concawe
review

Foreword

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2005 has been a year of positive developments for CONCAWE. Through its heavy involvement in the development of the CAFE programme and in the Fuels Directive review process, our Association has confirmed its established reputation as a professional organisation that can provide essential support for the legislative process. The data gathered by CONCAWE over the years and the modelling expertise it has acquired have proved to be essential building blocks in this respect. Contributing sound facts to the European legislative debate is increasingly vital if we are to ensure that decisions are based on solid foundations rather than on emotions.

One good example of what sound modelling can deliver is illustrated in this *Review* in the article on EU-wide BAT. Based on the Integrated Assessment Modelling undertaken under the CAFE programme, the article clearly demonstrates that only by taking into account regional and local conditions can the cost of environmental and public health targets be minimised.

The European Well-to-Wheels study, undertaken jointly by JRC, EUCAR and CONCAWE and published in December 2003, has gained wide recognition as a sound basis for policy development. In the emotional debate on alternative fuels, exacerbated by increasing oil prices, the key questions of cost and potential availability are often played down or forgotten. The Well-to-Wheels study has helped to better understand what alternatives are available in reality and to evaluate their likely impact. A second version of the study, to be published by year end, includes additional and updated fuel production pathways and revised engine technology data. The cost and availability chapters have also been fully reviewed and updated. An article in this *Review* highlights the main changes over the first version, then goes on to focus on the potential of bioethanol and biodiesel and prospects of more advanced biomass conversion options.

Another article presents best estimates of the economic and CO_2 impact on refineries of the ongoing sulphur reduction in road fuels. While sulphur-free fuels are fast becoming a reality, the associated costs and extra CO_2 emissions must now be compensated by expected—though yet to be demonstrated—benefits in vehicle emissions. The following article presents a similar analysis for polycyclic aromatic hydrocarbons in diesel fuel, an issue currently under debate in some EU countries.

The last two articles present an update on two of the traditional core areas of CONCAWE's activities. The final phase of an extensive work programme on hearing protection of oil industry workers has recently been completed, culminating in the publication of a CONCAWE report. CONCAWE's guidance for companies on oil product classification and labelling, first published in 1995, has been updated once again to reflect the latest changes in legislation.

In recent years evidence has been gathering that reducing air pollutants such as SO_x, NO_x, VOC, O_3 and PM may have a significant impact on climate. As a result, CONCAWE has decided to increase its knowledge in the crucial field of atmospheric chemistry by becoming a member of Massachusetts Institute of Technology's world-leading Global Change programme. Our lead article in this issue of the *Review* is by Prof. Ronald Prinn, one of the programme directors, who offers a detailed and enlightening analysis of the state of scientific understanding in this complex field.

I believe that this *Review* once again embodies CONCAWE's dual objective: maintenance of its expertise and historical knowledge in key areas, coupled with anticipation of, and research work on, those issues that will be at the heart of the future societal and legislative debates.

Contents

PAH content of diesel fuels

CONCAWE has evaluated the potential impact on EU refineries of a reduction of the polycyclic aromatic hydrocarbon content of diesel fuel. The study, recently published in a full report, highlights the high costs and extra CO_2 emissions that would be associated with such a change.

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Updated CONCAWE guidance for classification and labelling of petroleum substances

With the pending implementation of the 29th Amendment to Technical Progress to the Dangerous Substances Directive, CONCAWE has updated its guidance for the classification and labelling of petroleum substances with impacts on petroleum substances containing benzene, or 1,3-butadiene or toluene.

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Occupational risks to hearing reviewed

An extensive CONCAWE work programme has recently been completed on the various factors that may influence the hearing of petroleum industry workers, including the issue of 'ototoxic' chemical exposure. This has been published as a CONCAWE report and provides guidance for health professionals on hearing risk factors that need to be considered as part of health management programmes.

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Impacts of air pollutant caps on climate

Could policies designed to address air pollution impact climate?

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Air pollution is a major issue in an increasing number of megacities around the world, and new policies to address urban air pollution are likely to be enacted in many developing countries irrespective of the participation of these countries in any explicit future climate policies. The emissions of gases and aerosols[1] that are important in air pollution and climate are often highly correlated due to shared generating processes. Most important among the generating processes is combustion of fossil fuels and biomass which produces carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOCs), carbon dioxide (CO_2), black carbon (BC) aerosols, and sulphur oxides (SO_x, comprised of some sulphate aerosols, but mostly SO_2 gas which subsequently forms reflective sulphate aerosols). In addition, the atmospheric lifecycles of common air pollutants such as CO, NO_x and VOCs, and of the climatically important methane (CH_4) and sulphate aerosols, both involve the fast photochemistry of the hydroxyl free radical (OH). Hydroxyl radicals are the dominant 'cleansing' chemical in the atmosphere, annually removing about 3.7 Gt of reactive trace gases from the atmosphere; this amount is similar to the total mass of carbon removed annually from the atmosphere by the land and ocean combined.

Effects of pollution on climate

The climatic effects of atmospheric constituents are typically expressed by their contributions to radiative forcing, which is a measure of the imbalance between incoming solar energy and outgoing infrared energy for the Earth. We expect that air pollutant reductions will influence climate for several reasons. Specifically, placing caps on NO_x alone, or NO_x, CO and VOCs together, leads to lower ozone levels and thus less radiative forcing of climate change by this gas, and to less inhibition by ozone of carbon uptake by ecosystems which also leads

to less radiative forcing (this time by CO_2). Less radiative forcing by these combined effects means less warming and less sea level rise. Capping NO_x alone also decreases OH and thus increases CH_4. These OH decreases and CH_4 increases are lessened (but not reversed) when there are simultaneous NO_x, CO and VOC caps. Increases in CH_4 lead to greater radiative forcing. Placing caps on SO_x leads to lower sulphate aerosols. This causes less reflection of sunlight back to space by these aerosols (direct effect) and by clouds seeded with these aerosols (indirect effect), and thus to greater radiative forcing of climate change. Enhanced radiative forcing by these aerosol and CH_4 changes combined leads to more warming and sea level rise.

In this article, recent exploratory calculations designed to quantify the above effects of specific global air pollutant emission caps on climate are reviewed. The key question is, could future air pollution policies help to decrease future climate change or increase it?

Integrated Global System Model

The connections between the chemistry of the atmosphere and climate are complex and require a systems modelling approach that considers urban, regional and global scales. The calculations by Prinn *et al.* (2005)[2] reviewed here utilise the MIT Integrated Global System Model (IGSM). The IGSM, as illustrated in Figure 1, consists of a set of coupled submodels of economic development and its associated emissions, natural biogeochemical cycles, climate, air pollution and natural ecosystems. It is specifically designed to address key questions in the natural and social sciences that are

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[1] *Aerosols are suspended particles in air (other than water droplets or ice).*

[2] Prinn, R.G., Reilly, J., Sarofim, M., Wang, C. and Felzer, B., 2005: Effects of air pollution control on climate, MIT Joint Program on the Science and Policy of Global Change, Report 118 (http://web.mit.edu/globalchange/www/reports.html#pubs). Also to appear in *Integrated Assessment of Human-Induced Climate Change*, Cambridge University Press, 2005.

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amenable to quantitative analysis and are relevant to environmental policy. Of particular importance to the calculations reviewed here, the urban air pollution submodel of the IGSM is based upon, and designed to simulate, the detailed chemical and dynamical processes in current three-dimensional urban air chemistry models. For this purpose, the emissions calculated in the economics submodel are divided into two parts: urban emissions which are processed by the pollution submodel before entering the global chemistry/climate submodel, and non-urban emissions which are input directly into the large-scale model.
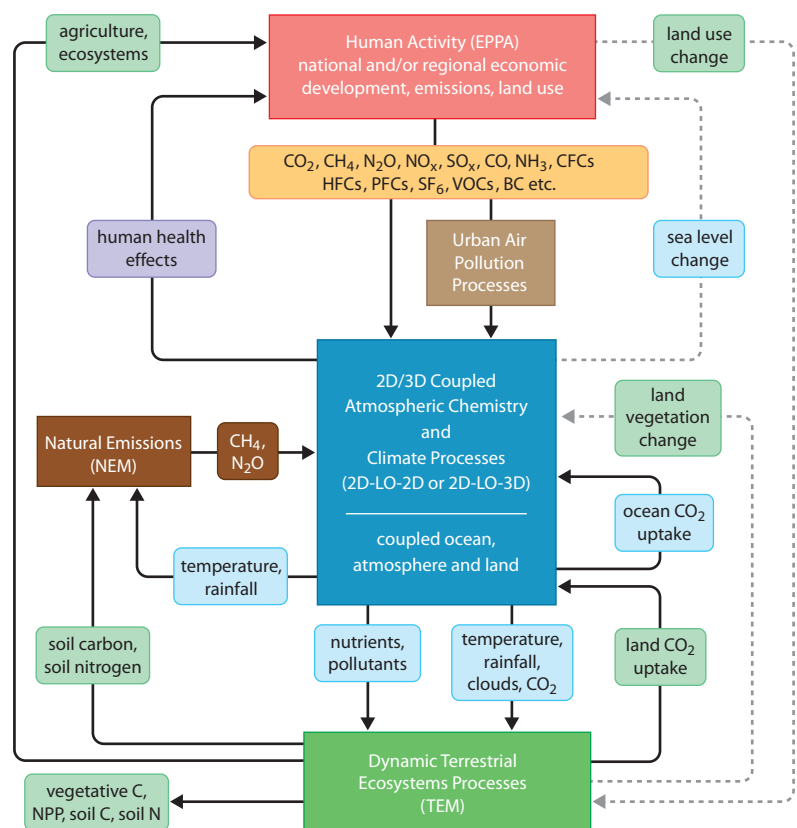
IGSM runs with pollutant caps

To illustrate some of the possible impacts of controls of air pollutants on temperature and sea level, Prinn *et al.* (2005) carried out runs of the IGSM in which individual pollutant emissions, or combinations of these emissions, are held constant from 2005 to 2100. These are compared to a reference run (denoted 'ref') in which there is no explicit policy to reduce greenhouse gas emissions.

