COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 31.1.2007
SEC(2007) 55/2

CORRIGENDUM: Cover page - Title of the proposal

COMMISSION STAFF WORKING DOCUMENT

Accompanying document to the

Proposal for a

DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions from the use of road transport fuels and amending Council Directive 1999/32/EC, as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC

Impact Assessment

{COM(2007) 18 final}
{SEC(2007) 56}

COMMISSION STAFF WORKING DOCUMENT

Impact Assessment of the Proposal for a Directive of the European Parliament and of the Council modifying Directive 98/70/EC relating to the quality of petrol and diesel fuels

TABLE OF CONTENTS

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

1.1. Organisation and timing

Article 9 of Directive 98/70/EC requests the Commission to review the fuel specifications of Annexes III and IV of the Directive. The Commission has carried out an extensive review of the specifications during 2005. Based on this material and other material it is necessary to assess the need for any change to the Directive. The Commission's Work Programme for 2006 foresees a proposal to amend the Directive.

An Inter Service Group was established in April 2006 to prepare the Impact Assessment for this proposal. The Directorate Generals AGRI, ECFIN, ENTR, JRC, SG, SJ, TREN participated in the group. It held 4 meetings to prepare the draft final Impact Assessment.

1.2. Consultation and expertise

1.2.1. External expertise

The review of the Fuel Quality Directive covers a wide range of areas and involves a significant number of industrial sectors. Many aspects and the issues underlying them are highly technical. In view of these factors DG ENV has sought input from a wide range of bodies with relevant expertise. This input has been sought through a specific contract, a structured stakeholder process and through dialogue and meetings with individual stakeholder or groups of stakeholders.

In 2004 DG ENV entered into an administrative arrangement with the JRC to provide support for some of the technical areas in the review. JRC tackled the various areas of work with the support of different stakeholders. The work was taken forward through a number of subgroups. These dealt with detergents, metallic additives and the evaporative emissions test programme. The JRC made presentations of progress at the stakeholder meetings and responded to questions and comments. The final advice was received on 28 February 2006[1].

1.2.2. Consultation of stakeholders

Two stakeholder meetings were held on 5 April 2005 and 6 October 2005. All member States and a wide range of representative organisations were present at these. Organisations invited are listed in annex 1. At the first meeting there was a broad discussion of issues to be addressed in the review. At the second meeting the Commission's services presented 14 working papers focussed on the main areas of the review and setting out the main issues and possible ways forward. Stakeholders were invited to provide comments on these working papers.

To facilitate debate among stakeholders a publicly accessible CIRCA web site was established http://forum.europa.eu.int/Public/irc/env/fuel_quality/home . All presentations made at the stakeholder meetings were made available here as well as the majority of

[1] Accessible at: http://forum.europa.eu.int/Members/irc/env/fuel_quality/library?l=/jrc_report_annexes&vm=detailed&sb=Title

stakeholder comments. In a limited number of cases stakeholders were not willing to make their responses public.

In addition DG ENV has held meetings with ACEA, Afton Chemicals, eBIO, EBB, EFOA, EUROMOT, EUROPIA, UEPA to discuss different aspects of the review.

1.2.3. Respect of the Commission's minimum standards

The Commission's minimum standards for consultation have been met during the course of the work to review the Fuel Quality Directive. The criteria are assessed below:

Clear content of the consultation process

The objectives of the review of the Directive have been clearly described in the stakeholder meetings. The meetings have been publicised to relevant stakeholders. The Commission's services have made clear how comments received would be dealt with and how the review process would proceed.

Consultation target groups

The Directive concerns the use of Petrol and Diesel for road and non-road mobile applications. It was therefore necessary to involve in the consultation, manufacturers of equipment that would use the fuel, manufacturers of emission control equipment, fuel suppliers, suppliers of alternative fuels, environmental organisations and the Member States. These different industries were represented through EU wide organisations. Some national representative organisations requested to participate but this was rejected because it would have made the process excessively cumbersome. The Commission's services are not aware of any group that believes its views have not been represented. The publication of all the documents and most stakeholder comments on CIRCA has enabled other interested parties to follow the discussion and if they wished to submit comments.

There has not been a consultation of the general public because of the extremely technical nature of the content of the Directive.

Publication

The review of the Directive was identified within the Directive itself. Interested parties were aware that there was to be consultation on the issues to be addressed. No other publicity was required to inform the relevant stakeholders.

Time limits for participation

The Commission provided stakeholders with a month or more notice of the stakeholder meetings. For the second meeting the non-papers were circulated in the week preceding the meeting. Stakeholders have been given adequate time to provide written comments, and there have been no examples of stakeholders being unable to respond because of time constraints.

Overall, the Commission has been in ongoing dialogue with stakeholders over the course of more than a year concerning issues relating to the review. There is no reason to believe that any stakeholder believes that they have not been able to express their views.

Acknowledgement and feedback

Responses from stakeholders following the stakeholder meetings have been acknowledged and the stakeholders were asked whether their responses could be made public on the CIRCA web site.

In general the Commission has not responded to the points raised in individual responses because of the wide range of issues to be addressed and the excessive burden that this would involve. However, following the first stakeholder meeting the Commission analysed the comments received and produced a series of non-papers, which noted the range of views expressed. In some cases, meetings have taken place where the points raised by stakeholders have been further explored.

1.2.4. Main results and how these have been taken into account

The majority of consultation responses have been made publicly available on CIRCA. The Commission has analysed the comments. Following the first round of comments, working papers were prepared for the main subject areas that gave an indication of the range of views expressed by stakeholders. This Impact Assessment provides further indication of stakeholders views on the options.

2. PROBLEM DEFINITION

2.1. Underlying drivers

Directive 98/70 established a minimum specification for petrol and diesel fuels for use in road transport. These specifications were established for health and environmental reasons. The specifications were established following the Auto Oil Programme which sought to establish the optimal balance between tighter vehicle emission standards and fuel specifications to achieve reductions of pollutant emissions for environmental and public health reasons at lowest cost.

Directive 2003/17 modified the Directive in a number of aspects. In particular it established tighter specifications for sulphur content. It also established a requirement in Article 9 of the Directive that a review should take place. This Article states:

Review process

1. By 31 December 2005 at the latest, the Commission shall review the fuel specifications of Annexes III and IV with the exception of sulphur content and propose amendments, if appropriate, in keeping with current and future requirements of Community vehicle emission and air quality legislation and related objectives. In particular, the Commission shall consider:

(a) *the necessity of any change to the end date for the full introduction of diesel fuel, with a maximum sulphur content of 10 mg/kg, in order to ensure that there is no overall increase in greenhouse gas emissions. This analysis shall consider developments in refinery processing technologies, expected fuel economy improvements of vehicles and the rate at which new fuel-efficient technologies are introduced into the vehicle fleet;*

(b) the implications of new Community legislation setting air quality standards for substances such as polycyclic aromatic hydrocarbons;

(c) the outcome of the review described in Article 10 of Council Directive 1999/30/EC of 22 April 1999relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air (*);

(d) the outcome of the review of the various commitments by the Japanese (**), Korean (***) and European (****) automobile manufacturers to reduce the fuel consumption and carbon dioxide emissions of new passenger cars in the light of the fuel quality changes introduced by this Directive and progress towards the Community target of 120 g/km CO_2 emissions for the average vehicle;

(e) the outcome of the review required by Article 7 of Directive 1999/96/EC of the European Parliament and of the Council of 13 December 1999 on the approximation of the laws of the Member States relating to measures to be taken against the emission of gaseous and particulate pollutants from compression ignition engines for use in vehicles, and the emission of gaseous pollutants from positive ignition engines fuelled with natural gas or liquefied petroleum gas for use in vehicles and amending Council Directive 88/77/EEC (*****) and the confirmation of the mandatory NOx emission standard for heavy duty engines;

(f) the effective functioning of new pollution abatement technologies and the impact of metallic additives and other relevant issues on their performance and developments affecting international fuel markets;

(g) the need to encourage the introduction of alternative fuels, including biofuels, as well as the need to introduce modifications to other parameters in the fuel specifications, both for conventional and for alternative fuels, for example the modifications to the maximum volatility limits for petrol contained in this Directive required for their application to blends of bioethanol with petrol and any subsequent necessary changes to EN 228:1999.

2. When considering its proposal for the next stage of emission standards for compression ignition engines in non-road applications, the Commission shall establish in parallel the required fuel quality. In so doing, the Commission shall take into account the importance of the emissions from this sector, the overall environmental and health benefits, the implications in the Member States regarding fuel distribution and the costs and benefits of a more restrictive sulphur level than is currently required for fuel used in compression ignition engines in non-road applications, and shall then align appropriate fuel quality requirements for non-road applications with the on-road sector by a certain date, currently expected to be 1 January 2009, to be confirmed or amended by the Commission in its review in 2005.

3. In addition to the provisions of paragraph 1 the Commission may, inter alia, bring forward:

— proposals taking into consideration the particular situation of captive fleets and the need to propose levels of specifications for the special fuels they use,

— proposals setting levels of specifications applicable to liquid petroleum gas, natural gas and biofuels.

(*) OJ L 163, 29.6.1999, p. 41; Directive as amended by Commission Decision 2001/744/EC (OJ L 278, 23.10.2001, p. 35).

(**) OJ L 100, 20.4.2000, p. 57.

(***) OJ L 100, 20.4.2000, p. 55.

(****) OJ L 40, 13.2.1999, p. 49.

(*****) OJ L 44, 16.2.2000, p. 1.';

It can be seen that the Article lists a number of issues that should be taken account of in the review. These aspects have all been addressed by the Commission in the course of the work that has been performed. The underlying drivers of the evaluation are to determine the likely effects of changes on human health and the environment and to assess the desirability of these changes. The specific problem relating to each aspect of the review is identified in the relevant sections of the Impact Assessment.

The Thematic Strategy on Air Pollution and its related Impact Assessment carried out an in-depth assessment of the need to lower air pollutant emissions in the EU and thus improve air quality. The objective was to provide an envelope to guide future decision making. Underlying these documents was the extensive work carried out within the Clean Air For Europe (CAFE) programme to develop a better understanding of the impacts of such emissions on human health and the environment. This therefore establishes the reference framework within which measures proposed here should be assessed.

Greenhouse Gas emissions from road transport fuels account for approximately 19% of EU total emissions. So far EU measures to respond to transport Greenhouse Gas emissions have primarily focussed on reducing car emissions. Measures have also been taken to improve the attractiveness of less energy intense modes of transport. The worrying continuing increase in transport Greenhouse Gas emissions has been noted in the review of the European Climate Change Programme (ECCP), one of whose recommendations was to better monitor transport GHG emissions and to work on reducing the carbon intensity of transport energy.

The Biofuel Directive set a first step in the direction of addressing Greenhouse Gas emissions from transport fuel. The Commission is currently carrying out a review of this Directive and will consider whether it is necessary to propose any changes to the Directive. Elements of the fuel specification established in Directive 98/70 can constrain how targets for biofuel use can be achieved.

As part of the ECCP, a working group was set up to consider a comprehensive approach to reduce CO2 emissions from light-duty vehicles. The objective of this group was to assist the Commission services in preparing the review of the Community strategy to reduce CO2 emissions from light-duty vehicles, and provide assistance in the preparation of the impact assessment of the future strategy. One of the tasks of the group was to assess the potential contribution of measures that could be included in the approach taking into account their measurability, monitorability and accountability.

2.2. Who is affected, in what ways, and to what extent?

Changes in fuel specification will result in impacts on the sectors responsible for fuel supply, vehicle and equipment supply and on their users.

For the fuel supply sector, it is the parts responsible for supplying road transport fuels and fuel for non-road mobile equipment that will be most affected. Specific fuel sub-sectors can be identified that will be impacted in different ways, these are primarily: suppliers of biofuels, suppliers of fuel oxygenates, suppliers of fuel additives, oil refiners and fuel distributors.

For the manufacturing sector, it is the parts responsible for supplying road vehicles, non-road mobile equipment and engine and fuel system components that will be most affected. Specific sub-sectors can be identified that will be impacted in different ways, these are primarily: manufacturers of heavy duty and light duty vehicles, manufacturers of after-treatment equipment, manufacturers of fuel system components and manufacturers of exhaust after treatment components.

With regard to the impact of resulting changes in pollutant emissions, these will affect all citizens directly, citizens whose property is damaged by pollutant emissions, different levels of government that have responsibility for managing local air quality, and other sectors that may be affected by the need to tighten controls to achieve air quality standards. All members of the public will be affected by resulting changes in vehicle pollutant emissions. Vehicles account for a significant proportion of air pollutant emissions and the effects of this on local air quality and on human health are significant.

The impact of greenhouse gases will be felt worldwide and over a long period of time. In view of the likely changes to weather patterns, and sea levels as well as the introduction of policies to combat climate change, it is likely that the effect will be felt by all citizens and organisations. It is however difficult to predict precisely what the impacts will be.

2.3. How would the problem evolve, all things being equal?

The Thematic Strategy on Air Pollution sets out a range of air pollution objectives for Community policy to achieve by 2020. The CAFE baseline provided a thorough assessment of the level of pollutant emissions in the Community, the improvements that will be achieved through existing Community policy and the impacts of the remaining pollutant emissions on human health and the environment. The fuel used for road transport provides a major contribution to emissions of these pollutants and therefore its specification is a key element in the cost effective achievement of these objectives.

The problem will evolve differently depending on which aspect of the review is considered. Demand for petrol and diesel is projected to grow slightly[2]. The level of Greenhouse Gases emitted from the use of these fuels depends not only on their use but also on how they are produced. Without changes to the vehicle fleet and vehicle emissions standards, increased fuel consumption will, all other things being equal, result in increased pollutant emissions.

However, pollutant emissions standards for road vehicles and non-road mobile machinery are being progressively tightened. Most recently the Commission made a proposal for a Euro 5 standard for light duty vehicles. Average fleet emissions are worse than those from the most modern vehicles, but continual fleet renewal results in a gradually reducing level of overall pollutant emissions per vehicle km. To some extent this is counteracted by increasing total distances driven.

While these improvements might on one hand be claimed to reduce the need for tighter fuel standards, on the other hand certain technical improvements to vehicles (e.g. combustion and after-treatment systems) are dependent on the fuel specification.

2.4. The EU right to act

2.4.1. Treaty base

The EU has previously legislated in this area using Article 95. Because vehicles are primarily marketed in a single EU market, it is desirable for them to use a homogeneous fuel across the EU. Variations in the fuel specification do exist to take account of local climatic conditions, but excessive variation could lead to higher vehicle costs or malfunction. In view of the fact that the Directive, through establishing a common minimum fuel specification, creates a single market for road transport fuel, individual action by Member States in this field can no longer be appropriate.

2.4.2. Subsidiarity

In some areas some Member States have expressed a desire to take action that goes beyond the limits permitted by the Directive. In some cases Member States have encouraged tighter fuel specifications and implemented measures faster than required by the Directive. Some

---

[2] Energy and Transport Outlook.

Member States have also sought to relax some requirements of the Directive. In the absence of the Directive it appears that there would be less homogeneity in the EU road transport fuel market. This would not be desirable from an environmental perspective since it would be more difficult and costly to achieve environmental performance of vehicles with differing fuels specifications. It would also be undesirable from an economic perspective since it would reduce the potential for intra-community trade in fuel and lead to higher costs for vehicle and equipment manufacturers.

3. OBJECTIVES

3.1. General policy objectives

The Directive ensures a single market in the fuels covered by setting the minimum specification based on environmental and health grounds. This is of particular importance to vehicle manufacturers who effectively operate on a European market.

The General Policy objectives are to ensure that environmental and health concerns arising from the use of petrol and diesel are adequately taken into account in the establishment of the minimum fuel specification. The economic costs of options need to be taken into account to ensure that the social benefits of the policy options chosen are greater than the social costs.

3.2. Specific/operational objectives

More specific objectives relate to the objectives set out in the Thematic Strategy on Air Pollution[3] which set a number of high level goals to be achieved in terms of reducing air pollutant emissions by 2020. This followed an extensive analysis of the impacts of air pollutants and set out for the Community a level of ambition in terms of reducing a range of pollutant emissions. The Thematic Strategy objectives are set at a level of ambition to achieve €42 billion health benefits per year at a cost of approximately €7 billion per year. The objectives of the strategy include reducing by 2020: SO_2 emissions by 82%, NOx emissions by 60%, VOC emissions by 51% and PM2.5 by 59%. Different parameters in the fuel quality Directive impact on all 4 of these pollutants. The proposed measures need to be developed to be compatible with this objective.

3.3. Consistency of these objectives with other EU policies and objectives,

There are interactions with a number of areas of Community policy. In some cases these are over-arching strategies encompassing a wide range of policies such as the Lisbon and Sustainable Development strategies. In others these are more narrowly defined policies that have implications for a range of policy areas such as Climate Change policy. In other cases, quite a narrow objective, promoted by Community legislation has interactions with legislation on fuel quality for example the promotion of biofuels.

3.3.1. Over-arching strategies

Lisbon

In 2005 the Commission produced a Communication on common actions for growth and employment. This stated that the goal "is to modernize our economy in order to secure our unique social model in the face of increasingly global markets, technological change, environmental pressures, and an ageing population. This strategy is also to be seen in the wider context of the sustainable development requirement that present needs have to be met without compromising the ability of future generations to meet their own needs.

---

3 Communication from the Commission to the Council and the European Parliament: Thematic Strategy on air pollution - COM(2005) 446, 21.9.2005.

There are a number of relevant aspects to be considered. As has been noted, the fuel specification has implications for the manufacture of vehicles, non-road mobile machinery and fuel and exhaust system components. These implications can increase or reduce costs for those sectors. Similarly the specification has implications for the size of market and cost of fuel provided by fuel suppliers. It can also have implications for overall energy use.

Any measures leading to increased fuel costs will feed through into higher costs for transport and the economy. Reducing pollutant emissions will lead to lower health damage resulting in lower health care costs and a healthier population. A consistent fuel specification helps to ensure that a single market exists for road vehicles in the EU.

There are wider implications in terms of whether vehicles and machinery able to use EU specification fuel can also be sold on the world market and vice versa. These are tied in with the degree of convergence of emission specifications established for different sectors in the different major world markets.

Finally, industry needs a predictable framework to enable effective investment decisions and future research and development activity.

Sustainable Development strategy

The European Council in Gothenburg in 2001 adopted the Sustainable Development Strategy. The principles and objectives of sustainable development – economic prosperity, social equity, environment protection and international responsibilities – were reaffirmed by the European Council in June 2006 by the adoption of the renewed EU sustainable development strategy.

In the context of this review, the goal is to reduce undesirable pollutant emissions that lead to environmental and health impacts. This needs however to be done in the most economical manner and it needs to be shown that reductions are cost effective considering the societal benefit.

Climate Change

The Commission has taken many climate-related initiatives since 1991, when it issued the first Community strategy to limit carbon dioxide (CO_2) emissions and improve energy efficiency. Action by both Member States and the European Community needs to be reinforced if the EU is to succeed in cutting its greenhouse gas emissions to 8% below 1990 levels by 2008-2012, as required by the Kyoto protocol.

Road transport fuel plays an important role in the production of greenhouse gas emissions. Road transport accounts for 94% of domestic EU transport Greenhouse Gas emissions, excluding international[4] transport. Transport overall accounts for 19% of EU-25 Greenhouse Gas emissions. The Greenhouse Gas emissions from the fuel per unit of energy differ depending on the fuel pathway used to produce it.

Comprehensive approach to reducing CO2 from light-duty vehicles

---

4 That is air and maritime journeys having their start and end points in different countries.

Within ECCP II a working group was set up on reducing CO2 emissions from light-duty vehicles. The general objective of the Working Group was to assist the Commission services in preparing the review of the Community strategy to reduce CO2 emissions from light-duty vehicles, and specifically provide a stakeholder consultation forum giving assistance in the preparation of the impact assessment of the future strategy. As regards future actions beyond the current commitments, in view of the Community's objective of 120 g CO2/km, the Commission is preparing a Communication based upon this work.

3.3.1.1. Interactions with specific Directives

Biofuels

The Community has adopted Directive 2003/30 on the promotion of biofuels. This has as its objectives contributing to climate change commitments, environmentally friendly security of supply and promoting renewable energy sources. The Directive establishes a reference value of achieving 5.75% biofuel substitution in petrol and diesel by 2010.

The Commission adopted in 2005 a Biomass Action Plan[5] and in 2006 a subsequent Biofuel Strategy[6]. These noted the constraints on the use of certain types of biofuels established in the CEN standards for technical reasons and in the Fuel Quality Directive primarily for environmental reasons. It was noted that the Commission intended to review these limits.

As set out in these documents, for a number of reasons the desire has been expressed to further increase the use of biofuels in the Community. Beyond the current Community objective, the European Council has asked the Commission to consider the potential for reaching an 8% share of road transport fuels by 2015. These political wishes raise a number of economic, practical and environmental questions. These issues are explored in the Commission service's review of the Biofuel Directive.

The in-use environmental implications (as opposed to the impacts from their cultivation) of different biofuels vary. For example synthetic diesel generally results in much lower pollutant emissions than fossil diesel fuel and the Directive contains no constraints on its use. Synthetic diesel alone could be used to satisfy an 8% biofuel goal. The first commercial production of synthetic biodiesel, albeit produced from animal and vegetable fats, will start in 2007. With regard to petrol substitutes there are a range of options. ETBE is currently the most widely used in the EU. Ethanol may be directly blended but this gives rise to environmental problems that are explored in this Impact Assessment. Other compounds may also be used, and for example Butanol will start to be produced as a petrol substitute in the EU in 2007 and while being produced from the same feedstocks as ethanol, it avoids many of the problems associated with ethanol. Nevertheless, Butanol will not be available in substantial quantities on the biofuel market in the next years.

The existing constraints on the maximum volume of different biofuels contained in Directive 98/70 are set out below as well as the equivalent maximum energy content of road transport fuel that could be supplied if these limits were exploited to the maximum. The table is based on the ratio of petrol to diesel sales reported in 2004.

5 COM(2005) 628.
6 COM(2006) 34.

Biofuel	Constraint in Directive 98/70	Maximum % of road transport fuel energy	
Petrol substitutes			
Ethanol	Max 5%	1.45%	Because of the 2.7% oxygen limit, the maximum achievable is 4.4% (equal to 10% of petrol energy).
Other alcohol	Max 10%	3.7%[1]	
Ethers	Max 15%	3.1% [2]	
Diesel substitutes			
FAME	None[3]	56% (EN590 sets a 5% volume limit)	
Synthetic diesel	None	56%	

1. Based on Butanol energy content

2. This is based on the Biofuel Directive definition of bio-energy content of ETBE, the energy content of other Ethers is not defined in that Directive.

3. However, a limit is currently set on FAME in EN 590 for technical reasons. CEN has been requested to review this limit and if there is no longer technical justification for it, there seems no reason why the limit would not be altered.

The Commission's biofuel strategy states that: "To capture the potential environmental benefits, a biofuel strategy has to focus on (1) optimising greenhouse gas benefits for the expenditure made, (2) avoiding environmental damage linked to the production of biofuels and their feedstocks, (3) ensuring that the use of biofuels does not give rise to environmental or technical problems." The current review of Directive 98/70 primarily concerns the third of these aspects. Biofuel technology will evolve, and this raises risks and opportunities from an environmental perspective. Because it is not possible to fully foresee the biofuel technology that will be available in 5 years time, it is desirable to foresee a further consideration of this aspect of the Directive in that time frame.

In January 2007 the Commission adopted a Biofuels progress report and Communication on "An energy policy for Europe" as part of its Energy package. In these documents it signalled its intention to achieve a minimum level of biofuel use of 10% by 2020 and a view that 14% biofuel use was achievable by that date.

<u>Other Community legislation</u>

There are interactions with a number of other pieces of Community legislation. Some of these are specifically referred to such as Directives 1999/96/EC[7], 1999/30/EC[8] relating to pollutant

---

7 Directive 1999/96/EC of the European Parliament and of the Council of 13 December 1999 on the approximation of the laws of the Member States relating to measures to be taken against the emission of gaseous and particulate pollutants from compression ignition engines for use in vehicles, and the emission of gaseous pollutants from positive ignition engines fuelled with natural gas or liquefied petroleum gas for use in vehicles and amending Council Directive 88/77/EEC.

emissions while others are not such as Directive 1997/68/EC[9] on Non-Road Mobile Machinery (NRMM) emissions.

3.3.1.2. Security of Energy Supply

Transport energy plays a key role in the functioning of the EU economy. The security with which this can be supplied is therefore important and has been discussed by the Commission in a Green Paper[10]. The concept of security of supply encompasses a wide range of different issues and many factors impinge on the overall level of supply security.

A uniform fuel standard across the EU improves the fungibility of the fuel system and its robustness to disruption. The extent to which EU consumption is supplied from EU production has an impact on the likelihood of supply disruption for political purposes. However, the degree to which any one producer can disrupt fuel supply is in itself dependent on that producer having a degree of control over the market. Some sources of supply may be more vulnerable to disruption than others, for example because of geopolitical factors, for technical reasons or if they are dependent on weather conditions.

In the Commission's Biofuels Progress Report adopted on 10 January 2007it stated that:

"-Biofuels contribute to short-term security of energy supply by reducing the need to keep oil stocks to protect against disruptions. The value of this can be estimated at about €1 bn per year (under the hypothesis of a 14% biofuel share).

- The best way to promote long-term security of supply is to diversify energy sources. In transport, energy diversity is rather low. Biofuels add to energy diversity by increasing the diversity of fuel types and of regions of origin of fuels. It is not obvious how to place a monetary value on this benefit."

It is clearly desirable that changes to Directive 98/70 should not exacerbate risks to the security of energy supply in the EU. The potential implications of modifications to security of energy supply are discussed where appropriate in the individual sections of the Impact Assessment.

---

8 Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air.

9 Directive 97/68/EC of the European Parliament and of the Council of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery.

10 Towards a European strategy for the security of energy supply - COM(2000) 769, November 2000.

4. ISSUES ADDRESSED IN THE REVIEW

Directive 98/70 establishes limits on 23 parameters of petrol and diesel. Article 9 of the Directive contains 10 paragraphs specifying areas for consideration within the process of the review of the Directive. Many of these areas cover a range of possible parameters. It has been necessary to limit the scope of the review to areas that it is most useful and appropriate to address.

During the stakeholder process and building on the areas requested for consideration in the Directive, the following main areas have been identified for investigation.

1. World Wide Fuel Charter
2. Biodiesel limits in diesel
3. LPG, CNG and Biofuel specifications
4. Captive fleets
5. End date for sulphur in diesel
6. Review of Directive 99/96
7. Review of CO_2 and cars
8. Review of Directive 99/30
9. Polycyclic Aromatic Hydrocarbons
10. Non-road applications
11. Detergents
12. Metallic additives
13. Diesel density
14. Petrol ethanol ETBE and oxygenate content
15. Petrol vapour pressure
16. Lifecycle Greenhouse Gas emissions

For each of these areas an assessment is provided of the policy options in the following sub-sections.

4.1. World Wide Fuel Charter

4.1.1. The problem

The World Wide Fuel Charter (WWFC) is a proposal from car manufacturers recommending harmonisation of fuel standards. Adoption of such harmonised standards would facilitate the marketing of vehicles calibrated for many different markets. In establishing the proposed fuel specifications in the charter, it seems unlikely that car manufacturers will have taken full account of the implications for other sectors such as fuel suppliers.

4.1.2. Policy options

The review currently being performed of Directive 98/70 considers a number of different fuel characteristics. Possible changes to these characteristics are assessed for their effects and a conclusion reached based on this analysis. In asking for the WWFC to be adopted, the automotive industry is asking, rather than for such a parameter by parameter analysis, for the existing fuel specification to be replaced by that within the WWFC. Therefore the options are either:

- Do nothing

- Adopt the WWFC specifications in place of the existing fuel specifications in the annexes.

4.1.3. Impact of the options

The do nothing option, implies that those aspects of the fuel specification that have been proposed in the stakeholder discussions or in the Directive to be considered for review will analysed one by one and a conclusion reached on the desirability of change. Changes would therefore be made only if these made sense through taking account of their impacts on all the relevant sectors and parameters.

The option of deciding whether or not to adopt the WWFC specifications implies making a decision on the totality of the specification. This could be done through an extensive analysis of the difference between the WWFC specification and the existing EU specification and summing together the impacts.

4.1.4. Comparing the options

After the automotive industry requested consideration of the use of the WWFC specification, the Commission asked it to bring forward evidence showing that modification of the parameters requested would result in improved environmental performance that can be justified from a cost-benefit analysis point of view. The WWFC is supported with data suggesting that the proposed changes would provide environmental benefit. However, the conclusions to be drawn from this data are disputed and different trends or different conclusions are put forward by other stakeholders. In some other cases, while there is evidence that by modifying certain fuel parameters, e.g. cetane number, emissions can be reduced, it has not been demonstrated that this is justified in cost-benefit terms.

It should be recalled that the oil companies' European Association for environment, health and safety in refining and distribution (CONCAWE) published a paper[11] in 1999 assessing the proposed WWFC standards. This paper stated that while fuel quality changes alone have a relatively small impact on emissions from engines of a given technology, they offer great potential to reduce emissions if used to enable new engine technologies.

The evidence requested has not been offered and therefore the request for wholesale adoption of the WWFC specification was not further considered. Nevertheless, many of the specific aspects addressed in the WWFC are extensively analysed elsewhere in this Impact Assessment.

4.1.5. Preferred Option

The preferred option is to assess the impacts of changing those individual fuel characteristics where a need has been identified.

[11] Fuel quality, vehicle technology and their interactions; CONCAWE report 99/55.

4.2. Limits on FAME content in diesel

4.2.1. The problem

The diesel specification contained in the Directive does not specify a maximum limit for FAME content. Such a limit is established in European Standard EN 590 for technical reasons, because of a number of technical concerns principally over the stability of FAME and its effect on injection equipment..

During the stakeholder process, the FAME industry requested that consideration be given to putting in place a limit setting a maximum FAME content for diesel in Directive 98/70. No evidence has been provided by any stakeholder of any justification for the establishment of such a limit on health or environmental grounds. However, the fuel injection equipment manufacturers have reiterated their concerns over higher proportions of FAME than permitted in EN 590. The Commission is not in a position to assess the accuracy of these claims.

