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Foreword

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In the past two years, a number of European refiners have joined CONCAWE, their principal motivation being to benefit from the work undertaken to prepare for the REACH legislation and to participate in the ongoing activities that will lead to registration of their products by the end of the decade.

As representatives of these new member companies begin to attend our Management Groups and Task Forces, they discover that, beyond the reports that can be downloaded from our website, the real value of CONCAWE membership is in the personal contacts they establish, and the experience they can share with experts having similar responsibilities in other companies and who are addressing similar challenges. This is particularly true in those areas of CONCAWE's activities that may not be regarded as 'core business' in the oil industry and where individual companies have a limited expertise within their own organisations. During these meetings, they can share views on current and upcoming technical issues, and assess the implications of new potential challenges within the bounds of anti-competition legislation. Although, in this age of decreasing manpower and high work loads, spare time is a rare commodity, experts find that involvement in CONCAWE work groups is time well spent and is more than justified by their gaining broader expertise, a clearer vision of the critical issues and an efficient network to serve their company.

This is in fact a two-way process. Indeed, although CONCAWE's Technical Coordinators play a key role, CONCAWE can only function and deliver value through its members and through their representatives in the working groups. This is where the work is done and where results are obtained, but also where the meeting of specialists generates most of the ideas that will shape the future CONCAWE work programme. Over the past 43 years, this method has demonstrated its effectiveness in helping our industry and our members to recognise upcoming issues in the HSSE area and to anticipate related developments in EU legislation.

Some of the articles in this *Review* provide good examples. When the CAFE programme was launched by the Commission five years ago, there were no experts in our companies on cost-benefit analysis (CBA). With health impacts of air pollution becoming the main driver for new environmental legislation it was clear that this methodology would become central to CAFE and subsequent programmes. Some volunteered to work together on CBA and, as a result, CONCAWE was able to critically review and comment on the Commission proposals. We now have a good grounding for involvement in this aspect of future programmes. Although the subject matter was closer to home, we also built a solid expertise on energy scenario analysis and are now in a strong position to comment on any initiative from the Commission in the National Emissions Ceilings Directive review in relation to new energy scenarios from Member States. Our Technical Coordinator, Lourens Post, played a key role in this process, but without the assistance of the different Action Groups and Task Forces he could not have been as efficient and would not have had the support of our members.

The Refinery Technology Support Group (RTSG), which celebrated its 100th meeting in September, presents an article on the issue of the continuously increasing demand for diesel in Europe. Extreme growth of diesel demand relative to gasoline, a plausible scenario based on recent trends, could double the required refinery investment as well as significantly increasing refinery energy consumption and CO_2 emissions. There also we must thank Jean-François Larivé for his very active management of that group, but again, without the involvement of active participants in RTSG, he would not be able to achieve this level of quality and reliability of work.

CONCAWE exists through its members but also gives individuals the opportunity to deepen and broaden their expertise. This is the way it can, and will, continue to be a trusted stakeholder in European debates and bring value to the European oil industry.

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How can EU refineries cope with future transport fuels demand?

The importance of the relative development of the gasoline and diesel fuel markets

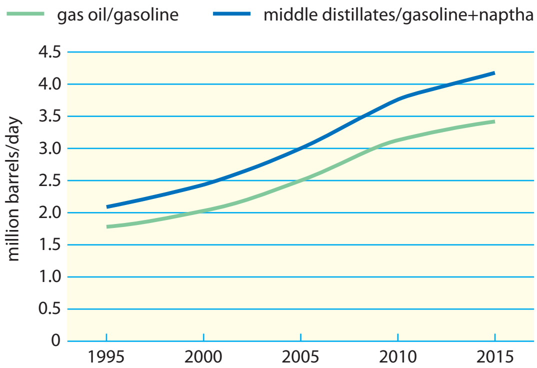
EU fuel demand and call on refineries

The petroleum product market is dominated by transport fuels, particularly gasoline and diesel for road transport and jet fuel for aircrafts. The evolution of the demand in these markets is therefore a crucial parameter for refiners when it comes to planning the size and configuration of future refineries.

Fuel demand is of course the result of demand for mobility but is in practice impacted by many other factors both technical, such as vehicle efficiency, and non-technical such as incentives for smaller vehicles or changes in behaviours, e.g. changes in driving behaviour and style. In the road transport sector there is also the flexibility to resort either to spark-ignited (gasoline) or compression-ignited (diesel) engines. Alternative fuels (particularly biofuels) may cover part of the future demand, leaving the refiners to provide the balance. Substituting more gasoline than diesel or vice versa can lead to distortion in the proportion of these two fuels that the refiners have to provide. Finally, EU refiners do not operate in isolation but have full access to the international markets for import and export of products and components.

The combination of all these factors creates a complex environment where forecasts are difficult and uncertain. The increasing imbalance between gasoline and diesel demand has been highlighted by the EU refining industry for many years and is the result of two simultaneous trends: the increasing 'dieselisation' of the European private car population and the steady increase of freight transportation. From a more or less balanced situation in 1995, demand for diesel fuel today is already nearly 50% higher than for gasoline. The full impact of the fast-rising diesel car sales of recent years is still to come as more gasoline than diesel vehicles are being scrapped. With freight transport still growing, this imbalance will inevitably continue to grow at least for some years. From the refiner's point of view this is aggravated by the simultaneous growth of jet fuel demand which puts extra pressure on the so-called 'middle-distillate' pool[1]. This trend is illustrated in Figure 1 which shows the evolution of the gas oil and middle distillate to gasoline demand ratio in the past 10 years and a forecast for the next 10 years from an industry study by consultants Wood McKenzie.

Figure 1 Historical and forecast gasoline and distillate demand in EU-25, 1995–2015



This evolution of the road fuel market is of concern to EU refiners who are already faced with several challenges such as production of sulphur-free fuels, ever tightening emission standards and CO_2 emissions restrictions. Refineries are flexible and can, to an extent, adapt their production to the market, both in terms of quality and volumes, by changing processing modes and adapting their crude oil and feedstocks diet. Within a given refinery there are obviously limits to what can be achieved and there comes a point where further changes to the production barrel require investments for new plants or major modifications to existing ones. EU refineries were mostly designed in the 1960s–70s to produce gasoline, and turning them into 'middle-distillate' machines could require major surgery.

[1] *The term 'middle distillate' applies to jet fuel, kerosenes, road diesel and other gas oils including marine gas oil and heating oil. Demand for the latter is expected to decrease, but only slowly, within the next decade.*

Thus far the market has come to the rescue of EU refiners by providing both a profitable outlet for their surplus gasoline (the USA) and a ready source of middle distillates supply (mostly Russia for gas oils and the Middle East for jet fuel). According to the IEA statistics EU gasoline exports have grown from 10 Mt in 1995 to more than 25 Mt in 2005 while middle distillates imports have progressed from hardly anything to well over 30 Mt during the same period. Whether this situation will continue to prevail and whether these markets will be able to accommodate ever growing trade volumes is a matter of debate.

In order to make sure the EU market can be adequately supplied in the future, refiners have to try and double guess all these trends in order to come up with an investment strategy that will be fit for purpose and turn out to be profitable.

A CONCAWE study to investigate the impact of different demand scenarios on EU refineries

In this context, CONCAWE has recently carried out a study to analyse the impact of various demand scenarios on the investment requirement of EU refineries and on the likely consequences in terms of energy consumption and CO_2 emissions. This article briefly summarises the methodology and analyses the main results. A full report will be published in due course.