Specifically, in five runs of the IGSM, they considered caps at 2005 levels of emissions of the following air pollutants:

(1) NO_x only (denoted 'NO_x cap')
(2) CO plus VOCs only (denoted 'CO/VOC cap')
(3) SO_x only (denoted 'SO_x cap')
(4) Cases (1) and (2) combined (denoted '3 cap'),
(5) Cases (1), (2) and (3) combined (denoted 'all cap').

Cases (1) and (2) were designed to show the individual effects of controls on NO_x and reactive carbon gases (CO, VOC), although such individual actions are very unlikely. Case (3) addresses further controls on emissions of sulphur oxides from combustion of fossil fuels and biomass, and from industrial processes. Cases (4) and (5) address combinations more likely to be representative of a real comprehensive air pollution control approach.

The MIT Integrated Global System Model (IGSM)

In interpreting their results, it is important to note that they are neglecting the effects of air pollutant controls on: (a) the overall demand for fossil fuels (e.g. leading to greater efficiencies in energy usage and/or greater demand for non-fossil energy sources); and (b) the relative mix of fossil fuels used in the energy sector (i.e. coal versus oil versus gas).

The ratios of the emissions of NO_x, CO/VOCs, and SO_x in the year 2100 to the reference case in 2100 are about 1/3, 1/2 and 3/5 respectively, when their emissions are capped at 2005 levels. For calibration, the reference global emissions of NO_x, CO/VOCs, and SO_x in 2100 are about 4, 2.5, and 1.5 times their 2000 levels. Because these chemicals are short-lived (hours to several days for NO_x, VOCs, and SO_x, a few months for CO), the effects of

Figure 1

Schematic illustrating the framework, submodels and processes in the MIT Integrated Global System Model (IGSM). Feedbacks between the component models that are currently included, or proposed for inclusion in later versions, are shown as solid or dashed lines respectively.

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Table 1 Sign of the changes from the reference of O_3, OH, CH_4 and sulphate aerosol levels in 2100 in the 5 capping cases

Effect	SO_x	NO_x	Cap CO/VOC	3-cap	all cap
O_3	0	–	+	–	–
OH	+	–	+	–	0
CH_4	–	+	–	+	+
sulphates	–	–	+	0	–

their emissions are largely restricted to the hemispheres in which they are emitted (and, for the shortest-lived pollutants, restricted to their source regions).

As summarised in Table 1, the major global effects of capping SO_x are to decrease sulphate aerosols and slightly increase OH (due to lower SO_2 which is an OH sink). Capping of NO_x leads to decreases in O_3 and OH and an increase in CH_4 (caused by the lower OH which is a CH_4 sink). The CO and VOC cap increases OH and thus increases sulphate (formed by OH and SO_2) and decreases CH_4. Note that CO and VOC changes have opposing effects on O_3, so the net changes when they are capped together are small. Combining NO_x, CO and VOC caps leads to an O_3 decrease (driven largely by the NO_x decrease) and a slight increase in CH_4 (the enhancement due to the NO_x caps being partially offset by the opposing CO/VOC caps). Finally, capping all emissions causes substantial lowering of sulphate aerosols and O_3, and a small increase in CH_4.

The two hemispheres generally respond somewhat differently to these caps due to the short air pollutant lifetimes and dominance of northern over southern hemispheric emissions. The northern hemisphere contributes the most to the global averages and therefore responds similarly. Because methane has a long lifetime (about 9 years) relative to the interhemispheric mixing time (about 1–2 years), its global concentrations are influenced by OH changes in either hemisphere alone, or in both.

Caps on air pollutants significantly affect the land ecosystem sink for carbon due to reductions in ozone-induced plant damage. The land sink, which is the differ-

ence between plant photosynthesis and the sum of plant respiration and soil respiration plus decay, increases when ozone decreases. This is evident in the case where all pollutants are capped, causing an ozone decrease of 13% globally, and a land sink increase of 30–49% or 0.6–0.9 Gt of carbon (in CO_2) in 2100 (the range of these values depends on assumptions about managed land fertilisation).

The Prinn *et al.* (2005) ecosystem calculations do not include the additional positive effects on the land sink of decreased acid deposition and decreased exposure to SO_2 and NO_2 gas, that would result from the pollution caps considered. They also do not include the negative effects of decreasing nutrient nitrate and possibly sulphate deposition that also arise from these caps.

Effects of caps on climate

The effects of these pollutant caps on global and hemispheric mean surface temperature and sea level changes from 2000–2100 are shown in Figure 2 (Prinn *et al.* 2005) as percentages relative to the global average reference case changes of 2.7°C and 0.4 metres respectively. The largest increases in temperature and sea level occur when SO_x alone is capped due to the removal of reflecting (cooling) sulphate aerosols. Because most SO_x emissions are in the northern hemisphere, the temperature increases are greatest there. For the NO_x caps, temperature increases in the southern hemisphere (driven by the CH_4 increases) but decreases in the northern hemisphere (due to the cooling effects of the decreases in O_3 exceeding the warming driven by the increases in CH_4). For CO and VOC reductions, there are small decreases in temperature driven by the accompa-
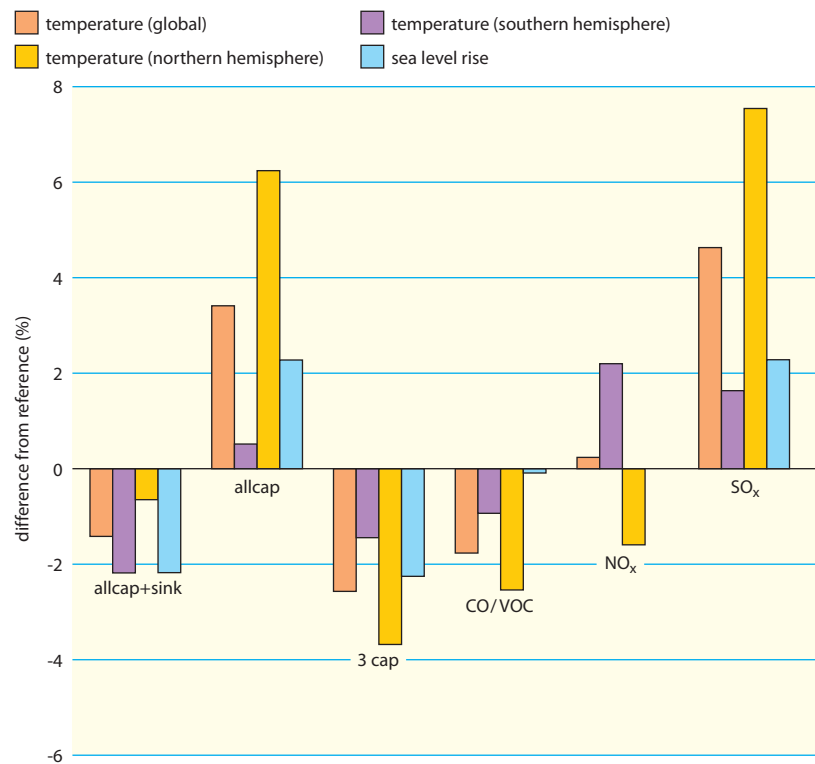
nying aerosol increases and CH_4 reductions, with the greatest effects being in the northern hemisphere where most of the CO and VOC emissions (and aerosol production) occur.

The nonlinearity in the system is evidenced by the fact that the combined effects in the '3 cap' case are not simple sums of the effects from the individual caps. Ozone decreases and aerosol increases (offset only slightly by CH_4 increases) lead to even less warming and sea level rise than obtained by adding the CO/VOC and NO_x capping cases. Finally the capping of all emissions yields temperature and sea level rises that are smaller than, but qualitatively similar to, the case where only SO_x is capped. However, the rises are greater than expected from simple addition of the SO_x-capped and CO/VOC/NO_x-capped cases. Nevertheless, the capping of CO, VOC and NO_x serves to reduce the warming induced by the capping of SO_x.

The calculations for the five capping cases in Figure 2 omit the cooling effects of the CO_2 reductions caused by the lessening of the inhibition of the land sink by ozone. This omission is valid if we presume that anthropogenic CO_2 emissions, otherwise restricted by a climate policy, are allowed to increase to compensate for these reductions. This is the basis for the economic analysis discussed below. To illustrate the lowering of climate impacts if the sink-related CO_2 reductions actually occur, Prinn *et al.* (2005) considered a sixth case ('allcap+sink') which combined the capping of all air pollutant emissions with the enhanced carbon sink (Figure 2). The enhanced sink is sufficient for the sign of the warming and sea level rise seen in the 'allcap' case to be reversed in the 'allcap+sink' case. If this lowering of climate impacts could be valued, it would provide an alternative to the economic analysis discussed below.