4.2.2. Policy options

The options available are to:

- Do nothing,
- Consider establishing a limit on FAME in Directive 98/70
- Request CEN to reconsider the evidence and determine whether the existing FAME limit in EN 590 is justified.

4.2.3. Impact of the options

The do nothing option would leave the existing EN 590 limit in place. Current EU levels of FAME use are significantly below the maximum permitted in EN 590 and so this does not constrain the current use of FAME in the EU. However, investment in FAME may be constrained because of the current future prospects for development of the EU market for FAME. The development of more advanced bio based diesel substitutes is likely to lead to a situation where, because of their better fuel characteristics, and ultimately the introduction of more advanced biodiesel production technologies with better greenhouse gas balance, the CEN limit on FAME will cease to be important.

A limit for biodiesel could be established in Directive 98/70. There do not appear to be convincing reasons for health or environmental reasons to establish such a limit, and therefore it would not be expected that any health or environmental benefit would flow from it. The existing limit is established for technical reasons and these appear to provide the major justification for establishing a limit on FAME. The Commission's Better Regulation initiative aims to make sure that regulation is used only when necessary. In this case, there is no convincing reason to duplicate the CEN limit in Community legislation.

A request could be made to CEN to reconsider the evidence in the light of subsequent technical progress and determine whether or not the limit in EN 590 remains justified or not. This would have the benefit that the relevant industry experts would be brought together to reappraise the evidence.

4.2.4. *Comparing the options*

Since the limit in EN 590 is established because of technical concerns principally over the stability of FAME and its effect on injection equipment, , were the Commission to consider overturning this limit it would need to consider whether the technical reasons for the limit were invalid or had been superseded. This is beyond the scope of the current review and is a process that should more appropriately be considered within the appropriate technical body. Liability issues might arise were a decision taken to overrule the existing technical limit if this was then discovered to cause malfunction or damage to vehicles.

The absence of evidence of any significant environment or health problems arising from the use of different proportions of FAME has led to no further consideration being given to introducing a maximum limit for FAME content in diesel.

The Commission has already requested CEN to reconsider the limit set in standard EN 590. This clearly rules out further consideration of the "no action" option and in view of the difficulties inherent in the other option appears to be the optimal way forward.

4.2.5. *Preferred Option*

The Commission has requested CEN to reconsider the FAME limit set in EN590. Because there are no good reasons for a limit on FAME content in diesel to be set in Directive 98/70 no other action is proposed.

4.3. LPG, CNG and Biofuel specifications

4.3.1. The problem

There might be a need on the grounds of environmental or health protection to establish specifications for one or more of these fuels as has been done for petrol and diesel. In recognition of this, Article 9, paragraph 3 of Directive 98/70 states that the "*Commission may bring forward proposals setting levels of specifications applicable to liquid petroleum gas, natural gas and biofuels.*"

There may also be technical reasons for defining EU wide specifications for these fuels. For example, to facilitate their use across the single market. This has been suggested in the case of natural gas. Nevertheless, the establishment of specifications for fuels based purely on technical reasons falls outside the scope of the Directive. In view of this, it is also necessary to consider whether the scope of the Directive should be expanded to include technical reasons.

The Directive specifications only cover fuels that are at least 70% derived from mineral oil. There may therefore also be a need to consider whether fuels that contain less than 70% mineral oil might be put on the market and raise health or environmental risks.

Whether specific vehicle emission standards are required for these different fuels is not considered.

CEN standards

CEN standards exist for Fatty Acid Methyl Esters (FAME) (EN 14124?) for automotive use, and automotive LPG (EN 589). CEN/TC 19 is working on an ethanol standard for blending up to 5% in petrol. A workshop agreement has been concluded on emulsion fuel (CWA 15145:2004). Development is also currently underway on a workshop agreement concerning ethanol fuel (E85) for use in flexible fuel vehicles (FFV).

A CEN working group (CEN/BT/WG 149) has reported on "The need for European Standards for liquid and gaseous alternative fuels" on 6th December 2004. This recommended some further action in a number of fields.

Other alternative fuels

It is also worth considering other potential transport fuels and therefore DME, Hydrogen, emulsion fuel and synthetic fuels are also covered.

There have not been any requests by stakeholders on environmental or health grounds to set specifications for LPG, CNG, hydrogen, emulsion fuel or synthetic fuels.

It has previously been suggested by the European Natural Gas Vehicles Association (ENGVA) in the Commission Alternative Fuels Contact Group, established to consider economic and technical barriers to CNG playing a larger role as a transport fuel, that it could be desirable to establish minimum specifications for transport fuel CNG. It was suggested that these specifications could relate to oil, moisture and impurity content.

4.3.2. Policy options

The options available are:

- No action
- Set specifications for one or more of these fuels.
- Extension of the scope of the Directive to regulate fuel specifications for technical reasons.

4.3.3. Impact of the options

In discussing the impact of the options in this section, climate change impacts are not addressed. This is because in general, the climate change impacts of different fuels are highly dependent on the pathway employed for the production of the fuel. The degree of dependence varies between fuels, being highest for hydrogen, fairly high for biofuels and less dependent for LPG and CNG. Climate change issues relating to different fuel pathways are addressed in section 4.16.

4.3.3.1. LPG and CNG

An argument frequently advanced for greater use of LPG and CNG as road transport fuels in the past is that these are cleaner burning fuels than petrol or diesel resulting in lower levels of pollutant emissions and less health damage. The reasons for this relate firstly to their relatively homogenous hydrocarbon composition, and the fact that because they are gases, there are no issues relating to vapourisation resulting in more complete combustion. These factors mean that there is likely to be a need for less stringent after-treatment equipment to achieve emission standards. As vehicle emission standards are increasingly tightened for petrol and diesel vehicles, it is likely that the pollutant emission benefit of these fuels will disappear.

There do not appear to be any environmental benefits from including specifications for LPG and CNG in the Directive. For CNG, it has been noted that there could be benefit to the wider use of CNG as a transport fuel if a uniform specification was agreed. With regard to LPG, the existence of a CEN standard indicates that there would be no economic or social benefit from including a specification in the Directive. Nevertheless, the Commission's attention has been drawn to the fact that there may be technical problems arising from the technical requirements currently set by EN589. In view of this, the Commission proposes to approach CEN to consider whether there is a need for modification or clarification of the standard.

4.3.3.2. Biofuels

With regard to biofuels the situation is rather more complex. The term biofuel covers a large range of potential fuels. At present the main biofuels used in the EU are ethanol (used as ETBE) and FAME. The potential impacts of ethanol as a blend in petrol are discussed in section 4.14.

Synthetic fuels may be produced from different feedstocks such as coal, gas and biomass, but the resulting products are very pure paraffinic hydrocarbons that are indistinguishable. Information provided by industry shows that these fuels produce substantially less pollutant emissions than conventional diesel and there are no additional known health impacts beyond those from conventional diesel engine emissions.

The only aspect considered here is whether a full specification for any or all biofuels needs to be contained within this Directive. The effect of neat ethanol and biodiesel on pollutant emissions appears to be unclear. Study results are inconclusive particularly for certain pollutants. A key factor is that neat ethanol and biodiesel have very different properties compared to conventional diesel and petrol. For example, biodiesel has a much higher density, a narrower distillation curve and a higher average boiling point than diesel fuel. In general engine parameters are optimised for conventional fuels and therefore neat biofuels can lead to non-optimal functioning of the engine with worsened environmental performance. However, this situation might change if engines and their management systems were optimised to use high biofuel blends of fuel. While this might point to the desirability of regulating these fuels, there is no evidence that there is a problem with the composition of the fuel or the existence of impurities or other compounds. If this is not the case then it is difficult to see what gain for health or the environment would be achieved through such a regulation, however it does point to the need to control the mixture of these fuels with conventional fuel and the need to ensure that fuel specification remains as homogenous as possible.

If no action is taken in the Directive, it does not preclude other action such as further standardisation work by CEN in relation to these fuels

4.3.3.3. DME and Hydrogen

In the case of DME and Hydrogen, which are both gases at room temperature and pressure, it is likely that these will also be supplied in a very pure form as a result of the production processes employed. There do not seem to be particular risks from pollutant emissions with using these fuels, although results are not conclusive for DME, nor the need to manage trade offs between fuel suppliers and vehicle manufacturers to achieve desired levels of exhaust cleanliness. At the extreme where hydrogen is used in fuel cells, the only emission is water vapour. With regard to the purity of hydrogen, it should be noted that there is a trade-off between the cost of purifying the gas and the cost of the fuel cells. This may indicate the desirability of establishing purity levels in the future.

4.3.3.4. Emulsion Fuels

Emulsion fuels are produced through emulsifying a blend of water and diesel with the use of a surfactant to ensure that the emulsion remains stable. These fuels are reported to consistently result in significant reductions in PM, NOx and CO emissions. An extensive study performed by CARB[12] and confirmed by others has shown that emulsion fuels can results in an increase of some pollutants, especially unburnt hydrocarbons; however CARB concluded that the benefits to PM emissions are overwhelming compared to the possible adverse effects on some other emissions. The existence of a CEN workshop agreement for emulsion fuels indicates that there would be no economic or social benefit from including a specification in the Directive.

4.3.3.5. Other impacts

Any change to the coverage of fuels by the Directive would impact primarily on suppliers of that fuel who would then have to ensure compliance with the relevant specification. There is unlikely to be any significant impact on the general public because no significant health or

12 CARB. Multi-Media Assessment of Lubrizol's PuriNOx Water/Diesel Emulsion. California Environmental Protection Agency. California, 2004.

environment risks have been identified. There could be some impact on vehicle manufacturers and fuel retailers who might benefit from handling a more homogeneous fuel. Nevertheless, as noted, the existence of a number of CEN agreements in this area limits this potential impact.

It is not considered likely that the situation in relation to the fuels discussed will change. The fuels themselves are unlikely to become more contaminating and it is not considered likely that any major new health or environmental risks will be identified.

4.3.4. Comparing the options

There does not appear to be any demand for addressing CNG, LPG or biofuel specifications in Directive 98/70. Where a CEN standard already exists, there is unlikely to be a single market benefit from introducing such a specification in Directive 98/70.

DME and Hydrogen are fuels that are not yet commercialised. There is no evidence that a lack of an EU specification is hampering their introduction although the need for such a specification may well arise. In view of the lack of identifiable health and environmental risks presented by these fuels addressing this through Directive 98/70 is probably not the most desirable approach.

It has been noted that CEN has undertaken work on technical standards for biofuels, LPG and emulsion fuel. In view of its expertise, this would probably the most appropriate sphere for defining any further technical specification for the fuels discussed.

4.3.5. Ranking the options

For the different fuels considered, an assessment of the likely change from setting further EU specifications is set out below.

	LPG	**DME**	**CNG**	**Hydrogen**	**Biofuel**	**Emulsion Fuel**
Health and Environmental benefits from establishing specification in 98/70	No – generally lower pollutant emissions than conventional fuel	No – generally lower pollutant emissions than conventional fuel	No – generally lower pollutant emissions than conventional fuel	No – lower pollutant emissions than conventional fuel	Reported impacts vary. Some pollutant emissions appear lower.	No– lower pollutant emissions than conventional fuel
Single market benefits from establishing specification in 98/70	No (CEN standard)	No – no market at present.	Possibly	No – no market at present.	No - (CEN standard for FAME and E85 workshop agreement)	No - (CEN workshop agreement)
Benefit from establishing a technical specification	No	Possibly	Possibly	Probably	Possibly in some areas	No

Since pollutant emissions are generally lower from combustion of the fuels considered than for conventional petrol or diesel, there is not a strong case for regulating their specification through Directive 98/70. In addition, the market share of these various fuels is currently small, and even in the most optimistic scenarios will only supply a small proportion of the market in the foreseeable future. These factors combined indicate that only a very limited health and environment benefit, if any, could be derived from regulating the specification of these fuels in the Directive. If such a regulation were to add cost to the fuels it could even have an adverse effect through discouraging their take up. Where there is no European standard, single market benefits could be realised, however this may be most appropriately pursued through standardisation.

4.3.6. Preferred Option

In view of the expertise of CEN in establishing technical standards for fuels, and the absence of any request from stakeholders that this task should be included in the scope of the Directive, it is concluded that the scope of the Directive should not be extended to cover technical questions relating to fuel specification in line with the Commission's better regulation initiative.

In view of the lack of health and environment benefit and the undesirability of extending the scope of the Directive to cover technical issues, specifications for the fuels considered should not be included in Directive 98/70.

4.4. Captive fleets

4.4.1. The problem

There might be environmental or health benefit that could be realised by establishing special specifications for fuels used by captive fleets. This could arise because of their use in urban areas where there might be specific air quality problems.

Only one stakeholder commented specifically on this aspect of the review suggesting that it might be desirable to establish special fuels for captive fleets but did not provide any further detail on the desirability of addressing any particular parameters of the fuel specification or the cost or practicality of doing so.

4.4.2. Policy options

The options available are:

- No action
- The definition of a specific captive fleet fuel in the specification.

The no action option would retain the existing rules in the Directive. Article 6 of Directive 98/70 states that "*By way of derogation from Articles 3, 4 and 5 and in accordance with Article 95(10) of the Treaty, a Member State may take measures to require that in specific areas, within its territory, fuels may be marketed only if they comply with more stringent environmental specifications than those provided for in this Directive for all or part of the vehicle fleet with a view to protecting the health of the population in a specific agglomeration or the environment in a specific ecologically or environmentally sensitive area in that Member State, if atmospheric or ground water pollution constitutes, or may reasonably be expected to constitute, a serious and recurrent problem for human health or the environment*". It may be concluded that it is therefore possible for a Member State to establish specific criteria, for example for captive fleets, in a given area provided that there are specific health or environmental justifications.

4.4.3. Analysis of impacts

There are two reasons indicated why it may be desirable to establish specific fuel specifications for captive fleets.

In the first case this is because captive fleets may offer a means of introducing new or alternative types of fuels into a self contained market. Captive fleets can facilitate the use of unconventional fuels such as LPG, CNG, DME, hydrogen, high blend biofuels and emulsion fuels. This avoids the problem of introducing the fuel at a sufficiently wide proportion of filling stations for it to be useable by vehicles operating freely throughout the territory. The possibility of establishing specifications for these fuels is discussed in section 4.3. With the exception of emulsion fuels, all of these fuels require specially purchased or adapted vehicles. A decision to acquire such vehicles would necessarily involve making arrangements for the supply of the fuel required. These factors mean that no further consideration needs to be given to this aspect here.

The second case may arise because of air quality problems in a specific area, almost certainly urban. The question to be answered is whether there is benefit in air quality terms to be derived from defining a specific alternative specification for petrol and diesel compared to that for general use. If there is such benefit, does the Directive need to be modified to achieve this and would the benefits outweigh the costs.

It is unlikely that specially adapted vehicles would be manufactured for this segment of the market and therefore that the environmental benefit would need to be achievable from the use of the fuel in conventional vehicles. This issue is considered in general within the review for a number of elements of the petrol and diesel specification to assess whether there would be environmental benefit from a further tightening of the general specification.

For those aspects of the specification where it is concluded that it is not desirable to change the general specification, this indicates that if the situation is different for a specific geographic area it must be because the nature of that area is such as to give rise to very different costs for example for abatement of pollutant emissions from other sources. This would indicate that the problem to be tackled must be highly specific to that narrow area. This argues against the possibility of defining a single "captive fleet" blend since the problems to be addressed may differ throughout the Community. Many such specific problems can also be tackled in other ways.

It is likely that the use of such a specialised fuel in such a limited way would pose economic challenges. The Commission does not believe that a generalised need for a specialised fuel specification for captive fleets have been demonstrated.

4.4.4. Comparing the options

	No action	**Captive fleet specification**
Availability of special fuel for urban captive fleets	Possible provided Article 6 is complied with.	Possible
Ability to reduce PM	Further fuel possibilities already exist eg non-sulphur diesel and emulsion fuels. Low Emission Zones may also be employed. Filters may also be employed.	In addition to the no-action options, the captive fleet specification, if it offered lower PM emissions, would provide a possible means of reducing PM.
Ability to reduce NOx	Emulsion fuels may be used to reduce NOx emissions. NOx traps may also be employed.	In addition to the no-action options, the captive fleet specification, if it offered lower NOx emissions, would provide a possible means of reducing NOx.
Air quality	In addition to the possible specific measures on fuels and vehicles listed above, air quality can also be improved by restrictions on more polluting vehicles and traffic	In addition to the no-action options, the captive fleet specification offering lower emissions would provide a possible means of improving air

	restrictions. More cost effective non traffic related options may exist.	quality. The effect of the captive fleet fuel would depend on the proportion of total emissions produced by the captive fleet, which is likely to be small.
Vehicles	No change	Unlikely that vehicles will be developed specifically to use “captive fleet” fuel. No evidence has been presented of any vehicle technology that would be introduced in captive fleets if a different fuel specification were available.
Refiners	Logistic challenges could arise if special fuel is required under Article 6, the cost of which would be passed on to the user.	Logistic challenges could arise if special fuel is required, the cost of which would be passed on to the user.
Local authorities	Options other than fuel exist to tackle specific local air quality problems. If a need is identified for special fuel, this can be required under the procedure in Article 6. Local Authorities would need to establish the cost effectiveness of this compared with other measures.	Options other than fuel exist to tackle specific local air quality problems. Captive fleet specification fuel would be available as an option. Local Authorities would need to establish the cost effectiveness of this compared with other measures.

4.4.5. Preferred Option

Many options are available for addressing air quality problems, and in particular transport sources of emissions. The option of establishing a captive fleet fuel specification offers little if any environmental benefit over other alternative approaches. The specific nature of the local air quality concerns mean that it is not possible to establish at an EU level what the most economically desirable approach would be to address such local problems.

The current possibility provided by the Directive does enable a tighter fuel specification to be employed if this is considered to offer the most attractive ratio of costs to benefits. No overall EU benefit has been identified from establishing a specific captive fleet specification. In view of this and the absence of any specific request for a tighter specification of fuel parameters for captive fleets, no action is the preferred option.

4.5. End date for 10ppm sulphur diesel

4.5.1. The problem

10ppm sulphur diesel is an enabling fuel for higher vehicle efficiency due to the fact that its use results in the need for less regeneration of DPFs. Reducing sulphur content also leads to benefit in SO_2 and PM emissions. Sulphur content is also relevant to the future introduction of De-NOx after-treatment systems since it can poison these.

Article 4(1)e of Directive 98/70 establishes a maximum sulphur content of road diesel of 10ppm to take effect provisionally from 1 January 2009. However this end date is subject to the provisions of Article 9(1)(a) which requires the Commission to consider "the necessity of *any change to the end date for the full introduction of diesel fuel, with a maximum sulphur content of 10 mg/kg, in order to ensure that there is no overall increase in greenhouse gas emissions. This analysis shall consider developments in refinery processing technologies, expected fuel economy improvements of vehicles and the rate at which new fuel-efficient technologies are introduced into the vehicle fleet"*.

The Directive's provisional end date may be confirmed or modified on the basis of an assessment of the various contributory factors.

4.5.2. Policy options

The Directive contains a provisional end date for 10ppm sulphur. It is necessary to confirm or modify this date and therefore no action is not an option.

The options available are:

- To confirm this current end date of 1 January 2009
- To propose an alternative date. This date could be earlier or later.

An earlier date has been requested by some stakeholders, however this option was quickly discarded because it will in practice not be possible for the proposal to complete its legislative process in the European Institutions and be transposed into national law in time to allow an earlier date.

4.5.3. Analysis of Impacts

The main implications of the change in diesel sulphur content relate to lower emissions of SO_2 and PM from all diesel engined road vehicles and higher CO_2 emissions from oil refineries. Because refineries are included in the Emission Trading Scheme, the increased CO_2 emissions will mean that a larger number of allowances will be required implying additional cost. The investment and allowance costs are likely to lead to a small increase in fuel costs which will be passed on to final consumers.

The main stakeholders that will be affected by this decision are oil refiners and fuel suppliers. Automotive manufacturers will also be affected in view of the impact of the fuel specification on the technical characteristics of the vehicles and their ability to conform with vehicle emission standards and the voluntary agreement.

Most stakeholders were supportive of confirming the end date for 1/1/2009 or of advancing the date, particularly if this would result in environmental benefits. A number suggested that an earlier end date is feasible. It was suggested that the earlier introduction has other benefits in particular enabling the use of NOx reduction technologies.

CONCAWE has recently published[13] an update of its modelling of the cost and CO_2 implications of 10ppm sulphur. This concludes that the cost and CO_2 emissions for moving from 50ppm to 10ppm diesel are approximately half of those estimated in 2000. The figures are now €3.2 billion and 1.1-1.4Mt CO_2 per year.

To provide technical background for the decision, the JRC carried out an analysis of the factors influencing the desirable end date for 10ppm sulphur in diesel. The main conclusions from this work are:

- CO_2 break-even only occurs if a sufficient number of vehicles present a sufficient energy benefit from 10ppm sulphur diesel. However, the break-even date is highly sensitive to the assumed energy benefit. Changing this from 2% to 1% moves the date from around 2010 to around 2015.

- It is very difficult to precisely foresee developments because of e.g. EURO 5 levels, fleet renewal, territorial disparities, DPF technology and regeneration strategies, impact of heavy and medium duty vehicles, impact of "real world" driving.

- Modelling already shows that the cost and GHG emissions from the refining side are lower than first thought. Continuous enhancement of refinery processes reducing the additional GHG due to 10ppm sulphur diesel production could be expected.

- Confirmation of the 2009 end date taking into account only GHG/energy aspects is not clearly demonstrable, as the GHG break-even parameter is unclear and uncertain.

- 10ppm sulphur diesel also has benefits for regulated pollutant and emission abatement.

- Low sulphur fuels are beneficial for PM reduction from pre 2005 vehicles. The fuel is also considered vital for advanced combustion engine concepts. For advanced engines with PM traps, the impact on PM reduction is much less apparent.By reducing regeneration frequency for PM traps and NOx storage traps, there may be an impact on vehicle fuel economy. One important factor not considered in JRC's modelling of impacts is the medium and heavy-duty fleet, which uses 70% of road diesel. New technologies with a potential efficiency gain are only expected after 2008. In view of the rate of fleet renewal, and the lack of data on these technologies at present, the impact of this class of vehicle was not included. However, even a small effect would be significant.

With regard to the security of supply of diesel fuel, requiring 10ppm sulphur diesel could limit the range of suppliers of diesel fuel to the EU. At present the EU imports significant volumes of diesel. Refiners of this fuel will need to carry out the necessary upgrading and investment if they wish to carry on supplying diesel to the EU. There is no reason to believe

[13] The impact of reducing sulphur to 10ppm max in European automotive fuels an update; CONCAWE 8/05.

that this investment will not be possible since the EU market for diesel is predicted to remain buoyant.

In their responses to the Euro 5 consultation stakeholders have stated the need to have 10ppm diesel fuel available for the technologies that will be required. While the date of coming into force of the new standard is not known, the possibility that this could be some time in 2009 is not unlikely.

To some degree there may be a chicken and egg situation, in that vehicle manufacturers will be reluctant to deploy technologies that need 10ppm sulphur diesel or that may be damaged by higher sulphur levels if it is not certain that this fuel will be widely available. Certainty about the end date will then enable manufacturers to make their plans for the roll out of technology appropriately.

Fuel quality monitoring shows that there has been a gradual roll out of 10ppm sulphur diesel across the EU. Monitoring data for 2004 shows that 10ppm sulphur fuel accounted for around 25% of all EU diesel sales.

Basing a decision on the 10ppm sulphur end date purely on the impact on CO_2 emissions is difficult in view of the uncertainties identified. Other environmental benefits flow from 10ppm sulphur diesel and these will be achieved regardless of the outturn of the other uncertain factors. In addition, the achieving of Euro 5 emission standards appears to be dependent on complete availability of 10ppm diesel. Since achieving the 2009 end date does not appear to present any major difficulties and will deliver environmental benefits it seems desirable to confirm this date.

4.5.4. Comparing the options

The positive and negative aspects of the options to confirm the 2009 end date and to set a later end date are set out in the table below with reference to the different stakeholders. This assessment does not consider what the later end date would be. If this latter option were favoured then a balance of the different impacts would need to be made to establish the optimal date.

	Confirm 2009	**Set later date**
Refiners	Provides certainty, in particular for investments. Fits with expectations.	Uncertainty unless a new date is fixed. New date cannot be fixed with any greater certainty than the 2009 date.
Vehicle manufacturers	Helps with vehicle emission control, eg enabling Euro 5 technologies. Will enable higher efficiency vehicles, eg through reducing trap regeneration frequency.	Greater uncertainty and difficulty for vehicle manufacturers in meeting tighter vehicle emission standards
Air Quality	Will result in lower PM emissions from all diesel vehicles. Greater benefit will flow from older vehicles so the greatest benefit will be early.	Lower PM emissions from all diesel vehicles will be delayed. As older vehicles are retired from the fleet the possibility of PM

	Through enabling Euro 5 it facilitates the next stage in vehicle emission reductions.	reductions from their emissions will be lost.
Greenhouse gases	Possible small overall increase in GHG emissions. However, this might be offset by improved HDV efficiency.	Might result in slightly lower emissions over the time period considered. However it might delay introduction of more efficient vehicle technology, thus hampering CO_2 and cars strategy and leading to higher emissions overall.
Economics	Costs are estimated to be substantially lower than originally calculated. Now around €3.2 billion	Costs unlikely to differ substantially from an end date of 2009. Technical advance could lead to cost reductions.
Local Authorities	Assists Local Authorities to meet 2010 PM targets by reducing transport PM emissions. Facilitates use of NOx traps on vehicles after phase in.	Will not assist meeting of 2010 PM targets. Will delay possible introduction of NOx traps till after the new later date.

4.5.5. Preferred Option

Article 9(1)(a) requests that the decision on the end date should be based on ensuring that there is no overall increase in GHG emissions. As described, this cannot be established with certainty. The analysis based on light duty vehicles indicates that the break even point for GHG emissions might be later than 2009. However, this does not take account of any possible energy saving from Heavy Duty Vehicles. Even if there was a small benefit for HDVs, in view of their large share of the fuel used, this could have a significant impact on the aggregate GHG emissions.

However, it is equally the case that there are no clear benefits in any of the areas considered from delaying the end date of 10ppm sulphur diesel beyond 2009. The only possible benefit is that there might be a slight GHG saving from doing so, but as noted this is uncertain.

A confirmation of the 2009 end date will deliver immediate air quality benefits from all diesel road vehicles and provide assurance to vehicle manufacturers about the future fuel that will be provided to vehicles, thus enabling them to roll out new technologies requiring it. Complete coverage of 10ppm diesel also facilitates the achievement of the Euro 5 emission limits. Although it is not possible to base a definitive conclusion on the greenhouse gas emissions alone, in view of these other identifiable benefits and the substantial progress that has been made so far, it appears desirable to conclude that the end date for 10ppm sulphur in diesel should be confirmed as 1 January 2009.

4.6. Review of Directive 99/96

4.6.1. The problem

Directive 1999/96/EC amending Directive 88/77/EEC established emission limits for Heavy Duty Vehicles (Euro IV from 1 October 2005 and Euro V from 1 October 2008). This Directive has been recast as Directive 2005/55/EC and Commission Directive 2005/78.

Directive 98/70 requested that the Commission consider "*the outcome of the review required by Article 7 of Directive 1999/96/EC on the approximation of the laws of the Member States relating to measures to be taken against the emission of gaseous and particulate pollutants from compression ignition engines for use in vehicles, and the emission of gaseous pollutants from positive ignition engines fuelled with natural gas or liquefied petroleum gas for use in vehicles and amending Council Directive 88/77/EEC and the confirmation of the mandatory NOx emission standard for heavy duty engines*".

Directive 98/70 does not contain specifications for natural gas or LPG. The possibility of establishing specifications for these fuels is discussed in section 4.3.

The review required by Art.7 of Directive 1999/96/EC has been carried out in connection with the recasting of Directive 88/77/EEC.Following this the Commission is currently working on the preparation of a further Euro VI stage for HDV emissions that will further tighten the limit values.

Stakeholders have been asked in advance of the preparation of the Euro VI proposal by the Commission, by means of a questionnaire what fuel quality would be required for different limit value scenarios. A draft summary of the responses is available. No proposal for a Euro VI standard has yet been agreed and therefore the precise requirement for the fuel cannot yet be inferred. Nevertheless, there are indications that fuel composition will not need to be altered to comply with any likely change in emission requirements for HDVs.

During the course of the discussions with stakeholders for the review of the Fuel Quality Directive, none have expressed any views on fuel quality in relation to further tightening of HDV emission standards.

4.6.2. Policy options

No action appears to be the only option.

4.6.3. Preferred option

There should be no change to the diesel specification in response to the review of HDV emission limits.

4.7. Review of CO_2 and cars voluntary agreement

4.7.1. The problem

There might be a need to make amendments to the fuel specifications in Directive 98/70, other than the sulphur content of diesel, in view of the need to facilitate further reduction in CO_2 emissions from passenger cars in line with the voluntary agreements with the car manufacturers. In view of this the Commission is requested to consider *"the outcome of the review of the various commitments by the Japanese (JAMA), Korean (KAMA) and European (ACEA) automobile manufacturers to reduce the fuel consumption and carbon dioxide emissions of new passenger cars in the light of the fuel quality changes introduced by this Directive and progress towards the Community target of 120 g/km CO_2 emissions for the average vehicle*".

Stakeholders have not expressly requested any modification to the fuel specification in relation to the current CO_2 and cars voluntary commitments. In particular, ACEA and JAMA carried out jointly with the European Commission as part of the monitoring of their commitments a review[14] of the situation up to 2003 included. Both associations expressed general satisfaction with the fuel qualities provided during the review period. KAMA carried out the same review exercise covering the commitment period up to 2004, and signalled a general satisfaction similar to the other two associations.

The review of the Community strategy on CO_2 and cars to move beyond the current commitments towards the Community objective of 120 g CO_2/km has been completed and the Commission has published a Communication. There is no indication from the analysis that has been carried out that fuel specification changes are required to enable further progress in improving the efficiency of light duty vehicles.

4.7.2. Policy options

No action appears to be the only option to be considered.