The study considers the 2015 horizon under two main scenarios. In the Reference scenario the demand is based on the Wood McKenzie study mentioned above. It assumes vehicle efficiency improvements in line with EU objectives and a slowdown of the dieselisation trend from 2010 as a result of increased cost of diesel vehicles and technological progress of gasoline powertrains. Steady economic growth makes for a robust growth of freight transport. Introduction of alternative fuels is slow. Imports/exports remain at the current level.

An analysis of the various factors led us to the conclusion that a 'Low Demand' scenario was equally plausible as a result of a combination of continued dieselisation of the private car population, faster progress in vehicle efficiency, the success of non-technical measures to reduce demand and the sustained introduction of alternative fuels. Biofuels feature prominently in this scenario with 18 Mt/a of ethanol and 11 Mt/a of bio-diesel incorporated into road fuels[2]. Fossil gasoline and total gas oil demands of 97 and 334 Mt/a, respectively in the Reference scenario, fall to 62 and 308 Mt/a in the Low Demand scenario. This corresponds to a significant increase in the gas oil to gasoline ratio from 3.4 to 5.0. With the same assumed figures of 28 Mt/a of middle

[2] *This corresponds to 20% more ethanol than bio-diesel on an energy basis in absolute terms and considerably more when expressed as a volume percentage of either gasoline or diesel, based on our assessment of a likely higher availability of ethanol than bio-diesel within the timeframe considered.*

Table 1 Demand scenarios and resulting call on refineries (COR)

Figures in Mt/a	G	GO	G	GO	G	GO	G	GO	G	GO	G	GO	G	GO
	Reference		*R1*		*R2*		*R3*		*R4*		*R5*		*R6*	
Dieselisation			14.8	-13.4	10.0	-9.0	-13.3	12.0	-4.0	3.6	-13.5	12.1	-13.7	12.3
Import(-) / export(+)	21.9	-20.3	22.0	-20.3	22.0	-20.3	21.9	-20.3	15.9	-13.8	13.8	-13.0	5.4	-4.2
Demand	96.8	333.7	111.6	320.4	106.8	324.8	83.4	345.7	92.8	337.2	83.3	345.8	83.1	345.8
COR	118.7	313.4	133.6	300.1	128.8	304.5	105.4	325.4	108.7	323.4	97.1	332.8	88.6	341.6
GO/G production	*2.6*		*2.2*		*2.4*		*3.1*		*3.0*		*3.4*		*3.9*	
	Low Demand		*L1*		*L2*		*L3*		*L4*		*L5*			
Dieselisation			14.0	-12.6	9.0	-8.1	-4.0	3.6	-4.5	4.0	-4.4	4.0		
Import(-) / export(+)	22.0	-20.3	22.0	-20.3	22.0	-20.3	22.0	-20.3	16.0	-13.8	12.0	-10.0		
Demand	62.0	307.9	76.0	295.3	71.0	299.8	58.0	311.5	57.6	311.5	57.6	311.6		
COR	84.0	287.6	98.0	275.0	93.0	279.5	80.0	291.2	73.5	297.7	69.6	301.5		
GO/G production	*3.4*		*2.8*		*3.0*		*3.6*		*4.0*		*4.3*			

G = gasoline **GO** = gas oil

How can EU refineries cope with future transport fuels demand?

The importance of the relative development of the gasoline and diesel fuel markets

distillates import and 22 Mt/a of gasoline export, the ratio is reduced to 2.6 for the Reference scenario and 3.4 in the Low Demand scenario in terms of actual 'call on refineries'. Note that similar ratios could result from plausible reductions of the trade volumes.

As it quickly became clear that the gas oil/gasoline ratio plays a central role in determining what investment would be required in refineries, we also explored the sensitivity of each scenario to more extreme changes in that ratio as a result of different levels of dieselisation of the car population and changes in import/exports. The resulting demand and call-on-refinery figures are shown in Table 1. Cases R1/2 and L1/2 depict a future where dieselisation of the car population is reversed (note that a switch of some 15 Mt/a from diesel to gasoline would require a very quick fall of diesel car sales down to some 20% of the total by 2010). Cases R3/L3 consider high dieselisation and constant trade flows. Cases R4/5/6 and L4/5 explore the impact of reduced trade. In the most extreme cases (R6, L5) total elimination of the trade flows resulted in an infeasible case. Some import/export was therefore reinstated to obtain feasible scenarios. Although some of the sensitivity cases are a little extreme they are still based on combinations of plausible individual trends.

Figures 2 and 3 indicate that the gas oil/gasoline production ratio is the single most important parameter determining the process configuration that will be needed.

All these cases were modelled with the CONCAWE EU-wide refining model with fixed demand and minimum crude and feedstock flexibility. The model includes olefins and aromatics production which, although they belong to the chemical industry, are closely associated with refineries. The model delivered an optimised solution for each case, essentially based on investment in new plants and best use of existing ones.

The gas oil to gasoline ratio is the key

The total demand for oil products is only expected to grow by a few percent between now and 2015 in the Reference scenario. In the Low Demand scenario, curtailment of the road fuel market leads to a contraction of the total oil product demand in 2015. As a result it is not expected that Europe will require new primary distillation capacity, any marginal increase being covered by minor revamps of existing units and capacity creep. The way refineries process crude oil must, however, be adapted in order to cope with changes in the product slate, particularly with regard to the relative demands for middle distillates and gasoline.

The gas oil/gasoline production ratio (GO/G) is the single most important parameter determining the process configuration that will be needed. This is illustrated in Figures 2 and 3 which show the required refinery capital investment and total CO_2 emissions as a function of the gas oil to gasoline production ratio and for each demand scenario.

Figure 2 Capital investment required in EU refineries for different demand levels and different gas oil to gasoline ratios (Base 2005)

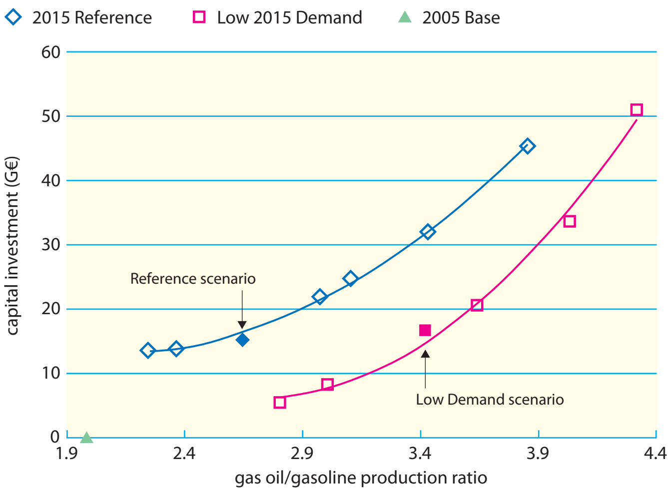
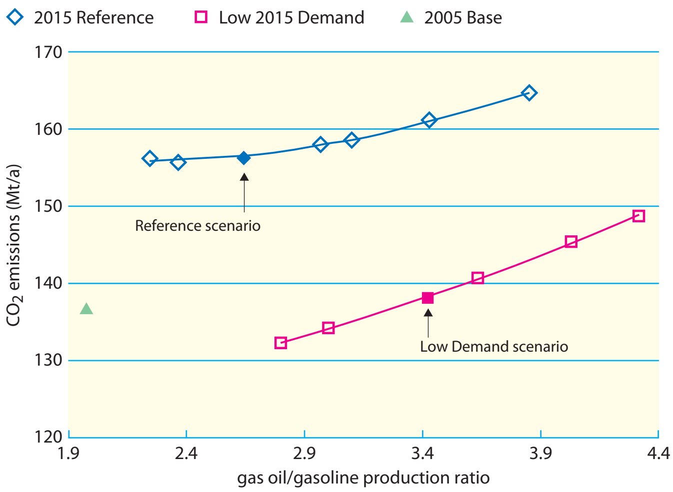


Figure 3 CO_2 emissions from EU refineries for different demand levels and different gas oil to gasoline ratios (Base 2005)



The large investment costs required to install additional capacities correlate remarkably well with the GO/G ratio for a given level of demand. The trend is similar in both demand scenarios. Noting that the Reference scenario requires 15.2 G€ of investment (from the 2005 Base case where the GO/G ratio is close to 2), increasing the GO/G ratio from 2.6 to 3.4 virtually doubles this cost.