To summarize, the study by Prinn *et al.* (2005) showed that the impacts on climate of pollutant caps partially cancel each other. Specifically, depending on the capping case, the 2000–2100 reference global average climate changes are altered only by +4.8 to −2.6% (temperature) and +2.2 to −2.2% (sea level). Except for the NO_x alone case, the alterations of temperature are of

Effects of five air pollution capping cases on average temperature and global sea level between 2000 and 2100

the same sign but significantly greater in the northern hemisphere (where most of the emissions and emission reductions occur) than in the southern hemisphere.

Economic consequences

One approach to estimating some of the economic effects of air pollutant caps is to value the above increases in carbon storage in ecosystems in terms of the avoided costs of fossil fuel CO_2 reductions needed to achieve an atmospheric stabilisation target. The above extra annual carbon uptake (due to avoided ozone damage) of 0.6–0.9 Gt of carbon is only 2–4% of year 2100 reference projections of anthropogenic fossil CO_2 emissions (which reach nearly 25 Gt C/year in 2100). However, this small level of additional uptake can have a surprisingly large effect on the cost of achieving a climate policy goal. Prinn *et al.* (2005) used a 5% discount rate, and adopted the policy costs associated with 550 ppm CO_2 stabilisation, to estimate the policy cost savings that would result from the increased carbon

Figure 2
Impacts of air pollution caps in the five capping cases on the global, northern hemispheric and southern hemispheric average temperature increases, and the global sea level rise, between 2000 and 2100 are shown as percent changes from their average values (global or hemispheric) in the reference case from Prinn et al. *(2005). Also shown are the percent changes for the case where the enhanced sink due to the ozone cap is included along with the caps on all pollutants. For this case, they assume the average of the computed range of sink enhancements.*

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uptake through 2100 in the 'allcap' compared to the 'ref' scenarios. The savings are \$2.5 to \$4.7 trillion (1997 dollars). These implied savings are 12 to 22% of the total cost of a 550 ppm stabilisation policy. There are two reasons for the large economic value of the additional carbon uptake. One reason is that the fossil carbon reduction savings are cumulative; the total additional 2000–2100 carbon uptake is 36 to 75 Gt, or about 6–13 years of fossil carbon emissions at current annual rates. The second reason is that the additional uptake avoids the highest marginal cost options.

Concluding remarks

To further check on the validity of the Prinn *et al.* (2005) conclusions, future work should include:

(1) the effects of air pollution policy on overall demand for fossil fuels and individual demands for coal, oil and gas;

(2) the effects of caps on black carbon (as a regulated air pollutant) on climate (there are multiple, regionally variable and partially-offsetting effects of black carbon on absorption and reflection of sunlight, reflectivity of clouds and the strength of lower tropospheric convection); and

(3) the effects on ecosystems of changes in deposition rates of acids, nitrates and sulphates, and levels of exposure to SO_2 and NO_2 resulting from air pollution reductions.

Nevertheless, the Prinn *et al.* (2005) calculations suggest that, while urban air pollution policies are obviously beneficial for human health and downwind ecosystems, they may have only a small influence, either positive or negative, on mitigation of global-scale climate change. However, even small contributions to climate change mitigation can be disproportionately beneficial in economic terms as they may take the place of the highest cost climate change mitigation measures, i.e. those occurring at the margin.

The potential of biofuels for energy and GHG savings in road transport

Updated data from the joint European Well-to-Wheels study

In December 2003, a consortium of JRC, EUCAR and CONCAWE published the first version of a comprehensive Well-to-Wheels (WTW) analysis of fuels and power-trains in the European context, focusing on energy efficiency, GHG (greenhouse gas) emissions, costs and potential availability issues. The fields of alternative fuels as well as motor vehicles are in constant development. From the outset, the consortium agreed to update the study at regular intervals, taking into account comments and suggestions from interested third parties. The second version of the study is about to be released, and now includes both updated and new pathways as well as revised cost and availability estimates (see Table 1). While a full presentation of all results would be beyond the scope of this short article, we focus on the potential of biofuels with particular emphasis on ethanol and biodiesel, the two short-term alternatives currently being promoted in the EU, and look briefly at the prospects for more advanced biomass conversion options.

Ethanol and biodiesel: the first generation of biofuels

In the short term, and for most of the next 5 to 10 years, there are only two serious contenders for biomass-derived road fuels in Europe, namely ethanol as a substitute for gasoline and biodiesel (esterified vegetable oil) as a substitute for diesel fuel. In Europe, these biofuels will be produced from traditional agricultural crops: sugar beet and wheat for ethanol; predominantly rape-seed for biodiesel.

In all these pathways, only a fraction of the plant biomass is used to produce the desired fuel. The fate of the remaining biomass has a large impact on the overall energy and GHG balance. Looking at the different routes to ethanol from wheat gives a good illustration of the wide range of energy and GHG benefits that can be obtained when producing the same biofuel from the same raw material.

Table 1 Main additions and modifications to the joint WTW study

Conventional powertrains	• Fuel efficiency penalty associated with a diesel particulate filter reduced from 4 to 2.5%
Ethanol	• Additional wheat to ethanol pathways including four energy source options for the ethanol plant and two separate uses for DDGS • New pathways for straw and sugar cane to ethanol
Ethers	• New pathways for MTBE and ETBE
Biodiesel	• Rape ethyl ester (based on wheat ethanol) in addition to methyl esters of rape and sunflower oil
Nitrous oxide emissions from agriculture	• Revised data based on updated land model
CNG	• Minor revision of methane losses for gas pipeline transport and discussion of the potential of higher pressure pipelines for reducing gas transport energy • New CNG engine data yielding somewhat more favourable efficiency figures
Biogas	• Pathways for conversion of organic waste into biogas for road transport
LPG	• Pathway for remote LPG (associated to gas field) into bi-fuel PISI vehicle
Synthetic fuels	• Synthetic diesel and DME from coal in addition to natural gas and biomass • Special option for diesel or DME from wood via 'black liquor'
Hydrogen	• No changes
CO_2 capture and storage (CCS)	• Preliminary comparative data produced (with/without CCS) for a number of pathways
Costs	• Revised fossil fuel costs with two crude price scenarios (25 and 50 €/bbl) • Revised cost of crops and biomass in line with latest projections from DG-AGRI
Potential availability	• Revised estimates of crops and other biomass availability in Europe based on DG-AGRI data

Full report with detailed results and analysis at: http://ies.jrc.cec.eu.int/WTW

The potential of biofuels for energy and GHG savings in road transport

Updated data from the joint European Well-to-Wheels study

Ethanol from grain is obtained through hydrolysis of starch, followed by fermentation and distillation of the alcohol. The overall process requires a large amount of energy chiefly in the form of heat (mostly steam) and, to a lesser extent, electricity. There are several practical options for supplying that energy.
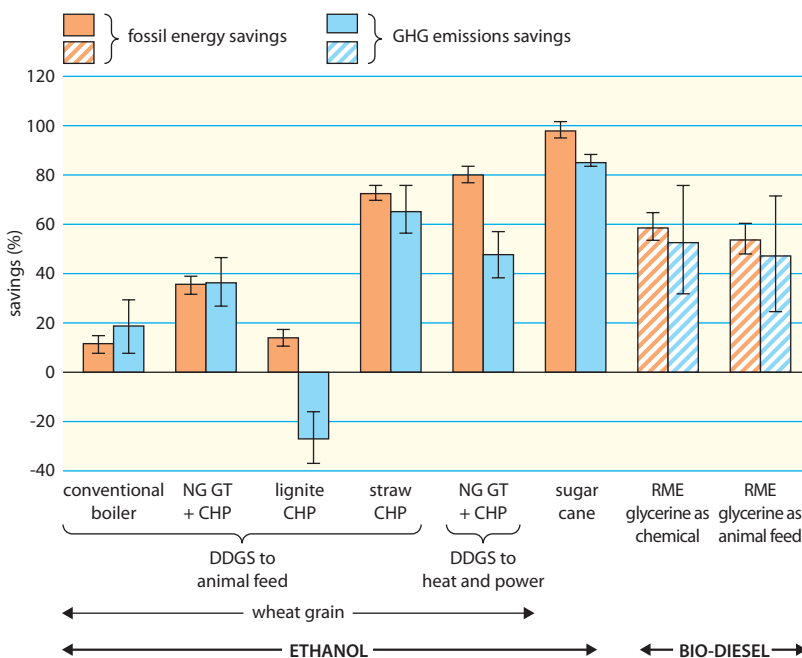
In the most basic (and low capital) scheme, representative of many existing facilities (in Europe and elsewhere), a simple, usually gas-fired, boiler provides the steam while electricity is taken from the grid. However, because the heat is required at low temperature, ethanol plants offer good opportunities for combined heat and power (CHP) schemes. Combining this with a natural gas (NG) fired gas turbine (GT) results in a very energy-efficient if capital-intensive process. In areas where coal or lignite is cheap and abundantly available, a simpler CHP scheme based on a coal-fired steam boiler combined with a backpressure steam turbine can also be envisaged. Finally surplus straw from the wheat itself can, in principle, be used as fuel through a similar CHP scheme. If this is likely to be a winner in terms of GHG emissions, this is also a very expensive and largely untested scheme to set up and to operate. Figure 1 shows the fossil energy and GHG savings for each pathway, compared to conventional gasoline.