4.7.3. Analysis of impacts

It is conceivable that certain engine designs might require a tighter or different specification fuel for optimal operation. There could be an interest in introducing a new engine design to achieve a higher combustion efficiency, for example the introduction of 10ppm sulphur petrol was driven by the desirability of introducing more efficient direct injection petrol engines.

As noted there have been no specific requests for fuel specification changes related to CO_2 emissions or engine efficiency in either the process of reviewing the voluntary agreements or reviewing Directive 98/70. However, it cannot be ruled out that ongoing research could in the future identify new fuel requirements, for example in relation to HCCI technology.

4.7.4. Preferred option

With the exception of diesel sulphur content discussed in section 4.5, the fuel specifications do not need to be adjusted to enable vehicle manufacturers' compliance with the current

[14] SEC(2005) 826, 22.6.2005.

voluntary commitments on CO_2 and cars, nor with further foreseeable progress in vehicle efficiency beyond these commitments and towards the Community objective of 120 g CO_2/km.

4.8. Review of Directive 1999/30

4.8.1. The problem

Article 9, paragraph 1 (c) of Directive 98/70 requests consideration of "the outcome of the review described in Article 10 of Council Directive 1999/30/EC relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air".

Directive 1999/30/EC relates to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. That Directive contained a requirement for a review, in particular with respect to limit values. This review took place as part of the Clean Air For Europe (CAFE programme) which has led to the Communication on a Thematic strategy on air pollution[15].

Underpinning this work is the CAFE baseline[16]. This was established to indicate the nature and extent of air quality problems. Part of the work illustrates which Member States would have difficulties meeting the requirements of the National Emission Ceiling Directive. The baseline shows that for NOx, ten Member States are projected to fail to meet the limits for 2010. These are Austria, Belgium, Denmark, France, Germany, Ireland, Luxembourg, Netherlands, Spain and Sweden. In 2000, 60% of NOx emissions were estimated to come from mobile sources.

The Thematic Strategy recommended that:

- there should be no change to existing air quality limit values;
- new standards and objectives should be established for fine particulate matter ($PM_{2.5}$);
- vehicle standards should address $PM_{2.5}$ emissions and NOx from diesel cars and vans.

Sulphur dioxide and lead pollutant emissions are no longer a major source of concern from road transport. The question of the sulphur content of diesel, which is primarily of concern because of its effects on engine and after-treatment systems is addressed in section 4.7 of this Impact Assessment. Therefore for the foreseeable future, the main challenges from road transport for air quality attainment will be NOx and PM emissions.

It had been planned to prepare a questionnaire based on the outcome of the replies to the EURO 5 questionnaire and circulate it to Member States and stakeholders concerning whether fuel parameters needed to be modified. However, the replies to the Euro 5 questionnaire contained no requests for a review of fuel parameters other than sulphur and it was decided to wait for inputs from stakeholders.

CONCAWE has stated that data showing the influence of fuel quality on emissions of advanced vehicles is very limited. Diesel vehicles equipped with particulate traps are insensitive to fuel quality as far as particulate emissions are concerned. Sulphur is the only parameter that seems to still have a significant influence on particulate emissions, especially

15 COM(2005) 446.

16 http://ec.europa.eu/environment/air/cafe/activities/pdf/cafe_scenario_report_1.pdf

in terms of particle numbers, and this aspect is discussed in section 4.7. NOx emissions are typically dependent on engine parameters and are affected to a limited extent by fuel quality. CONCAWE therefore believes that further modification of the fuel specifications would not lead to significant environmental benefits.

ACEA has presented some data showing the role fuel can play in reducing emissions. However, the fuels referred to were produced with processes such as gas to liquid (Fischer-Tropsch) conversion. Fischer-Tropsch diesel is currently only available in small quantities. In the long term they might play a more significant role, particularly as an advanced biofuel. ACEA asked for the introduction of Class 4 fuel specifications outlined in the WWFC discussed in section 4.1.

A number of stakeholders stated that any change to the fuel specifications should not lead to any deterioration in environmental performance.

Other stakeholders have stated that there are no requirements leading to a need for a change of any of the fuel parameters.

4.8.1.1. Lead

There is no need for any further action since the use of lead is prohibited in petrol except for specialist old vehicles. This aspect is therefore not considered further.

4.8.1.2. Sulphur

The dates for achieving 10ppm have recently been fixed and confirmation of the end date for 10ppm sulphur diesel is considered in section 4.7. This aspect is therefore not considered further here.

4.8.1.3. NOx

NOx is formed as a product of combustion due to the presence of nitrogen and oxygen in air. Higher combustion temperatures lead to increased NOx emissions. Issues associated with the effect of ethanol on NOx emissions are discussed in section 4.14.

For petrol engined vehicles NOx emissions are mainly controlled with three way catalysts. Aromatic content is reported by CONCAWE to be the main petrol parameter affecting NOx emissions although the effect is complex and it is unclear that any change in this parameter would result in lower emissions.

For diesel, the WWFC claims that reducing total aromatics content leads to lower NOx emissions. ACEA reports that a lower T95 leads to lower NOx emissions for HDVs but an increase for LDVs. However NOx emissions are typically affected to a very limited extent by fuel quality and mainly depend on engine parameters like injection advance. EPEFE tests showed a wider variation in NOx emissions between engines than changes caused by fuel quality.

These various factors point to the desirability of tighter engine emission controls as the way to further reduce NOx emissions rather than changes to the fuel specification. In this context, the WWFC reports tests on NOx conversion technologies that indicate that when these technologies are in use there may be benefit for such technologies to reduce sulphur levels below 10ppm.

4.8.1.4. Particulate matter

Particulate matter emissions from combustion engines arise either from incomplete combustion or secondary formation from sulphates. The main drivers of PM emissions related to fuel quality are density, sulphur content and PAH content. WWFC reports that a larger proportion of heavy components appears linked to PM emissions.Lower T95 is reported to lower LDV PM emissions.

4.8.2. Policy options

The outcome of the review implies a need to ensure that any changes do not lead to increasing NOx or PM emissions. Previous publications have provided some information on the linkage between different fuel parameters and these pollutant emissions. For petrol CONCAWE states in the conclusions of a report[17] that:

- A reduction in fuel volatility, representing the combined effects of vapour pressure, E70 (38% v/v to 22% v/v) and E100, had no consistent effect on NOx emissions, increased HC across all vehicle technologies (10%), but decreased CO emissions in two cars.

- A reduction in FBP from 197ºC to 176ºC increased NOx emissions in one car but had no significant effect in the others. HC emissions were directionally reduced (9%) and CO emissions directionally increased (20%), with significant effects in both cases in two cars.

- A reduction in aromatics content from 38% v/v to 26% v/v showed conflicting effects, increasing NOx emissions in two cars, decreasing in the others, but the effects were significant only in one vehicle. Reducing aromatics increased HC emissions in the two lean DI cars but showed the opposite effect in the MPI car.

- A reduction in olefins content from 14% v/v to 5% v/v gave no significant improvement in NOx, HC or CO emissions in any of the cars.

- The stoichiometric and lean DI vehicles showed a similar response in PM emissions to changes in fuel quality. Lowering FBP and lowering olefins content gave a reduction in PM emissions whereas lowering aromatics and volatility showed no significant benefits. PM emissions from the advanced MPI car, which is more representative of the current fleet, were very low on all fuels tested and insensitive to fuel changes.

In a further paper[18]on PM emissions CONCAWE states in the conclusions that for diesel:

- In the advanced engine technologies, fuel effects other than sulphur on particulate emissions were small in absolute terms.

while for petrol it is stated that:

- There was no clear short-term effect of gasoline sulphur content on the particulate emissions from direct-injection gasoline vehicles.

---

17 Report 2/04; Fuel effects on emissions from modern gasoline vehicles part 2 - aromatics, olefins and volatility effects.

18 Report 1/05; Fuel effects on the characteristics of particle emissions from advanced engines and vehicles.

The WWFC links sulphur, metallic additives and detergents parameters in petrol to NOx emissions. The latter two parameters are addressed in sections 4.12 and 4.11 respectively. For diesel the WWFC refers to cetane, aromatics, density and sulphur, while PM emissions are linked to polyaromatics, density and sulphur. The density and sulphur parameters are addressed in section 4.13 and 4.7 of this Impact Assessment respectively.

4.8.3. Analysis of impacts

Most stakeholders have not indicated any desire for the fuel specifications related to these pollutants to be modified for environmental or health reasons.

CONCAWE has provided experimental evidence which does not appear to provide convincing evidence of benefit from changing the fuel parameters tested.

4.8.3.1. PM

For particulate matter there is a difference of opinion between the main stakeholders. CONCAWE believes that beyond 10ppm sulphur, fuel parameters have little effect on PM emissions when a particulate trap is employed. On this assumption the rate at which non trap equipped vehicles are phased out would determine whether or not there is justification for action on any other parameter that could affect PM emissions.

The increasing availability of 10ppm sulphur will lead to lower PM emissions, particularly from older vehicles. Tighter vehicle emission limits are likely to lead to the use of more sophisticated emission control equipment which will reduce the impact of most fuel parameters on PM emissions.

4.8.3.2. NOx

In particular with a view to reaching ambient air limit values for NO_2 in the future, further tightening of vehicle NOx emission requirements is being considered. However, there does not appear to be convincing evidence that adjusting any fuel parameter would conclusively achieve this.

Further evidence would need to be presented on the costs and benefits of the change and a comparison with equivalent costs and benefits from a change in vehicles.

4.8.4. Comparing the options

The evidence does not appear to point clearly in the direction of any particular characteristic of either petrol or diesel that could be changed to further reduce PM or NOx emissions.

4.8.5. Preferred action

It is clear that for lead, no further action is required. For sulphur, no further action is required beyond a final decision on the end date for 10ppm diesel discussed in section 4.7.

For PM, the fuel characteristics should not be modified in a direction that drives PM emissions eg by increasing density. However, there is currently an absence of convincing evidence of further changes in the fuel specification that would reduce PM emissions, or that this would provide the most cost effective approach.

For NOx, the fuel characteristics should not be modified in a direction that leads to increased NOx emissions. There is currently an absence of convincing evidence of further changes in the fuel specification that would reduce NOx emissions, or that this would provide the most cost effective approach.

4.9. Polycyclic Aromatic Hydrocarbons

4.9.1. The problem

Article 9, paragraph 1 (b) requests the Commission to consider "the implications of new Community legislation setting air quality standards for substances such as polycyclic aromatic hydrocarbons".

Certain Polycyclic Aromatic Hydrocarbons (PAHs) such as benzo(a)pyrene (BaP) are considered to be carcinogenic. PAHs are known to be emitted in vehicle exhausts and a maximum limit of 11% PAH in diesel fuel is established by Directive 98/70 annex IV.

In its 2001 proposal to amend Directive 98/70, the Commission stated in paragraph 5.1.1

There has been concern over human exposure to Poly Aromatic Hydrocarbons PAHs) in air. Diesel vehicle exhaust is known to contain PAHs and attention has focussed, therefore, on the levels of PAHs in diesel fuel. The relationship between the PAHs in diesel fuel and in the exhaust gases was not studied in the EPEFE programme. However, a review of the available literature regarding fuel quality and PAH emissions has been published by CONCAWE. Several studies have demonstrated that PAHs are formed during the combustion process ("pyrosynthesis").

Emissions testing in heavy-duty engines showed that fuels containing low levels of PAHs produced similar emissions of PAHs compared to high PAH containing fuels when other fuel parameters were left unchanged. Other studies comparing a reference diesel fuel (based upon EN 590) and a Swedish Class I diesel fuel have shown apparently larger contributions from fuel-borne PAHs based upon the total mass of PAHs emitted. However, fuel parameters other than the PAH content were also changed significantly. The CONCAWE report also describes the positive impact of after treatment technologies. These can reduce the emissions of PAHs from diesel engines by between 60-80% even with fuels containing 0.05% sulphur.

The proposal also noted that it was estimated that road transport would in 2010 contribute less than 10% of total PAH emissions.

In the Commission's position paper on PAH[19] it was stated that: *New vehicle emissions regulation ('EURO IV') will, in time, further reduce particulate emissions too; this will result in further PAH reductions. The effect of these measures is hard to predict.*

The fourth daughter Directive[20] addressing the ambient air quality related to PAH has recently been adopted. Since the proposal for this Directive was under discussion during the CAFE process, it was not felt necessary to consider this issue further within CAFE which instead focussed to a large extent on PM and ozone. The Directive sets an air quality target for BaP and requires monitoring of a number of other PAHs. The Communication on a Thematic Strategy on air pollution does not make specific reference to PAH emissions.

The Directive requires monitoring of PAH concentration and deposition and sets a target value for BaP to be attained where possible from 2012 on. The Directive itself comes into

---

19 PAH Position Paper; 27 July 2001; http://ec.europa.eu/environment/air/pdf/pp_pah.pdf

20 Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air

force in 2007 and is due to be reviewed in 2010. In the absence of consistent Community-wide information on PAH concentrations it is unclear whether there is a need for any specific action in the vehicle sector to reduce PAH emissions. However emissions from this sector could contribute to the exceedance of limit values in conurbations. Efforts to reduce vehicle PM emissions will also help to reduce PAH emissions. In this context, the current discussions about Euro 5 and the likely future proposal for Euro VI will influence the future PAH concentrations.

In the context of the stakeholder discussions on the review of Directive 98/70, ACEA has requested a lowering of diesel PAH content. In the current draft of the World Wide Fuel Charter (WWFC), for category 4 fuel, which is intended for use where advanced emission control equipment is in use, a maximum PAH content of 2% is requested. ACEA claim that EU diesel fuel samples show a PAH range of between 2.9% and 6.3%. In contrast EUROPIA state that PAH content does not need to be further lowered because vehicle emission control equipment has a higher effect on PAH emissions than the PAH content of the fuel.

4.9.2. Policy options

The options available are:

- No action
- Tighter limits on PAH in fuels.

The control of vehicle PAH emissions can through exhaust after treatment has not been a subject of this Impact Assessment. Tighter exhaust emission limits are currently under development.

4.9.3. Analysis of impacts

In view of the fact that Directive 2004/107 has only recently been adopted, there is little information available on levels of exposure to PAH. Once this Directive has been in operation for a while there will be more information available on general exposure levels as well as on the need for action on specific sources.

Nevertheless, it is clear that ambient air concentrations of PAH such as BaP in urban areas are affected by traffic emissions and this could lead to problems in achieving the BaP target value. If it is desirable to reduce road transport PAH emissions, it is not clear whether this is better achieved through action on fuel composition or vehicle technology. It is likely that the proposed Euro 5 standard for cars and vans will lead to the fitting of particulate traps to most new cars and vans sold in the EU. This is likely to lead to reductions in PAH emissions.

ACEA requested in stakeholder discussions, the use of the specification referred to as "class 4 fuels" in the WWFC.In the WWFC it is claimed that reducing fuel PAH content reduces engine PM emissions. The WWFC provides some information on fuel PAH effects on PAH emissions indicating a linkage between the two. However, no overall analysis was presented of the environmental benefits that would result from a change in the fuel PAH specification, nor a cost-benefit analysis.

Most stakeholders other than the fuel supply industry did not express any views in relation to PAH content.

CONCAWE has recently reported21 on the results of a series of tests on PAH emissions from petrol and diesel engined vehicles. CONCAWE's main conclusions from this work are:

"*Older diesel vehicles showed relatively high exhaust PAH emissions, which increased linearly with higher diesel fuel poly-aromatics content. However, reducing diesel fuel poly-aromatics, even to zero, would not eliminate exhaust PAH emissions, as a significant proportion is combustion derived.*

Gasoline vehicles with three-way catalysts or other advanced exhaust after-treatment showed very low PAH emissions compared to the older diesel vehicles. Advanced diesel vehicles with state-of-the-art exhaust after-treatment systems showed very low PAH emissions, close to or below the gasoline vehicles. In these advanced diesel vehicles PAH emissions were so low that there was no longer any sensitivity to diesel fuel aromatics content.

Overall, it is clear that advanced exhaust after-treatment systems, which are being implemented for the control of total hydrocarbon and particulate emissions, are also effective in controlling PAH emissions."

CONCAWE also claims in a recent paper[22] on the implications for the refining industry of tighter PAH specifications that:

"Depending on the specification level envisaged, reduction of the PAH content of diesel fuel would require between investment of 0.8 G€ at the 6% m/m level and nearly 9 G€ at 1% m/m. The majority of the capex would be for new hydrodearomatisation plants and hydrogen production plants."

This paper also shows that maximum PAH content could be reduced to 8% at the same time as sulphur content is reduced to 10ppm at no additional cost.

CONCAWE's work appears to show that even reducing fuel aromatics to zero would not eliminate PAH exhaust emissions and there is a large body of evidence supporting this conclusion. The mechanisms through which PAHs may occur in exhaust gas can be summarised as follows:

a) **Survival of fuel PAH during combustion**: some of the PAH present in the fuel will not be combusted and be emitted as part of the unburnt hydrocarbons. The survival rate depends on each PAH, on engine design, test cycle and other engine and fuel parameters.

b) **Creation of PAH during combustion:** experimental and theoretical work indicates that PAHs may be formed during the combustion process by pyrosynthesis from non-PAH, including non-aromatic, fuel components. In view of the amount of carbonaceous soot in exhausts (all formed by pyrosynthesis), a substantial fraction of exhaust PAH could be created by this mechanism.

c) **Transformation of one PAH into another:** this mechanism is somewhere between survival and creation and is very difficult to quantify experimentally, but undoubtedly occurs.

---

21 CONCAWE 4/05 of June 2005; Evaluation of automotive polycyclic aromatic hydrocarbon emissions

22 Concawe 7/05; Impact of a potential reduction of the polyaromatics content of diesel fuel on the EU refining industry

d) **Contributions from the lubricating oil:** lubricating oil may act either as a net source or sink for exhaust PAH. In general fresh lubricating oil tends to act as a sink while it tends to become a source when aged.

These different mechanisms easily explain why even fuels containing no PAH, such as neat biodiesel, have PAH in their exhaust emissions of. CONCAWE argues that further progress will instead be made through tighter emission control requirements on vehicles.

Comparing the options

	No Action	**Reduced PAH content**
Effect on PAH emissions	No change for individual vehicles. Overall fleet emissions will continue declining as older vehicles are removed from the fleet.	Reduced PM and PAH emissions. [ACEA] Limited effect on exhaust PAH emissions. Larger effect on older vehicles, negligible effect for modern vehicles. [CONCAWE]
Costs to fuel suppliers	None	Reported by CONCAWE as No change for 8% PAH when 10ppm diesel introduced 0.8 G€ for 6% PAH 9 G€ at 1% PAH
Costs to vehicle manufacturers	None	Either none or a small reduction if as claimed reduced PAH makes meeting vehicle emission limits easier.

In the light of the limited evidence about the costs arising from vehicle PAH emissions, it is difficult to place a value on the benefit arising from a reduction in PAH emissions. It is clear that the value of the benefits will reduce over time as current older vehicles are phased out of the fleet. If it is assumed that there is no reduction in PAH emissions from Euro 4 vehicles or later, then the benefit from these older vehicles will have largely ceased beyond 2010.

There does not appear to be sufficient knowledge on PAH concentrations in ambient air to make a convincing case for measures to reduce vehicle PAH emissions. As has been clearly demonstrated, if such action is desirable, it may not be achieved through further reduction in fuel PAH content. Whether specific action is needed on fuels or vehicles may be appropriate for consideration within the review of Directive 2004/107 foreseen for 2010. In any case, it appears that the overall situation will improve even if no further action on fuel PAH content is taken.

Despite the uncertainty as to whether there would be an environmental benefit, it appears that a reduction in the maximum PAH level to 8% can be achieved at the same time as the introduction of the 10ppm limit on sulphur in diesel at no cost.

4.9.4. Preferred action

On the evidence available there does not appear to be a case on environmental grounds for a change to the maximum diesel PAH content. Nevertheless, a reduction in maximum PAH content to 8% in parallel with the introduction of 10ppm sulphur is reported to be achievable at no cost and might deliver benefit to vehicle manufacturers through reducing maximum fuel variability.

4.10. Non-road mobile machinery

4.10.1. The problem

Non-Road Mobile Machinery (NRMM) consumes some 9% of diesel fuel, equivalent to around 25 M tonnes per year. NRMM is responsible for a higher proportion of total pollutant emissions than implied by its fuel consumption because of the limited regulation of their emissions. This is illustrated by the CAFE baseline[23] which shows that off road machinery accounted in 2000 for 15% of NOx emissions (total 11.5MT) and 12% of PM2.5 emissions (212kT). In 2010 when any changes to this Directive would be effective, off-road machinery emissions are predicted to be 13.5 MT NOx and 140kT PM.

In its proposal that led to the 2003 revision of Directive 98/70 the Commission noted that the sulphur content of non-road fuel would in the longer term need to be modified to allow more stringent engine emission standards. As a result Article 9, paragraph 2 of Directive 98/70 requests that "*When considering its proposal for the next stage of emission standards for compression ignition engines in non-road applications, the Commission shall establish in parallel the required fuel quality. In so doing, the Commission shall take into account the importance of the emissions from this sector, the overall environmental and health benefits, the implications in the Member States regarding fuel distribution and the costs and benefits of a more restrictive sulphur level than is currently required for fuel used in compression ignition engines in non-road applications, and shall then align appropriate fuel quality requirements for non-road applications with the on-road sector by a certain date, currently expected to be 1 January 2009, to be confirmed or amended by the Commission in its review in 2005* ".

The current requirement is set out in Article 4, paragraph 5 of Directive 98/70, which states that "*Member States shall ensure that gas oils intended for use by non-road mobile machinery and agricultural and forestry tractors marketed within their territory contain less than 2,000 mg/kg of sulphur. By 1 January 2008 at the latest, the maximum permissible sulphur content of gas oils intended for use by non-road mobile machinery and agricultural and forestry tractors shall be 1,000 mg/kg. However, Member States may require a lower limit or the same sulphur content for diesel fuels stipulated in this Directive*."

Subsequently, Directive 2004/26 was adopted, establishing emission requirements for type approval of NRMM. In particular from 31/12/2009, new machinery meeting Stage IIIB requirements should only emit 0.025g/kwh particulate matter. This requirement is gradually introduced for different sectors. The reference fuel for stage IIIA type approval has a 300ppm sulphur content while that for stage IIIB and stage IV has a 10ppm sulphur content. The enhanced emission control equipment required to meet the more advanced specifications requires better quality fuel, particularly in relation to the sulphur content which can lead to deterioration of emission control equipment. To enable Stage IIIB emission levels, and to ensure that real world emissions reflect certified levels, a fuel with a sulphur content of 10-50ppm is required.

The same Directive also regulates emissions from inland waterway vessels. For these, the Stage IIIA requirements come into force from 31 December 2006 for smaller engines and 31 December 2008 for larger engines. The reference fuel used for type approving these engines

[23] Baseline Scenarios for the Clean Air for Europe (CAFE) Programme; IIASA; February 2005

against emission limits is also 300ppm sulphur. Further emission limits beyond Stage IIIA are subject to a technical review.

In some Member States, the specification for non-road fuel is more stringent than that set in Directive 98/70. This doesn't appear to have led to any problems with higher priced fuel. It means that an assessment of the costs and benefits of changes to the fuel specification in the Directive based on the whole NRMM fuel market will over estimate both of these. Nevertheless, such an approach is not misleading since it will only affect the magnitude of the impacts not whether they are overall positive or negative.

A further factor to be taken into consideration is the potential use of non-road diesel in road vehicles. In most Member States the fuel for road and non-road applications is differently taxed. This makes it financially attractive, but illegal, to use non-road fuel in road vehicles. While it is for Member States to put in place the appropriate controls to ensure that fuels are used for their correct applications, the possible misuse of non-road diesel in road vehicles poses a threat of increased pollutant emissions from these vehicles due to its different composition.

In addition to the references in Directive 98/70 to fuel for non road applications, Directive 99/32 as amended by directive 2005/33 also makes explicit reference to the fuel to be used by inland waterway vessels. While the limits specified in both Directives are the same, a modification of Directive 98/70 will result in an inconsistency between them.

4.10.2. Policy options

The options available in respect of fuel used by NRMM are:

- No action.
- Adjustment of only the sulphur content.
- Adjustment of other fuel parameters in addition to the sulphur content.

If it is decided to change the parameters then this decision requires assessment of:

- The appropriate level of sulphur content (and other parameters)
- Whether there should be phased changes or one step.
- Timing of changes.

The option of no action can be rapidly excluded from consideration because without action on sulphur content it is not possible for engine manufacturers to comply with the requirements of Directive 2004/26.

4.10.3. Analysis of impacts

Changes to the fuel specification for NRMM will have impacts on air pollutant emissions from NRMM, Greenhouse Gas emissions from oil refineries and NRMM, the ease of introducing new technologies to comply with NRMM emission requirements and costs for the different sectors affected.

To achieve sulphur levels under 500ppm diesel components must be desulphurised. Removing sulphur from fuel reduces the exhaust emissions of sulphur dioxide and particulates. It also enables the use of after treatment technologies that are used to reduce NOx and Particulate emissions. It is already assumed, following the adoption of Directive 2004/26, that the environmental and health benefits of reducing air pollutant emissions from this equipment will be achieved. The impacts that must be assessed are therefore in addition to these. As a minimum, the fuel assessed must be capable of enabling the machinery to operate satisfactorily to meet the legislated emission requirements.

Directive 2004/26 is expected to result in a greater alignment of world wide NRMM emission limits facilitating a global NRMM market. Provided the fuel supplied is adequate to enable the equipment to operate in the EU it is not considered that there is any additional benefit, within or outside the EU in this respect, since any benefits will have been taken account of in the assessment of that Directive.

Major uncertainties relate to the impact of fuel characteristics on the performance of the machinery, in particular the rate of degradation of after-treatment equipment. There is also uncertainty about the air pollutant benefits that could arise from aligning other elements of the NRMM fuel specification with road fuel.

There is unlikely to be any variation in the impact between social groups. Since minimum emission performance limits are specified in Directive 2004/26, it is these that will determine the overall level of air pollutant emissions from NRMM and thereby its impact on citizens.

The major economic sectors that will be affected are manufacturers of NRMM equipment, users and fuel suppliers. NRMM manufacturers may be impacted through the ease of compliance with the emission requirements, for example through which technology may be employed, as well as through reliability in use and possible warranty claims. Users could be impacted through higher costs for NRMM and the fuel that it requires as well as by any change in the fuel consumption of the machinery. Refiners will need to make investments to comply with the fuel requirements, however they will recover the additional costs through the price charged for the fuel. There may also be impacts on fuel distribution logistics.

The main potential obstacle foreseen to compliance is the time required for any necessary investment by refineries to further reduce sulphur content. In addition a number of challenges may need to be addressed, for example by Member States in relation to the methods employed to ensure that non-road fuel is not used for road applications. It will also be of vital importance to ensure that heating oils are not used in future for NRMM because of the damage this could cause to their after-treatment systems. Responsibility for communicating this to users would primarily rest with equipment manufacturers and retailers although fuel suppliers could also play a useful role. There could also be a need to modify distribution and storage arrangements in view of the divergence of the fuel specification from that of heating oil if the NRMM specification is changed.

The assessment is carried out on the assumption that all non-road mobile fuel currently has a higher sulphur content than 50ppm. Therefore the calculations are performed for the whole non-road fuel volume. This assumption is not correct since in some parts of the EU, non-road fuel already has a maximum of 10ppm sulphur. This only affects the magnitude of the costs and benefits but does not affect whether they are overall positive or negative.

4.10.3.1.Directive 2004/26

In the explanatory memorandum of the Commission's proposal that led to this Directive it was stated:

Today about 9% of gas oil consumption is for non-road purposes - if inland waterways are included. About 50% is used for the on-road sector and about 40% as heating oil. At European level, there is no separate non-road diesel quality, and with a market share of less than 10% this situation is unlikely to change in the future. At national level, special fuel qualities might well be made available.

...

Given the above conclusions on limit values, we will in the future have a situation where the Stage III A limit values for gaseous pollutants can be met by using heating oil. However, to meet the Stage III B PM limit values, a fuel with a maximum of 10-50 ppm sulphur must be used. Thus, it is necessary to ensure that low-sulphur fuel is used once the PM limit values enter into force or in Member States that want to encourage earlier implementation of those limit values.

The Commission proposal included an assessment of the costs of the tighter emission requirements and included in this an assessment of supplying fuel with the tighter specification. It concluded that the overall benefits of the package proposed for the NRMM engines shows that the benefits per engine are about 75 Euro higher than the costs.

It is therefore clear that the sulphur parameter of NRMM diesel fuel does need to be tightened to the level required for correct operation of NRMM emission control equipment in time for that equipment to be placed on the market.

Land based NRMM

Through the decision to implement tighter NRMM emission requirements requiring a tighter fuel specification, the Community has already determined the need to modify the requirements in Directive 98/70 for NRMM fuel. The economic assessment of the proposal on NRMM equipment emissions included the estimated costs of the changes to the fuel specification. As discussed in section 4.5 on the introduction of 10ppm sulphur in road diesel, recent evidence shows that the costs and CO_2 emissions resulting from lowering diesel sulphur content are around half those that were previously foreseen when considering the end date for 10ppm road diesel. This implies that the benefits for NRMM engines will now exceed the costs by more than 75 Euro per engine.

According to information provided by CECE, CEMA and Euromot, the technologies foreseen by the NRMM manufacturers for Stage IIIB are:

C-EGR = Cooled Exhaust Gas Recirculation

SCR = Selective Catalytic Reduction

DPF = Diesel Particulate Filter

NOx adsorber.

The manufacturers state that in view of the complexity of NOx adsorber, the probability that such a technology is used with stage IIIB is very low. SCR and cooled EGR can easily cope with a sulphur fuel content of 50 ppm without significant adverse effects.

It is claimed by EUROMOT that a significant proportion of equipment manufacturers will use DPF technology to achieve Stage IIIB emissions. This is surprising in view of the fact that Stage IIIB is comparable to HDV Euro 5 (2008) emission limits and DPFs are not foreseen to achieve those limits. If DPFs would be used, manufacturers argue that 50ppm sulphur fuel could shorten their lives, increase customer downtime and operating costs such that larger, more cumbersome systems would be required with the risk of manufacturers' development time going beyond the Stage IIIB introduction date.