The main investments required are in hydrocracking, with some residue desulphurisation or conversion capacity, particularly in the most extreme cases. This has already started as several major conversion projects have been announced in EU refineries.

Meeting the Reference scenario demand would result in an increase in EU refinery CO_2 emissions by about 20 Mt/a while the Low Demand scenario would be about neutral compared to the 2005 Base case. Note that these scenarios were run with an assumption of constant refinery energy intensity compared to 2005. Historically, EU refineries have improved their energy intensity by between 0.5 and 1% per year. Although further improvements are gradually becoming more difficult and costly, some further reductions are expected in the future. This would partly offset the extra energy consumption (and CO_2 emissions).

A more extreme GO/G ratio could increase these emissions by another 10 Mt/a. It must also be noted that the picture is similar in terms of specific CO_2 emissions (in t/t of crude processed), i.e. the higher the GO/G ratio, the higher the specific energy consumption and therefore CO_2 emissions.

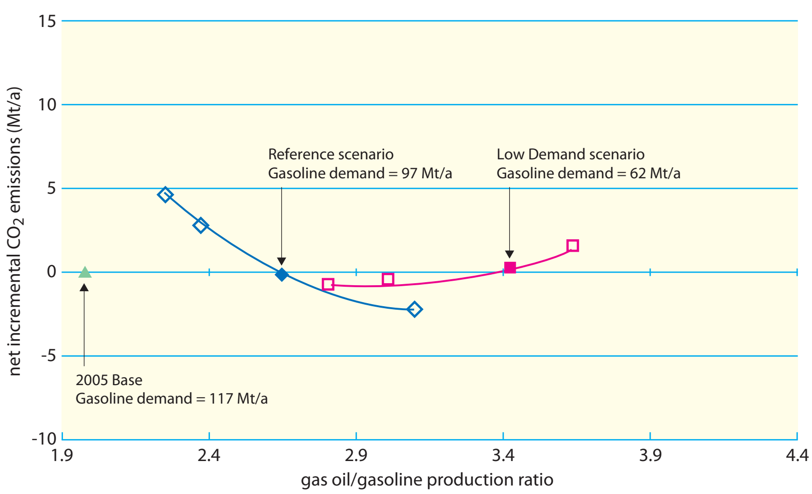
A continued increase of the GO/G ratio would present a very serious challenge to EU refiners in terms of adaptation of their refineries, choice of processes and magnitude of required investments. It would also lead to a further increase in refinery energy consumption and CO_2 emissions.

Where the change in GO/G ratio stems from increased dieselisation, these significant CO_2 emissions increases can be compared to what would potentially be saved in the car fleet by more efficient diesel rather than gasoline powertrains. At the 2015 horizon, it is generally considered that the efficiency gap between spark-ignited and compression ignition engines will narrow from the current 15–20% to possibly as little as 5%. In all sensitivity runs we have assumed a value of 10%, i.e. a reduction of 1 Mt of the gasoline demand is compensated by an increase of 0.9 Mt of the diesel demand. On this basis, one can estimate the CO_2 emission savings from cars resulting from a certain rate of dieselisation. The net 'well-to-wheels' CO_2 emissions are the combination of the decrease in emissions from vehicles and the increase in refinery emissions. For those sensitivity cases where the change in demand is due to changes in the rate of dieselisation, Figure 4 shows the net CO_2 impact as a function of the GO/G ratio, compared to either the Reference or the Low Demand scenario.

For the Reference scenario series, increasing dieselisation (i.e. higher GO/G ratio) does result in lower net CO_2 emissions over the studied range, i.e. the benefit of the more efficient vehicle fleet is higher than the debit due to additional refinery energy use. For the Low Demand scenario series, however, the curve is at best flat or even slightly reversed: more dieselisation results in the same or slightly higher net CO_2 emissions. Although this calculation is only approximate, it highlights the fact that the CO_2 benefit of diesel vehicles could reach a limit and extreme dieselisation actually lead to increased overall CO_2 emissions.

More diesel cars could eventually lead to increased CO_2 emissions.

Figure 4 Net incremental CO_2 emissions resulting from different rates of dieselisation of the EU car population



Evaluation of health impacts in an environmental cost benefit analysis

The challenge of allocating a monetary value to changes in human health due to air pollution

Introduction

In CONCAWE *Review* Vol. 14 No. 2, Autumn 2004, a general introduction was given to the cost benefit analysis methodology (CBA) in which the net economic cost of certain decisions is evaluated by expressing all costs and benefits in monetary terms. This methodology was applied in the Clean Air For Europe (CAFE) programme which looks at future air pollution abatement measures in Europe.

One of the issues highlighted in the previous *Review* article will be discussed here in more detail, namely the complexity of assigning a monetary value to changes in human health impacts due to air pollution and the way this has been done in the CAFE CBA. Two aspects of this will be examined: the choice of the right metric (or 'unit of measurement') to express the health impacts, and the issues around assigning an actual value to this metric.

A matter of the right metric: VOLY versus VPF

Two concepts are often used to assign a monetary value to changes in human mortality. A metric that is often used is called the Value of a Statistical Life (VSL) or, to use a more neutral term, the Value of a Prevented Fatality (VPF). The VPF is the amount of money that a community of people is willing to pay to lower the risk of one anonymous instantaneous premature death within that community (e.g. by certain traffic safety measures). Whereas to save a specific individual in danger usually no means are spared, the VPF is about lowering the risk of premature death in the statistical sense and this leads to a finite value for VPF.

VPF is calculated by dividing the amount of money that people are willing to pay by the change in mortality risk (see box). It will be clear that VPF is the correct metric within a context where we can speak of *observable* deaths, e.g. in traffic accidents.

The Value of a Prevented Fatality (VPF)

Suppose that, in a certain community of people, traffic measures are proposed that will decrease the chance of having a fatal traffic accident by 1 in 10,000 for every individual in that community. Members of that community would be willing to pay for making traffic safer because they all run the risk of having a fatal accident and it would be a benefit for them to make this risk smaller. Suppose that it has been found in some way or another (we will discuss this in more detail in the main text below) that people are prepared to pay on average € 50 per person for such traffic safety measures. Then the VPF is calculated by dividing the amount of money that a person is willing to pay by the change in mortality risk for this person. So in this example the VPF value is € 50 divided by 1/10,000 which gives € 500,000. In a community of say 200,000 people the traffic measures are expected to save 20 people (200,000 times 1/10,000) and it would therefore be justified to pay 20 times the VPF (€ 10 million in our example) for these traffic measures. The effect of the traffic measures would, of course, be observable by looking at the decrease in fatal traffic accidents after implementation of the measures.