All schemes yield a saving of fossil energy but the potentials are very different; from 11% in the simplest scheme to 72% when using straw. The variations are even greater in terms of GHG emissions, the lignite pathway actually producing a net increase! The wider uncertainty range for GHG emissions is due to nitrous oxide emissions from agriculture which are subject to large variations depending on soil type and agricultural practices.

It is important to keep in mind that the above schemes are not all equivalent from a cost point of view. For a 100 kt/a ethanol plant, the total capital investment would start at around 60 M€ for the basic scheme increasing to about 80 M€ for a NG turbine CHP and above 100 M€ for the solid fuel schemes. This is partly compensated by the different fuel costs and the potential revenues from surplus electricity sales. Our calculations suggest that the NG gas turbine CHP scheme is likely to be the most attractive from an overall cost point of view, even in a high fossil fuel price scenario. Although the straw pathway achieves the greatest reduction in GHG emissions, it is unlikely to be selected; besides the high costs, a straw burning scheme also involves issues of continued straw availability, transport logistics, complex and less reliable solid fuels handling and combustion systems, making it relatively unattractive.

In most of these pathways the fate of by-products is crucial to the final energy and GHG balance. DDGS (Distillers Dried Grain with Soluble), the biomass left over after fermentation of the grain, is a high-protein product suitable as an animal feed component. This is overwhelmingly the way it is used today, typically as a substitute for soy meal. After drying, it could also, in principle, be used as fuel e.g. co-fired with coal in a power plant, now replacing coal and generating a much increased fossil energy saving and, to a lesser extent, GHG saving. The economics are however unlikely to favour this application in the foreseeable future.

For reference, Figure 1 also shows that the typical savings achieved with sugar cane in Brazil are considerably higher than what can be hoped for in Europe. The main reason for this attractive balance is the use of 'bagasse', the leftover after extraction of the sugar, which

Figure 1

All schemes yield a saving of fossil energy, although potential savings vary widely between schemes. The wider uncertainty range for GHG emissions is due to the large variations in nitrous oxide emissions from agriculture.

WTW fossil energy and GHG savings of: a) various ethanol pathways; and b) biodiesel pathways, compared to conventional fuels

The potential of biofuels for energy and GHG savings in road transport

Updated data from the joint European Well-to-Wheels study

is a convenient and abundant fuel for which there is no alternative use. In the best cases surplus electricity can be produced, further boosting the energy balance.

Figure 1 also shows the same data for RME, the methyl ester produced from rape seed oil and methanol. This process splits the tri-glyceride molecule, separating out glycerine as a by-product and producing a fuel which boils at around 350°C and can be blended into diesel fuel. Pure vegetable oil is very viscous and unstable, so unsuitable as a component in road diesel fuel.

RME can save up to around 55% of fossil energy and 50% GHG emissions compared to conventional diesel fuel. The fate of the glycerine by-product has a discernable but limited impact on the balance. Field nitrous oxide emissions have a particularly large effect on the GHG balance because rape requires a lot of nitrogen fertiliser.

The future: advanced biofuels

There are two promising routes to turn more biomass into liquid road fuels. Cellulose can be broken down into fermentable sugars, serving as raw material for ethanol. This opens the possibility of large scale conversion of various cellulosic materials such as wheat straw, wood etc. Biomass can also be used as the raw material for production of synthetic diesel via gasification followed by Fischer-Tropsch synthesis (the so-called biomass-to-liquids or BTL process). Although these processes are energy-intensive, they use part of the biomass feed to generate the process energy, resulting in very low fossil energy usage (mostly for agriculture, transport and the like) and very favourable GHG balances.

Various processes are in the development stage but there are still many technological and economic issues to be resolved before commercial scale plants are a reality. BTL in particular requires complex and capital-intensive plants for which scale is likely to be a major economic argument, whereas the feasibility of providing the biomass feed to a large plant and the associated logistics are a challenge.
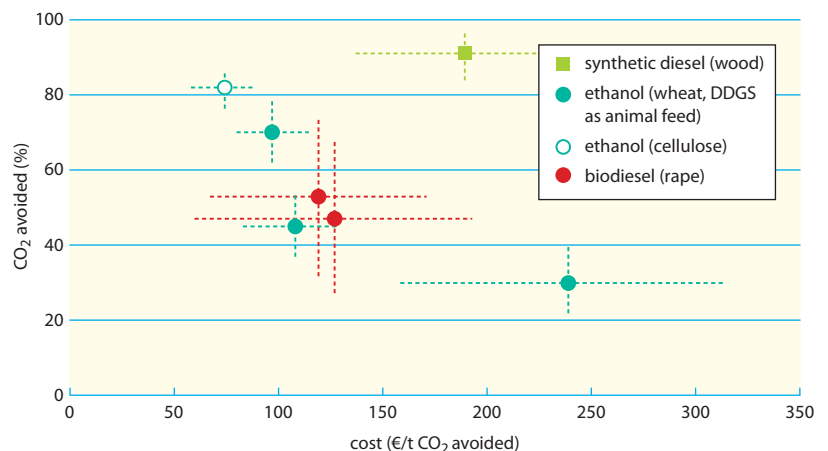
Availability and cost

Because they rely on traditional food crops and are obtained from only a fraction of the available biomass, there is limited potential for first generation biofuels. Our estimates suggest that Europe will only be able to produce the net equivalent of about 5% of its road fuels demand (energy content basis). Production costs are high while GHG emissions avoidance is limited. As a result the cost per tonne of CO_2 avoided is substantial.

Second generation biofuels offer better prospects. A range of biomass feedstocks can be used including various waste products but also farmed biomass using crops specially selected for their capacity to efficiently metabolise biomass.

Figure 2 shows the relative costs of CO_2 avoidance versus the potential for CO_2 savings (100% represents the CO_2 emissions from fossil fuels meeting the same energy demand for transport). Even in this high crude oil price scenario, the cost of CO_2 avoidance remains high. The BTL option offers the highest savings albeit at a somewhat higher CO_2 cost than most other options, as these routes are penalised by the high capital required. Because they are in development, the investment figures are only estimates at this stage: it is clear that process improvements and economies of scale will be required to make these routes viable.

Figure 2
Even in a high oil price scenario, the cost of CO_2 avoidance remains high.

Cost and potential for CO_2 avoidance of selected biofuels pathways (50€/bbl crude oil) compared to conventional fuel case

EU-wide BAT—an expensive suit that doesn't fit everybody!

What light does the CAFE programme shed on the concept of a common EU-wide BAT in the context of the IPPC Directive?

The 'Clean Air For Europe' (CAFE) programme, carried out over the past three years by the EU Commission's DG Environment, has resulted in the recent publication of the 'Thematic Strategy on Air Pollution' (TSAP) which provides a 'road map' for the review of existing Directives and the drafting of any new legislation. CAFE addressed multi-pollutant, multi-effects issues with the declared goal to identify cost-effective solutions. A major building block of the programme has therefore been the use of Integrated Assessment Modelling (IIASA's RAINS model) to inform and shape the resulting policy initiatives. RAINS employs an 'effect driven' optimisation strategy aimed at delivering given environmental improvements in the most cost-effective manner.

One of the existing Directives to be reviewed is the so-called IPPC Directive (Integrated Pollution Prevention and Control, Council Directive 96/61/EC) which tackles pollutants to air, water and soil. The major thrust of this Directive is the concept of 'Best Available Techniques' (BAT) for industrial installations. In setting forth the notion of BAT, the Directive recognises:

(a)   the importance of focusing on the health/environmental impact of a given installation's emissions rather than on their emission levels *per se*;

(b)   the need to consider the influence of the technical characteristics of the installation on applicability/costs of a given abatement technique.

To quote from Article 9.4 of the Directive:

" … the emission limit values and the equivalent parameters and technical measures … shall be based on the best available techniques, without prescribing the use of any technique or specific technology, **but taking into account the technical characteristics of the installation concerned, its geographical location and local environmental conditions.***"*

The IPPC Directive clearly recognises that the notion of BAT is local rather than universal or EU-wide.

In this article we affirm the importance of retaining this notion of 'local BAT' in any future revision of the IPPC Directive. Indeed this is fully consistent with the effect-driven, cost-effective approach underpinning the Thematic Strategy on Air Pollution, while contributing to a better alignment of health and environmental legislation with the Commission's drive to ensure EU competitiveness.

Using a relevant example, we show that, in contrast, an 'EU-wide BAT' (expressed as a common emission limit) would seriously depart from the approach underpinning the TSAP. For a given improvement ambition, it would result in significantly higher financial burdens both for the EU as a whole and for many individual Member States (MS).

We have chosen the case of exposure to fine particulates because, within CAFE, it (a) represents the priority concern; and (b) involves controlling four of the five pollutants considered (SO_2, NO_x, NH_3 and Primary $PM_{2.5}$). The results that follow are derived from a side-by-side analysis using the following two basic strategies to bring about a reduction in the exposure of EU citizens to fine particulates:

1.   The progressive application of increasingly stringent '**Common EU-wide BATs**' (expressed as common emission limits). In the analysis, this was achieved by applying the same marginal cost threshold to the emission reduction cost curve for each Member State, then reading across the corresponding emission reduction. This is indeed a fair representation of a common BAT inasmuch as the cost of a given technology is similar in all Member States. The process was repeated for each of the four pollutants, with a progressively increased cost threshold to generate the curve of cost versus reduction in exposure to fine particulates.

