid to the need for State inputs for transshipment terminals.

Our continuing work

As our work continues, we will be addressing all the problem fields observed in the course of the evaluation. We will be studying the principles and general issues of traffic policy concerning the way in which the transport system is to be organised, controlled and financed.

In our overarching traffic policy analyses of the structure of financial responsibility, the state of competition between different types of traffic, State procurement of regionally necessary transport etc., air transport and shipping will figure much more prominently than they have done in our interim report, the main concern of which has been with the focus of investment planning.

Appendix 2: Report on the assignment

Meeting to consider KFB/SIKA/NUTEK's report to KomKom

Time and venue: Tuesday September 10, 1996; offices of KFB
Present:

Ingmarie Andersson	Department of the Environment
Rolf Berg	Befri
Lars Dahlgren	LRF
Nils Elam	Atrax AB
Sten Flodin	SSEU
Roland Jarsin	SPI
Håkan Johansson	National Roads Administration
Hans-Åke Maltesson	Swedish Gas Association
Andres Muld	Eccotraffic
Björn Renlund	Alternative Fuel Commission
Thomas Sterner	Gothenburg University
Helene Sundberg	SLTF
Urban Karlström	KFB
Sören Bucksch	KFB
Tommy Månsson	KFB
Hans G Pettersson	KFB
Henrik Swahn	SIKA
Gunnar Kinbom	NUTEK
Magnus Brandel	IVL

September 10 meeting at KFB

List of invitees

MaTs' steering committee

Carl John Engström	National Housing Agency
Kristina Feldhusen	KomKom
Reidar Grundström	Swedish Civial Aviation Authority
Roland Jarsin	SPI
Helene Engberg	National Roads Administration
Lars Näsman	Swedish Association of Automotive Manufacturers and Wholesalers
Kurt Palmgren	Swedish Association of Automotive Manufacturers and Wholesalers
Janeric Reiyer	National Roads Administration
Monika Selahn	National Railtrack Agency
Christine Wallgren	KFB
Stephen Wallman	Volvo Passenger Cars Division
Staffan Widlert	SIKA
Thomas Åhsberg	National Board of Shipping and Maritime Affairs

Alternative Fuel Commission

Karin Jonsson	City of Stockholm Environment Department
Björn Rehnlund	Ministry of the Environment
Eva Jernbäcker	Ministry of the Environment
Vibeke Sylten	Ministry of the Environment
Tom Andersson	Ministry of Transport and Communications
Susanna Åkerfeldt	Ministry of Finance
Rolf Berg	SSEU BEFRI Konsult
Karin Kvist	Swedish Association of Automotive Manufacturers and Wholesalers
Kjell Lindqvist	Lantmännens Energi AB
Anders Roth	Swedish Society for the Conservation of Nature
Hans-Åke Maltesson	Swedish Gas Association
Per Camner	IMM
Reino Abrahamsson	Swedish Environment Protection Agency

The above list does not include individuals who participated in the production of this report or those who participate in the work of MaT or ABU.

KFB (The Swedish Transport and Communications Research Board) is a government authority with planning, initiating, coordinating and supporting functions in Swedish transport and communications research. KFB's activities encompass transportation, traffic, postal services and telecommunications, as well as the impact of transports and communications on the environment, traffic safety and regional development.

KFB is also responsible for information and documentation within its areas of responsibility.

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