However, in the context of air pollution, the use of the VPF metric is far less obvious. Rather than causing observable instantaneous deaths, the health impact of air pollution, especially of particulate matter (PM), can be described much more adequately in terms of a shortening of the *life expectancy* of people (often called chronic mortality). Because of this, an alternative metric proposed in more recent times is the Value of a Life Year (VOLY), which is the amount of money associated with an increase in a person's life expectancy by one year. The actual calculation of VOLY is similar to that of VPF, with the change in mortality risk now being replaced by a change in life expectancy.

There is considerable discussion in the scientific literature on the use of these two metrics. As argued by the researchers of the Commission sponsored ExternE project, it is *impossible* to tell from the information available in epidemiological studies whether a given exposure has resulted in a small number of people losing a large amount of life expectancy or in a lot of people losing a small amount of life expectancy. In this case only the average number of years of life lost can be calculated. In our opinion this is a convincing reason to use VOLY as the only relevant metric in the context of chronic mortality caused by air pollution, where health effects are hugely dominated by PM, as is the case for the CAFE programme.

The CAFE CBA methodology does not make a clear choice for the VOLY metric. Instead both metrics (VPF and VOLY) are used to present sets of (different) results which, in our opinion, is not only confusing but also wrong for the reason discussed above.

Finding a value for VOLY

Once the correct metric to quantify the health benefits of certain improvements has been selected, there is still the issue of assigning an actual monetary value to the metric. This holds true for both the VPF and for the VOLY. Although there are methods to derive a VOLY value from a VPF value, it is generally accepted that if one needs to use VOLY it is preferable to use methods which find a VOLY value directly, i.e. by attributing a monetary value to a certain change in life expectancy.

There are several ways to estimate the actual VPF or VOLY value for a specific community. Here we only discuss a widely used survey technique in which respondents are asked to explicitly state monetary values for a hypothetical change in mortality risk (for VPF) or life expectancy (VOLY). This amount of money is often called the Willingness To Pay (WTP) and these survey methods are sometimes called WTP methods.

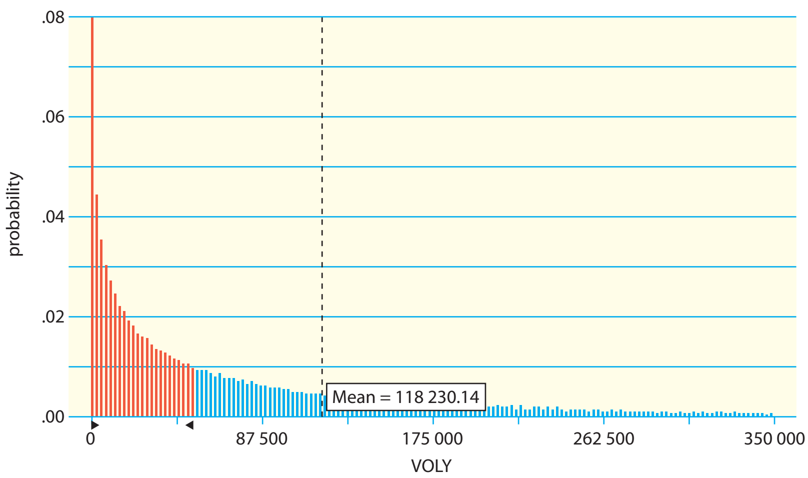
Of course this method has all the complexities of any survey technique in terms of asking the right questions, the extent to which the sample is representative, the possible bias because of age, social status, income or other factors. An additional major problem for VPF (or when deriving VOLY from VPF) is that the concept of risk proves to be difficult for people to understand. Evaluating very small changes in risk is difficult anyway, even for people who are familiar with probability concepts. The concept of a change in life expectancy is easier to grasp, which is another reason for asking directly about changes in life expectancy when trying to find VOLY, rather than asking about changes in mortality risk to establish VPF and then deriving VOLY from that.

The distribution of WTP values as given by respondents in a survey is not at all similar to the well-known normal (Gaussian) distribution, but is a highly skewed one. This is illustrated in Figure 1, which shows such a distribution found in the NewExt study, a European survey carried out to determine VPF as well as a derived VOLY. The horizontal axis gives the VOLY value (as calculated from the WTPs given by the respondents) and the vertical axis the probability of the answers, i.e. the proportion of respondents who indicated a certain VOLY. The red to blue change indicates the median value (the point of the 50/50% split of the answers) which is about € 52 000. The mean (average) value is indicated by the dotted line (€ 118 000).

The large difference between the mean and median is typical of these highly skewed distributions. For such distributions, using the median as a basis for estimating a representative value is a much more robust approach than using the mean, since the latter is very sensitive to a few large 'outliers'. The CAFE CBA methodology presents results for both mean and median. In our opinion this is again not only confusing but also incorrect, because the mean is not a robust estimator of a representative VOLY value.

The distribution of WTP values as given by respondents in a survey is is a highly skewed one. Figure 1 shows such a distribution as found in the NewExt study, a European survey carried out to determine VPF as well as a derived VOLY.

Figure 1 Forecast distribution of VOLY (NewExt study survey)



Evaluation of health impacts in an environmental cost benefit analysis

The challenge of allocating a monetary value to changes in human health due to air pollution

In the scientific literature much work has been done to find a value for the VPF. However, there are only a few studies that aim to find a value for VOLY directly and, as explained above, this is the preferred method to bring out VOLY.

Figure 2 presents the results of three studies directly eliciting VOLY: Defra (United Kingdom survey by Chilton *et al*. commissioned by Defra); Johannesson and Johansson (Swedish survey); and Morris and Hammitt (United States survey). The NewExt study is also included here, because it is the study used by the CAFE CBA to assign a value to VOLY. However, the NewExt study measures VPF and derives VOLY from that.

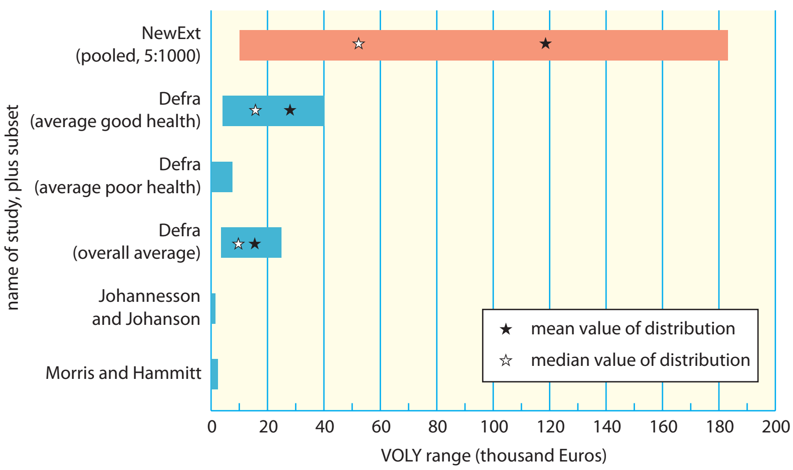
Because the whole VOLY range found in these studies can be very broad, as shown in Figure 1, Figure 2 shows the distribution range between the 20 and 80 percentiles. Mean and medians are also indicated in some cases.

The monetised health benefits calculated with the median NewExt value are four times higher than if the Defra value had been used. In our view this should be taken into account when interpreting the numbers coming from the CAFE CBA.

The Defra study is the most recent of these studies and it is interesting in that it asked three different groups of respondents (all from the United Kingdom) to state their WTP for one, three or six months' increase of life expectancy, both in good and poor health, respectively. So we have no less than six separate VOLY estimates from this study. There are several possible ways to aggregate the Defra results. Three of these are given in Figure 2: 'average' here means that we have averaged the underlying six distributions to give a new distribution.