2.   The so-called '**optimum EU solution**' approach. Here the emission reductions for each Member State and each pollutant were determined in such a way that a

EU-wide BAT—an expensive suit that doesn't fit everybody!

What light does the CAFE programme shed on the concept of a common EU-wide BAT in the context of the IPPC Directive?

given reduction in PM exposure was achieved at the lowest overall cost to the EU. This approach is in line with the Integrated Assessment modelling work undertaken in CAFE, using IIASA's RAINS model.

In both cases, the databases and algorithms used in the analysis are entirely consistent with those of the RAINS model. We also made full use of the results of the final round of scenario analysis undertaken by IIASA as input to DG Environment's development of the TSAP.

In essence the first approach is 'Technology Driven' and the second 'Environmental Quality Driven'. Before looking at the resulting overall cost burdens, it is worth exploring the principal differences in burden sharing between the two approaches in a little more detail.

EU-wide BAT: a 'Technology-driven' approach

As explained above, this approach is based on setting the same marginal cost level for emission reduction (€/tonne) in each Member State. When set against the overall objective to reduce human exposure and its impact on health e.g. the 'years of life lost' (YOLL) concept, this approach results in a very different burden sharing between Member States from a 'polluter pays' principle, i.e. what each Member State is paying for a unit improvement in

the statistic that the EU is seeking to improve. This is because the relationship between emission level and exposure is very different amongst the Member States, i.e. the environmental potency of a tonne of pollutant (YOLL/tonne) varies significantly between different areas of Europe. This is illustrated in Figures 1 and 2.
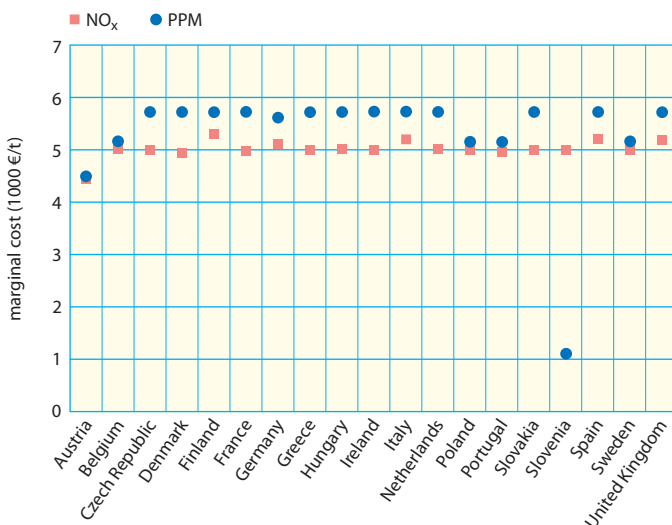
Figure 1 shows, for a common cost threshold of 5000 €/t, the actual marginal cost per unit reduction in emissions for NO_x and PM pollutant by individual Member State (the variations around 5000 are due to the discrete increments in the IIASA cost curves i.e. the nearest point to 5000 is chosen). In Figure 2 the corresponding marginal cost per unit YOLL (€/YOLL) is shown. As seen from the plot (note it is a logarithmic scale), a seemingly even burden sharing (per tonne of pollutant emitted) results in widely different costs towards solving the problem at hand, some Member States, particularly those in southern Europe, paying up to an order of magnitude higher contribution per unit reduction in YOLL than others.

This illustrates the economic inefficiency of the technology-driven approach as a means of delivering a given improvement in YOLL. The implications in terms of increased burden to the EU and to individual Member States are explored later. For now let's turn to the alternative 'Optimised EU' or environmental quality driven approach.

Figure 1 (below left)
Marginal costs per unit reduction in NO_x and Primary $PM_{2.5}$ emissions for each Member State, and …

Figure 2 (below right)
… the corresponding marginal costs per unit reduction in YOLL. This illustrates the economic inefficiency of an 'EU-wide BAT' approach as a means of delivering a given improvement in YOLL.

Marginal cost of emission reductions based on 'EU-wide BAT'
(based on IIASA data from RAINS and '5000 €/t' scenario)

Marginal cost per unit reduction in YOLL resulting from 'EU-wide BAT'
(based on IIASA data from RAINS and '5000 €/t' scenario)

EU-wide BAT—an expensive suit that doesn't fit everybody!
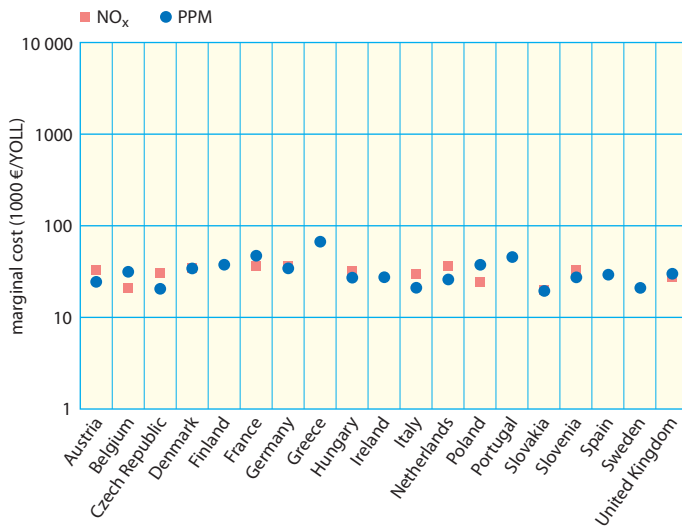
What light does the CAFE programme shed on the concept of a common EU-wide BAT in the context of the IPPC Directive?
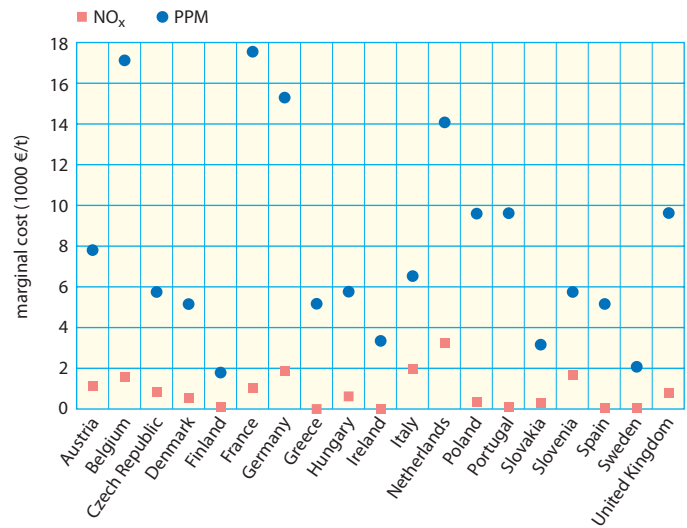
Marginal cost per unit reduction in YOLL based on 'local BAT'
(based on IIASA data from RAINS and CAFE scenario A 'PM Only')

Marginal cost of emission reductions based on 'local BAT'
(based on IIASA data from RAINS and CAFE scenario A 'PM Only')

Figure 3 (above left)
A 'local BAT' approach results in virtually the same cost per unit change in YOLL for all Member States.

Figure 4 (above right)
The marginal cost of emission reductions now varies significantly between Member States.

Local BAT: an 'environmental quality-driven approach'

In this approach the first step is to define the environmental or health target for the EU. Emission reductions by pollutant/Member State are then determined using optimisation techniques to achieve the target at the least cost to the EU as a whole. Fundamentally, this represents a commitment to the 'polluter pays' principle, where individual Member State burdens are based on an equal cost per unit improvement towards meeting the environmental or health-based target.

As illustrated in Figure 3, the application of this 'least cost' concept results in virtually the same cost per unit change in YOLL for all Member States (within the minor scatter stemming from the discrete steps in the cost curve). This indeed represents the minimum cost case since no Member State is spending either more or less than any other Member State for a unit improvement in YOLL. As such the plot serves to demonstrate that the RAINS optimiser has found the optimum for this ambition level. The consequence of this 'optimised approach' however, is that the marginal cost for a unit reduction in emissions now varies significantly between Member States (Figure 4).

Comparison of the two approaches

The foregoing demonstrates that a common emission standard by pollutant, i.e. an 'EU-wide BAT', cannot deliver the least cost solution for the EU. This is confirmed by the resulting cost burden versus gap closure[1] plots that follow.

Figure 5 provides a comparison of the two approaches in terms of annual cost to EU-25 as a whole for various improvement ambitions (the so-called 'gap closure'). Consistent with the scope of the IPPC Directive the measures considered here are exclusively those applicable to stationary sources.
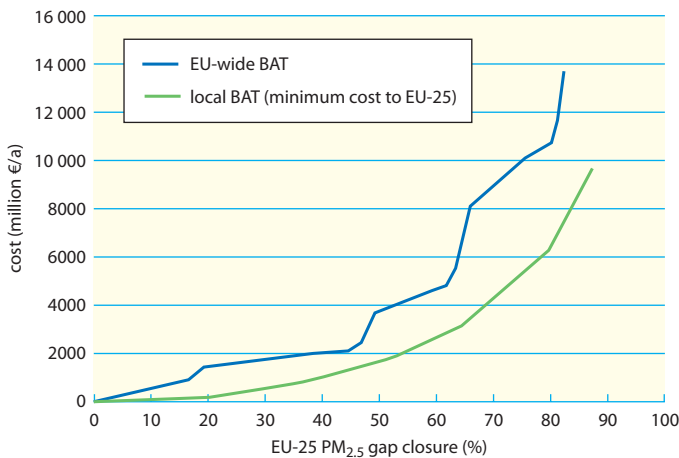
Figure 5 clearly shows the significant increase in economic burden to the EU as a whole in moving away from the optimised approach of CAFE to the application of common emission limits ('EU-wide BAT'). At a gap closure ambition of 65%, the economic burden to the EU roughly doubles. This represents an additional burden of more than 3 G€/a, increasing to 5 G€/a at 75% gap closure. This additional cost does not achieve any further improvement, but simply represents the economic consequence of an inefficient means of delivering the benefits!