Impact on cost

As discussed in section 4.5 on the introduction of 10ppm sulphur in diesel, recent evidence shows that the costs resulting from lowering road diesel sulphur content from 50 to 10ppm are approximately half of those estimated in 2000. This NPV cost is now estimated at €3.2 billion for 140MT of diesel. Assuming that the cost impact would be comparable for NRMM diesel, this would be 570M€ for 25MT of fuel per year.

Set against these investment costs are the benefits of reduced fuel consumption, greater reliability and longer life for the equipment. Estimates for this have been provided by Euromot and EMA[24]. It is estimated that for 130-560kW stage IIIB engines, fuel consumption will be 1.5% higher with 50ppm sulphur and after treatment will have a 25% shorter life. The paper estimates that these equate to additional fuel costs of 35M€ per year and additional servicing costs of 20M€ per year. If manufacturers were to develop machines, specifically designed for 50 ppm fuel, the development costs are estimated to be some 160M€.

Year after Stage IIIB introduced	**1**	**2**	**3**
Investment cost (M€) for 10ppm sulphur	**570**		
Development cost (M€) avoided	-160		
Servicing cost (M€) avoided	-60	-60	-60
Fuel cost (M€) avoided	-105	-105	-105
Aggregate cost change(M€)	245	80	-85

It can be seen that the additional investment cost will approximately be offset by reduced costs after 3 years. In addition, there is an unquantified cost due to logistic challenges if a separate grade for only non-road equipment is established. Fuel suppliers have not provided any cost information but have indicated that these costs might result in suppliers choosing to supply 10ppm sulphur fuel in any case. This cost would make the case for setting a 10ppm sulphur limit stronger.

Impact on air pollutant emissions

24 Review of 98/70/EC – Fuel for nonroad mobile machinery, Jooint Euromot – EMA position; 18 October 2006

Reducing the sulphur content of NRMM fuel can be expected to reduce PM emissions. In part this will be because of changes to combustion and in part because their will be a smaller sulphate proportion in the exhaust.

With regard to the sulphate fraction, the beneficial effect of lower sulphur content is illustrated by a US study[25] assessing the implications of different sulphur contents on the effectiveness of DPFs. This showed a significant reduction in PM post-DPF when sulphur levels were lowered from 30 to 3 ppm. There was a 95% reduction efficiency with 3ppm compared to 75% for 30ppm. The major reason for the reduction was due to the reduced levels of hydrated sulphuric acid in the exhaust. This reduction implies around a 0.01g/kw/hr reduction in emitted PM with 10ppm compared to 30ppm sulphur.

CONCAWE in a report[26] on the effect of fuel sulphur content shows that for Euro 4 and 5 Heavy Duty engines, a reduction of sulphur content from 38 to 8 ppm appears to have a small absolute impact on engine-out PM emissions. The report states "In the D2-D4 sulphur fuel series, the PM results are broadly consistent with the changes expected for a sulphate conversion factor in the range of 1-2%, which has been the recognised conversion factor for older (Euro-1 and Euro-2) engines. From these tests, there is no evidence of substantially higher sulphate conversions with these more advanced heavy-duty engine technologies."

Since it is assumed that a maximum sulphur content of 50ppm is required to enable correct operation of Stage IIIB equipment, the following analysis only compares 50ppm sulphur with a lower sulphur content.

The Commission's assessment[27] of the costs and benefits of reducing road diesel sulphur from 50 to 10ppm estimated that this change would reduce PM emissions by 5%. There was no effect on NOx, CO or HC emissions. In an earlier assessment[28], the Commission concluded that the rate of PM reduction in HDV exhaust decreased by 0.87% per 100ppm reduction in sulphur content over the range of 2000 to 500ppm. If it is assumed that this reduction continues linearly to 50 ppm, then the approx 140kT emitted in 2010 would be reduced by 17% to 116kT per year. A further reduction to 10 ppm would then result in a further 6kT PM avoided. Based upon the lower value for PM used in the CAFE assessment of marginal damage costs[29] this results in a damage saving of 156 M€.

Impact on Greenhouse Gas emissions

There will be two main impacts on Greenhouse Gas emissions; the increase in emissions required at refineries to remove sulphur from the fuel and a decrease in emissions from any increased efficiency offered by more sophisticated engines or after-treatment. Since it is assumed that at the least sulphur content must be reduced to 50ppm to enable Stage IIIB equipment to operate, no assessment of the Greenhouse Gas implications of this is made.

---

[25] Diesel Emission Control – Sulphur Effects (DECSE) Program; US Department of Energy, Engine Manufacturers Association, Manufacturers of Emission Controls Association; January 2000

[26] Fuel effects on emissions from advanced diesel engines and vehicles; CONCAWE; 2/05

[27] The costs and benefits of lowering the sulphur content of petrol & diesel to less than 10 ppm; European Commission DG Environment; 9/9/2001

[28] Effect of fuel qualities and related vehicle technologies on European vehicle emissions, an evaluation of existing literature and proprietary data; European Commission, ACEA, EUROPIA; 17/7/0995

[29] 26,000€ per tonne of PM 2.5

There are two possible effects on operating emissions resulting either from more efficient engines or more efficient operating procedures such as less frequent regeneration of DPFs. There does not appear to be any suggestion that there will be any increase in engine efficiency beyond business as usual improvement. It seems clear that DPF use is not essential to meet Stage IIIB requirements (since these are equivalent to HDV Euro 5) although some manufacturers have indicated that they might use the technology.

If it is assumed that 10% of NRMM equipment is renewed each year, and that of this 25% uses DPFs and that the use of 10ppm fuel reduces the overall part of the energy used just to regenerate the filter by 2%[30] then the following table indicates the likely growth in energy saved and CO_2 avoided.

Year after Stage IIIB introduced	1	2	3	4	5	6	7
MT of Diesel saved annually with 10ppm	0.032	0.064	0.096	0.128	0.160	0.192	0.224
MT CO_2 saved with 10ppm	0.031	0.063	0.094	0.126	0.157	0.189	0.216
Aggregate MT CO_2 saving	0.031	0.094	0.188	0.304	0.461	0.65	0.866
Aggregate increase in refinery MT CO_2 emissions	0.2	0.4	0.6	0.8	1.0	1.2	1.4

The table shows that under these assumptions, after 7 years, the CO_2 annually saved from the equipment using DPFs offsets the additional CO_2 annually emitted at the refinery. Approximately 5 more years are needed for the aggregate increase in CO_2 emissions to be offset by the aggregate decrease in operating emissions.

Impact on ease of introduction of lower emission equipment

The equipment manufacturers argue that the added cost and effort of 10ppm sulphur in NRMM fuel will be minor compared to the additional after-treatment costs to customers. In addition optimising the life of the DPF system will provide further environmental benefit. They cannot say that machines equipped with DPF to fulfil Stage IIIB will not operate with 50ppm fuel. However, they believe that, in many cases, it will not permit them to meet their customer's expectations and therefore request 10 ppm sulphur fuel for Stage IIIB.

Due to the lack of hard evidence it is not possible to judge whether or not this will be the case.

Inland Waterway vessels

As has been noted above, there is currently no emission requirement for inland waterway vessels that would result in a requirement for fuel containing less than 300ppm sulphur. The sulphur limit currently foreseen in Directive 98/70 for fuel to be used by inland waterway vessels from 2008 is substantially higher than the sulphur content of the reference fuel used to certify those engines. This means that pollutant emissions from those engines in use could

[30] As assumed in the Commission CBA on 10ppm sulphur in road fuel

substantially exceed their certified emissions. It also means that there is a danger of damage to or a reduction in effectiveness of the engines and emission control equipment.

Impact on air pollutant emissions

Sulphur content has an impact on PM emissions from engines. CCNR phase 2 emission requirements that come into force in 2008 have a PM emission limit of 0.2g/kWh which is slightly above that of a EURO 2 HDV. Following the 1995 literature review cited above, the likely reduction in PM emissions following a reduction from 2000ppm to 300ppm sulphur will be 15%. A further reduction from 300ppm to 50ppm would result in a further PM emission reduction of 1.7%.

In contrast the inland waterway sector has provided modelling[31] results showing PM emissions due to sulphur content in the fuel from an earlier inland waterway engine. At their peak at a temperature of around 500C emissions are around 0.55g/kWh with a sulphur content of 1500ppm, reducing to just under 0.2g/kWh for 500ppm, and of the order of 0.02g/kWh for 25ppm. These figures imply a much greater reduction in PM emissions from reduced sulphur content than indicated by the Commission's review referred to.

Impact on cost

Recent estimates are not available for the cost of reducing inland waterway fuel sulphur content. However, during the previous review of Directive 98/70, CONCAWE estimated[32] that reducing the sulphur content of road diesel from 350ppm to 50ppm would result in an NPV cost of 8G€.This estimate related to a market of 140MTOE of diesel. If a comparable effect were experienced for inland waterway fuel, which represents approximately 0.5MTOE per year, the NPV cost would be roughly 30M€.

Impact on Greenhouse Gas emissions

There will be two main impacts on Greenhouse Gas emissions; the increase in emissions required at refineries to remove sulphur from the fuel and decrease in emissions from any increased efficiency offered by more sophisticated engines.

There is not believed to be any more efficient technology under consideration for use to meet current inland waterway emission limits that would require fuel with a sulphur content lower than 300ppm for its operation. It may therefore be assumed that any gains from more efficient engines will be equal for the two fuel sulphur options.

During the previous review of Directive 98/70, CONCAWE estimated[33] that reducing the sulphur content of road diesel from 350ppm to 50ppm would result in a 3MT increase of CO_2 emissions of per year for 140MTOE of diesel or approximately 0.02TCO_2/TOE. If a comparable effect were experienced for inland waterway fuel, which represents approximately 0.5MTOE per year, it would result in an increase of 0.01MT CO_2 per year.

Impact on ease of introduction of lower emission equipment

---

31 Carried out by Emitech and provided to the Commission by Inland Navigation Europe

32 EU oil refining industry costs of changing gasoline and diesel fuel characteristics; CONCAWE; 99/56

33 EU oil refining industry costs of changing gasoline and diesel fuel characteristics; CONCAWE; 99/56

Inland Waterway Europe has told the Commission that the introduction of more advanced engines and emission abatement equipment is being hampered by the high levels of sulphur in the fuel. Evidence has also been provided of engine manufacturers requiring their engines to be operated on fuel with a maximum sulphur content of 50ppm or the warranty would be invalidated.

As discussed above, CCNR phase 2 equipment has PM emissions slightly above Euro 2 HDV standards that were introduced in 1996 while their NOx emissions are slightly below the HDV emissions. The table below illustrates the progression in maximum permitted sulphur content in EU diesel fuel where it can be seen that sulphur content remained at 350ppm even when EURO 3 for HDVs was introduced in 2000. Euro 3 has PM emissions around half of CCNR phase 2 and NOx emissions about 15% lower.

EU road diesel standard grade permitted sulphur content				
Year	1993	1996	2000	2005
max sulphur ppm	2000	500	350	50

It can be seen that provided comparable technology is being used for inland waterway engines to that used in earlier HDV applications, a sulphur content below 350 ppm should not be necessary until considerably tighter emission requirements are put in place and more sophisticated equipment is required.

Some manufacturers may already be offering equipment that anticipates such much tighter emission limits. If this is the case, it is likely to represent a small proportion of the market and it must therefore be for Member States and fuel suppliers to respond appropriately to this need.

Timing of any change

EUROMOT argues for an early change in the sulphur content of diesel fuel for non-road applications. However, such an early change is impractical. Directive 2004/26 provides dates beyond which engines of different power categories and uses may not be placed on the market. These are shown below.

Date	**Stage**	**Types of engines**
Before 31/12/2007	IIIA	Engines with power between 19 and 560kW other than constant speed engines. Engines for inland waterway vessels. Engines for railcars and locomotives.
31/12/2009	IIIA	Constant speed engines except those with power between 37 and 75 kW
	IIIB	Engines with power between 130 and 560kW other than constant speed engines.
31/12/2010	IIIA	Constant speed engines with power between 37 and 75 kW
	IIIB	Engines with power between 56 and 130kW other than constant speed engines.

		Engines for railcars and locomotives.
31/12/2011	IIIB	Engines with power between 37 and 56W other than constant speed engines.

It can be seen that for land based applications Stage IIIB equipment will start to be placed on the market from 31 December 2009 and therefore this should be the latest date for ensuring that appropriate fuel is available.

A realistic timetable in view of the need to modify Directive 98/70 is: Commission proposal for a Directive in late 2006, probable conclusion of co-decision process late 2007 or 2008, likely date for implementation of new limits 2009. In view of this, a change from 1000mg/kg sulphur in 2008 as requested by EUROMOT is unlikely to be possible. Introducing a tighter NRMM fuel specification is not feasible before 2009.

EUROMOT notes that because of the fact that fuel tanks are unlikely to be fully emptied before refilling, it will take a number of fills to achieve satisfactory sulphur levels. This will be most serious for NRMM other than inland waterways. If it is assumed that a tank that was previously filled with 1000ppm fuel is refilled when it is 10% full with 50ppm fuel, after a second refilling with 50ppm fuel, the sulphur content of the tank contents will be 59ppm. This ought to present no significant problem. For inland waterways this problem would be much less severe with 300ppm fuel due to the smaller difference between initial and future sulphur content. In any case, fuel suppliers have a role to play in encouraging users to as far as possible empty their fuel tanks before refilling with low sulphur fuel to avoid any problems.

4.10.3.2.Non-sulphur parameters

While changes do not appear to be required to other fuel specifications to enable the use of advanced emissions control equipment and comply with the requirements of Directive 2004/26, it is desirable to also consider whether the other specifications should be tightened. Some stakeholders have argued for aligning NRMM diesel fuel with the road fuel specification.

Since a large proportion of NRMM is operated where its emissions have a similar impact on air quality to road operated vehicles, the volume of non-road fuel use and emissions would suggest that a tightening of the non-road fuel specification to make it equivalent to the road specification would have significant air quality benefits. In this respect EUROMOT submitted a paper[34] assessing the effects of non-sulphur parameters on emissions. This draws on the EPEFE study. The main relevant conclusions are that reducing aromatic content from 30% to 10% would reduce NOx emissions by 4%. EPEFE also established a clear linkage between density and PM emissions and therefore placing an upper limit on density would further reduce PM emissions. With regard to Cetane number, it is argued that an increase would improve cold start performance and could reduce NOx emissions especially at low load. No significant effect is reported from varying the T95 point between 320 and 375C. However, information is not available on the actual quality of NRMM fuel in use and therefore the level of any savings that will be achieved is questionable.

[34] Considerations on diesel fuel quality required for non road mobile machinery

A further consideration is that lowering the sulphur content of NRMM fuel would result in a separation of non-road diesel from the heating oil specification. There might be substantial costs in maintaining a separate production and distribution system for these fuel specifications. Therefore for logistical reasons, fuel suppliers might wish to have other specifications aligned to minimise the types of fuel that they must handle (i.e. non-road fuel aligned with road diesel). EUROPIA has rejected this argument, arguing that the fuel specification should only be adjusted where it makes environmental sense. In view of this, there is no analysis of any possible cost implications in this respect.

4.10.4. Comparing the options

It is clear that a certain level of reduction in sulphur content will result in lower pollutant emissions from NRMM and facilitate international alignment of NRMM emission limits and the creation of a more global NRMM market. However, tightening the fuel specification will result in costs for fuel suppliers. There is no doubt that these costs will be passed on to customers.

It has already been determined in the assessment of the proposal for Directive 2004/26 that the benefits of introducing a lower minimum level of sulphur in the fuel and tighter NRMM emission limits outweighed the costs of doing so. However, with regard to non-inland waterway applications, engine manufacturers suggest that it would be desirable for the fuel used to be at the lower end of the sulphur range envisaged in that analysis.

For inland waterway applications, no reduction of sulphur content in fuel was foreseen to attain the emission limits in Directive 2004/26.

4.10.4.1.Land based NRMM applications

For non inland waterway applications, a fuel sulphur content between 10 and 50ppm will enable manufacturers to meet the requirements of the Directive 2004/26. However, fuel at the higher end of this range may lead to higher rates of malfunctioning and failure of emission control equipment.

It has been noted that different levels of fuel sulphur and alignment of other fuel specifications need to be considered for non inland waterway fuel. The table below illustrates the impacts of the different specification options. A second table illustrates the costs and benefits of the different options.

Impact of specification options for land based NRMM applications			
	Sulphur 50 ppm	**Sulphur 10 ppm**	**Align complete spec with road fuel**
Cost	One-off equipment development cost of 160M€. Additional fuel cost of 105M€ per year. Additional servicing cost of 60M€ per year.	Additional refinery investment of 570M€ NPV compared to 50ppm. Resulting annual fuel price increase of between 94 and 188 M€.	Annual fuel price increase of a further 220 M€ to align specification.
Greenhouse Gas emissions		Additional refinery emissions will be	No significant impact identified.

		offset by reduced equipment emissions in medium term.	
Air pollutant emissions.	No saving compared to 50ppm.	Estimated saving of 156M€ per year due to lower PM emissions.	Might lower pollutant emissions e.g. NOx. Improved cold start performance.

The overall benefits of lowering the sulphur content to 10ppm appear to outweigh the costs that this would entail after a few years.

A full alignment of the fuel specification with that of road fuel will lead to an approximately 200M€ cost increase without clear counter balancing savings in reduced air pollution.

4.10.4.2. Inland waterway applications

For inland waterway applications the emission limits set in Directive 2004/26 are less strict. It is therefore not necessary to tighten the sulphur limit to the same degree. In this case, a tightening to the levels foreseen in the reference fuel will enable the equipment to perform as anticipated.

Comparison of the impacts of tightening Inland Waterway fuel specification to 300 or 50ppm sulphur. Impacts specified relative to 300ppm.		
	Sulphur 300 ppm	**Sulphur 50 ppm**
Environmental benefit	Enables operation of all Stage IIIA equipment.	Enables operation of all currently envisaged after treatment technology up to Stage IIIB which is not yet foreseen for Inland Waterway. Increased GHG emissions of 0.01MT per year from refineries. Will reduce PM emissions from Inland Waterways by 2% (0.056kT).
Cost to Equipment Manufacturers	Possibly higher unreliability, increased warranty claims compared to 50ppm. Could restrict use of some technologies.	None foreseen.

Additional cost to fuel suppliers over 300 ppm expressed as price per litre	0	NPV estimated at 30M€[35]. Estimated resulting price increase of 1 cent per litre.
Cost to users	May increase downtime and operating costs[36]. Possibly invalid warranties as certain manufacturers[37] recommend use of EN590 compatible fuel. Additional cost of separate storage facilities where heating oil also used.	Increase in fuel price of 1 cent per litre of fuel. Additional cost of separate storage facilities where heating oil also used.

If it is assumed that Inland Waterways are responsible for 0.5MT of fuel use, this is equivalent to 2% of non-road fuel. The 2% reduction in PM emissions would represent approximately 0.056kT of PM with a value of 1.5M€. An increase in fuel price of 1 cent per litre would equal a cost increase of some 6M€.

A review of the emission limits is underway and there is likely to be a need for tighter fuel sulphur content for inland waterway applications at an appropriate future date. A working group is currently assessing the most desirable approach. CCNR has indicated that the introduction of stage IIIB engines could be desirable from around 2012 with a further stage, stage IV somewhere around 2016. In view of this, a provisional further lowering of inland waterway fuel sulphur content could be desirable, linked to the introduction of tighter engine emission limits.

4.10.5. Preferred action

The sulphur specification for non-road diesel fuel should be tightened to enable compliance with Directive 97/68 as amended. This implies:

- For non-road applications other than inland waterways, achieving a maximum sulphur content of 10ppm by 31/12/2009.
- For inland waterway vessels, the sulphur content of the fuel should be reduced to 300ppm. Appropriate modification is also required of Directive 99/32 to avoid any legal inconsistency or uncertainty.

---

35 Based on CONCAWE report 99/56; EU oil refining industry costs of changing gasoline and diesel fuel characteristics; April 1999.

36 Inland Navigation Europe reports the following reduced lifetimes from using 2000ppm fuel compared to 50ppm: cylinders - 50% life, injectors shorter life, filter replacement after 500 instead of 2,000 hours, engine life estimated at -15 to 25% hours.

37 The following manufacturers recommend EN590 fuel for engines meeting CCNR stage II: Caterpillar, Volvo Penta, Daf, John Deere, Scania, Koning Milieudiesel.

- A review of the inland waterway sulphur content is needed by 2012 to determine the timing of the introduction of a maximum 10ppm sulphur limit for this fuel

4.11. Detergent issues

4.11.1. The problem

Deposits can be formed as a result of normal operation in inlet valves, injection equipment and combustion chambers. Different detergents are used to tackle the deposits in these areas, making the definition of a desirable standard more complex. Nevertheless, the usefulness of multifunctional detergent additives for the control of intake valve deposits (IVD) is well established.

Typically detergent additives do not have a direct influence on emissions; they may only reduce or avoid a possible increase of emissions due to formation of IVD which are known to affect pollutant emissions, driveability and fuel economy.

However, in general, detergent additives used to control IVD tend to increase combustion chamber deposits (CCD). This effect seems to be mainly related to the nature of the additive and its solvent and also to additive dosage. Combustion chamber deposits may adversely affect emissions especially of NOx while CO and HC can either decrease or increase.

Car manufacturers are increasingly required to ensure that vehicles comply with emission requirements over their whole life. In view of this, the avoidance of deposits on injects, inlet valves and cylinder heads is increasingly important.

Detergents of different types have been used in fuels for different purposes for a number of years. Because of their benefits, in the US detergent use was made mandatory. It is generally accepted that this has not had the desired effects and since the minimum standards were first established by EPA in 1995 the concentration level of detergent additive in most petrol has reduced by up to 50%.

At present detergents may be added to fuel in the EU, but there is no obligation. EN 228 recommends their use. Fuel suppliers make considerable claims for more advanced fuels containing sophisticated detergent packages. It is suggested that if there are such significant benefits to be had from the use of these additives, there use should be generalised.

There is no quick, cheap and effective test to evaluate the detergency capability of additized fuel. In theory the presence of a detergent could be deduced from simple tests like total gums. In view of this it is not possible to monitor detergency capability by sampling fuel, in the same manner as other fuel parameters are monitored. The only effective approach to date would be to determine appropriate rates of fuel treatment and monitor the processes involved in adding the detergent and thus indirectly ensure appropriate use.

The main challenges can be defined as:

- Diversity of detergent types and properties
- Uncertainty concerning overall benefits from detergent use
- Lack of quick, cheap, effective test of fuel detergency effectiveness

4.11.2. Policy options

There is a wide divergence of views among stakeholders. Some argue for mandatory use. Others believe that more study is required, particularly of their long term effects. Some suggest that testing of their impacts and certification of their use is required. Some argue that detergents are vital for proper use, but there is no need for EU legislation although there may be benefit from standardisation. Different packages of additives offer a means for fuel suppliers to differentiate products. It is also argued that while the WWFC details a number of tests, none of these are appropriate for rapidly verifying appropriate use of detergents during fuel sampling.

The following options are considered to be feasible:

- No action
- Encourage greater use of detergents through provision of more information by vehicle manufacturers/fuel suppliers.
- Voluntary Agreement with fuel suppliers to use more detergents.
- Mandatory detergent use.

In the absence of mandatory requirements for the use of detergents, a number of actions could be taken that would stimulate greater awareness of detergents, their properties and the desirability of their use. Packages of such measures could lead to greater detergent use. The types of action that could be envisaged are:

Possible action by vehicle manufacturers.

- Inclusion of information and obligations relating to use of fuel containing detergents in owners manual.
- Publicity emphasising the importance of fuel components to vehicle performance.
- Certification programme (e.g. Top Tier Programme): manufacturers could issue a certificate for fuels complying with detergency requirements. (similarly to what already happens in the lubricant field)

Possible action by fuel suppliers

- Need to take account of the likely impact of the fuel they supply on engine performance.
- Testing of engine cleaning additives used in fuel and documentation of results (this could be submitted to manufacturers for certification purposes).
- Provision of information to consumers on the use of detergents in fuel supplied.
- Making information available on deposit performance of fuels supplied.
- Retention of records demonstrating treatment rates used.

It would almost certainly require action by both vehicle manufacturers, to stimulate vehicle owners to seek fuel containing detergents, and fuel suppliers to ensure that fuel detergent properties are publicised, for there to be effective progress.

4.11.3. Analysis of impacts

Detergent packages form a part of a large proportion of road fuel sold in the EU. Nevertheless, it appears to be the case that some fuel is sold that contains no detergent. The proportion of this fuel varies between Member States. It appears that un-branded fuels may be more likely not to contain detergent packages. In view of this, overall levels of detergent use may depend on the structure of the fuel retailing market in each Member State.

Detergent properties are complex to measure. Significant industry effort is put into their development. Enhanced detergent packages form part of premium grade fuels that are sold at a higher price by fuel suppliers. It is likely to be difficult if not impossible for consumers to detect any difference between different fuels. Fuel suppliers claim significant benefits for their premium fuels[38] although the comparison being made is not always clear.

Positive and negative impacts

To the degree that detergent use does keep engines cleaner, it is likely to result in more optimal combustion leading to higher efficiency, lower pollutant emissions, reduced maintenance costs and lower fuel use.

Indirect positive effects could be lower costs for vehicle manufacturers to ensure that their vehicles remain within pollutant emission limits over the vehicle lifetime. This would also lead to lower consumer costs since there would be less servicing required.

No serious negative effects from correct detergent usage are anticipated other than the small increase in fuel costs for consumers. Fuel suppliers are however concerned that if detergent use was mandated, this could undermine their ability to differentiate prices between additive packages and thus reduce their profitability. At present fuels marketed as premium products tend to use among other components, advanced detergent packages. However, in petrol engines a non-optimised detergent use can lead to an increase of combustion chamber deposits resulting in octane requirement increase (knocking problems) and even in higher HC emissions.

The only effect foreseeable outside the EU might be the increase in demand for supplying detergent products to the EU fuel market.

It is likely that over time, combustion engine technology will become more refined and this will lead to a requirement for operating conditions that deviate as little as possible from the initial state of the engine. This is likely to imply over time a greater need for effective use of detergents throughout the fuel supply system. There is unlikely to be much change in cost of detergent use which is fairly low at present.

Uncertainties

---

[38] Total claim 4% better fuel economy for its Excellium brand: http://www2.total.fr/excellium/site.html BP claim 5% better petrol economy and 3% better diesel economy for its Ultimate brand: www.bp.com/ultimate

Main uncertainties are the actual effect achieved from the use of detergents. Benefits for the environment and for fuel economy, if existing, cannot be easily estimated as the data available are very variable and in some cases even contrasting.

Social groups affected

The main social groups that would benefit from improved pollutant emission performance are those which suffer the greatest impact from vehicle emissions. These tend to be poorer people. Vehicle users, would have to pay a slightly higher price for fuel, but would receive compensating reductions in fuel consumption if the claims are true. Mandatory detergent use could result in fuel suppliers losing profitable opportunities to price discriminate, although there is no reason to believe that these would disappear completely since there would be likely to remain differences in detergent performance.

Compliance

The main issue with compliance would be an appropriate monitoring of the arrangements that fuel suppliers would use to demonstrate what additive and how much had been used in different fuel batches.

The regulatory aim is to achieve an as near optimal treat rate of detergents in as large a proportion of fuel as possible. It is desirable that the policy should not discourage improvements in detergent technology.

At present it appears that:

- Detergents have many different chemical compositions. It is not straightforward to provide a definition that would encompass these types. If this were done and used as a basis for obligatory use it would inhibit technical progress.
- There are different optimal treat rates depending on the detergent and on the fuel composition.
- There is no test method to assess fuel detergency capability suitable for routine control purpose.
- There is no quick test of whether detergent has been used in a fuel.
- There is no sure test of effectiveness in modern engines (test techniques exist but are based on old engines – in any case this type of tests will always have the problem of technological progress making the tests obsolete)
- There is a danger that in specifying detergent usage there might be the effect of inhibiting technical progress and the development of alternative detergent approaches.
- There is a danger that a mandatory use of detergent could lower usage levels as in US.
- The detergent required for optimal performance may vary depending on fuel composition.

There have been discussions within CEN and more recently between the interested parties and the JRC on the potential to develop a test that would establish the deposit avoiding potential of a fuel. These discussions have not produced any likely ways forward. A working group previously set up by CEN and CEC failed to develop a test method meeting the requirements specified in the mandate. In particular, the test was not considered suitable for routine control purposes.

In the US a new programme called Top Tier[39] has been developed by car manufacturers and fuel suppliers that seeks to certify fuels with good detergent properties.

During discussions, fuel suppliers have stated that before introducing detergents on to the market, extensive testing and evaluation is carried out. The availability of such test results coupled with data certifying treatment of fuels supplied offers a means of assuring detergent usage. There would therefore be potential for a scheme similar to Top Tier that could be established in the EU.

Since vehicle manufacturers are the party most concerned by the effects of fuel used without detergent, they have a key responsibility to take in educating vehicle users of the need for using fuel containing detergent and the benefit that this delivers.

If it proves possible to develop a test for additive impact on vehicle performance, this test would also offer a means of verifying and comparing the effects of detergents which might be of interest to additive manufacturers as well as vehicle manufacturers and fuel suppliers.

4.11.4. Comparing the options

The cost of using detergents is low. At present a large proportion of fuel on the EU market does contain detergent. Any additional fuel costs would be recovered by fuel suppliers through the fuel price. Therefore while increased use of detergents would lead to higher fuel prices, this increase would be small. Nevertheless for detergent technology to continue to evolve to cope with evolving engine technology implies development costs. It is important that the incentives exist to invest in this development and that over time these costs can be recovered. This implies that there needs to remain the possibility of fuel suppliers marketing premium fuels for which they can claim significant benefit and charge a high enough premium to justify the investment.

It appears likely that detergents do have desirable effects on vehicle engines with knock-on benefits for emissions of pollutants from vehicles and greenhouse gas emissions. The table below summarises the likely impacts for the options considered.