What is clear from this figure is that when the CAFE CBA methodology selects the NewExt value for VOLY (mean or median) it uses a value which is much higher than the values coming out of the other studies. As an example, the median NewExt value (€ 52 000) is almost four times as high as the median Defra average for good health (€ 14 000), and this is not even the lowest estimator from the Defra results. This means that monetised health benefits calculated with the median NewExt value are four times higher than if the Defra value had been used. In our view this should be taken into account when interpreting the numbers coming from the CAFE CBA.

Figure 2 VOLY distributions (20 to 80 percentiles) according to three studies directly eliciting VOLY (NewExt study results are also included for comparison)



Concluding remarks

Estimating the monetary benefits to society of health improvements is a complex endeavour. To start with, it is essential to select the correct metric. In the context of air pollution by PM, we strongly believe that VOLY is the most appropriate concept. Interpretation of the numbers is also crucial: in particular with the highly skewed distribution functions, median values provide a much more robust representation of the results than mean values.

The CBA methodology adopted for the CAFE programme uses both VPF and VOLY represented by both median and mean values. In addition the actual values are derived from a single study (NewExt) which gives much higher numbers than all other comparable studies. This should be taken into account when interpreting the outcome of the CAFE CBA and it may mean that calculated benefits are grossly overstated and may in some cases not exceed the costs.

Full details, including all references, on what has been presented in this *Review* article can be found in CONCAWE report no. 4/06, *Analysis of the CAFE cost benefit analysis*.

The Thematic Strategy on Air Pollution—under the microscope

Analysing the implications of the Commission's ambitious air pollution targets

The European Commission adopted its 'Thematic Strategy on Air Pollution' (TSAP) in September 2005. This was the culmination of more than three years' work undertaken in the Clean Air For Europe (CAFE) Programme. Since that time the other European Institutions have been scrutinising the strategy. In particular the EU Parliament (EP) recently indicated that, while they welcome the TSAP, they consider the targets are not ambitious enough. Table 1 shows the resulting 2020 emission levels in EU-25 for the five pollutants targeted by the CAFE programme/TSAP for '2020 CLE', the TSAP and those proposed by the EP. The small emission reduction increments between the TSAP and the EP 'more ambitious' targets should be seen in the light of the substantial increase in attendant costs to EU-25 from the € 7.1 billion/year of the TSAP to the € 11 billion/year estimated by the EP.

A key follow-up to the strategy is the review and revision of the National Emission Ceiling Directive (a process already well under way within DG Environment). Given that Member State emission ceilings proposed in the revision of this directive will be designed to deliver the TSAP, it is vital to address this question of the appropriateness of the ambition levels set out in the strategy and their vulnerability to uncertainties. In this brief article we seek to do just that as we, as it were, examine it under the microscope.

Table 1 Emission of pollutants in EU-25 in 2020 vs. 2000 for various scenarios

Scenario	SO_2	NO_x	NH_3	PM	VOC
2020 CLE	32%	51%	96%	55%	55%
TSAP	18%	40%	73%	41%	48%
EU Parliament	18%	35%	73%	39%	45%

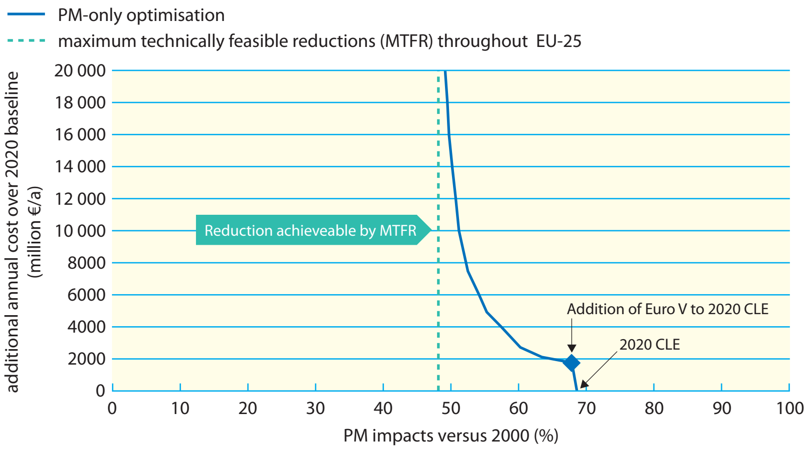
Of course, if we are to do this we need a suitable microscope and here we have used CONCAWE's in-house Integrated Assessment Model (IAM) which incorporates the functional relationships (relating emissions to impacts) and cost databases from IIASA's RAINS model used throughout the CAFE programme.

Getting things in focus

CONCAWE's IAM was run with various reduction targets for fine particulate health impacts (reduction in statistical life expectancy only). Reducing these impacts was the highest priority goal for the CAFE programme and the TSAP.

Figure 1 shows the resulting relationship between additional costs to the EU (compared to the 2020 Baseline of

Figure 1 Additional cost to EU-25 versus reduction in PM impacts: optimised for PM impacts only

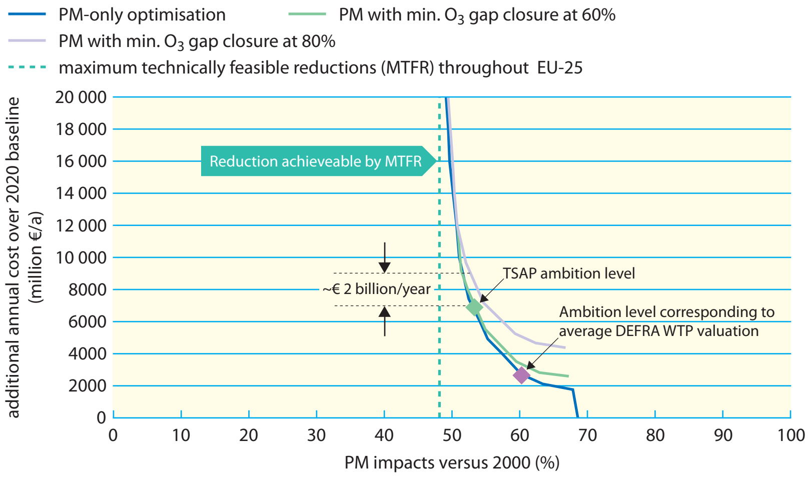


The first point on the curve results from the addition of Euro V vehicle measures to the 2020 Baseline. Each subsequent point on the curve represents the optimum cost (i.e. least cost to the EU) of delivering a given further reduction in impacts.

The Thematic Strategy on Air Pollution—under the microscope

Analysing the implications of the Commission's ambitious air pollution targets

Figure 2 Additional cost to EU-25 versus reduction in PM impacts with additional ozone targets



Increasing the ozone gap closure from 60% (as in the TSAP) to 80% would increase the cost by € 2 billion per year.

Current Legislation) and the reduction of impacts. The impacts are related to the situation in 2000 to provide a suitable perspective. The first point on the curve results from the addition of Euro V vehicle measures to the 2020 Baseline. Each subsequent point represents the least cost to EU-25 of delivering a given further reduction in impacts. The vertical dotted line shows the maximum reduction in impacts achievable by implementing Maximum Technically Feasible Reductions (MTFR) throughout EU-25.

This figure demonstrates the importance of already-agreed measures in reducing the impacts of fine particulates on human health since the reduction in impacts between 2000 and '2020 CLE' represents some two-thirds of the maximum feasible improvement over this period. We shall return to this important matter later in the article.