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[1] *With a starting point of 2020, the 'Gap' is defined as the maximum further reduction in impacts that can be achieved by the application of all available technical abatement measures (Maximum Technically Feasible Reductions). The 'Gap Closure' is the extent to which further measures move toward this point expressed as a percentage.*
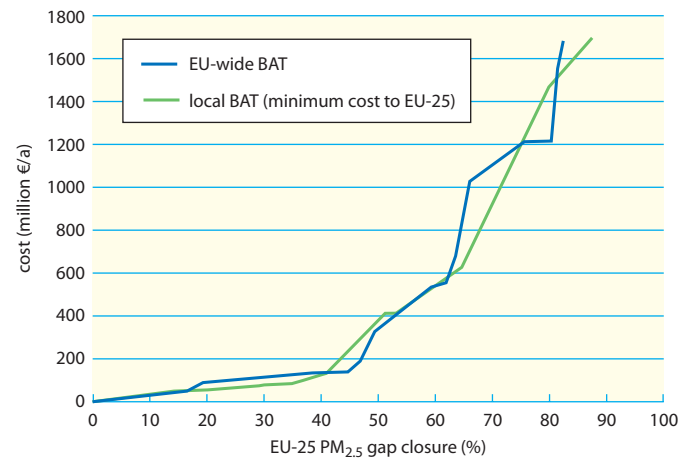
EU-wide BAT—an expensive suit that doesn't fit everybody!

What light does the CAFE programme shed on the concept of a common EU-wide BAT in the context of the IPPC Directive?
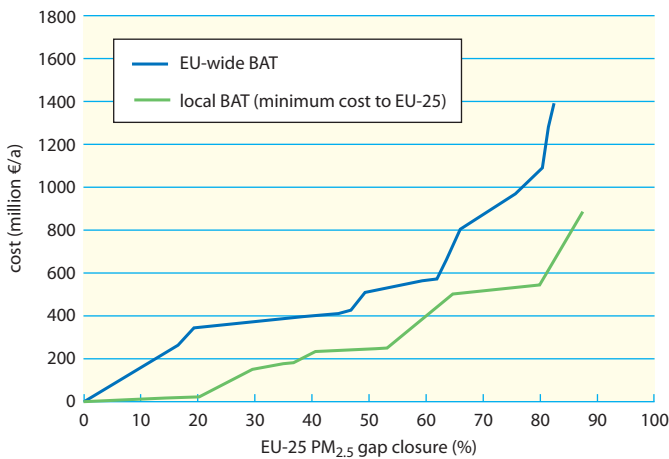
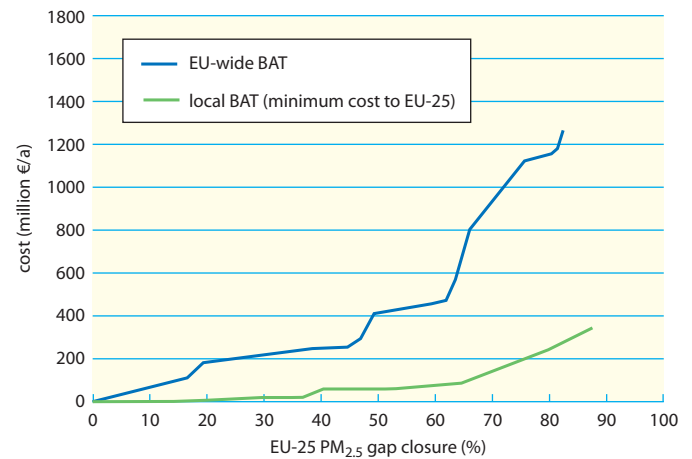**Figure 5   Costs v. PM2.5 gap closure: annual costs of 'EU-wide BAT' and 'local BAT' approaches compared for EU-25**

Figure 6   Costs v. PM2.5 gap closure: annual costs of 'EU-wide BAT' and 'local BAT' approaches compared for Germany

Figure 7   Costs v. PM2.5 gap closure: annual costs of 'EU-wide BAT' and 'local BAT' approaches compared for Poland

Figure 8   Costs v. PM2.5 gap closure: annual costs of 'EU-wide BAT' and 'local BAT' approaches compared for Spain

At the individual Member State level, the impact of a shift to the concept of 'EU-wide BAT' varies significantly. The shift has little impact on Germany which, as a result of the cross-boundary effects of reductions in neighbouring countries, would in fact face a lower economic burden at ambitions beyond 75% (Figure 6). Similar curves apply for both Belgium and the Netherlands.

This stands in stark contrast to the situation in southern European countries and new Member States. For Poland (Figure 7) the shift to an 'EU-wide BAT' would represent a twofold increase in the economic burden, a similar ratio applying to Italy. For Spain (Figure 8) and Greece the increase would be as much as seven to tenfold.

CONCAWE believes that the results of this analysis strongly support the need to retain and strengthen the concept of 'local BAT' in any future revision of the IPPC Directive. The dramatic differences in costs between the 'EU-wide' BAT approach and the 'Optimum EU Solution' approach, at both overall EU level and in many Member States, clearly demonstrates the economic inefficiency of the 'EU-wide BAT' concept. In contrast, the retention and strengthening of the concept of 'local BAT' ensures that legislation designed to tackle human health and environmental concerns is better aligned with the Commission's commitment to ensure EU competitiveness.

Figures 5–8

The Figures compare an 'EU-wide BAT' approach (application of equal EU-25 BAT) with a 'local BAT' (minimum cost to EU-25) approach in terms of the cost burden to the EU-25, Germany, Poland and Spain, respectively.

Figure 5 shows the significant increase in cost to the EU in moving away from the optimised approach of CAFE to the application of common emission limits ('EU-wide BAT').

Road fuels desulphurisation

*How EU refineries are affected by the gradual move
to a 10 ppm sulphur limit*

For many years CONCAWE has maintained a model of the European refining system in order to be able to evaluate the potential impact of major changes, such as more stringent product specifications or shifts in crude supply and/or product demand patterns. Although the original focus was on costs, the model has now been adapted to also estimate impacts on CO_2 emissions, both from the refinery sites and globally, i.e. including the impact of changes in fuels' carbon/hydrogen ratio on in-use emissions. Originally focused on EU-15 (plus Norway and Switzerland), the model has been extended to cover new member countries as well as near-future members (Bulgaria and Romania).

This particular study aimed to evaluate the cost and CO_2 emissions associated with the reduction of sulphur in EU road fuels to the 10 ppm level, using the year 2000 specifications as the starting point. From this point of view, it is an update of the estimates produced in 2000 (CONCAWE report 00/54). Since this reduction is occurring alongside other specification changes (e.g. gasoline aromatics), as well as evolution of the crude basket and of the product demand, these factors were also incorporated into the study. A full report has recently been published (report 8/05) and is available on the CONCAWE website.

The main estimates were produced on the basis of a relatively favourable core scenario including:

- no change in the crude diet between 2000 and 2010;
- a 1% per year overall energy efficiency improvement in refineries; and
- no change in the specification for non-road diesel fuel.

A number of sensitivity cases were run to show the potential additional effects of these factors, taken individually and combined. Because cracked gasoline desulphurisation is central to the production of 10 ppm sulphur gasoline and because the processes are still relatively new, an additional sensitivity case was considered involving 50% higher energy consumption for such plants.

A reference case was established with the 2010 product demand, road fuels sulphur specifications unchanged from 2000 (i.e. 150/350 ppm for gasoline and diesel fuel respectively), and all other specifications set at the current limit or the already legislated limit for 2010 (e.g. heating oil at 0.1% m/m sulphur maximum). Comparison with a 2000 base case featuring 2000 demand and specifications gives an estimate of the impact of changes in demand and non-sulphur specifications. Further study cases included sulphur limit reduction to 50 and 10 ppm for gasoline and diesel fuel either separately or together.

Table 1 summarises the results in terms of incremental annualised cost and CO_2 emissions from the refining sites.

Reduction of the sulphur specification of road fuels to less than 10 ppm will require an estimated refinery capital expenditure of 6.7 to 7.5 G€. Gasoline and diesel share the burden roughly equally.

These investment figures are in addition to another 7.3 G€ required to meet the evolution of demand and the changes to other specifications between 2000 and 2010. This figure would rise to nearly 8.8 G€ with a heavier crude slate.

The EU refineries will emit an estimated additional amount of CO_2 of 7.3 to 9.2 Mt/a. Gasoline is responsible for 65% and diesel fuel for 35% of the increase.