	Effectiveness	**Societal Cost**	**Regulatory burden**	**Environmental impact**
No action	None	No additional cost. But higher pollutant emissions, energy use and GHG emissions.	None	Possible increase over time
Voluntary Agreement with	High if agreement is	Slight increase in cost of detergent	None	Stable/reduction

[39] http://www.toptiergas.com/

fuel suppliers to use more detergents	appropriately formulated	used. Offsetting reductions in vehicle manufacturer costs. Possible additional monitoring and reporting costs.		
Provision of more information by vehicle manufacturers/fuel suppliers	Low.	Marginal increase for vehicle manufacturers and fuel suppliers	None	Possibly increasing but at a lower rate than with no action.
Mandatory detergent use	High provided negative impacts on detergent benefits can be avoided	Increase in cost of detergent used. Offsetting reductions in vehicle manufacturer costs. Additional monitoring and reporting requirements.	High	Low provided the action is formulated in a way that leads to increased penetration of detergents.

It can be seen that EU action could have overall positive effects. This would depend on the proportion of fuel supplied that was not already treated with detergents. This in turn will depend on the marketing strategy of the market players. It may be for example that some sectors may compete strongly on price and seek to reduce costs, for example by not using detergent. France has a greater proportion of fuel sold by supermarket than non-supermarket sites. In the UK approximately 22% of fuel is reported to be sold by supermarkets.

If 25% of fuel is currently sold without detergents, if it is assumed that the difference between conventional detergent fuel and premium detergent fuel is small, and the manufacturers claims are correct, the CO_2 savings from ensuring that all fuel marketed contains detergent could be around 1% of total road transport emissions.

Based on this analysis the effect of the options can be outlined as follows:

No action will not lead to an immediate problem. However, there is a risk that vehicle manufacturers' might as a result in future face higher costs of compliance with pollutant emission values.

Provision of more information could encourage vehicle users to actively seek out fuel containing detergents, provided that they believe the claims. This would require vehicles manufacturers to inform users of the benefits and fuel suppliers to provide information on which fuels contain detergents. The provision of information on detergent use could be made obligatory. Information about detergents used might need to distinguish between the effects of the detergent and its efficacy.

A voluntary agreement, for example along the lines of the Top Tier programme could enable a large proportion of the potential benefits to be realised.

Mandatory use would if appropriately formulated have the highest benefit. However there are major challenges in defining the detergents to be used, in particular in a way that still enables innovation. An appropriately designed scheme could still facilitate competition between suppliers.

4.11.5. Preferred action

In view of the problems outlined, it appears that the most appropriate means of addressing detergent use is through processes and procedures rather than through legislation. This is in line with the Commission objective of better regulation.

A number of non-legislative actions are possible in this area. Whatever approach is followed, it needs to impact on all fuel suppliers not just refiners and integrated oil companies. Further work on the development of an acceptable whole life test for additive performance might open the way to specifying actual detergent performance standards.

In view of the claimed improvements to vehicle efficiency, the benefits from detergent use could be brought within the life cycle Greenhouse Gas monitoring mechanism described in section 4.16.

4.12. Metallic additives

4.12.1. The problem

A number of metallic additives exist for transport fuels. These are employed for the characteristic that they provide such as improving combustion or enhancing octane. Some examples include Ferrocene, MMT for petrol and Cerium for diesel. There is the possibility that other types of metallic additive could be developed. Concerns have been raised about the health effects of emissions from engines using fuel containing these additives and the impact of the additives on engines and emission control equipment.

With regard to the health effects, there has been no comprehensive assessment of the health impacts of the use of the additives. However, in the case of MMT, work has been underway in the US on a risk assessment. This is likely to be completed in 2007. Work is also underway in the EU, but this is likely to be subsumed within a REACH notification. Individual additive manufacturers have also carried out their own research on possible health impacts. In the future the health effects of metallic additives will fall under REACH. The health effects are not considered further in this assessment.

Currently nothing is said in the Directive about metallic additives. There is no existing test methodology accepted by all parties that would enable testing of the impacts of these additives on engines and emission control equipment. Damage to engines and emission control equipment could lead to a worsening of performance, higher pollutant emissions and possible malfunctioning and need for repair. If they exist, these factors would cause costs for vehicle manufacturers and users as well as to society that could counterbalance the possible cost savings due to their use.

A number of different tests have been carried out to assess the additive effects on engines and emissions. Results of different tests have been reported, for example SAE papers 2004-01-1084 and 2005-01-1108 report on tests on Ford vehicles with MMT. From the series of tests performed in the US, vehicle manufacturers claim conclusive evidence that MMT caused an increase in pollutant emissions. In contrast the additive manufacturer claims that the results do not have any statistical significance and have also presented studies leading to opposite conclusions. However in all cases the test results remain controversial.

Canada is currently carrying out a review on the effects of MMT.

Article 9, paragraph 1 (f) of Directive 98/70 requires consideration to be given to "*the effective functioning of new pollution abatement technologies and the impact of metallic additives and other relevant issues on their performance and developments affecting international fuel markets*".

Stakeholders have a wide range of views on this subject. Some believe that these type of products are safe. Others are concerned over possible damage to vehicles and in particular there is concern in view of the longer period over which emission performance must be assured. Some want responsibility for proving that products are safe to use to be placed on the producers. Some don't favour their use but wish to have certainty before allowing them to be used. Others believe that the effects are unclear and more research is needed and that possibly the precautionary principle should apply. Some believe that any testing should be in real life conditions.

4.12.2. *Policy options*

The Impact Assessment needs to address a number of issues. These are:

What evidence is available of risks to vehicles and emission abatement systems and what action should be taken as a result of the evidence available? This may include improving the availability of evidence for example through systematic monitoring, improving flows of information, and preventing use of additives that are shown to be undesirable.

It is assumed as a starting point that vehicle manufacturers will supply information both to their customers and to regulatory authorities if they consider that there is a problem resulting from specific formulation of fuel. It is also assumed that fuel suppliers will wish to avoid any risk to their reputation from supplying fuel containing additives that are known to them to be damaging to their customer's vehicles.

The options available are:

- No action
- Development of a test protocol for testing additives.
- Vehicle manufacturers to voluntarily include advice and requirements in owner's manual and guarantee and publicise the risks to vehicle performance that they are aware of and for which they have evidence that arise from the use of specific additives.
- Fuel suppliers to voluntarily take account of the likely impact of fuel additives on vehicles.
- Fuel labelling with fuel containing metal additives labelled at the point of sale and in publicity to leave the choice to customers.
- Obligation on fuel suppliers to carry out tests on additives before they are used, to only use additives that do not result engine and emission control equipment deterioration and to retain records demonstrating treatment rates.
- Obligation on Additive manufacturers to provide information to enable risk assessment and to test additives to prove that they do not cause harm.
- Banning of any metallic additives.

If no action is taken then this means that as at present, metallic additives can continue to be used in fuel supplied to the EU market.

4.12.3. *Analysis of impacts*

Despite the concerns expressed and the tests performed, it does not appear to be possible to state at present with certainty that currently permitted metallic additives cause damage to vehicle engines or emission control equipment. In view of this there are a number of possible avenues that may be pursued, such as working to better understand any risks that may exist and acting to avoid any that may be believed to exist, even in the absence of conclusive proof. At the same time, such actions may lead to costs for different parties. Some of the costs are uncertain, since they may depend on whether or not damage is caused, while others would be more definite.

The likely impacts of the different options on these factors is shown in the table below:

	Understanding of damage risk	**Avoidance of possible risk**	**Possible effect on vehicle cost**	**Possible effect on fuel supplier cost**	**Possible effect on additive supplier cost**
No Action	0	0	+	0	0
Test Protocol	++	0	0	0	0
Manufacturer advice	0	+	0	0	0
Fuel supplier voluntary action	0	+	0	+	0
Obligation to test	+	+	0	+	0
Obligation to supply information	+	+	0	0	+
Ban	0	++	0	0+	++

Metallic additives are employed in fuel because they are able to bring specific performance characteristics in a manner that is cheaper than other possibilities. In the case of particulate filter using fuel born catalyst, metallic additives are vital to ensure the correct functioning of the after-treatment device. If their use were limited or restricted it could increase the cost of achieving given levels of performance. However in some cases the alternative is investment in additional refining capability. It might be the case that in the future other metallic additives could be developed whose use would be desirable. In view of this, action taken should try to avoid restricting future development.

There are a number of possible impacts outside the EU. As has been noted, there is dispute over the impacts of metallic additives. In view of this, some countries might take a lead from any action that is taken at EU level. Some countries have introduced bans on specific metallic additives. Trade related issues might arise for additives that are manufactured outside the EU if their use were restricted without conclusive evidence of damaging effects.

On the international level introduction of such a ban would need to be assessed in light of the WTO rules, in particular the Agreement on Technical Barriers to Trade. Such a restriction would be considered a technical regulation within the meaning of the TBT Agreement, therefore would need to be formally notified at the stage of the legislative proposal to the attention of other WTO Members to allow them for comments.

From the outset any such proposed legislation would need to target the imported as well as domestic products (i.e. the legislation would need to cover placing of fuels with metallic additives on the EC market rather than sole importation of such fuels), as the Agreement imposes a general obligation to treat products imported from the territory of other WTO Members treatment in a manner no less favourable than those produced domestically.

Under the TBT Agreement WTO Member have the right to enact technical regulations to pursue certain legitimate objectives, protection of environment among them. Such regulations, however, cannot be more trade-restrictive than necessary to fulfil the objective they pursue taking into account the risk non-fulfilment would create. The latter would be assessed by referring to a number of relevant elements such as available scientific and technical information.

Over time it is likely that advanced vehicles will become more sensitive to possible unforeseen interactions between engine parts like sensors or after-treatment devices and compounds present in the fuel. This implies that there will be pressure for further narrowing of fuel specification. Metallic additives, because they may or may not be present, allow a wider variation in the fuel characteristics. In view of this, concern over metallic additives is unlikely to diminish over time and there is a likelihood that it will increase.

The social groups that will be most affected by any damaging effect of metallic additives would be those who are most affected by pollutant emissions from transport now, and the owners of the vehicles. Vehicle manufacturers would also be affected since they have to guarantee that their vehicles comply with emission limits up to 80000 km and in the future probably up to 160000 km. The “in use compliance programme” will be used to check this compliance and in the case of non compliance with the limits, manufacturers will have to recall the vehicle for modifications. There is unlikely to be any variation between regions, except that due to variation of use of metallic additives. Comprehensive information on the use of metallic additives is not available, but for example MMT is reported to be used in the EU in one refinery in Belgium and some Eastern Member States. Cerium is widely used as catalyst for particulate filter regeneration and it is marketed in nanoparticle form as a diesel combustion improver.

To improve understanding of the issue, it was considered that the way forward was to establish a test protocol that could be used to determine the effect of the additives. Work in this area had started in MVEG and a group was established by JRC to continue this work with ATC, CONCAWE, ACEA, AECC as members. Within the group there were considerable differences of opinion on the desirable form of a test.

The crucial points that prevented consensus being reached are:

- Any test designed to evaluate the long-term effect of a fuel additive on vehicle emission control system should be able to reproduce the interaction mechanisms between the fuel additives and the emission control technologies in real-world engine operating conditions. There are different views on the capability of an accelerated test to reproduce correctly the interactions between a fuel additive and the vehicle’s emission control system.

- In particular, it was stated that the use of a test for high temperature catalyst poisoning based on the ZDAKW cycle (as proposed in the draft version of the test protocol developed by the MVEG working group) to demonstrate no-harm to the vehicle's emission control system does not fulfil the above mentioned requirement.

There are two possible options for a test that could be acceptable to all parties:

- Validation of ZDAKW test through an extensive experimental programme.
- Development of a new fleet test.

In both cases the test should cover the vast majority of real world driving conditions.

Development of a test protocol to assess risk to vehicles is ongoing. It is likely that its use will be expensive. Its development may take a considerable amount of time and may not be possible with the complete agreement of all stakeholders. When the protocol has been developed the question will arise of who would pay for performing tests on additives. In principle additive manufacturers should have an obligation to assess the risks associated with the use of their products and verify that their use is safe. There will always be a question of whether the results will in all cases be conclusive unless clear and uncontroversial fail/pass criteria are established. Definition of fail/pass criteria might be even more problematic than reaching an agreement on the test protocol.

A number of parallel approaches might be possible to tackle the problem:

1. Continue to develop protocol and then identify funds to perform tests. If the tests identify specific problem substances then these could be prohibited through Directive 98/70. A possible time frame could be: agreement on protocol –end 2006. Arrange finance by mid 2007. Tests concluded by end 2008. Proposal made by Commission to modify annex of Directive in 2009. Agreement in 2010 and coming into force in 2011.

2. Recognise that uncertainties around metallic additives are likely to persist. In view of this, the onus could be placed on car manufacturers to place appropriate phrases in their guarantees about the use of fuel containing additives over which they have concern. Fuel suppliers could be required to carry out testing of additives that they intend to use in fuel and publicise the use of these additives on fuel dispensers.

3. The Directive might be modified to include an annex where additives over which there is considered to be sufficient evidence to prohibit their use in the EU could be listed. Where car manufacturers have a concern over a particular product they might bring it to the attention of the Committee for a decision. They would need to substantiate this with evidence for example from maintenance records showing clear linkage to use of a specific additive. (this could lead to endless discussion on the statistical significance of these data as already happened in Canada)

4.12.4. Comparing the options

It can be seen from the analysis of the impacts of the different options that each contributes in a different way to the goals sought. Better understanding of the possible risks will be achieved through more testing and provision of information on the results of that testing. Possible risk can be reduced by greater provision of information about the use and possible effects of these additives. The easiest way to avoid any risk would be to ban the use of the substances. While no action could result in increased vehicle cost because of the scope for variation in fuel, none of the other options leads to any increase in vehicle cost. By contrast, a number of the actions have the potential to increase fuel supplier costs. Similarly a number of the options could increase additive supplier cost, with the most dramatic effect arising from a ban.

If banning any or all metallic additives is not pursued, voluntary action by the different industries could enable the avoidance of any risk as effectively as any mandatory action. This is because the risks are as well known to the different industry parties who each have a responsibility with regard to their customers.

It can be seen that voluntary action to provide information to consumers, coupled with further development of understanding of the risks through testing appears to provide as much benefit as any other course of action while avoiding undesirable costs.

4.12.5. Preferred option

There does not at present appear to be sufficiently compelling evidence for either a generalised ban on the use of metallic additives in petrol or diesel, or a ban for a specific product.

The Commission will proceed with the development of the test protocol. This will at a later stage require agreement on how the necessary tests should be funded.

In parallel with this, the relevant industries should be requested to take their responsibility to their customers seriously by providing them with information that should enable them to avoid any undesirable impacts.

4.13. Diesel density

4.13.1. The problem

Directive 2003/30 was adopted as a means of encouraging the use of biofuels. Article 2(2)b of that Directive lists biodiesel (FAME) as one of the fuels that it seeks to promote. Directive 98/70 contains no specific restrictions on the proportion of FAME that may be blended in diesel. In contrast CEN standard EN590 sets a 5% limit on the volume of FAME that may be blended in diesel fuel because of a number of technical concerns principally over the stability of the fuel and its effect on injection equipment.

Article 9, paragraph 1 (g) requests consideration in the review of "*the need to encourage the introduction of alternative fuels, including biofuels, as well as the need to introduce modifications to other parameters in the fuel specifications, both for conventional and for alternative fuels*".

Directive 98/70 establishes a maximum density for diesel fuel density to reduce pollutant emissions from diesel engined vehicles. A maximum density for diesel is established because there is a linkage between this parameter and pollutant emissions. In its world wide fuel charter ACEA illustrates increasing PM emissions with density, particularly from light duty vehicles and increasing NOx emissions from Heavy Duty Vehicles.

FAME is denser than this maximum permitted density having a density of 880kg/m^3 whereas the maximum density of diesel permitted in Directive 98/70 is 845 kg/m^3. It may therefore be the case that the limits on the density of diesel fuel constrain the introduction of FAME into the EU market.

At the 5th April 2005 stakeholder meeting the European Biodiesel Board (EBB) asked for the limit set in European Standard EN590 to be raised to allow a higher content of FAME in diesel fuel (from 5% to 10%) or alternatively for such a change to be mandated in Directive 98/70 as discussed in section 4.2 above, and as a consequence, an increase of the maximum permitted density for diesel set in Directive 98/70 to accommodate the increased content of FAME.

Following this meeting a number of stakeholders commented on this issue in their responses. Some thought that an increase of the permitted density for diesel containing FAME would be acceptable while others found this a concern.

4.13.2. Policy options

The options available are:

- No action.

- Increase of the maximum permitted density of diesel containing biodiesel.

4.13.3. Analysis of impacts

Increasing the maximum permitted diesel density for diesel containing FAME to compensate for the higher density of FAME than diesel would slightly reduce the cost of blending FAME. This is because it would not require a lighter feedstock than if the fuel were used without

FAME. However, unless such an increase were linked to the volume of FAME incorporated it would mean that the benefit could be exploited by fuel suppliers to use higher density diesel products while only using a small proportion of FAME.

EPEFE tested the effect of decreasing diesel density from 855kg/m^3 to 828kg/m^3. It should be noted that the vehicle technologies on which these tests were performed are no longer representative of the new vehicles being placed on the EU market, although some proportion of the EU fleet is comprised of the vehicles tested. The EPEFE tests showed the following effects:

Table showing effect of reducing diesel density.

	LDV (ECE+EUDC)	**HDV**
CO	-17.1%	+5%
HC	-18.9%	+14.3%
NOx	+1.4%	-3.6%
PM	-19.4%	Not significant

Based on these results it can be concluded that an increase in diesel density would have an impact on vehicle pollutant emissions. The effect would not be the same for HDV and LDVs and because the effect for different pollutants is contradictory, to a large extent these will counterbalance each other with no overall change. However, in the case of PM, because there is no significant effect on HDV emissions, the overall effect would be an increase in PM emissions with increased density.

However it needs to be borne in mind that the EPEFE programme tested only conventional diesel fuels having different density values. With FAME in addition to the higher density, the oxygen content of the fuel is increased. As a consequence, emissions and especially PM can be reduced. In other words, a higher density due to a higher FAME content could be offset by the oxygen content.

Uncertainties in this analysis relate to how modern LDV and HDV engines would behave with heavier density fuel and to the extent to which the effect on other pollutant emissions counterbalance each other.

If it is assumed that there is no effect on overall FAME demand from a change to the maximum blend density, the only effects outside the EU would be to create a possibility for other states to export heavier diesel blends to the EU.

With increasingly tight vehicle emission requirements, it is desirable from the vehicle manufacturers' perspective to ensure that the fuel used has as narrow a specification as possible. This argues against allowing an exception for diesel containing FAME. However, to the degree that this obstructs use of FAME, it hampers the benefits of FAME to be realised. It is likely that over time the need for tighter specification fuel will become more intense.

The practical effect of blending FAME on the density of the blend is small. Adding 5% FAME to a base diesel requires that the base diesel has a maximum density of 843.16 kg/m^3 to remain within the 845kg/m^3 maximum permitted density. Even were EN 590 to permit 10% FAME to be added to a base diesel, this would require that the base diesel had a maximum density of 841 kg/m^3 to remain within the 845kg/ m^3 maximum permitted density.

4.13.4. Comparing the options

The table below summarises the main pros and cons of the options considered. The second option of raising the density for blended diesel has been considered in two ways, either as in increase in the limit for all blended diesel, or as an increase linked to the proportion of FAME.

Option	For	Against
Retain existing density limit.	There is no overriding reason to change the density limit.	Minor impact on ability to blend FAME.
Higher maximum limit for diesel containing FAME.	Would permit a higher density diesel stock to be used for blending with FAME. Easy to control without need to verify FAME proportion.	Would permit heavier diesel components to be used in a blend with some FAME leading to higher pollutant emissions. The lack of a linkage to the FAME content would provide an incentive to use only a small FAME content and other heavy components.
Maximum limit increased in relation to FAME content.	Could be set so as not to change the density of the diesel stock to be used for blending with FAME.	More difficult to control because of the need to verify FAME proportion. Pollutant emissions might be higher than with current density level.

The constraining effect of the current limit on FAME blending has been shown to be minor. Any change to the maximum diesel density creates, to differing degrees, a danger of higher pollutant emissions. The least damaging method of raising the limit would be the last option, but this would be the most difficult to control.

In view of the limited benefit and the dangers and difficulties of a higher limit there does not appear to be a strong argument for any change to maximum density for diesel blends containing FAME.

4.13.5. Preferred option

No change in the maximum density of blends containing FAME.

4.14. Oxygenate content of petrol

4.14.1. The problem

Directive 98/70 establishes environmental specifications for the quality of petrol and diesel fuel sold in the EU. It does not regulate biofuels directly, but the environmental specifications can affect indirectly the use of biofuel components in petrol and diesel. Directive 2003/30 has been adopted as a means of encouraging the uptake of biofuels within the EU. The Directive does not establish any preference between the different types of biofuel. Currently the two main biofuels used as blending components in petrol are ethanol and ETBE (Ethyl Tertiary Butyl Ether), which is synthesised from ethanol. The former accounts for 25% of ethanol use and the latter 75%.

Currently around 14% of European ether capacity[40] is used to produce ETBE allowing a 7 times expansion in production (by conversion from production of other ethers) before new investment is required. The ethanol required would represent 7 times EU ethanol production in 2004. If sufficient ethanol could be provided, the ETBE produced would be valued by the biofuel Directive as substituting around 3% of road transport petrol use.

Article 9, paragraph 1 (g) of Directive 98/70 requires consideration of “the need to encourage the introduction of alternative fuels, including biofuels, as well as the need to introduce modifications to other parameters in the fuel specifications”. One issue that arises in relation to the petrol specification established in Annex III of Directive 98/70 is the maximum permitted content of oxygenates (ethanol, other alcohols, ethers and oxygen).

The Directive sets a maximum limit of 2.7% by mass of the oxygen content of petrol (the oxygen is incorporated into the chemical structure of fuel molecules). This limit originated in the US and was considered the optimal level for air quality benefits from oxygenates while avoiding potential disadvantages of higher levels. Increasing the oxygen limit can lead to higher exhaust emissions of NOx and reduced VOC exhaust emissions. Depending on the oxygenate, there may be offsetting effects from higher evaporative and permeation emissions of VOCs.

The Directive also specifies the maximum volumetric content of various oxygenates including alcohols and ethers. The overall maximum permitted oxygenate content is determined by these volumetric limits in conjunction with the global oxygen limit of 2.7% by mass. The chemical formula of each compound determines its oxygen content (e.g. ethanol contains 34.8% oxygen by mass, Butanol 21.9% and ETBE 15.7%).

	Ethanol	**ETBE**
Maximum permitted volume in 98/70	5%	15%
Energy equivalent	3.4%	12.9%
Bioenergy under 2003/30	3.4%	6.1%

Emissions of NOx and VOCs are a concern because of the damage they cause to the environment and health. The CAFE baseline provides information on the extent of air pollution problems in the EU. This shows that in 2010 it is predicted that 10 Member States[41]

---

40 Letter from EFOA to DG TREN (P. Hodson); 1/4/2005

41 Austria, Belgium, Denmark, France, Germany, Ireland, Luxembourg, Netherlands, Spain, Sweden.

would exceed the national emission ceiling for NOx while 4 Member States[42] would exceed the VOC ceiling. Both NOx and VOC are ozone precursors. In 2000 it was estimated that 21,400 premature deaths per year resulted from ozone exposure and total health costs were quantified as 6.3 billion € per year. Ozone related crop damage was estimated at 2.8 billion € per year in 2000.

In the troposphere ozone is a health hazard and a greenhouse gas. Tropospheric ozone is produced by photochemical reactions in the troposphere via its precursors: NOx and non-methane volatile organic compounds (NMVOC). Emissions of these pollutants are covered by the 1999 Gothenburg Protocol under the United Nations Convention on Long-Range Transboundary Air Pollution, and by the EU national emission ceilings directive (NEC Directive 2001/81/EC). Motor vehicles are a major contributor of NOx and NMVOC. In Europe roughly a quarter of total anthropogenic NMVOC emissions are from road transport.

Other issues that stakeholders have raised in relation to increasing oxygen content include: customer awareness of energy content, oxygen sensor functioning, and the single market for fuel. Vehicle compatibility and driveability can be affected by elevated ethanol contents. A further issue to consider is the refinery structure and already stretched petrol/diesel split in the EU and the implications of further increasing the available volume of petrol through the use of oxygenates. Some stakeholders questioned the availability of sufficient ethanol to justify any increase in the limits.

Consideration of any constraints on the use of biofuels in petrol needs to reflect the Commission's objective set out in the Strategic Energy Review to achieve a 10% share of biofuels in road transport fuel by 2020.

4.14.1.1.Common issues

Petrol surplus

Due to increasing demand for diesel fuel for cars, there is an imbalance in the production of petrol and diesel in the EU. Currently Europe has a surplus of around 29MT of petrol and a deficit of around 23MT of diesel per year. The main result is that diesel fuel is imported into the EU primarily from the Former Soviet Union and high quality petrol components are exported primarily to the US. An environmental impact of this trade is increased GHG emissions. For the export of petrol to the US the penalty is about 3% of the CO_2 emitted in burning the fuel. Operating refineries away from their optimal petrol diesel mix also results in an increase in overall energy use in refining and increased GHG emissions. These increased emissions reduce the GHG benefits resulting from the use of biomass derived oxygenates. Increasing the volume of oxygenates in petrol will lead to a growth in this imbalance and the resulting trade.

Energy content

Alcohols have a lower energy content by volume than petrol. Methanol has an energy content half that of petrol while Ethanol's is about 66% and that of ETBE and Butanol is around 85%. Of these, ethanol and ETBE are the only biofuels currently used in significant volume in the EU at present. Users may become aware of a worsened fuel economy (lower distance covered

42 Belgium, Germany, Netherlands, Spain

by their vehicles per litre or per refuelling) with increasing oxygenate content. The effect will be more noticeable with higher oxygenate contents and more noticeable with methanol and ethanol than ethers or butanol. There have been reports that the oxygen content in the oxygenate counteracts part of the energy loss through improved combustion, however there is no reliable evidence supporting this claim. If higher levels of oxygenate content are permitted these factors could become important since fuel is sold by volume rather than energy content. The energy content of petrol containing 10% ethanol will be 3.3% lower than that of the base petrol.

Single market

A key concern behind Directive 98/70 is to ensure the integrity of the single market for road transport fuel. Apart from the benefits for fuel producers and vehicle manufacturers and users, this also enhances energy supply security. It is therefore essential that fuel placed on the market in one part of the EU may also be marketed and used in other parts of the EU. Apart from certain time-limited derogations the only exception to this is that a higher vapour pressure is permitted for countries with extremely cold weather conditions to ensure driveability of vehicles. To ensure the continuation of the single market for fuel it is important to avoid a variation of fuel parameters that can lead to operating problems for fuel-vehicle combinations.

Pollutant emissions

There is in general an inverse relationship between CO and HC emissions and NOx emissions from a petrol engine. Generally CO and HC emissions increase with a more fuel-rich combustion while NOx formation is enhanced through the availability of excess oxygen. Emission testing on engines without sophisticated control systems illustrates this and shows that addition of oxygenates, through increasing the availability of oxygen, will lower CO and HC emissions and increase NOx emissions. For example, Reuter et al.[43] in a review of US oxygenated fuel use found that NOx emissions increased for all oxygenates. The average effect for the complete fuel set was found to be significant, about $(+1.6 \pm 1)\%$ NO per wt % oxygen. The greatest effect was observed with ethanol. Acetaldehyde emissions increased greatly for ethanol and ETBE fuels. Emissions of Formaldehyde, which is a nasal carcinogen, increased slightly for all oxygenates.

Modern adaptive learning vehicles compensate to some extent for increased oxygen content, so the effects of a change in fuel may not be so large. Nevertheless, some effect of ethanol on exhaust emissions is also expected in modern vehicles. This may be explained as follows. During start and warm up, the vehicle’s Engine Control Unit (ECU) works in "open loop" (without lambda regulation). In this period the ECU does not compensate for the increased oxygen content of the fuel mixture. Therefore THC and CO emissions can be expected to decrease in this phase and CO_2 and NOx emissions to increase. After the catalyst reaches its light-off temperature, the vehicle works in "closed loop" (regulated by the oxygen sensors). In this condition the THC, CO and NOx exhaust emissions should not be affected by the addition of ethanol to gasoline since the vehicle adjusts the air/fuel ratio to the level of oxygen in the fuel (in the same way as for a fuel without ethanol). At full engine load the ECU will again change to an open-loop control mode in order to produce maximum power, resulting again in lower THC and CO emissions thanks to the enleanment effect of the oxygenate. As

43 Air Quality effects of the winter oxyfuel program: Howard, Russel, Atkinson, Calvaert

the vehicle fleet is gradually renewed over time, this mode of behaviour will increasingly become the case for the whole car fleet.

Oxygen sensors

Modern emission control technology measures the proportion of oxygen in exhaust gases and uses this parameter to control the air-fuel ratio of the combustion. This means that more modern vehicles are less sensitive to oxygenate content in the fuel. However, oxygen sensors have limitations on their range and might not function correctly if the fuel itself has a large oxygen content.

4.14.1.2. Ethanol issues

Pollutant emissions

In uncontrolled spark ignition engines ethanol-petrol blends increase NOx emissions. Typically NOx emissions increase around 1.4% per % increase in ethanol content as reported in reference 45 above. Ethanol's effect on NOx emissions appears to be statistically more significant than that of oxygenates such as ETBE and MTBE. Ethanol's effect on other regulated pollutants results is less consistent with either positive, negative or negligible effects recorded. Ethanol also significantly increases acetaldehyde emissions, a probable human carcinogen and respiratory irritant that may exacerbate asthma.

As discussed above, modern engine control technologies react to fuel composition and engine operating conditions and therefore the impact of ethanol on new vehicle exhaust emissions is likely to be smaller. Effects will be more pronounced in older vehicles with less sophisticated emission control equipment.

Single market

The addition of ethanol to petrol causes the mixture to have a greater vapour pressure that that of the sum of the individual components because of the very different physical and chemical properties of petrol and ethanol. The peak vapour pressure is observed around 5% (by volume) ethanol content in petrol. Problems may arise in raising the maximum ethanol content above 5% because of the shape of the ethanol-petrol blend vapour pressure curve. A 10% blend that is within the maximum pressure specification would, if mixed with a lower ethanol content blend, cause the vapour pressure limit to be exceeded. This could occur in filling stations when tanks are refilled and in vehicle tanks when refuelling.

Effect of ethanol on permeation.