Figure 2 shows the implications on costs of adding a fixed ozone health target to the PM target viz. 60% gap closure[1] and 80% gap closure for ozone impacts.

To provide a perspective on the implications of adding an ozone target, Figure 2 indicates the position on the curve of the TSAP ambition (and associated cost). While the finally adopted TSAP proposes a 60% gap closure for ozone impacts, this curve serves to indicate the significant cost implications of moving from this to an 80% gap closure target—an additional cost to the EU of some € 2 billion a year.

Ambition levels under the microscope

Such a significant increase in cost prompts the obvious question of justification for a given ambition. To support their proposed ambition level for both PM and ozone health impacts in the TSAP, DG Environment drew on Cost Benefit Analysis (CBA). Benefits were essentially derived from a 'willingness to pay' analysis based on the work of NewExt[2]. In the previous article in this *Review* as well as in an earlier *Review* article[3] CONCAWE has highlighted the large uncertainties associated with this work and the relevance of other published 'willingness to pay' studies which give much lower benefit valuations, e.g. a study commissioned by UK Defra[4].

To illustrate the importance of these uncertainties and variation in valuations between studies, the point that would correspond to the Defra study 'average' valuation is also shown in Figure 2. This cost-benefit study would result in the selection of a much lower ambition level, with significant implications for costs to the EU.

Attainability under the microscope

During the closing stages of the CAFE programme and into the technical discussions around the TSAP, CONCAWE highlighted the potential problem of attainability, should overly ambitious targets be proposed by the Commission. The reasons for this are already clear in Figure 2, which shows that the TSAP ambition is on the steep part of the curve and rather close to the MTFR 'stonewall'. Should any important sector 'under-deliver',

1 *As in CAFE the 'gap' here is defined as the change in impacts between 2020 CLE and 2020 MTFR. The 'gap closure' (expressed in percent) is therefore defined as the extent to which this gap is reduced by introducing additional measures beyond 2020 CLE.*

2 *'New Elements for the Assessment of External Costs from Energy Technologies', EU Research Project 2004.*

3 *CONCAWE* Review *Vol. 13 No. 2, Autumn 2004.*

4 *Chilton, S., Covey, J., Jones-Lee, M., Loomes, G. and Metcalf, H., 2004.* Valuation of health benefits associated with reductions in air pollution', *Defra publication PB 9413, May 2004.*

making up for this shortfall by further measures would result in large cost increases to achieve the ambition, a significant shift in individual Member State costs (as some key contributing countries run out of further available measures) and possibly render the ambition unattainable if emission reductions beyond those achievable by MTFR were required.

The agricultural sector, from which the TSAP foresees a significant and necessary contribution from ammonia (NH_3) reductions, provides a suitable example. What would be the consequences of agriculture not delivering this contribution? Figure 3 shows the results of CONCAWE's IAM when NH_3 control measures are excluded from the optimisation. Although perhaps an extreme case, it serves to highlight the potential problem of attainability. A further IAM run indicates that, if agriculture delivers only two-thirds of the reductions foreseen in the TSAP, the TSAP ambitions would drive other sectors to MTFR with an attendant cost of more than € 25 billion/year compared to the TSAP cost of € 7.1 billion/year.

Figure 3 Additional cost to EU-25 versus reduction in PM impacts: importance of NH_3 reduction measures

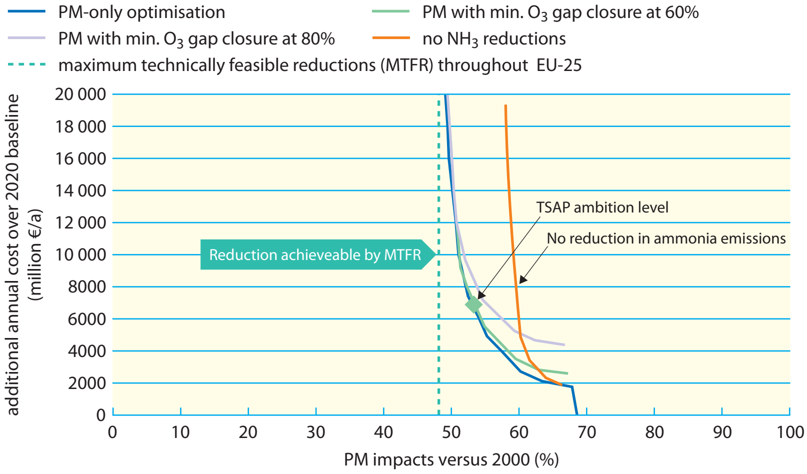


Figure 3: Excluding NH_3 control measures from the optimisation serves to highlight the potential problem of attainability: even if agriculture delivered two-thirds of its expected contribution, the TSAP ambitions would drive other sectors to MTFR or be unattainable.

Figure 4 2020 baseline emissions: difference between National and CAFE data

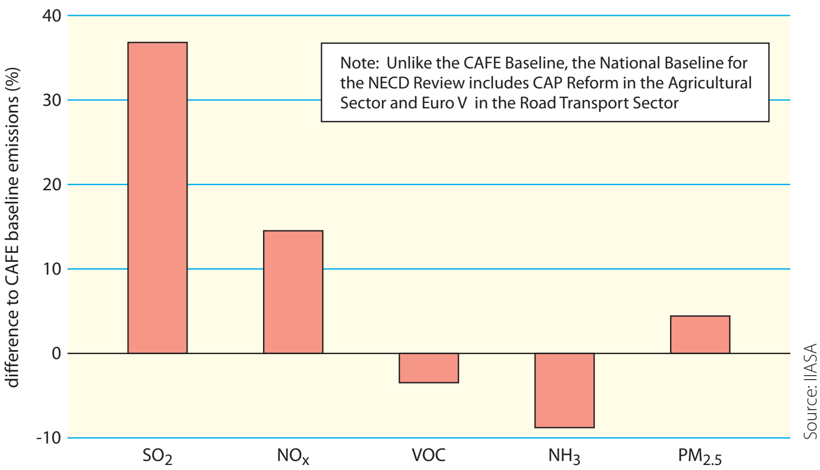


Figure 4: The change in EU emissions between the CAFE 2020 baseline and that based on the national energy scenarios will have potentially significant implications for the cost of delivering the ambitions of the TSAP and/or the attainability of these ambitions.

2020 CLE under the microscope

As noted above, the delivery of the TSAP at the level of burden indicated by the CAFE programme is highly dependent on already-agreed/legislated measures delivering the expected CAFE '2020 CLE'.

It is already clear from the NECD Review process that the new national baseline scenario results in lower than expected reductions in SO_2, NO_x and primary $PM_{2.5}$ emissions compared to the CAFE 2020 baseline. Figure 4, showing the change in EU emissions between the CAFE 2020 Baseline and the new national baseline, is abstracted from IIASA's first report on the NECD Review[5].

This will potentially have significant implications for the cost of delivering the ambitions of the TSAP and/or the attainability of these ambitions.

It is clear that the NECD review process will need to face up to these important issues. The notion that the ambition levels of the TSAP are fixed (or in the Parliament's view need to be more ambitious) will have to contend with the likelihood of significant increases in attendant costs, a significant change in distribution of costs across individual Member States and sectors of the economy, the potential for non-attainability and finally the difficulty of justification. As further data emerges from the process, these challenges will inevitably become more and more apparent. It will therefore be essential for the analyses to include appropriate sensitivities around the core scenarios as the basis for the development of robust policy.