In order to cope with demand evolution and with the changes in other specifications between 2000 and 2010, EU refineries will further increase their CO_2 emissions by 13.3 Mt/a, increasing to 26.8 Mt/a in the worst scenario considered.

The annualised costs to EU refineries will increase by 1.8 to more than 2 G€/a. This is equivalent to around 6.2 € per tonne of sulphur-free fuel produced.

Road fuels desulphurisation

How EU refineries are affected by the gradual move to 10 ppm sulphur limit

Table 1 Capital investment, incremental annualised cost and CO_2 emissions from EU refineries

	2000	2010				
	Base	**Reference**	**Alternatives**			
Refinery production (Mt/a)						
gasoline	136	136				
diesel fuel	140	195				
Study Case	gasoline 150 ppm	gasoline 150 ppm	both fuels 50 ppm	both fuels 10 ppm	gasoline 10 ppm	diesel 10 ppm
Nominal sulphur specification (ppm max)						
gasoline	150	150	50	10	10	50
diesel fuel	350	350	50	10	50	10
Other key specifications						
gasoline aromatics (% v/v max)	42	35.0				
IGO sulphur (% m/m max)	0.2	0.1				
Capital investment (G€)		Additional to base	Additional to reference			
Core scenario		**7.3**	**2.9**	**6.7**	**4.8**	**4.8**
Sensitivity 1		8.8	3.1	6.9	5.1	5.0
Sensitivity 2		7.4	3.0	6.8	4.9	4.8
Sensitivity 3		7.4	2.8	6.6	4.7	4.6
Sensitivity 4		7.6	3.1	7.3	5.1	5.3
Sensitivity 5		8.8	3.5	7.5	5.6	5.8
Overall annualised cost (G€/a)			Additional to reference			
Core scenario			**0.84**	**1.89**	**1.38**	**1.34**
Sensitivity 1			0.78	1.82	1.37	1.25
Sensitivity 2			0.78	1.85	1.37	1.25
Sensitivity 3			0.76	1.82	1.35	1.24
Sensitivity 4			0.83	1.97	1.41	1.38
Sensitivity 5			0.89	2.05	1.50	1.44
Site CO_2 emissions (Mt/a)	Additional to reference	Total	Additional to reference			
Core scenario	-13.3	**154.5** (*)	**3.5**	**7.3**	**5.9**	**4.6**
Sensitivity 1	-19.1	160.3	3.6	7.6	6.4	5.0
Sensitivity 2	-13.3	154.5	3.5	7.9	6.5	4.7
Sensitivity 3	-20.5	161.7	3.5	7.7	6.2	4.9
Sensitivity 4	-13.4	154.6	3.8	8.2	6.5	5.3
Sensitivity 5	-26.8	168.0	4.3	9.2	7.4	5.7

Sensitivities: 1: *Heavier crude slate (5% shift towards heavy crude)*   2: *50% higher energy consumption for FCC gasoline desulphurisation*
3: *Energy efficiency unchanged from 2000*   4: *Non-road diesel at AGO specification*   5: *Combined changes*
(*) *138 when excluding petrochemicals*

When considering the change from 50 to 10 ppm sulphur for both gasoline and diesel, the new estimates represent about 2/3 of the overall costs and of the additional CO_2 emissions estimated in the 2000 CONCAWE study. These changes are the result of the very significant technology developments that have taken place in the intervening period, as well as changes in predicted 2010 demands and crude slate.

It must be kept in mind that the model estimates the overall effect of a change on the industry. In practice, each refinery will seek the most cost-effective route to address its own specific set of technical, financial and other constraints. When expressed as a percentage of the total, the increased CO_2 emissions estimated by the model should therefore only be regarded as an average of a wide range of values. Individual circumstances (crude intake, refinery technology, product mix) will dictate the scale of the actual increase for any given refinery.

PAH content of diesel fuels

How EU refineries would be affected by a reduction of the current limit

Using the EU-refinery model introduced in the previous article, CONCAWE has evaluated the potential consequences of a reduction of the diesel fuel polycyclic aromatic hydrocarbons (PAH) specification on the European refining industry from the point of view of costs and CO_2 emissions, both from the refineries and from a global point of view i.e. including the impact of changes in fuels carbon/hydrogen ratio on in-use emissions. A full report has recently been published (report 7/05) and is available on the CONCAWE website.

The PAH content of diesel blending components depends on many factors, notably the operating conditions of desulphurisation plants, the severity of operation of cracking units and, to a lesser extent, the crude origin. As a result there are considerable variations between regions and refineries. Indeed, in their present configurations, the vast majority of refineries do not have a direct way to control the PAH level of diesel fuel. The value obtained is a result of the effect of the desulphurisation processes which go some way towards converting poly- into mono-aromatics. The extent of this is a complex function of feed properties, catalyst performance and operating conditions. As refineries gradually reduce the sulphur content of diesel fuel, the average PAH content is also reduced. Even at the 10 ppm sulphur level a wide range will remain, reflecting individual refinery circumstances. We have therefore approached the modelling of PAH on the basis of current and forecast levels, indicated by a survey of some 30 refineries, and after consultations with catalyst technology suppliers.

Reducing PAH in European diesel fuel is technically feasible but would entail at least either major revamps of existing desulphurisation facilities (for the more modest reduction figures) or, more generally, installation of dedicated de-aromatisation plants.

The current diesel fuel PAH specification is 11% m/m max. The move to the 10 ppm sulphur specification will result in a reduction of the average measured PAH level to about 4% m/m, with maximum values up to 8% m/m. As a result of the variability, any specification below 8% m/m would entail costs and additional CO_2 emissions for the industry.

The further the specification falls below this level, the more refineries would need to install additional process units, essentially in the form of dedicated de-aromatisation and hydrogen production facilities. Investment would be required, gradually increasing to nearly 9 G€ at 1% m/m with total annualised costs of 2.2 G€/annum representing 12.4 €/t of diesel fuel.

A reduction of the diesel fuel PAH specification below 8% m/m would cause refineries to emit additional CO_2, up to 15.9 Mt/a for a 1% m/m limit, corresponding to an increase of more than 10% of the total refinery emissions in the reference case. Even after accounting for end-use emission reduction due to the lower CO_2 emission factor of the de-aromatised diesel fuel, a net effect of up to 9.2 Mt/a can be expected.

Table 1 summarises the evolution of costs and CO_2 emissions as a function of the PAH specification level.

Table 1 Costs and CO_2 emissions as a function of the PAH specification level

Diesel fuel PAH specification (% m/m)	8.0	6.0	4.5	3.5	2.0	1.0
Capital investment (M€)	14	1278	2627	4748	7538	8762
Annualised costs * (M€/a)	3	312	634	1203	1893	2249
Extra CO_2 emissions: from refineries (Mt/a)	0.0	1.5	4.2	8.4	13.4	15.9
net (Mt/a)	0.0	0.8	2.4	4.8	7.6	9.2

* Assuming an annual capital charge of 15%

Updated CONCAWE guidance for classification and labelling of petroleum substances

Impacts on petroleum substances containing benzene, 1,3-butadiene or toluene

Introduction

The 29th Amendment to Technical Progress (ATP) to the Dangerous Substances Directive (DSD) was published in 2004, and introduced specific changes to the hazard classification (Annex 1 entries) for Petroleum Gases and for certain individual hydrocarbons present in Low Boiling Point Naphthas (LBPN, including gasoline). CONCAWE guidance on hazard classification and labelling for petroleum substances has recently been updated and re-issued to take account of these changes (Report No. 6/05). The purpose of CONCAWE's recommendations is to promote harmonisation in the classification and labelling of petroleum substances throughout Europe and thereby to help in the safe handling and use of petroleum substances.

As previously, the guidance includes details of mandatory hazard classification (as presented in Annex 1 to the DSD), along with recommendations for industry self-classification for the full range of safety, health and environment endpoints according to the criteria laid down in the DSD. The 29th ATP is due to be implemented into Member States' legislation for compliance by 31 October 2005.

Summary of changes

Petroleum Gas entries: Revised entries now appear in the 29th ATP as a result of the revised hazard classification for 1,3-butadiene in the 28th ATP. Both 1,3-butadiene and Petroleum Gases containing more than 0.1% m/m of 1,3-butadiene are now classified as **Carcinogenic Category 1 - R45** and **Mutagenic Category 2 - R46**: May

cause heritable genetic damage. Since petroleum gases containing more than 0.1% of 1,3-butadiene were previously classified as Carcinogenic Category 2 - R45, the inclusion of the new hazard classification (R46) does not require the application of additional precautions regarding exposure.

Low Boiling Point Naphthas (Gasolines): Changes follow from updating of the hazard classifications for benzene and toluene in the 29th ATP. Benzene is now classified as Mutagenic - Category 2, and CONCAWE recommends inclusion of self-classification **Mutagenic Category 2 - R46: May cause heritable genetic damage** to LBPN when benzene is present at more than 0.1% m/m. Since LBPN containing more than 0.1% of benzene are already classified as Carcinogenic Category 2 - R45, the inclusion of this classification does not require the application of additional precautions regarding exposure.

Similarly, following updating of the hazard classification for toluene (now classified as Reproductive toxicant - Category 3), CONCAWE recommends inclusion of self-classification **Reproductive toxicant Category 3 - R63: Possible risk of harm to the unborn child** to LBPN when toluene is present at more than 5% m/m. In view of the other hazards of LBPN, the inclusion of this additional hazard classification does not require the application of additional precautions regarding exposure.