The California Air Resources Board (CARB) has carried out a study[44] to investigate the effect of petrol-ethanol blends on permeation. This found that a standard California 5.7% by-volume ethanol blend increases permeation emissions on average 65% compared with MTBE-blended RFG and 45% over non-oxygenated fuels. This equated to a 1.1g per day increase in VOC emission per vehicle per day (more than 50% of EU permitted evaporation emissions per vehicle per day). The proportion of permeation in total evaporative emissions will determine the relative importance of petrol vapour pressure and ethanol content.

---

44 Fuel permeation from automotive systems; Final Report CRC Project No. E-65; September 2004

Recently CARB has published a follow-up study[45] assessing the impact of different ethanol content on permeation rates. This study shows that on average, for the vehicle fuel systems tested, permeation rates with 10% ethanol were lower than those with 6% ethanol. It should be noted that these tests only covered 5 vehicles meeting the following California emission specifications: enhanced evaporative (2 vehicles), LEVII (1 vehicle) or PZEV (1 vehicle). All of these have substantially lower permitted evaporative emissions than EU type approved vehicles. One of the vehicles showed different behaviour with 10% ethanol resulting in an increase in permeation emissions.

The study also shows that it takes a long time for permeation levels to stabilise, typically three weeks. This indicates that permeation effects will not be measured in standard EU evaporative emission tests and therefore permeation can potentially lead to very significant increases in the total evaporative emissions from petrol cars.

Vehicle component compatibility

Adding ethanol to petrol can create compatibility problems with fuel system components such as elastomer swelling[46] and corrosion. This has led car manufacturers to declare the non-compatibility of many existing vehicles with higher ethanol content in petrol. Although the Commission has not carried out any assessment of whether vehicles offered on the EU market would be capable of operating on 10% ethanol, information has been provided in other markets. In Australia the automotive industry has published details of vehicles that may only be used with fuel containing a maximum of 5% and 10% ethanol according to their manufacturers[47] as well as vehicles that are not compatible. The list of manufacturers whose vehicles are not suitable for 10% ethanol includes many vehicles that are likely to be in the EU fleet[48]. The fact that some manufacturers have not warranted their vehicles, which have been sold in the EU, for petrol containing more than 5% ethanol means that fuel to this specification needs to continue being supplied.

For modern vehicles there is less of a compatibility problem and a number of vehicle manufacturers[49] supplying vehicles for the EU market currently supply vehicles in the US covered by a 10% ethanol warranty. If petrol containing 10% ethanol were to be made available in the EU, there would not appear to be a problem for manufacturers to adapt their production to use appropriate components in new vehicles. Manufacturers have not supplied any information on the resulting cost if any.

If 10% ethanol content in petrol were to be authorised there are two possible approaches to overcome the problem of existing vehicles; either the 10% blend could be sold separately and clearly marked or existing incompatible vehicles would need to be modified. Were a 10% ethanol blend to be permitted, this would need to have a lower maximum vapour pressure to avoid an exceedance of the maximum vapour pressure if this fuel is mixed with petrol

---

45 Fuel permeation from automotive systems: E0, E6, E10 AND E85; Interim Report CRC Project E-65-3; August 2006

46 Elastomer compatibility measured according to DIN 51605

47 http://www.fcai.com.au/ethanol.php/2006/08/00000005.html

48 Alfa Romeo, Audi (some models), Fiat Punto, Ford (some models), Daewoo, Lexus (IS200 pre 2002), Lotus(some models), Mazda (some models), MG, Peugeot 306, Porsche, Rover, Renault, Subaru (some models), Suzuki (some models), Toyota (some models). All motorcycle and all terrain vehicles manufactures by Honda, Kawaskai, Piaggio, Suzuki and Yamaha.

49 Chrysler, Ford, BMW, Hyundai, Jaguar, Kia, Land Rover, Mazda, Mercedes, Mitsubishi, Nissan, Rolls Royce, Saab, Subaru, Suzuki, Toyota, Volkswagen, Audi, Volvo.

containing no ethanol. The cost of lowering petrol vapour pressure has been assessed by the Commission, however no up to date information is available on the likely costs of additional fuelling infrastructure for the provision of a separate blend.

In addition, there would have to be a change to the specified reference fuel which new vehicles use in order to be type-approved. This is to ensure that the certified emissions performance is replicated in the real-world. The Commission has proposed such a change as part of the discussions on Euro V.

Driveability

CONCAWE concludes in a report on driveability[50] that:

"In general, ethanol splash blends increased demerits and in some cases overall severity rating. Matched volatility ethanol blends gave similar driveability to the equivalent hydrocarbon fuels. This suggests that the effects seen are not due to the presence of ethanol per se but are a consequence of the increase in volatility that is caused by the addition of ethanol."

In the absence of any evidence to the contrary this seems to show that the ethanol content itself is not a driveability concern.

Distribution of ethanol-petrol blends

The distribution of ethanol-petrol blends gives rise to a number of specific challenges. The main problems relate to ethanol's willingness to absorb water and the resulting phase separation of the blend. This behaviour has resulted in EU fuel suppliers not distributing petrol containing ethanol through pipelines because of the risks that its behaviour poses for other products distributed in the pipelines. However, it is claimed that in Brazil petrol blends containing ethanol are transported by pipeline.

Because of these problems, ethanol is usually blended directly into petrol at distribution centres. This means that the ethanol has to be trucked to the centres leading to an increase in the environmental impacts from the fuel distribution. There is an overall increase in the complexity of fuel distribution as a result.

4.14.1.3. Ether issues

GHG emissions

Production of ethers, even using bioethanol, requires significant energy input and leads to significant emissions of greenhouse gases. In view of this, any policy to dramatically expand ether use might need to be assessed for its climate change impact. The latest version of the JRC/CONCAWE/EUCAR Well to Wheel Greenhouse Gas assessment51 contains a comparison of the WTW impacts of replacing existing MTBE production with ETBE and a separate calculation of the WTW impacts of large scale ETBE production. These show that while ETBE is used to replace MTBE there is a GHG benefit of a comparable size to that

---

50 Gasoline volatility and ethanol effects on hot and cold weather driveability of modern European vehicles; CONCAWE 3/04

51 http://ies.jrc.ec.europa.eu/wtw.html

from using ethanol to replace petrol. Current ETBE production could be expanded 7 times before that scenario is invalidated.

Pollutant emissions

As noted earlier, NOx emission increases due to ethers are less than those resulting from the use of ethanol. Modern emission control technologies react to fuel composition and engine operating conditions and therefore the impact on new vehicle exhaust emissions is likely to be small.

Single market

There do not appear to be any concerns about the ability to mix petrol containing ethers with other blends. The effect of ETBE is to slightly reduce vapour pressure so mixing of different blends does not run the risk of leading to higher vapour pressure and VOC emissions. In contrast there is a slight benefit from ether use for fuel suppliers who are able to blend additional lighter components into the petrol.

Vehicle component compatibility

Car manufacturers have not expressed any concern over the compatibility of vehicles in the existing fleet with higher ether content in petrol.

4.14.2. Policy options

The issue under consideration relates to the limits on oxygenates in the Directive. There are a number of different limits and different permutations of changes to these which need to be considered. The options available are:

- No action - ie retain existing ethanol, ether and oxygen limits.
- Reduce maximum ethanol content
- Higher maximum oxygenate limit
- Higher maximum limit for ethanol and oxygen
- Higher maximum limit for ether and oxygen
- Higher maximum limit for ethanol, ether and oxygen
- Removal of limits on ethanol, ether and oxygen

4.14.3. Analysis of impacts

The analysis of the impacts commences by considering the impacts that are common to oxygenate use in general before considering which issues are specific to different oxygenates. Following this it carries out a structured assessment of the need for the limits, the need for any change and the implications of any possible change.

Should oxygenate limits be tightened for pollutant emission reasons?

Actual levels of pollutant emissions from new vehicles are determined by setting exhaust emission limits. Vehicles are assessed against these levels using a test cycle and a test fuel. The test cycle is not relevant to the fuel issue.

However, the test fuel ought to be representative of fuel actually marketed. At present the test fuel does not contain oxygenates and this needs to be appropriately modified to take account of changes in the fuel used. It is currently being proposed within discussions relating to Euro V that reference fuels should contain 5% ethanol.

In view of this, any reduction in oxygenate levels in petrol would only impact on emissions from existing vehicles since new vehicles would be designed to operate to fully exploit the fuel properties within any revised specification.

Are the current oxygenate limits a constraint on biofuel use?

There are a number of different ways of using biofuel in petrol. The current community legislation does not favour any particular approach. Currently about 25% of biofuel used in the EU (biofuel use represents 1% of the transport fuel market) is blended in petrol. Three quarters of this is blended as ETBE and one quarter as ethanol. At EU level there is room for significant growth in the use of ethanol. However, if biofuel use substantially expands, and this takes place through a growth in the use of petrol oxygenates, then constraints could, but need not necessarily, arise.

While ethanol is one biofuel component that may be used on its own or as a component of ETBE, there are other possibilities. For example it has recently been announced that commercial scale production of biobutanol would in 2007. Biobutanol avoids many of the problems presented by ethanol as a fuel.

If there is a constraint on biofuel use, what effect does this have?

A constraint could have a number of effects. It would not affect the cost of production of biofuels in existing facilities. It might discourage investment in further manufacturing facilities, although it might also encourage innovation to develop and introduce biofuel components that satisfy the different objectives sought in a more optimal manner. The current level of the oxygenate limits does not prevent 5.75% biofuel by energy content being used in petrol. However, specifically for higher levels of ethanol use, difficulties could arise.

If the current limits are a constraint, what relaxation of the limits would improve the situation?

Increases in any of the relevant limits would enable increased use to be made of the related oxygenate components in petrol. The maximum proportion of oxygen would however set an absolute upper limit. At present, the 2.7% oxygen limit corresponds by volume to approximately 7% ethanol (5% energy content), 11% butanol (10% energy content) and 17% ETBE (15% energy content). Increasing the oxygen limit would enable an increase in the use of different oxygenates and combinations of them up to the different levels permitted in the annex of the Directive.

What would be the other impacts of such a change?

The other impacts of a relaxation of the oxygenate limits would be changes to the pollutant emissions from vehicles. Increased use of oxygenates are likely to lead to increases in NOx emissions, primarily from older vehicles. This impact could be largely avoided if petrol with higher oxygenate content would only be used in more modern cars. Otherwise, over time this will become less of a problem.

Increased use of ethanol is likely to lead to higher VOC permeation from vehicles. There is also a risk of damage from higher general levels of ethanol use to vehicle fuel systems that are not appropriately adapted. It seems clear that if higher ethanol content is to be permitted, it would need to be as a separate clearly identified fuel to avoid problems with its use in existing non-adapted vehicles. Higher ether content does not raise the same vehicle compatibility problems and could therefore be used in the normal petrol blend. This may also be the case with other oxygenates such as butanol.

What is the trade-off between the different goals pursued?

The Thematic strategy on air pollution has shown the desirability of further reducing a range of pollutant emissions. The benefits from these reductions considerably outweigh the costs and result in major reductions in years of life lost, illness and damage to buildings and the environment. It is undesirable to weaken the commitment to these goals.

Climate change and security of supply are also threats. This is why the Roadmap on renewable energy, as well as the progress report on biofuel directive, adopted by the Commission concludes that increased biofuel use will bring substantial security of supply and greenhouse gas benefits. Biofuel use in the EU is growing rapidly – due largely to the efforts of a limited number of Member States – but not fast enough to achieve the biofuel directive (a market share of 5.75% in 2010). In 2007, the Commission will bring forward a proposal to strengthen the regulatory framework by setting a binding minimum target of 10% and by introducing a system to ensure the sustainability of biofuel production and use.

Brazil and the United States are the world's largest producers of ethanol for use as a transport fuel. While the United States uses its production for domestic transport, Brazil is exporting production. If fuel quality limits constrain total ethanol use in petrol in the EU this will have implications for the maximum size of the ethanol market. However, at present this is not a constraint on imports.

The economic sectors most affected by the oxygenate limits are the producers of fuel oxygenates, fuel suppliers, vehicle manufacturers and consumers. Some regions where there are specific air quality problems may have more of an impact from any change in pollutant emissions. The social groups most likely to be affected by any change in pollutant emissions are those living in close proximity to road infrastructure, these are likely to be poorer social groups. Since biofuels are currently more expensive than fossil fuel and likely to remain so in the near future, any constraint on their use does not add to costs for consumers.

No major problems with compliance are foreseen. The fuel supply industry is highly regulated, primarily for safety reasons and fuel quality is monitored at Company, Member State and EU level. It is not foreseen that there would be any difficulty to accommodate any changes in the permitted fuel specification within these structures and ensure that the specifications continue to be respected.

The following table is intended to summarise the likely implications of the different options. It assumes that the ethanol, ether and oxygenate content is at the limits permitted. This is not an accurate reflection of the current situation where about 1% of road transport fuel is biofuel and 75% of this is biodiesel. However, it would be an accurate reflection of the situation where the use of biofuel was so high that it implied a need to change the limits if further expansion of the market was not to be constrained.

Table illustrating the effect of the different options on GHG and pollutant emissions and compatibility with vehicles

	GHG emissions	Pollutant emissions	Vehicle compatibility
No action - ie retain existing ethanol, ether and oxygen limits.	+ or – depending on the biofuel and pathway.	No change to base case. However, due to increasing volumes of oxygenate use, this implies NOx emissions can be expected to be higher than they would have been otherwise. VOC emissions will also increase due to permeation of ethanol. Non-regulated pollutants such as formaldehyde and acetaldehyde reported to rise.	Theoretically compatible with all vehicles. However note reported problems in Sweden
Reduce maximum ethanol content, same oxygenate content.	+ or – depending on pathway to produce ethanol.	Permeation emissions of VOCs will be lower. NOx similar to base case. Lower emissions of formaldehyde and acetaldehyde	Compatible with all vehicles.
Higher maximum oxygenate limit	+ or – depending on the biofuel and pathway.	Lower CO, higher NOx, particularly from older vehicles. No change if use limited to newer cars. Higher non-regulated pollutants such as formaldehyde and acetaldehyde.	Theoretically compatible with all vehicles. Some oxygen sensor limits might be exceeded. No impact if limited to more modern cars.
Higher maximum limit for ethanol and oxygen	+ or – depending on the biofuel and pathway.	Lower CO, higher NOx particularly from older vehicles. No change if use	Higher ethanol is not considered compatible with older vehicles. 10% considered to be

		limited to newer cars. High VOC emissions from permeation and from possible reduced effectiveness of carbon canisters. Higher non-regulated pollutants such as formaldehyde and acetaldehyde.	compatible with new vehicles. Some oxygen sensor limits might be exceeded.
Higher maximum limit for ether and oxygen	+ or – depending on the pathway to produce the ethanol. Since the additional ether will not substitute MTBE the GHG benefit from this will be low.	Lower CO, higher NOx particularly from older vehicles. No change if use limited to newer cars. Higher non-regulated pollutants such as formaldehyde and acetaldehyde.	No known compatibility problems for any vehicles. Some oxygen sensor limits might be exceeded.
Higher maximum limit for ethanol, ether and oxygen	+ or – depending on the biofuel and pathway.	Lower CO, higher NOx. No change if use limited to newer cars. High VOC emissions from permeation and from possible reduced effectiveness of carbon canisters. Higher non-regulated pollutants such as formaldehyde and acetaldehyde.	Higher ethanol is not considered compatible with older vehicles. 10% considered to be compatible with new vehicles. Some oxygen sensor limits might be exceeded.
Removal of limits on ethanol, ether and oxygen	+ or – depending on the biofuel and pathway.	Lower CO, higher NOx. If oxygen sensor limits exceeded then seriously increased emissions. High VOC emissions from permeation and from possible reduced effectiveness of carbon canisters.	Higher ethanol is not considered compatible with older vehicles. Absence of upper limits would mean that vehicles would have to be flexi-fuel. Some oxygen sensor limits might be exceeded.

		Higher non-regulated pollutants such as formaldehyde and acetaldehyde.	

4.14.4. Comparing the options

The table below summarises the implications of the different options, listing the arguments for and against the options.

Table comparing the different options

Option	For	Against
Retain existing ethanol, ether and oxygen limits.	No immediate need for change. Existing biofuels targets can be met with existing technology with existing limits. Technological progress with other biofuels may make these more attractive options and reduce ethanol's attraction as a fuel component.	Constraint on how the biofuel target can be achieved.
Reduce Methanol and Ethanol limits	Reduces permeation emissions.	Makes achieving target in Directive 2003/30 more difficult. No compatibility problems.
Higher maximum limit for ethanol and oxygen	Permits greater use of ethanol. Car manufacturers have stated that they have no difficulty with compliance with 10% ethanol blends for new vehicles. Many manufacturers already guarantee their new vehicles for 10% ethanol in US and many of the same manufacturers produce vehicles for 25% blends in Brazil. Ethanol requires less fossil energy input than ethers. Higher GHG benefit than ether.	No immediate need for change. Higher volatility requires removal of other volatile components. No reason to favour one oxygenate over others. Possible oxygen sensor problems. Incompatibility with older vehicles means that a higher blend has to be supplied as a separate blend. Lower energy content of fuel. Commingling effect and RVP implies that ethanol blends above 5% must have a lower vapour pressure.

		Distribution problems.
Higher maximum limit for ether and oxygen	Desirable petrol component. Extra capacity is currently available and C4 supplies appear adequate for expansion beyond current production. Lowers vapour pressure enabling use of other volatile components. No vehicle compatibility problems	No immediate need for change. No reason to favour one oxygenate over others. Possible oxygen sensor problems. Maximum available volume depends on C4 supplies and capacity. Reduced GHG benefit compared to ethanol.
Remove limits on ethanol, ether and oxygen	Permits maximum flexibility to meet requirements of Directive 2003/30.	No immediate need for change. Would create greater variability in fuel quality and eliminate the single market in petrol. Possible oxygen sensor problems. Incompatibility with older vehicles. Lower energy content of fuel. Commingling effect and problem of RVP.

It may be seen from the table that the biggest problems arise in relation to increasing maximum ethanol content. If it is desired to increase the proportion of biofuel blended into petrol this may be done more easily through routes other than by raising the maximum ethanol content. Industry is already responding to the challenge to find routes to incorporate biofuel products in a more acceptable way into fuel. The existence of limits that are intended to limit undesired air pollutant emissions, while these may constrain how biofuels may be used, are likely to also lead to research and development of innovative solutions that will enable biofuels to be used in more environmentally benign ways.

For older vehicles there is expected to be a greater impact on vehicle pollutant emissions from higher oxygenate use. In particular NOx emissions are expected to increase. There will also be a reduction in CO, but CO emissions are not considered to be a serious problem. In view of this, it is desirable to limit the use of higher oxygenate fuels to newer cars.

Increases of ethanol use from current levels will lead to significant increases in permeation from fuel systems (of the order of 20kT per year). For newer vehicles there should be less impact on NOx and CO. There is no reason to believe that permeation performance would be substantially different.

The main vehicle compatibility problems seem to relate to the compatibility of fuel system components with ethanol. Alternative approaches to substitution of petrol, through for example the use of ethers or higher alcohols, do not appear to give rise to these concerns. There do not appear to be any driveability problems related to the use of oxygenates in themselves.

Car manufacturers have indicated that they could manufacture vehicles that would operate satisfactorily on 10% ethanol blend. However, this would only apply across the whole fleet for new vehicles. It is however clear that some vehicles produced on the same production line for the US and EU markets will already be manufactured to be compatible with 10% ethanol since this is available on the US market.

Without a measure to take account of CO_2 savings, it is not possible to say what level of CO_2 saving would be achieved from increasing use of biofuel oxygenates due to the extremely wide variation in WTW CO_2 savings achievable with different fuel production pathways.

It does not appear to be the case that there are at present limits on supply of fuel ethers either because of restricted plant capacity or C4 supply. Greater ether use would enable expanded biofuel use within the current limits without the risk of higher VOC emissions.

Greater permitted variation of the petrol specification is likely to lead to increased costs for vehicle manufacturers and purchasers since it will need to be ensured that vehicles are able to cope with all variants of fuel remaining within the specification. Greater variation may also reduce the interchange ability of petrol and thereby reduce the security of the fuel supply system. This is a particular problem in case the maximum ethanol content is raised beyond the peak of the vapour pressure curve.

4.14.5. Preferred option

A higher ethanol content for petrol can only be permitted under the following conditions:

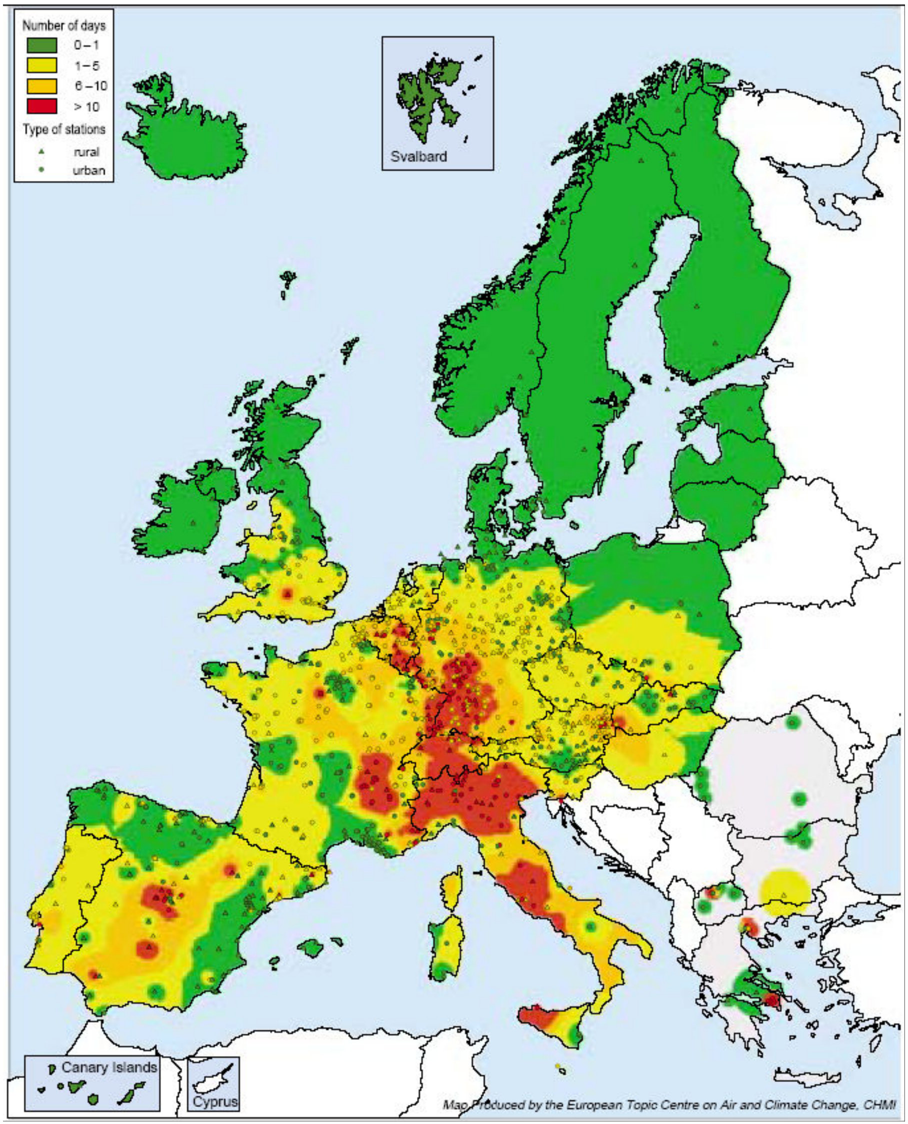
- A maximum of 10% ethanol could be added to petrol for use by modern cars.
- Petrol containing up to 10% ethanol must be sold as a separate blend.
- The 10% ethanol blend must be clearly marked to ensure that it is not incorrectly used in vehicles for which it is not compatible.
- The vapour pressure for the 10% blend must be sufficiently lower than standard petrol or alternatively there must be a waiver, linked to the vapour pressure increase due to ethanol, that when mixed together in any proportion, the resulting combination does not have a vapour pressure exceeding the permitted pressure for standard petrol.
- The marketing of the higher ethanol blend should be linked to establishment of other requirements leading to a reduction in VOC emissions to offset the VOC emission increase due to permeation.

- In view of the desirability of petrol of a similar specification being available throughout the single market and the limitations needed on the marketing of petrol containing up to 10% ethanol, it is desirable to assess, and if justified, bring forward a proposal to make the recovery of VOC emissions at petrol filling stations mandatory.

4.15. Petrol vapour pressure

4.15.1. The problem

The maximum summer vapour pressure of petrol is regulated by directive 98/70 to control emissions of Volatile Organic Compounds (VOCs). Emissions of VOCs are a concern because (1) they are precursors of ozone formation which harms the environment and human health; and (2) certain hydrocarbons such as benzene pose a specific risk for health.



Map showing annual number of days of exceedance of ozone information threshold at 180ug/m3.

The CAFE baseline shows in 2010 that 4 Member States[52] are predicted to exceed their national emission ceilings for VOCs pursuant to directive 2001/81/EC. Transport overall is predicted to account for around 16% of emissions in 2010. The EEA reports[53] that Austria,

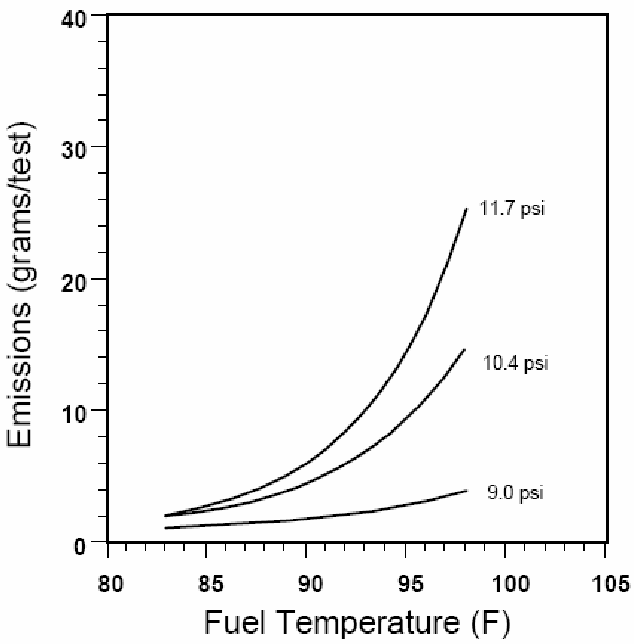
52 Belgium, Germany, Netherlands, Spain

53 The European Environment; State and outlook 2005

Belgium, Cyprus, Ireland, Luxembourg Portugal, Slovenia and Spain are not on track to meet their NECD targets for emissions of ozone precursors (NOx and VOCs). Average occurrence of ozone exceedances of the EU target for ozone increased between 1997 and 2003, particularly in Southern Europe. Similarly with targets for average ozone concentrations which are not complied with in large parts of central and southern Europe. It is therefore clear that large areas of Europe are affected by ozone exceedances. In Northern European countries the ozone problem is mainly one of long range transport.

The Thematic Strategy on air pollution has identified and quantified the impacts on health, crops and the natural environment from exposure to ground level ozone. In 2000 it was estimated that 21,400 premature deaths per year resulted from ozone exposure and total health costs were quantified as 6.3 billion € per year. Ozone related crop damage was estimated at 2.8 billion € per year in 2000. The Strategy established new health and environmental objectives for ozone impacts to be attained by 2020. These will require reductions in VOC emissions across the EU by roughly 50% relative to the position in 2000.

Petrol producers must ensure compliance not only with vapour pressure requirements but also with minimum octane requirements. Some hydrocarbon components such as butane provide octane whilst also being amongst the most volatile components. Refiners' strategies on the use of oxygenates (and therefore biofuels) will in practice also take octane requirements into account.



VOC emissions are affected by both vapour pressure and temperature. The graph to the left shows the interaction between these different parameters. A 1.4psi change is equivalent to a 10kPa change. The graph shows the non-linear behaviour of VOC emissions over the range from 26 to 40 centigrade. The maximum permitted vapour pressure of petrol in the Directive is 60kPA which is slightly less than 9psi. It is clear from the graph that an increase of vapour pressure results in a large increase in uncontrolled VOC emissions.

Directive 2003/30 was adopted to encourage the use of biofuels within the EU. Ethanol made from biological sources is one of several possible fuel components promoted by it, although the use of ethanol can have an effect on air quality. In view of the potential conflicts between the Air Quality and Biofuel objectives, Article 9, paragraph 1 (g) of Directive 98/70 requires consideration of “the need to introduce modifications to other parameters in the fuel specifications, both for conventional and for alternative fuels, for example the modifications to the maximum volatility limits for petrol contained in this Directive required for their application to blends of bio ethanol with petrol and any subsequent necessary changes to EN 228:1999”.

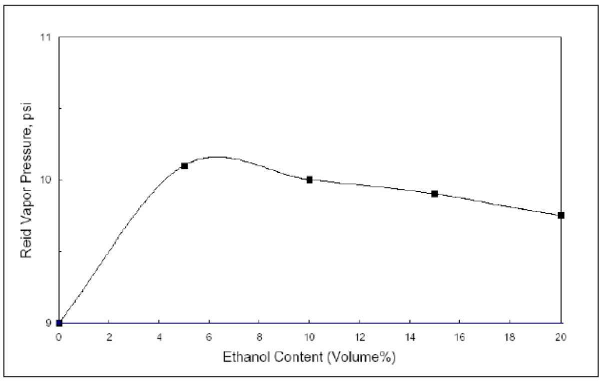
In addition to the question of whether the maximum summer vapour pressure should be amended, there are other issues relating to terminology and the wording of the legal text which need to be considered. These different issues are outlined below.

4.15.1.1.Footnote 4 of annex III

A problem has been noted with the current wording of footnote 4 of annex III of the Directive. This footnote is intended to take account of the climatic differences between Member States thereby allowing, as an exception to the general rule, a higher vapour pressure in Member States with particularly harsh winters. There are problems with the functioning of this reference as (1) the requirements are imprecisely defined and (2) the footnote principally refers to winter conditions but regulates summer vapour pressure. To resolve these problems it could be desirable to consider an alternative drafting that would clearly establish which Member States are subject to conditions requiring higher summer vapour pressure and specify these in a precise manner.