5 *IIASA NEC Scenario Analysis Report No. 1, September 2006*

French service station study of ambient benzene levels (2005)

New data demonstrate that benzene levels in air around service stations continue to fall

Background

In 2005 a study programme was initiated by a group of French operators of service stations, including oil companies (represented by UFIP), supermarkets and independent retailers, to study levels of benzene in the air around service stations. The principal motivation for conducting this study was an environmental health concern resulting from an earlier French study, published in the scientific literature in 2004, linking residence next to a service station during the period 1990–98 to increased childhood cancer risk. Prolonged high exposures to benzene in industrial work environments are a recognised cause of a particular type of leukaemia in adults, but no such link had previously been acknowledged between the much lower levels of benzene in ambient air and childhood leukaemia. The regulatory and technological developments of recent years have resulted in a general decrease of benzene levels in ambient air. Data on typical benzene levels in air in the 1990s are available for EU countries (collated in CONCAWE report 2/99) and can be compared with measured 2005 levels.

Approach

The study protocol was based on earlier studies by CONCAWE and others, in which levels are measured directly at the perimeter of the station where they are considered as representative of the reasonable worst case exposure of nearby residents. Measurements were also taken at a nearby point assumed not to be influenced by the station (e.g. 'upwind') to represent the local background and starting point for the estimation of the station's contribution. The measurement period was two weeks to allow for meteorological variation. Sampling was done in spring and autumn, thus avoiding extremes of temperature. Comprehensive additional data was recorded for each station, for example nearby traffic flows, to help interpretation of the results.

In 2005, approximately 14 000 service stations were in operation in France. Forty-three stations were included in this study, with operators invited to nominate stations in three categories: along motorways (15); in towns and suburban areas (19); and under apartment blocks (9). This sample was constructed to be indicative of typical potential population exposure, but cannot strictly be seen as a random sample out of the entire 14 000 stations. Therefore, care should be taken when applying the results on an individual level in environmental health studies. Current regulatory requirements in France for Stage II vapour recovery are linked to petrol throughput (> 3000 m^3/y). Both Stage I and Stage II stations were included in the study.[1]

Results of perimeter measurements were compared with the data collated by CONCAWE (Report 2/99) for the previous decade. Furthermore, data were compared with the French air quality standard, which was set at 10 µg/m^3 (annual average) in 2005 and which is reduced by 1 µg/m^3 each year to reach 5 µg/m^3 in 2010. This is identical to the EU guidelines. In addition, France has adopted a long-term policy objective of 2 µg/m^3.

Results

The overall contribution of service stations to local ambient benzene levels was considerably lower in 2005 than in the 1990s. The average perimeter levels were 1.2 µg/m^3 for motorway sites, 2.8 µg/m^3 for urban sites and 8.2 µg/m^3 for stations under apartment blocks. The

[1] *Stage I Vapour Recovery: system used to reduce hydrocarbon emissions during the refuelling of gasoline storage tanks. Vapours in the tank, which are displaced by the incoming gasoline, are routed through a hose back into the cargo tanker, instead of being vented to the atmosphere.*
Stage II Vapour Recovery: system used to reduce hydrocarbon emissions during the refuelling of vehicles at service stations. Special nozzles and hoses at the pump capture the displaced gasoline vapours from the vehicle's fuel tank and route them to the back to the service station's storage tank.

increases over the local background were on average 0.3, 0.5 and 2.1 µg/m^3, respectively. The station contributions were found to be comparable to what is commonly found at the exit of a road tunnel or a traffic light at a busy junction.

The highest figures were measured at a station inside an underground car park, but this station should probably not have been included in the study, as it has no direct impact on nearby residences. Another measurement inside a car park, but without a service station, confirmed the elevated level that can be found in such an enclosed environment.

Data available from the Paris city authorities showed a decline from 4 to below 2 µg/m^3 over the period 1998–2003 for city background levels, and from 24 to 6 µg/m^3 for monitored sites directly impacted by automotive traffic. These levels are expected to continue to drop in the coming years.

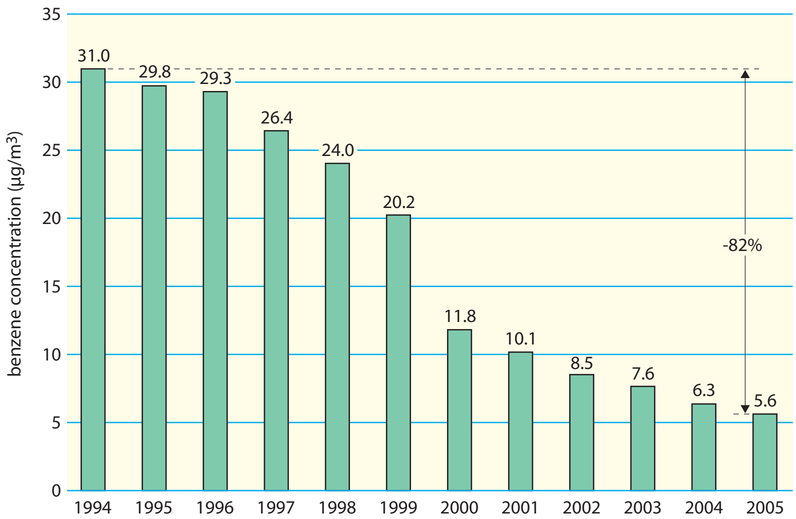
The study also examined the difference between Stage 1 and Stage 2 equipped stations, and in fact found none: the additional vapour recovery through Stage 2 appeared to be offset by the higher sales volume.

Conclusions

The authors concluded that for service stations on motorways and in suburban and urban areas, the increase of the benzene level in air at the boundary of the station compared to the background is less than 1 µg/m^3, considerably lower than a decade ago. Slightly higher numbers were found for stations at the foot of residential buildings, but these were nevertheless lower by a factor of three than in the mid-1990s.

This study updates the existing knowledge base, providing important new data on benzene levels in air around service stations after the introduction of Auto/Oil II policy measures, and documenting the significant decrease of benzene in air which has resulted from these measures.

Figure 1 Evolution of the average annual concentration of benzene at the traffic impacted monitoring station of Place Victor Basch, Paris



Source: AIRPARIF—Bilan de la qualité de l'air en Ile-de-France en 2005 (www.airparif.asso.fr/airparif/pdf/bilan_2005.pdf)

The full study report can be found at:

www.ufip.fr/_fichiers/03_04_2006_%20resume_etude_Bz_limite_prop_stations.pdf

Benzene levels near traffic are dropping in line with those of other primary pollutants emitted by traffic, with a more noticeable drop from 2000 following the introduction of European regulations limiting the benzene content of road fuels.

PETROTOX—CONCAWE's ecotoxicity predictor for petroleum products

A user-friendly tool to assess aquatic toxicity hazard of complex petroleum and related substances

Background

CONCAWE has been conducting a voluntary programme assessing the risks to man and the environment of petroleum substances in anticipation of proposed legislation (REACH). The process by which the risk assessments are being conducted is based on the guidance issued by the European Union in a technical guidance document (TGD) (EU, 2003). The TGD contains an extensive description of how to conduct a risk assessment for man and the environment, but was written primarily to address single pure substances. At the time the first TGD was written, CONCAWE proposed a technical framework to address complex petroleum substances referred to as the Hydrocarbon Block Method (Peterson, 1994; King *et al.,* 1996). This approach was subsequently adopted as an Appendix to the TGD and applied to a risk assessment on gasoline. In the case of gasoline, the individual constituents can be readily identified and logically grouped into hydrocarbon blocks with similar fate and effect properties. It was recognised at the time that the Hydrocarbon Block Method required further adaptation in order to be applied to higher boiling substances where detailed information on the identity of individual constituents cannot be obtained.