Updated CONCAWE guidance for classification and labelling of petroleum substances

Impacts on petroleum substances containing benzene, or 1,3-butadiene or toluene

For both LBPN self-classifications, the recommendations follow the precedent established by the Member States Classification and Labelling Working Group (application of the administrative rules of the Dangerous Preparations Directive) for hydrocarbon constituents of complex petroleum substances. However, in relation to both of these health end-points, there are test data to indicate that LBPN are neither mutagenic nor toxic to reproduction. The application of the administrative rules and inclusion of these additional Risk Phrases should not be taken to indicate that the underlying hazards of these products have changed in any way.

It is CONCAWE's intention to formally discuss with Member States the decision to self-classify LBPN in this way.

Future changes to hazard classification

This latest edition of the CONCAWE classification guidance highlights that there are two issues potentially impacting on the classification and labelling of petroleum substances that remain under discussion—the use of 'Indication of Danger' on labels for substances classified as carcinogenic and the environmental hazards of heavy fuel oil components.

The European Commission has also already signalled its intention to publish at least one further ATP that is likely to have relevance for petroleum substances.

Any changes resulting from these initiatives will be incorporated in a future update to the classification guidance.

Occupational risks to hearing reviewed

*A review of CONCAWE's work programme and the
European Directives on noise at work*

With the publication of CONCAWE report 5/05 an extensive work programme on the factors potentially affecting the hearing of petroleum industry workers has recently been completed by the CONCAWE Health Management Group. It was initiated some seven years ago when it became clear that the 1986 European Directive on noise at work would be revised. Noise at work legislation has been in place for many years in most countries with the principal aim of protecting workers' hearing. The legislation in most EU Member States is directly based on Directive 86/1898/EEC which contained an undertaking to review its provisions in the light of experience and developments in scientific and technical knowledge about the effects of noise exposure on health. In February 2003 a new Directive (2003/10/EC) was issued with lowered noise exposure limits. Member States are required to transpose the provisions of the Directive by 15 February 2006.

In the past decade researchers have reported effects from some organic solvents on the hearing function of exposed workers, and similar findings have been reported in experimental toxicology studies. Several of these so-called ototoxic solvents are also constituents of gasoline. Ototoxic solvents interact, after inhalation and distribution in the body via the blood, with sensory cells in the inner ear or with the auditory nerves involved in transmission of the signals to the brain. Toluene, in particular, has been implicated as having the potential to cause effects on hearing. Directive 2003/10/EC requires that attention be given to ototoxic substances as part of workplace health risk assessment for noise exposure, but offers no further guidance on how this should be achieved.

The CONCAWE work programme comprised:
- A recommendation for a health-based limit value for noise exposure to protect hearing, by the University of Southampton, UK (CONCAWE Report 01/52).
- An inventory of typical noise exposure ranges in a variety of European downstream oil industry operations using exposure data from CONCAWE member companies (CONCAWE Report 01/56).
- An analysis of hearing test results of refinery workers, by the Catholic University of Louvain (UCL) in Brussels, using data collected by the medical departments of CONCAWE member company refineries. These reported no general detectable hearing loss attributable to refinery noise exposure since the introduction of national legislation based on the 1986 Directive or, for that matter, to chemical exposures over the same period (CONCAWE Report 00/55).
- A review of the scientific evidence on ototoxic effects of gasoline constituents, by the UCL in collaboration with the University of Milan (CONCAWE Report 5/05).

Report 5/05 presents a full review of all risk factors that may affect a worker's hearing, including noise exposure (occupational and leisure), disease, some therapeutic drugs, smoking and alcohol consumption. The report addresses human and experimental studies of presumed ototoxic chemical exposures. It concludes that, in the only reported study on petroleum refinery workers, the evidence is unconvincing. Well-conducted studies of workers from other industries, where exposures to toluene and other solvents occur within current limits, do not report hearing losses. Exposures to potential ototoxic constituents of gasoline in modern European operations are usually well below these chemical exposure limits (see CONCAWE report 9/02).

Report 5/05 concludes that the scientific understanding of potential interactions between chemicals and noise is limited and it is not possible to make specific recommendations on health risk assessment or to set a limit value for the combined exposure to noise and to certain hydrocarbons that may cause ototoxic effects at high exposure levels. It does recognise, however, the irreversible nature of hearing loss and recommends remaining alert in occupational health surveillance programmes to the possibility of a combined effect of noise and solvent exposure.

Abbreviations and terms used in this CONCAWE *Review*

AGO	Automotive Gas Oil (diesel fuel)		LBPN	Low Boiling Point Naphtha
ATP	Adaptation to Technical Progress		LPG	Liquefied Petroleum Gas
BAT	Best Available Technique		MIT	Massachusetts Institute of Technology
BC	Black Carbon		MTBE	Methyl Tertiary Butyl Ether
BTL	Biomass-To-Liquid		N_2O	Nitrous oxide
C	Carbon		NEM	Natural Emissions Model
CAFE	Clean Air For Europe		NG	Natural Gas
CCS	CO_2 Capture and Storage		NH_3	Ammonia
CH_4	Methane		NO_x	Nitrogen oxides
CHP	Combined Heat and Power		NPP	Net Primary Productivity
CNG	Compressed Natural Gas			NPP = Photosynthesis Rate – Plant Respiration Rate (expressed in units of gram carbon/m^2/year).
CO	Carbon monoxide			
CO_2	Carbon dioxide			
DDGS	Distillers Dried Grain with Soluble (biomass remaining after grain fermentation)		O_3	Ozone
			OH	Hydroxyl free radical
DG-AGRI	European Commission's Directorate-General for Agriculture and Rural Development		PAH	Polycyclic Aromatic Hydrocarbon
			PFC	Perfluorocarbon
DME	Dimethyl Ether		PISI	Port Injection Spark Ignition (engine)
DSD	Dangerous Substances Directive		$PM_{2.5}$	Particulate with an aerodynamic diameter less than or equal to 2.5 μm
EPER	European Pollutant Emissions Register			
EPPA	Emissions Prediction and Policy Analysis		PRTR	Pollutant Release and Transfer Register
ETBE	Ethyl Tertiary Butyl Ether		RAINS	Regional Air Pollution Information and Simulation model (A tool developed by IIASA for analysing alternative strategies to reduce acidification, eutrophication and ground-level ozone in Europe)
EUCAR	European Council for Automotive R&D			
FCC	Fluidised Catalytic Cracking			
GHG	Greenhouse Gas			
GT	Gas Turbine			
HFC	Hydrofluorocarbon		RME	Rapeseed Methyl Ester
IGO	Industrial Gas Oil (heating oil)		SF_6	Sulphur hexafluoride
IGSM	Integrated Global System Model		SO_2	Sulphur dioxide
IIASA	International Institute for Applied Systems Analysis		SO_x	Sulphur oxides
			TEM	Terrestrial Ecosystem Model
IPPC	Integrated Pollution Prevention and Control (EU Council Directive 96/61/EC of 24 September 1996)		TSAP	Thematic Strategy on Air Pollution
			VOC	Volatile Organic Compounds
			WTW	Well-to-Wheels
JRC	European Commission's Joint Research Centre		YOLL	Years Of Life Lost

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We are pleased to welcome George Stalter of BP as our new Technical Coordinator for Water & Waste, replacing Philip Chown, and Sophie Bornstein who takes over from Anne-Laurence Voiseux as Office Manager.

CONCAWE publications

Reports published by CONCAWE from 2004 to date

2004	
1/04	Chronic toxicity studies on white oils
2/04	Fuel effects on emissions from modern gasoline vehicles: Part 2—aromatics, olefins and volatility effects
3/04	Gasoline volatility end ethanol effects on hot and cold weather driveability of modern European vehicles
4/04	Trends in oil discharged with aqueous effluents from oil refineries in Europe—2000 survey
5/04	Occupational health auditing
6/04	European downstream oil industry safety performance—statistical summary of reported incidents—2002
7/04	Performance of European cross-country oil pipelines—statistical summary of reported spillages—2002
8/04	European epidemiology studies of asphalt workers—a review of the cohort study and its results
9/04	Motor vehicle emission regulations and fuel specifications, Part 1—2002/03 update
10/04	Guidance document for application of the EU Commission's guidelines for monitoring and reporting of GHG emissions
11/04	European downstream oil industry safety performance—statistical summary of reported incidents—2003
12/04	Method for monitoring exposure to LPG containing small amounts of 1,3-butadiene
2005	
1/05	Fuel effects on the characteristics of particle emissions from advanced engines and vehicles
2/05	Fuel effects on emissions from advanced diesel engines and vehicles
3/05	Performance of european cross-country oil pipelines—statistical summary of reported spillages—2003
4/05	Evaluation of automotive polycyclic aromatic hydrocarbon emissions
5/05	Factors potentially affecting the hearing of petroleum industry workers
6/05	Classification and labelling of petroleum substances according to the EU dangerous substances directive (CONCAWE recommendations—July 2005)
7/05	Impact of a potential reduction of poly-aromatics content of diesel fuel on the EU refining industry
8/05	The impact of reducing sulphur to 10 ppm max in European automotive fuels—an update
9/05*	Air pollutant emission estimation methods for EPER and PRTR reporting by refineries

* Available shortly

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New reports are generally also published on the website.

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