4.15.1.2.VOC emissions from biofuels

The blending of some compounds such as ethanol and methanol into petrol can lead to an increase of vapour pressure because of their very different molecular properties. The effect of blending ethanol into petrol is illustrated in the graph below.



In uncontrolled circumstances, an increase in vapour pressure results in increased VOC emissions. In the case where ethanol is blended into petrol, emissions occur through evaporation from fuel, permeation through fuel system components, evaporation at fuel distribution system level; and “commingling” effects. These effects are not observed or are observed to a much lesser extent with other bio-components such as ETBE or butanol.

The ethanol industry argues that it is desirable to introduce a higher vapour limit for petrol containing directly blended ethanol to make the introduction of ethanol more straightforward. Other stakeholders have argued for there to be no increase in maximum permitted vapour pressure for ethanol blends in petrol. Many stakeholders have not specifically addressed the vapour pressure limit but in their general comments on ethanol have argued that any change in the limits set by the Directive should not lead to a worsening of environmental impacts.

4.15.2. Policy options

For Footnote 4 the options are:

- No action
- Clarify the text.

With regard to the vapour pressure limit the options are:

- No change to the existing maximum RVP and thus no specific exception for ethanol-petrol blends
- No change in maximum RVP but reduce the RVP for all base stock petrol ("base stock") to ensure that when blended with ethanol the RVP remains below 60kPA.

- To increase the RVP limit through a fixed RVP waiver for petrol blended with ethanol
- To increase the RVP limit following the volatility curve of the mixture when petrol contains ethanol.
- To decrease the limit
- To remove the limit altogether.

Removal of the vapour pressure limit is discarded as an option because it would undermine the attainment of the primary goal of the Directive which is to limit the health and environmental impacts of fuel evaporation as well as running counter to the aims set out in the Thematic Strategy on Air pollution.

Decreasing the limit is also discarded since although it would lead to a reduction in VOC emissions, it would through reducing the attractiveness of blending ethanol in petrol increase the difficulty of achieving the Community Objective of a 5.75% biofuel share of road transport fuels.

4.15.3. Analysis of impacts

4.15.3.1. Footnote 4

Countries with extremely cold winters need to be able to market petrol in winter with very high vapour pressure. Without this, vehicle users will have difficulty starting their engines. Because of this extremely high winter vapour pressure, a problem was anticipated with the changeover to summer fuel because of the effects of the fuel remaining in the fuel supply system. It may also be the case that lower summer temperatures in the same countries mean that VOC emissions from petrol would be lower and ozone formation will be less.

In view of the above it is desirable to ensure that the Directive enables the use of appropriate fuels in the Member States concerned, yet does not at the same time result in excessive emissions of VOCs.

The table below illustrates the volatility classes used by EU15 Member States as well as Iceland, Norway and Switzerland .

Table G2 Gasoline volatility classes adopted by individual countries in 1999 (CONCAWE, 2004)

Country	Winter Class	Transition 1			Summer			Transition 2		
		Class	Begins	Ends	Class	Begins	Ends	Class	Begins	Ends
Austria	D	D	01/03	30/04	A	01/05	30/09	D	01/10	31/10
Belgium	E	E	01/04	30/04	A	01/05	30/09	E	01/10	31/10
Denmark	E	E	01/04	30/04	A	01/05	30/09	E	01/10	30/11
Finland	F	F	01/04	31/05	B	01/06	31/08	F	01/09	31/10
France	D	C	16/03	30/04	A	01/05	30/09	C	01/10	15/11
Germany	D	D	16/03	30/04	A	01/05	30/09	D	01/10	15/11
Greece	C				A	01/04	31/10			
Iceland	F	F	01/05	31/05	B	01/06	31/10	F	01/09	30/09
Italy	D	C	16/03	30/04	A	01/05	30/09	C	01/10	15/11
Ireland	F	F	16/04	31/05	B	01/06	31/08	F	01/09	15/10
Luxembourg	E	E	01/04	30/04	A	01/05	30/09	E	01/10	31/10
Netherlands	E	E	01/04	30/04	A	01/05	30/09	E	01/10	31/10
Norway	F	F	01/05	31/05	B	01/06	31/08	F	01/09	30/09
Portugal	D	D	01/04	30/04	A	01/05	30/09	D	01/10	31/10
Spain	C	C	01/04	30/04	A	01/05	30/09	C	01/10	31/10
Sweden North	E	E	16/04	15/05	B	16/05	31/08	E	01/09	30/09
Sweden South	E	E	01/04	30/04	B	01/05	15/09	E	16/09	15/10
Switzerland	E	E	01/04	30/04	A	01/05	30/09	E	01/10	31/10
UK	F	F	16/04	31/05	B	01/06	31/08	F	01/09	15/10

The vapour pressure for each class is shown in the following table[54].

Class	**A**	**B**	**C**	**D**	**E**	**F**
VP Min	45,0	45,0	50,0	60,0	65,0	70,0
VP Max	60,0	70,0	80,0	90,0	95,0	100,0

It can be seen from the table that only France and Italy use a transitional vapour pressure fuel between the winter and summer grades.

4.15.3.2. Vapour pressure limit

Some stakeholders claim that changing the maximum vapour pressure is necessary to enable Member States to achieve their targets in the Biofuels Directive. However, vapour pressure alone does not limit the amount of biofuel that may be blended in petrol, this is determined by the oxygenate limits discussed in section 4.14. Changing the vapour pressure has an effect on the economics of using different components.

Vapour pressure is a problem for methanol and ethanol because both of these lead to a substantial increase in vapour pressure when blended in petrol within the volumes considered in this review. In contrast other approaches to incorporate biofuels into petrol are possible without vapour pressure problems. Blending 15% ETBE in petrol enables a bio-energy

54 Vapour pressures reported in EN228

content of over 6% to be achieved with no increase in vapour pressure. No information has been made available to the Commission on the cost of these alternatives.

However, the Commission requested consultants to assess the cost of enabling ethanol to be blended in petrol through the removal of other volatile components. This assessment showed a maximum cost of 0.14€cents per litre. Since this is the cost that would be incurred by oil refiners to provide a base petrol which when blended with ethanol would remain within the vapour pressure limit, it can be assumed to represent the reduction in value that ethanol will have as a result of the limit.

In addition, a detailed US study on alternatives to MTBE[55] carried out 7 years ago does give some indication of the likely costs of ether use. The two main drivers of the cost of ETBE are ethanol and isobutylene. At the time of the study, oil cost $20 per barrel and ethanol between approximately 22 and 26€cents per litre. At these ranges ETBE was estimated to cost between 23 and 25€cents per litre. These figures seem to indicate no cost disadvantage from converting ethanol into ETBE before blending it in petrol.

Approximately 75% of the total ethanol used in EU fuel today is employed as ETBE. This appears to suggest that the total cost to fuel suppliers of using ETBE as a route for incorporating ethanol in petrol is lower than direct blending. A major factor in this may be because it has a higher value as a blending component and creates less constraints in distribution.

A similar logic appears to be driving development of butanol production. Even though production of this is likely to be more expensive than ethanol, it appears not to suffer from the distribution or vapour pressure problems of ethanol, and this offsetting benefit appears sufficient to justify fuel industry investment in developing the technology.

In the case of petrol-ethanol blends vapour pressure increases above that of the base petrol. This increase affects emissions of VOCs through a number of mechanisms. The main elements are:

1. Emissions from filling stations and infrastructure
2. Emissions from road vehicles
3. Emissions from other petrol using equipment and storage

These different elements are assessed below.

1. Emissions from filling stations and infrastructure

The Commission has carried out a study looking at the possible use and costs and benefits of Stage II vapour recovery (to capture and recycle VOC emissions when refuelling vehicles) in petrol filling stations[56]. As part of this study the consultants calculated the change in VOC emissions that would arise in different scenarios from a 10kPa increase in petrol vapour pressure. The conclusions of this study show an approximately 4.5kT increase in VOC emissions for petrol with 70kPa vapour pressure compared to 60kPa.

---

[55] Supply and cost of alternatives to MTBE in gasoline; December 1998 for California Energy Commission

[56] Stage II Petrol Vapour Recovery – Final Report; ENTEC; 2005

The introduction of Stage II vapour recovery reduces the overall level of emissions as would be expected. The reduction is between 20kT and 50kT per year depending on the assumptions made about coverage. Nevertheless, an increase in vapour pressure results in a comparable increase in VOC emissions whether or not Stage II vapour recovery is in use.

2. Emissions from road vehicles

To gain a better understanding of the effects of fuel vapour pressure on modern vehicles the JRC has conducted a series of evaporative emission tests. The results are reported in annex 1 to the JRC's final report[57] in support of the review of Directive 98/70. Following these tests, the programme has identified issues related to the effect of ethanol on increasing permeation and possible reduced effectiveness of carbon canisters due to the interaction of ethanol with the active ingredient. It is hypothesied that ethanol binds more tightly to the carbon than do the normal hydrocarbons in petrol. This results in the canister having a lower capacity to absorb VOC emissions from the tank. It also appears to be more difficult for the canister to be purged. The overall effect from these factors would be an increase in diurnal VOC emissions. These effects are not included within the modelling of emission impacts performed.

JRC used the COPERT model to estimate for ethanol and ETBE the overall impact of the change in vapour pressure on the balance between evaporative and tail pipe emissions for the vehicle fleet. The effects of a change in vapour pressure are not the same for each Member State. The expected increases of evaporative emissions in the ethanol scenario are mainly attributable to differences in yearly average temperatures and therefore this scenario has a higher effect on countries with warmer climates. The fleet composition and share of vehicles without a carbon canister also contribute to the increase in evaporative emissions.

Fleet composition also affects exhaust emissions. The increased oxygen content assumed in the ethanol scenario results in a decrease in exhaust VOC emissions which is proportional to the share of older vehicles (up to and including Euro 2). COPERT assumes that oxygenated petrol does not have any direct influence on the exhaust emissions of Euro 3 and 4 vehicles. As a result, countries with older fleets are expected to have larger reductions in exhaust emissions.

Apart from the above parameters, the changes in total VOC emissions from road transport also depend, on the share of the petrol vehicles in the entire fleet. The ethanol scenario will have a lower impact on both evaporative and exhaust emissions in countries with higher shares of diesel vehicles. The table below shows the influence of the ethanol scenarios on VOC emissions in EU15 Member states.

Projected changes in total, evaporative (Evap) and exhaust (Exh) VOC emissions from road transport in 2010 (standard CORINAIR)

		Total	Evap	Exh			Total	Evap	Exh
Austria	(1)	-1.9%	10.6%	-3.2%	Italy	(1)	-1.4%	13.6%	-4.6%
	(2)	-1.1%	8.8%	-2.1%		(2)	-0.7%	10.3%	-3.2%

57 http://forum.europa.eu.int/Public/irc/env/fuel_quality/library?l=/jrc_report_annexes/annex_resultspdf/_EN_1.0_&a=d

Belgium	([1])	0.2%	9.4%	-0.8%	Luxembourg	([1])	2.2%	11.2%	-0.8%
	([2])	0.8%	8.3%	0.0%		([2])	1.6%	8.8%	-0.8%
Denmark	([1])	0.8%	12.9%	-2.5%	Netherlands	([1])	0.4%	10.8%	-1.9%
	([2])	-0.1%	7.8%	-2.5%		([2])	0.4%	8.3%	-1.4%
Finland	([1])	-0.3%	11.6%	-1.2%	Portugal	([1])	-1.1%	13.8%	-2.4%
	([2])	-0.8%	8.4%	-1.6%		([2])	-0.7%	11.0%	-1.8%
France	([1])	0.6%	9.4%	-1.0%	Spain	([1])	1.6%	13.8%	-2.9%
	([2])	0.6%	9.4%	-1.0%		([2])	1.3%	10.5%	-2.1%
Germany	([1])	-1.2%	11.5%	-2.5%	Sweden	([1])	-1.3%	12.2%	-3.2%
	([2])	-0.6%	9.8%	-1.7%		([2])	-0.6%	9.5%	-2.0%
Greece	([1])	1.8%	19.7%	-5.1%	UK	([1])	0.5%	5.8%	-1.4%
	([2])	2.1%	17.9%	-3.9%		([2])	0.3%	5.1%	-1.3%
Ireland	([1])	0.9%	9.8%	-0.8%					
	([2])	0.6%	6.0%	-0.5%					

([1]) Percentage change of ETH1 compared to BL1
([2]) Percentage change of ETH2 compared to BL2

The ETH1 and ETH2 scenarios both model the use of 3.5% oxygenate with a 70kPa summer vapour pressure. The difference between the scenarios lies in the other fuel parameters which are set based on country-specific data in ETH1 and use the COPERT default values in ETH2.

The aggregated results of the COPERT modelling are shown below:

Projected changes in total, evaporative and exhaust VOC emissions

	2010		2020	
	Delta (kTs)	Delta (%)	Delta (kTs)	Delta (%)
Evaporative emissions	+25.1…+33.8	+10.1%…+19.8%	+19.1…+23.5	+10.1%…+18.6%
Exhaust emissions	-24.2…-33.6	-2.1%…-2.9%	-9.0…-11.3	-1.1%…-1.5%
Total road transport emissions	-3.6…+3.6	-0.3%…+0.3%	+11.0…+13.4	+1.3%...+1.4%
Total emissions from all sources	-3.6…+3.6	-0.06%…+0.06%	+11.0…+13.4	+0.21%…+0.26%

The results of the modelling show that for the EU for 2010 within the range of uncertainty there is an approximate balancing out of increased evaporative emissions and reduced tailpipe emissions from vehicles. However, as older vehicles are progressively phased out, the emissions increase due to the absence of offsetting gains in combustion. It also has to be noted that this assessment does not include permeation emission increases due to ethanol. These could be of the order of 20kT per year.

3. Emissions from other petrol using equipment and storage

The Commission has not carried out any modelling of the effects on petrol storage cans and machinery. However, such analyses have been performed in a number of US states. According to the CAFE baseline, EU VOC emissions from other mobile sources and machinery account in 2010 for 621kT and in 2020 for 354kT. It is unclear whether all of these would be for equipment and storage containers with petrol. Exhaust emissions from these are less strictly controlled than from cars and they will also not benefit from evaporative emissions controls. The effect of vapour pressure on evaporative emissions will therefore more closely follow that shown earlier for an uncontrolled state.

In California, preliminary test results[58] show increases in emissions from petrol equipment of between +6 and +77% for hot soak and between 29 and 49% for diurnal emissions using a fuel containing 6% ethanol in comparison with one containing 10% MTBE when the ethanol containing fuel has a comparable RVP. In aggregate for summer fuels the assessment is of a 27% overall increase in evaporative VOC emissions.

Petrol storage cans are a significant source of VOC emissions. California has carried out an assessment of emissions from portable storage cans[59]. This concluded that emissions are about 86 tonnes per day. California's population is about 50 million so an equivalent level of emissions for the EU would be 860 tonnes per day. Wisconsin has also assessed the effect of the use of ethanol[60] on VOC emissions. This showed that evaporative emissions from portable petrol storage containers amounted to 22 tonnes per day. Wisconsin's population is 5 million so the equivalent level in the EU would be about 2200 tonnes per day. If EU petrol can usage is estimated at around half that of California's then emissions from storage cans could be estimated at about 500 tonnes per day.

As shown earlier, these emissions will increase with vapour pressure. It was estimated for Wisconsin that the increase would be 15% with a 1 psi (6.9kPa) RVP waiver. The equivalent increase in the EU for a 10kPa vapour pressure increase would be 110 tonnes per day or 5.4kT over a 50 day summer period.

Aggregate effects

The table below gives an indication of the likely scale of the effect of a vapour pressure waiver and widespread ethanol use.

	Increase in 2010	**Increase in 2020**

58 Estimation of the impact of ethanol on off-road evaporative emissions; Walter Wong; June 2006
59 http://www.arb.ca.gov/msei/offroad/pubs/msc9925.pdf
60 Ozone air quality effects of a 10% ethanol blended gasoline in Wisconsin; September 6 2005; Staff report from the Bureau of Air Management; Wisconsin dept. of Natural Resources.

Filling stations	+4.5kT	+4.5kT
Car evaporative emissions	+25.1 to +33.8kT	+19.1 to +23.5kT
Other uses and storage	+5.4kT	+5.4kT
Total change due to 10kPa vapour pressure increase	+35.0 to +43.7kT	+29.0 to + 43.4kT
Benefit due to improved combustion from 3.5% O2	-24.2 to -33.6kT	-9.0 to -11.3kT
Estimated increase due to permeation from ethanol	≈+20kT	≈+20kT
Total effect of 10kPa vapour pressure increase with 10% ethanol	≈+30kT	+40 to 52kT

Because of the ongoing replacement of the vehicle fleet, by 2020 exhaust VOC emissions are much lower. Evaporative emissions will also have reduced but by a lesser amount. In consequence the aggregate VOC emissions increase due to evaporative emissions from vehicles will have increased to the range of +11 to +13 kT.

There is disagreement over some assumptions underlying this analysis, with particular criticism from the bioethanol industry. The main issues of contention are:

- The behaviour of ethanol petrol blends
- The relevance of the type approval testing temperature
- The assumptions about changes to vapour pressure outside the summer period

Alternative approach to using ethanol

The analysis of the effects on vapour pressure and VOC emissions of blending ethanol directly into petrol have been performed because of the interest expressed in using this route for incorporating biofuel in petrol. However, it is important to note that ethanol can be used in ways that avoid an increase in vapour pressure. Alternative approaches to using ethanol include:

- blending into lower vapour pressure base fuels,
- conversion to ETBE or TAEE which can then be blended in petrol without vapour pressure problems.
- Use of high blends of ethanol

In addition other biofuels can be used for incorporation in petrol manufactured from the same raw materials that do not exhibit the same vapour pressure problem.

1. Blending into lower vapour pressure base petrol.

An analysis performed for the Commission[61] has shown that the cost of displacing butane from petrol to enable direct blending of 5% ethanol in petrol with no increase in vapour pressure varies between approximately 0.05 and 0.14 €cents per litre. EU15 petrol sales were approximately 130,000 million litres in 2003. Therefore the cost of enabling 5% ethanol to be blended in all petrol by removing Butane would be between 65m€ and 180 m€ per year for oil companies. These costs would be passed on to consumers. This study has been criticised for taking too simplistic an approach to determining the cost, which would imply that the costs may be higher.

2. Blending of ETBE or TAEE in petrol

COPERT model runs were performed for the EU-15 to demonstrate the impact of using petrol containing 15% ETBE on VOC emissions. The overall results for the EU-15 are shown in the table below:

Impact of using petrol containing 15% ETBE on VOC emissions				
	Change in 2005	**Change in 2010**	**Change in 2015**	**Change in 2020**
Filling stations	No change			
Car evaporative emissions	No change			
Benefit due to improved combustion from 15% ETBE	-2.4%	-1.9%	-1.4%	-1.0%
Total effect of using 15% ETBE	-2.1% (37.5kT)	-1.6% (21.3kT)	-1.2% (12.3kT)	-.8% (7.3kT)

It can be seen that the use of ethanol in ether form avoids vapour pressure problems and consequent environmental degradation associated with direct blending of ethanol and results in an overall reduction in VOC emissions in line with the Thematic Strategy on Air Pollution.

3. Use of high blends of ethanol

High blends of ethanol, primarily marketed as E85, containing 85% ethanol and 15% petrol, do not exhibit high vapour pressure. The use of these fuels is restricted to specially adapted vehicles known as flexi-fuel vehicles. The cost of constructing new vehicles to operate on E85 is reported to be of the order of 100€ per vehicle. The supply of the fuel requires a separate distribution and pump, the costs of which have not been assessed. However, it seems reasonable to suppose that the cost of supplying E85 will not differ significantly from that of supplying E10. The use of ethanol in this form avoids vapour pressure problems and consequent environmental degradation associated with low blends of ethanol.

[61] Reduction in butane content of petrol due to blending of ethanol in petrol; Beicip-Franlab; April 2002

4.15.3.3. Effect of higher vapour pressure on Driveability

Concern has been expressed in relation to a possible deterioration in vehicle driveability arising from an increase in petrol vapour pressure. CONCAWE has produced a paper[62] reporting results of a series of driveability tests performed with different fuels. For hot driveability this reports that:

"• Four of the eight vehicles tested (three MPI and one DISI) exhibited good hot driveability performance (≤24 demerits) under all fuel/temperature conditions tested. A fourth MPI vehicle only exceeded 24 demerits on the highest volatility, 10% ethanol splash blend at 30°C.

• The fifth MPI vehicle showed substantial demerits on high volatility fuels (>100 kPa DVPE, >55% E70) at 30°C, especially for the ethanol splash blends.

• Two of the DISI vehicles showed poor driveability performance with very high demerits (>200) on high DVPE fuels (>100 kPa) at 30°C (and for vehicle 2 at 20°C), also on some less volatile fuels at 40°C. One of these vehicles clearly suffered from vapour lock in some tests as a "low fuel pressure" engine warning was displayed.

• The limited number of vehicles tested and their wide variation in demerit levels and response to fuels meant it was not practicable to perform fleet analysis. Analysis of individual vehicle data suggested that DVPE and temperature were the variables that influenced driveability most, followed by E70 and then ethanol content.

• In general, ethanol splash blends increased demerits and in some cases overall severity rating. Matched volatility ethanol blends gave similar driveability to the equivalent hydrocarbon fuels. This suggests that the effects seen are not due to the presence of ethanol per se but are a consequence of the increase in volatility that is caused by the addition of ethanol.

• In all cases substantial increases in demerits were only seen at high temperatures on fuels with volatility beyond the summer limits of EN228. Test fuels that met the existing European summer specification for DVPE and E70, showed few driveability malfunctions at 30°C, although two DISI vehicles (2, 3) exhibited a higher level of demerits at 40°C. On fuel B, with similar DVPE but higher E70 than the EN 228 standard, vehicle 2 showed high demerit levels (>200) at 40°C, as did vehicle 3 on the more volatile 10% ethanol splash blend BS."

For the cold driveability effects of ethanol it is reported that:

"• The effects of ethanol were varied. Only on a single MPI vehicle (6) was a small statistically significant effect of ethanol seen. However, on the lowest volatility fuel, splash blending ethanol generally improved driveability at -10°C (but not at +5°C). The matched volatility ethanol blends behaved similarly to the HC fuels. It is likely that the effects seen are a consequence of the increase in volatility caused by the addition of ethanol rather than the presence of ethanol per se."

While these tests indicate the possibility of driveability problems from higher vapour pressure fuels, it should be borne in mind that these tests were carried out under extreme circumstances

62 Gasoline volatility and ethanol effects on hot and cold weather driveability of modern European vehicles; CONCAWE 3/04

and are not likely to occur in normal operating conditions. Nevertheless, there is likely to be a minor increase in driveability problems if wider variation is permitted in fuel specification.

4.15.4. Comparing the options

A summary of the positive and negative implications of the alternative options is presented in the table below.

	VOC emissions	**Incremental cost to fuel industry**	**Incremental cost to bioethanol producers**	**Incremental cost to consumers**
Lower RVP for all petrol to ensure that when blended with bioethanol the RVP remains below 60kPA.	0 to -	++	0	+
Fixed RVP waiver for petrol blended with bioethanol.	+++	-	0	0 to -
RVP waiver following the volatility curve of the mixture when petrol contains bioethanol.	+ to ++	0	0	0
No change in RVP	0	0	0	0

It should be noted that the accuracy of the modelling means that there are uncertainties relating to size of the changes in emissions. These uncertainties are reflected in the range of results produced for the vehicle emissions. There are also disagreements over the assumptions used for the modelling work. It should also be noted that over time, the proportion of road traffic VOC emissions emitted as a result of cold start, hot emissions and evaporative emissions will change. Essentially hot emissions will become significantly less important.

The main impacts of changes to petrol vapour pressure will arise in the locality and region where the VOC emissions from that petrol occur. However, there is also a degree of long range transport of these emissions which will result in impacts not just in other parts of the EU but also in neighbouring countries.

Industry will develop the necessary technology to provide fuels meeting the specifications provided it is clear what the goals sought are. It is not a goal of the biofuel policy to lead to higher emissions of air pollutants. If there was no change in the permitted vapour pressure but a clear signal that more Greenhouse gas savings through the use of biofuels are required, this would lead to an exploration of biofuel technologies that are able to meet these objectives. Such clear signals will encourage innovation in the direction desired by the Community. This is in line with the Lisbon agenda.

The current vapour pressure limits are respected throughout the Community and these are verified through monitoring by the Member States. The industry is one which is highly safety conscious and has effective monitoring systems in place. It is therefore considered that there would be no difficulty of compliance with any of the options. However, the option of varying vapour pressure with ethanol content could present a greater challenge in verification in view of the need to measure not just the vapour pressure but also the ethanol content to verify whether the requirement would be respected.

It has been shown that an RVP increase is not needed to allow blending of ethanol in petrol since ethanol can be blended while remaining within the specification through removal of other petrol components. It has also been shown that up to 7% ethanol can be incorporated into petrol as ETBE while retaining the current maximum RVP. In addition, the European Fuel Oxygenates Association claims that an increase in vapour pressure for ethanol alone would be discriminatory.

Ethanol is one of a number of biofuels. Its production in Europe with conventional technology leads to relatively low greenhouse gas savings compared to other options. Many new biofuel technologies will avoid problems of compatibility with fuel quality specifications and may offer more attractive environmental performance.

Concern has been expressed over the effect of variations in vapour pressure on the driveability of vehicles. Test results indicate that it is the change in vapour pressure which appears to be the factor causing the problem as opposed to ethanol content itself. However, it should also be noted that these effects are usually noted at more extreme vapour pressures than those under consideration here.

A summary of the arguments for and against the different options considered is set out in the tables below.

4.15.4.1.Footnote 4

The options are presented below with a short summary of the arguments for and against.

Options	For	Against
No Action		Does not resolve the problem
Clarify footnote.	Greater legal certainty. Greater certainty of homogeneous fuel specification. Avoids danger of higher VOC	

	emissions from incorrect implementation.	

There do not appear to be any strong arguments to refrain from proposing a modification of the text to clarify its meaning.

4.15.4.2. Vapour Pressure

The options are presented below with a short summary of the arguments for and against.

Options	For	Against
Require lower RVP for all petrol to ensure that when blended with bioethanol the RVP remains below 60kPA.	No increase in VOC emissions from ethanol. Decrease in VOC emissions from non blended petrol. Technologically neutral.	Cost – essentially for removal of butane – estimated at between 0.05 and 0.14 €cents per litre. If all EU petrol were to have such an RVP the cost would be between €65m and €180m per year.
Fixed RVP waiver for petrol blended with bioethanol.	The increase in VOC emissions is likely to be lower than that from increasing RVP of all petrol. This will be in part dependent on the extent of the commingling effect since if some suppliers use no ethanol and others use 10% ethanol then many vehicles will have fuel in their tanks with a vapour pressure higher than the maximum permitted for sale.	Increase in VOC emissions from blended fuel. Cost of €1,500 to €3,000 per tonne of VOC for offsetting stage II vapour recovery. Need to verify that petrol contains ethanol when checking RVP and that only bioethanol is blended not synthetic ethanol. Potential for use of higher volatility mineral oil components with some ethanol. A specific derogation such as this for ethanol will favour the use of this biofuel over other petrol substitutes and discourage investment in more environmentally benign alternatives.
RVP waiver following the volatility curve of the mixture when petrol contains bioethanol.	Lower increase in VOC emissions than increasing RVP of all petrol. No commingling problem.	Increase in VOC emissions from blended fuel. Cost of €1,500 to €3,000 per tonne of VOC for offsetting stage II vapour recovery. Need to verify ethanol content when checking RVP and that only bioethanol is blended not synthetic ethanol.

		A specific derogation such as this for ethanol will favour the use of this biofuel over other petrol substitutes and discourage investment in more environmentally benign alternatives.
No change in RVP	No increase in evaporative VOC emissions. Ethanol can be blended provided specific low RVP blend stock is available. Ethanol can be used without changing RVP through manufacture and blending of ETBE with no cost of removing butane. Ethanol can be used in high blends with no difficulty. Other biofuel components such as butanol may be employed to incorporate biofuel in petrol while respecting environmental constraints. Technologically neutral.	To directly blend ethanol will require removal of more volatile components e.g. butane – estimated at between 0.05 and 0.14 €cents per litre. If 25% of EU petrol is affected then the cost would be between €16m and €45m per year. Blending ethanol via ETBE will have a cost due to its higher cost per unit volume than petrol but has offsetting distribution benefits. Use of alternative biofuels such as butanol will depend on their cost of production.

It seems likely that a significant increase in VOC emissions would follow from an increase in permitted petrol RVP. There appears to be a steeply rising relationship between VOC reduction ambition and cost. An increase in VOC emissions from the supply of road transport fuel would run counter to the Community's recently adopted Thematic Strategy which aims for a halving of VOC emissions by 2020 compared to 2000. This could raise cost and competitiveness concerns for other sectors that would as a result be subject to higher VOC abatement costs. During the Impact Assessment of the Thematic Strategy Air Pollution it was clear that industry has concerns over the cost of achieving ozone reduction. In this context it is essential that limits on the release of ozone precursors should not be relaxed and these include VOC emissions.

These factors should also be considered in the light that there is no overriding need to raise the permitted petrol vapour pressure to promote use of biofuels in view of the availability of alternative routes to blending ethanol directly in petrol.

4.15.5. Preferred option

Increasing the permitted maximum vapour pressure for ethanol blends in petrol should not be permitted. This is because:

- An increase is not necessary for encouraging the use of biofuels or for ethanol
- An increase will lead to a significant increase in VOC emissions, contrary to the goal of the Thematic Strategy on Air Pollution and commitments in the Biofuel Strategy.
- An increase purely for blending ethanol in petrol would discriminate against alternative uses of ethanol as a petrol blending component and unfairly disadvantage those industries.
- An increase would discourage development of better biofuel components for blending in petrol running counter to the goal of encouraging development set out in the Biofuel Strategy.

If it is decided to permit a vapour pressure waiver to encourage the development of the ethanol industry, then this waiver should be defined according to the curve describing the actual change in vapour pressure. This is to ensure that when any legal blends are mixed together, the resulting mixture will itself also be legal. This approach will also ensure that perverse incentives are not created for fuel suppliers to blend small quantities of ethanol and incorporate other high volatility hydrocarbons as a result of the higher permitted pressure

4.16. Life cycle GHG emissions from road transport fuel

4.16.1. The problem

Article 1 of the Directive states that "This Directive sets technical specifications on health and environmental grounds for fuels to be used for vehicles equipped with positive-ignition and compression-ignition engines". In the past the Directive has been used to set limits on petrol and diesel fuels that are established primarily to limit pollutant emissions to air in view of the dangers that they pose directly or indirectly to human health or to the environment.

One aspect of the impact of emissions from fuel combustion in vehicles that has not previously been addressed in the Directive is that of the emissions of gases with climate change impacts. It is now well recognised that these gases have significant impacts on the environment and through climate change could also result in threats to human health.

The Community has established policy on reducing the emissions of climate change gases. Its immediate goal is to achieve an 8% reduction in greenhouse gas emissions by 2008-2012 compared to 1990 levels. In the medium term, it has stated the desirability of reducing its greenhouse gas emissions to between 15 and 30% below this level. By contrast, over the period between 1990 and 2003 road transport GHG emissions increased by around 24%.

A number of developments are leading to a situation where it is desirable for policy to take account of life cycle greenhouse gas emissions from transport fuels, which account for around a third of the EU's greenhouse gas emissions. Some measures have been taken such as the biofuel Directive that aims to promote fuels produced from biomass that have lower greenhouse gas emissions. There has also been work undertaken looking at other alternative fuels and research and demonstration activities for the use of hydrogen as a transport fuel.

The Community has also indicated the desirability of tackling GHG emissions from road transport. This was initially expressed through the voluntary agreements with car manufacturers which committed the latter to achieving average new vehicle CO_2 emissions of 140g/km by 2008/9. The Community also agreed a target of 120g/km for 2012. The Commission has recently published a Communication setting out the approach to achieving this.

At the same time, technological advances, energy costs and concern over security of energy supply have led to a number of advances in other routes to supply road transport fuel. Unconventional oil reserves such as oil sands and oil shale are being developed, in particular in Canada and Venezuela. Greenhouse gas emissions from these are around 20% above those from the use of conventional oil. The production of synthetic fuels is possible from a number of feedstocks such as coal, natural gas and biomass. The end product from these three feedstocks is indistinguishable but the lifecycle greenhouse gas emissions differ widely. BTL fuel might produce only 10% of the greenhouse gas of petrol or diesel, while GTL will produce a comparable amount and CTL is likely to produce around twice as much.

In addition, there has been interest in using gaseous fuels. So far LPG and natural gas have had the highest market penetration. In the future hydrogen may become an increasingly important fuel. DME may also have a role. Where these fuels are made from other materials (for example in the case of DME and hydrogen) there are highly significant variations in the overall greenhouse gas balance depending on the process employed. To date the only account taken of these differences at Community level has been in respect of the voluntary agreement on CO_2 and cars where natural gas vehicles are given a 25% reduction in GHG emissions.

Emulsion fuels are another example where in addition to lower pollutant emissions, their use also reduces overall GHG emissions. In this case the benefit is only realised in the tank to wheel part of the lifecycle rather than in the production part.

A further factor that has been explored in section 4.11 is the benefit that detergents are claimed to offer for improving vehicle efficiency. As was noted in that section, it is difficult to envisage a mandatory approach to the use of detergents. However, if the use of detergents or other additives could be shown in real world conditions to improve efficiency and thereby reduce GHG emissions per vehicle km there is no reason why these benefits should not also be captured in the life cycle analysis. This would reward fuel suppliers and provide an appropriate way of incentivising the use of detergents.

Compared with the current situation where most road transport fuel is derived from conventional oil, it is likely in the future that there will be a more diverse range of production pathways for road transport fuel and these will result in a wider variation in the greenhouse gas emissions. Since greenhouse gas emissions have the same warming effect wherever they are emitted, the fact that some installations may be built in other countries should not mean that their greenhouse gas emissions are ignored by EU policy. It is desirable for EU policy to send a clear signal to fuel producers that the life cycle emissions of the fuels they supply should be reduced.

The public consultation on the review of the Biofuel Directive asked whether it was desirable to implement monitoring or certification of life cycle greenhouse gas emissions for biofuels. There appears to be considerable support for such a possibility, although with the caveat that it should avoid leading to excessive increases in cost. The UK and Dutch governments responded that a monitoring scheme should be a first step in setting standards. The Brazilian government responded that the approach should cover not just biofuels but also fossil fuels. A more detailed summary of responses to the consultation has been published[63].

These increasingly large differences in lifecycle greenhouse gas emissions from road transport fuels may mean that it is necessary to take action to ensure that this does not lead to even higher greenhouse gas emissions from the transport sector than is currently the case. It could be possible for Directive 98/70 to be modified with the objective of encouraging greenhouse gas emission reductions from road transport fuels in an environmentally focussed manner.

The Comprehensive Approach to CO_2 and cars also creates an opportunity to consider the role that reducing GHG emissions from the fuel over its life cycle can play in reducing overall GHG emissions from transport. A measure to de-carbonise transport fuel could provide one part of such an approach. This issue has been the subject of debate among automotive manufacturers regarding the possibility of distinguishing between the sustainability of different fuels.

---

63 Review of EU Biofuels Directive public consultation exercise, summary of the responses, August 2006, http://ec.europa.eu/energy/res/legislation/doc/biofuels/contributions/2006_08_23_summary_responses.pdf

4.16.2. Policy options

In its Communication on alternative motor fuels, COM (2001)547 the Commission discussed the possibility and desirability of promoting different alternatives to conventional transport fuels. One of the main reasons for an interest in alternative fuels is if their use results in lower life-cycle greenhouse gas emissions.

The Commission proposal to promote the use of biofuels in transport was subsequently adopted as Directive (2003)30. In addition, the energy taxation Directive[64] permits Member States to de-tax biofuels as a measure to enable them to be price competitive. Neither Directive distinguishes between fuels on the basis of their greenhouse gas impacts. This means that the full potential of alternative fuels to avoid transport greenhouse gas emissions is not being met. However the Commission has already announced in the Action Plan on Energy Efficiency that it will prepare a green paper on indirect taxation in 2007 and will subsequently review the Energy Taxation Directive to facilitate a more targeted and coherent use of energy taxation by integrating notably energy efficiency considerations and environmental aspects, in particular to allow for more automatic tax differentiation according to the environmental characteristics of fuels.

In addition, in view of the advent of more sophisticated biofuel technologies that are likely to be more capital intensive but realise much greater greenhouse gas savings with lower environmental impacts it is desirable to include this environmental aspect in the fuel specification contained in Directive 98/70.

Directive 98/70 could be modified with the objective of encouraging greenhouse gas emission reductions from road transport fuels. In this way, the Fuel Quality Directive would act as an implementing measure of the biofuels Directive, as it would imply a strong incentive towards fuels with a greater carbon efficiency, including biofuels, while optimising the benefits in terms of CO_2 reductions, without prejudice to other complementary measures such as those examined in the framework of the review of the Energy Taxation Directive.

Reducing GHG emissions from the fuel over its life cycle can play a part in reducing overall GHG emissions from transport. In view of this, the options to be considered are:

- No EU action
- A voluntary agreement with fuel suppliers to progressively reduce fuel lifecycle GHG emissions.
- Mandatory obligation on fuel suppliers to measure life cycle GHG emissions and to progressively reduce these emissions.

4.16.3. Analysis of impacts

Under Business as Usual, total GHG emissions from road transport fuel in EU in 2010 are forecast to be around 800MTCO_2. This would be around 21% of total GHG emissions. The EU currently has in place two measures to address these emissions. These are the strategy on CO_2 and cars and the Biofuels Directive. The CO_2 and cars strategy is currently focussed on

[64] Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity

reducing CO2 emissions from passenger vehicles. This will translate into lower overall transport CO_2 emissions provided there is no rebound effect.

The Biofuels Directive seeks to promote the greater use of biofuels and sets a reference value for 2010 of 5.75% biofuel use by energy value in road transport fuel. This is equivalent to approximately 19MTOE. The GHG savings that will be realised by achieving this value will depend on the pathways used to produce the fuel. The table below indicates the theoretical resulting CO_2 savings from the use of different biofuel technologies. It should be noted that none of these individual technologies is likely to supply all of the biofuel consumed in 2010.

Fuel	Indicative GHG savings	Approximate overall GHG saving from 5.75% substitution
EU ethanol	30%	≈ 15 MT CO_2
EU FAME	60%	≈ 30 MT CO_2
Straw ethanol	89%	≈ 45 MT CO_2
FT diesel wood	91%	≈ 45 MT CO_2

It can be seen from this table that the potential variation in greenhouse gas saving between different biofuel options is large. It should be noted that the last two options are currently only operating in pilot plants. Achieving the volume objective of the Biofuel Directive could result in greenhouse gas savings of between approx 0.3 and 1% of EU CO_2 emissions.

Biofuels are only one of the fuel options available that offer a route to reducing overall GHG emissions. In recent Community documents, a number of fuel options have been explored. The table below gives an indication of the scale of GHG savings that can be expected from the use of different fuels. It has to be noted that most fuels present specific challenges, for example in relation to infrastructure, further research, or practicability of use. Notwithstanding these challenges it can be seen that a wide range of options exist.

Fuel	CO_2 saving WtW (CEJ study)
Tar sand/Oil Shale	[-20%][65]
GTL	≈ =
CTL	[-100%?]
CNG	14%
LPG	13%
Emulsion fuel	≈5% [EEFMA]

[65] Oil Sands Fever, The Pembina Institute, November 2005

Ethanol (EU wheat, NG CCGT)	45%
Biodiesel	50%
Cellulose ethanol*	74 to 89%
Synthetic diesel*	91 to 96%

All fuels listed are currently commercially available except those marked *.

In the longer term Hydrogen may become feasible and desirable for use as a transport fuel. However, in this case GHG emissions can be anywhere between much lower or much higher than the equivalent emissions from the use of fossil fuels. The variation is entirely dependent on the production pathway.

Another dimension that needs to be taken into account is the cost of achieving the GHG savings through the various options. The different fuels have varying costs per litre to produce them, but their costs per tonne of GHG avoided will also vary due to their differing overall GHG savings.

Table illustrating the cost of achieving a road transport CO_2 saving of 1MT per year, based on WTW analysis with oil at €50 per barrel.

	WTW saving	**Cost per tonne** CO_2**avoided.**	**Total cost**	**Total quantity fuel required PJ/a**
CNG	13%	334	334M€	89
LPG	13%	453	453 M€	94
Ethanol (wheat DDGS feed NG CCGT)	45%	140	140 M€	26
Biodiesel (RME, Glycerine as feed)	47%	145	145 M€	24
Cellulose ethanol (from straw)	89%	-20	-20 M€	13
Synthetic diesel (from wood)	91%	187	187 M€	12

One of the major uncertainties relates to the actual GHG savings for different fuel pathways. These can be affected by a wide range of factors. While these would affect the illustration of the results, the fact that the option would allow flexibility to fuel suppliers to choose between fuels would enable them to make decisions about the optimal approach to achieve the desired savings.

Outside the EU, the impacts would be independent of the policy. The overall benefit from a given level of GHG saving would be independent of how that saving was achieved.

The importance of addressing GHG emissions from transport is likely to become increasingly important as other sectors use up their lower cost abatement options. On current trends, the proportion of total GHG emissions from transport will increase, making it more important to take action in this area.

The impact of a measure to reduce transport fuel GHG emissions would not have particular effects on any specific economic sector or region. The choices made about fuels to be used will be based on their overall cost effectiveness in meeting the various goals required, among which will be a goal of reducing life cycle greenhouse gas emissions.

An obstacle to attempting to control lifecycle GHG emissions from transport fuel comes from differences between the methodologies used in such an assessment. However, substantial work has been carried out by the Commission's Joint Research Centre in collaboration with EUCAR and CONCAWE on a methodology for measuring life cycle emissions from a wide range of fuel production pathways. In addition, the UK and the Netherlands have developed methods to measure the life cycle emissions of biofuels and included these methods in their respective biofuel policies. The existence of alternative approaches is not problematic provided that the methodology to be used is defined and agreed. A recent assessment by the International Council for Clean Transportation[66] comparing the output of different life cycle assessment models shows that there is not a wide disagreement between the outcomes of these different models for similar fuel pathways.

Since it is suggested that alternative fuels can lead to an improvement in security of energy supply, it is desirable to consider whether or not the policy options would have any impact on security of supply. As is discussed in annex 2, there are a number of parameters that affect the influence of alternative fuels on security of supply. One major factor is whether the fuel substitutes for petrol or diesel. However, it has also been shown that the security of supply benefits of biofuels are diminished by the proportion of fossil energy used in their production. Therefore biofuels requiring a lower fossil energy input and therefore having a lower GHG balance would normally result in a greater security of supply benefit. It follows that a policy encouraging greater GHG avoidance whether through a voluntary or mandatory approach or fiscal incentives will enhance any security of energy supply benefits.

The Commission has performed a study[67] considering the lowest cost way of achieving 20% renewable energy in the EU energy mix on the basis of the Green-X model.[68]. The least cost modelling approach is based on meeting a 20% share of renewable energy in 2020 and optimises towards this 20% according to the substitution principle, which means that it chooses those renewable energy technologies that replace maximum conventional energy at minimum cost, across the EU and across the various sectors (electricity, heating and cooling and biofuels). It is therefore also a close proxy for maximising CO_2 benefit at minimum cost to meet a 20% renewable target.

---

[66] Renewable Fuels Portfolio Standard; ICCT; 2006

[67] Economic analysis of reaching a 20% share of renewable energy sources in 2020; ISI, EEG, ECOFYS;August 2006

[68] http://ec.europa.eu/environment/enveco/studies2.htm

The table below shows the main conclusions in relation to biofuels. It can be seen that while biofuels remain at very low levels until 2010, because cheaper options are available in other sectors (electricity and heating and cooling), the biofuel share in road transport fuels would increase from 0.8% in 2010 to 12.5% in 2020 or by 11.7 percentage points in total. According to this methodology, approximately 90% of this increase in biofuel would be from using biofuels with a high GHG saving (with almost equal shares of import and second generation biofuels), meaning that the total increase in GHG emissions saved would represent about 9% of total road transport fuel emissions in 2010. This corresponds to almost a 1% per year reduction. When other possible additional measures to reduce life cycle GHG emissions are included, the possible total saving exceeds 1% per year.

Share of renewables in electricity, heat and transport fuel demand

	2010	**2020**
Share of RES-E in electricity demand	25.6%	42.8%
Share of RES-H in heat demand	11.3%	16.3%
Share of RES-T in road transport fuel demand	0.8%	12.5%
Share of all RES in primary energy consumption **- Eurostat convention**	10.7%	20.0%

In view of the Commission's objective of a 10% minimum use of biofuels, but its view that 14% could be achieved, a mandatory goal to reduce GHG emissions by 10% will not lead to any additional increase in the volume of biofuel required over and above what is required under the biofuels Directive. It will provide an incentive to ensure however that the biofuel used does actually deliver significantly more GHG savings. It will also send a clear signal of the importance of developing more advanced second generation processes with greater GHG savings, which is also of interest from an industrial innovation policy perspective.

An obligation on fuel suppliers to reduce life cycle greenhouse gas emissions would leave them flexibility to choose which fuels to include in their mix to meet such obligation, and ensure a cost-effective approach to meet the obligation. Some might choose a mix of high and low GHG fuels while other suppliers might prefer to favour a balance of middle ranking GHG fuels. The choice ultimately will depend on the cost of the different fuel sources.

During stakeholder discussion, the fuel supply industry stated that it supported the goal outlined in the Commission's working paper on life cycle greenhouse gas emissions from road transport fuels.

4.16.4. Comparing the options

	Cost per tonne of GHG avoided from fuel related policies	**Total GHG avoided from fuel related policies**	**Burden on industry**	**Effectiveness**

No action	High	Low. Some savings in refineries from ETS and some saving from biofuel policy.	None	Low. No additional action and existing policies have a small effect.
Voluntary agreement to reduce fuel lifecycle GHG emissions	As low as technically feasible since all options are available.	Absolute savings will depend on the level agreed and public pressure. Will be higher than no action, but danger of free riding by participants to the agreement.	Low to monitor GHG savings. Small increase over effort required to meet biofuels target.	Medium. No sanction to ensure that agreement is respected.
Mandatory obligation to reduce fuel lifecycle GHG emissions	As low as technically feasible since all options are available. Probably zero additional cost on biofuel objective.	High. Absolute savings will depend on the level of obligation. Significantly higher than no action and biofuels policy alone.	Low to monitor GHG savings. Small increase over effort required to meet biofuels target.	High. Threat of effective sanctions is needed to ensure action taken and the polluter pays
Fiscal incentives linked to lifecycle GHG emissions	As low as technically feasible since all options are available.	High. Absolute savings will depend on the level of incentive. Can be much higher than no action.	Low to monitor GHG savings. Small increase over effort required to meet biofuels target. but offset by fiscal incentives.	Medium. Savings will be achieved through fiscal incentives, but government rather than the polluter pays.

A reporting requirement alone would not necessarily lead to any change in behaviour by fuel suppliers and therefore no reduction in Greenhouse Gas emissions. The only difference between the reporting requirement and a mandatory reduction target based on the reporting obligation would relate to the effectiveness. Introduction of the monitoring regime can be achieved through use of a Committee procedure to agree the methodology to be adopted. In view of the broad agreement between different life cycle models, the development of an appropriate methodology is not considered a major obstacle, but trade-offs between accuracy and complexity of the methodology will need to be made.

The application of the monitoring regime will involve some additional cost for those that fall under the obligation and for governments. For instance, studies in the UK in relation to the administrative costs of a monitoring scheme for biofuels, have estimated the cost for developing the methodological tools at €300-450k. Total costs for data collection and verification are estimated to be approximately 0.03 €c/litre biofuel or 0.0015€c/liter transport fuel (in the case of 5% biofuel blending). It must be noted that having a standardised methodology across the EU, rather than Member States developing individual methods under their domestic policy will reduce administrative costs substantially, not the least for industry that may otherwise be faced with a proliferation of national monitoring schemes for greenhouse gases.

4.16.5. Preferred option

A mandatory reduction target linked to life cycle GHG savings responds to a number of the goals established by the Commission in its biofuel strategy communication. In particular it incentivises innovation in the sector, encourages the development and commercialisation of 2nd generation biofuels and it ensures that the biofuel policy results in improving GHG savings. This means that this element reinforces the implementation of the biofuel Directive and significantly improves its effectiveness.

The analysis shows that there could be significant benefit from requiring the reporting of life cycle Greenhouse Gas emissions for road transport fuels. However, real Greenhouse Gas reductions can only be assured if the reporting is associated with a mandatory requirement to reduce the emissions. Therefore a mandatory reduction obligation should be introduced after a trial period of operation of the reporting obligation.

5. MONITORING AND EVALUATION

Core indicators of progress towards meeting the objectives

The core indicator of achieving the goals of Directive 98/70 is compliance with the fuel parameters. In view of this a Fuel Quality Monitoring system was established to provide necessary information on fuel quality in the Member States. Four reports have been provided for years 2001 to 2004 and the fifth for the year 2005 will be published at the end of 2006. Commission has published three reports that were transmitted to the Council and Parliament and the fourth will be published when the Member States' data is available. All data is available on the internet at: http://europa.eu.int/comm/environment/air/fuel_quality_monitoring.htm .

Most of the proposed changes do not result in any additional monitoring needs, although some do change the limit value of the parameter to be monitored. It will be necessary under the changes proposed to continue to monitor sulphur content of non-road fuel and introduce reporting and monitoring of GHG emissions from road transport fuel.

Possible monitoring and evaluation arrangements

The Fuel Quality Monitoring System will need to be adapted to take account of changes proposed. In particular it will be necessary following the changes that are proposed to also monitor non-road fuel and GHG emissions.

The arrangements for this monitoring will follow the current arrangements. The Commission employs a contractor who compiles data that is submitted by Member States. The requirements are set out in the Directive, and additional requirements are established by CEN. A report is published and made available on the internet with all of this data. A summary report is prepared by the Commission and submitted to the Council and Parliament.

In view of the continually evolving nature it is proposed that the Commission will undertake a review of the fuel and vehicle technologies available and assess the need for any further evolution of the fuel specifications approximately five years after adoption of the revised Directive.

GLOSSARY

BaP	Benzo(a)Pyrene (a marker for other Poly Aromatic Hydrocarbons)
BTL	Biomass To Liquid: process for producing synthetic diesel fuel
CAFE	Clean Air For Europe
CARB	California Air Resources Board
CEN	European Standardisation Organisation
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CONCAWE	Conservation of Clean Air and Water in Europe (the oil companies' European Association for environment, health and safety in refining and distribution).
COPERT	Model used to estimate emissions of pollutant gases from road vehicles
CNG	Compressed Natural Gas
CTL	Coal To Liquid (process for producing synthetic diesel fuel)
DME	Di Methyl Ester
DPF	Diesel Particulate Filter
DVP	Dry Vapour Pressure
ECCP	European Climate Change Programme
ECU	Engine Control Unit
ENGVA	European Natural Gas Vehicles Association
ETBE	Ethyl Tertiary Butyl Ether
EUCAR	European Council for Automotive R&D
FAME	Fatty Acid Methyl Ester (commonly referred to as Biodiesel)
FFV	Flexible Fuel Vehicle (commonly used to refer to a spark ignition engined vehicle able to use any blend of petrol and ethanol)
GHG	Greenhouse Gas
GTL	Gas To Liquid (process for producing synthetic diesel fuel)
HDV	Heavy Duty Vehicle
JRC	Joint Research Centre of the European Commission
LDV	Light Duty Vehicle

LEVII	Low Emission Vehicle (certified to the State of California's second phase of emission limits)
LPG	Liquid Petroleum Gas (usually either Propane, Butane or a mixture of the two)
MMT	Methylcyclopentadienyl Manganese Tricarbonyl (an octane enhancing metallic additive for petrol)
MTBE	Methyl Tertiary Butyl Ether
MVEG	Motor Vehicle Emission Group
NOx	Nitrogen Oxides
PAH	Poly Aromatic Hydrocarbons
PM	Particulate Matter
PZEV	Partial Zero Emission Vehicle (a vehicle with super ultra low exhaust emission levels (SULEV) and zero fuel evaporative emissions certified for the State of California)
RVP	Reid Vapour Pressure
SAE	Society of Automotive Engineers (automotive industry association in USA)
THC	Total Hydro Carbon
VOC	Volatile Organic Compounds
WWFC	World Wide Fuel Charter (a set of fuel specifications favoured by automotive industry)

Annex 1

List of stakeholder organisations that participated in stakeholder meetings on fuel quality

Acronym	Organisation
ACEA	Association of European Car Manufacturers
AECC	Association for Emissions Control by Catalyst
ATC	Additive Technical Committee for Europe
CEN/TC	European Standardisation Organisation
CLEPA	European Association of Automotive Suppliers
EBB	European Biodiesel Board
EEFMA	European Emulsion Fuel Manufacturers Association
EFOA	European Fuel Oxygenate Association
EUROMOT	European Association of Internal Combustion Engine Manufacturers
IFP	
IFQ	
IFQC	International Fuel Quality Centre
JAMA	Japanese Automotive Manufacturers Association
KAMA	Korean Automotive Manufacturers Association
EUROPIA	European Petroleum Industries Association
CONCAWE	Clean Air and Water in Europe
UEPA	European Ethanol Producer's Association
eBIO	European Bioethanol Fuel Association

Annex 3

In-use environmental impacts of biofuels

1. Oxygenates

Oxygenates primarily influence emissions by their effect on the balance of fuel and air in the engine. If a car, tuned to run on petrol runs on fuel containing an oxygenate without readjustment, the effective air-fuel ratio will be increased as a result of the oxygen contained in the fuel, at least for older model cars. This leaner air-fuel ratio will tend to reduce CO and HC emissions, but in some cases this will be at the expense of an increase in NOx.

Modern adaptive learning vehicles will compensate to some extent to the fuel characteristics, so the effects of a change in fuel may not be so large. However, a certain effect of oxygenates on exhaust emissions could be expected even in modern vehicles especially in particular operating conditions. This effect on exhaust emissions may be explained as follows. During the start and warm up, the vehicle's ECU works in "open loop" (without lambda regulation). In this period oxygenate-petrol blends increase the oxygen content of the fuel mixture. For this reason the THC and CO emissions should be expected to decrease and the CO2 and NOx emissions to increase. After the catalyst has reached its light-off temperature, the vehicle works in "closed loop" (regulated by the oxygen sensors). In this condition exhaust emissions of THC, CO and NOx should not be affected by the addition of oygenates to petrol since the vehicle adjusts the air/fuel ratio to the level of oxygen in the fuel (in the same way as for a fuel without oxygenate). However, at full engine loads the ECU will change to an open-loop control mode in order to produce maximum power, resulting again in lower THC and CO emissions thanks to the enleanment effect of the oxygenate.

With regard to unregulated pollutants, with increased oxygenate content, engine-out unburned ethanol and acetaldehyde emissions increase. However, three-way catalysts can effectively convert acetaldehyde emissions, but the conversion of unburned ethanol is low. The introduction of ethanol-petrol blends to an existing population of vehicles could therefore give immediate reductions in HC and CO emissions, but increase aldehydes.

The effects of ethers (MTBE, ETBE, TAEE) on emissions is based on the mechanisms described above. In general, the use of ethers allows some problems connected to the use of other oxygenates like methanol and ethanol (effect on vapour pressure, material compatibility, higher octane number), to be overcome.

In diesel engines, fuel is injected directly into the combustion chamber towards the end of the compression phase. Before igniting the fuel has to evaporate and mix with air. This mixing is not instantaneous and therefore at the moment of ignition the mixture will be highly non-homogeneous with areas where the air/fuel ratio is still very low. Soot is usually formed in these areas where there is not enough oxygen and the fuel undergoes processes like pyrolisis and dehydrogenation. If the fuel contains oxygen the air/fuel ratio will be higher and therefore the combustion process will result in less soot formation. However, NOx emissions can also increase.

1.1 Ethanol

The effect of low blends of ethanol in petrol on regulated emissions from modern cars:

CO Small decrease (up to 10%)

HC No effect or slight decrease (up to 5%)

NO_x No effect or small increase (up to 10%)

1.2 Other alcohols

Other alcohols can be produced from biomass and are permitted to be blended into petrol. Although there is little in-use experience, Butanol has been reported to offer minor CO reduction but no impact on other regulated emissions.

1.3 Ethers

The impact of ethers on exhaust emission is basically linked to the leaning effect on the charge due to the oxygen content.

The effects on regulated emissions reported in the literature are very variable; in particular, very effective after-treatment systems reduce the influence of ethers on exhaust emissions and therefore the effects appear to be larger for old vehicle technologies than for modern vehicles.

The effect on regulated emissions is typically within the following ranges:

CO Decrease (up to -30%)

HC Decrease (up to -20%)

NO_x No significant effect

Smaller variations when engine/vehicle technology becomes more sophisticated (and with low emitting vehicles)

1.4 FAME

Effects on emissions of FAME/ diesel blends have been investigated and a lot of data is available, although most tests have been carried out on heavy duty engines and these sometimes have conflicting conclusions. The situation with unregulated emissions such as PAHs adsorbed on particulates is less clear with some work showing increased PAH emissions with FAME blends while these are lowered in others.

Less data is available for light duty vehicles; however, when FAME blended with diesel, has been tested in these vehicles, in particular conditions, an increase of particulate emissions has been reported while NOx emission were substantially unchanged. CO and HC emission decreases are also reported. In the case of unregulated emissions most data available was obtained from tests on heavy duty engines. The situation is similar for other unregulated pollutants as aldheydes and ketones and therefore there is no a clear picture about the effect of FAME on these emissions.

The effect of FAME blends on regulated and unregulated emissions of diesel vehicles is summarized below:

Heavy duty engines

Regulated emissions:

HC In general significant reduction (HC reduction increases with % of FAME). Sometimes no differences or increasing values have been noticed.

CO Clear and general reduction of (except few results).

NOx Significant variations of emissions have been noticed (from -8% to +16%).

PM Generally significantly lower emissions (up to -50%); in few cases slight increase (due to higher SOF).

Unregulated emissions:

1. Slight differences in aldehydes/ketones emissions.

2. FAME blends generally lead to lower PAH emissions. However, some studies have shown increased PAH, the effect depending on different cycles/engines/fuels.

3. Same or lower mutagenic activity (Ames test).

4. Lower or higher VOC emissions (depending on different cycles/engines/fuels)

5. Reduced number of large particles, mean diameter peak shifted towards finer particles (below 90nm→ more fine particles)

Light duty engines

Blends containing up to 5% of biodiesel have very reduced effects on pollutant emissions. If biodiesel content is higher or neat biodiesel is used the effects on emissions can be summarized as follows:

HC and CO: Emissions tend to increase over the urban part of the NEDC cycle during cold start especially with neat biodiesel or high biodiesel contents (about 30%). This is probably due to the higher density and higher boiling point of biodiesel compared to the standard diesel fuel. When engine is warmed up HC and CO emissions are usually reduced. However when an oxidation catalyst is present there is no significant difference.

NOx: Limited increases of emissions have been noticed.

PM: Emissions are often lowered by the use of fuels containing biodiesel. The reduction is often roughly proportional to the biodiesel content. However, over the urban part of the NEDC cycle an increase of particulate mass has been noticed in some studies. This increase is explained by the higher SOF fraction of particulates compared to the standard diesel fuel while the soot fraction decreases in any case.

2. Synthetic diesel

The very good emission performance of pure synthetic fuels are in general linked to their composition as they mainly consist of simple hydrocarbon chains. The main features of synthetic diesel fuel when compared to standard diesel fuels are zero sulphur content, no aromatics and polyaromatics, very high cetane number, lower density and boiling point.

Heavy duty engines

Use of neat synthetic diesel (NEXBtL) gives the following results:

HC large reduction (about 60%)

CO large reduction (about 90%)

PM significant reduction (about 20 to 30% lower than sulphur-free diesel)

NOx small reduction (about 10-20%)

Passenger cars

Use of 85 % NExBTL in EN590 diesel fuel gives the following results:

CO and HC reduced by 30-50 %

PM reduced by 17-30 %

NOx there do not appear to be emission benefits.

When used as a blending component at 5% there were no measurably significant emission changes.