PETROTOX

As one part of this further work, CONCAWE has sponsored an external contractor (Hydroqual) to develop a general purpose spreadsheet-based model (PETROTOX) to predict the ecotoxicity of the petroleum substances under different test conditions for various aquatic organisms. PETROTOX is a user-friendly tool to assess aquatic toxicity hazard of complex petroleum and related substances; it:

- predicts toxicity of substances to different aquatic organisms (based on the Narcosis Target Lipid Model);
- assesses impact of composition/test design on toxicity results; and
- estimates Predicted No-Effect Concentrations (PNECs) needed as input to environmental risk assessments of petroleum substances using the Hydrocarbon Block Method.

The model can accommodate two types of inputs, low resolution or high resolution, which depend on the information known about the mass distribution of hydrocarbon classes in the petroleum substance. In the low-resolution approach, the mass distribution of two generic classes (aliphatic and aromatic) is entered over user-defined boiling point intervals. This format is patterned after the information derived from a Total Petroleum Hydrocarbon (TPH) method of analysis. In the high-resolution approach, the mass distribution for up to 16 classes of hydrocarbons can be entered: n-paraffins, iso-paraffins, n-substituted cylcohexanes, n-substituted cylcopentanes, other mono-naphthenics, di-naphthenics, poly-naphthenics, n-olefins, iso-olefins, sulphur-bearing aliphatics, mono-aromatics, naphthenic mono-aromatics, di-aromatics, naphthenic di-aromatics, poly-aromatics and sulphur-bearing aromatics. This format is patterned after the information derived from highly detailed 2D-GC that provides mass distribution information for the 16 chemical classes over 26 boiling point intervals. In both cases, the physical/chemical properties of the chemical classes that are used in the model to characterise the product are derived from a library of representative hydrocarbon structures that are included as a separate worksheet in the spreadsheet. A generic version of the model (User-Defined version) has also been developed that allows input of user-defined hydrocarbon blocks and associated properties.

Both the Default and User-Defined versions of the PETROTOX spreadsheet model are available on the CONCAWE website (www.concawe.org/Content/Default.asp?PageID=241) or by contacting Bo Dmytrasz at CONCAWE (bo.dmytrasz@concawe.org). For both versions of the model, there are user's guides that include tutorials which give detailed examples with step-by-step instructions to guide the user through various features of the model. PETROTOX is being made available without charge. However, certain restrictions apply. For complete details, please refer to the User Agreement and Disclaimer that is included in the user guide.

For those readers interested in more technical details, further discussion follows on the topics that underpin PETROTOX, namely target lipid models and aquatic toxicity of petroleum substances.

Target lipid models

In carrying out the gasoline risk assessment, a method for predicting the no-effect concentrations (PNECs) to aquatic organisms was needed. The method chosen was based on the Narcosis Target Lipid Model (NTLM), developed by Di Toro *et al.* (Di Toro *et al.*, 2000a,b).

The first observation of interest when trying to understand the relationships between chemicals and mortality of aquatic organisms, is that if a chemical causes death, without a specific mode of action, when quantified, the range of concentrations (expressed in molar terms per kg) in the body of the aquatic organisms is approximately similar regardless of the chemical. This body burden is a result of the bioconcentration of the chemical up to a critical concentration, and is thus the product, for a range of narcosis chemicals, of the BCF and the LC50 of the chemicals. As BCF increases and LC50 decreases with increasing octanol-water partition coefficient, K_{OW}, the result is approximately constant.

This also gives rise to the frequently observed inverse relationship between the LC50 and K_{OW}:

$$\log(\mathrm{LC50}) = a \log(K_{OW}) + b \qquad \textit{(Equation 1)}$$

The NTLM extends this observation by assuming a single universal slope for the log (LC50) versus log (K_{OW}) relationship, independent of the species. The universal slope is the slope of a linear free energy relationship between octanol and the target lipid in the organism. The y-intercepts are the species-specific critical target lipid body burdens (CTLBB), C_L^*, for narcosis mortality. These body burdens are adjusted for chemical classes that are slightly more potent than baseline narcotics. Further details on model theory and calibration with available aquatic toxicity data sets are provided by Di Toro *et al.*, 2000a and McGrath *et al.*, 2004.

Aquatic toxicity of petroleum products

Experimental evidence shows that the aquatic toxicity of individual narcotic chemicals, including hydrocarbons, can be categorised into two broad classes of hydrocarbons that:

- exhibit aquatic toxicity spanning several orders of magnitude and inversely correlated to K_{OW} (see Equation 1); and
- do not exhibit toxicity due to their low aqueous solubility.

Thus, to be able to predict the aquatic toxicity of petroleum substances both the nature and concentration of individual hydrocarbons in solution need to be understood. To account for compositional differences, the toxicity of individual compounds in a mixture can be conveniently expressed in terms of toxic units (TUs). A toxic unit is the ratio of the measured concentration of a chemical and the corresponding effect concentration in the same medium. Assuming additivity, toxic units for individual constituents can be summed to estimate toxicity of the mixture.

In the recent gasoline risk assessment, this approach was adopted and based on the hydrocarbon blocks chosen, sharing similar physiochemical properties, the toxicity of water accommodated fractions (WAFs) of six gasoline blending streams to an algae (*Selenastrum capricornutum*), a fish (*Oncorhynchus mykiss*) and a daphnid (*Daphnia magna*) were successfully predicted using the NTLM (McGrath *et al.* 2005). During this project, the NTLM was modified by expressing aquatic toxicity of petroleum products based on membrane-water partitioning (K_{MW}) rather than K_{OW}. This was required because at a log(K_{OW}) greater than approximately 5.5, the log(K_{MW})–log(K_{OW}) relationship that is assumed deviates from linearity resulting in higher predicted toxicity of higher boiling point products when compared to observed toxicity. This revision allowed NTLM predictions to be reconciled with

PETROTOX—CONCAWE's ecotoxicity predictor for petroleum products

A user-friendly tool to assess aquatic toxicity hazard of complex petroleum and related substances

measured toxicity data and provided a mechanistic model that could be used to derive PNEC values for hydrocarbon blocks comprising higher boiling point petroleum substances such as kerosines and gas oils.

Solubility limitations on chronic aquatic toxicity

A key finding from the gas oils and kerosine risk assessments is that the approximate chain lengths at which aliphatic hydrocarbons cease to exert aquatic toxicity need to be confirmed to ensure proper calibration of the revised target lipid model that is based on membrane-water rather than octanol-water partition coefficients. This work has commenced and the research now being conducted will better define chronic cut-offs for various aliphatic hydrocarbon classes in the C12–C16 range. The work will first concentrate on establishing high quality toxicity data on algae, before confirming that invertebrates follow a similar pattern, as predicted from the toxicity model.

References

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Pipeline integrity

Focus on pipeline ageing and third-party interference

In the spring issue of the CONCAWE *Review* we reported on COPEX 2006, the CONCAWE Oil Pipelines Operators Experience Exchange seminar that took place in Brussels at the end March of this year. This article focuses on the two main topics discussed at the Seminar and highlights the main conclusions and intended follow-up actions.

Repairing a damaged pipeline

Pipeline ageing

The bulk of the EU cross-country oil pipeline network was built in the 1960s. When CONCAWE started collecting performance data in 1971 the average age of the network was eight years. It was 34 years in 2004 (see Figure 1). There is no current plan for large-scale replacement of existing lines, and hence the average age of the existing network will continue to increase.

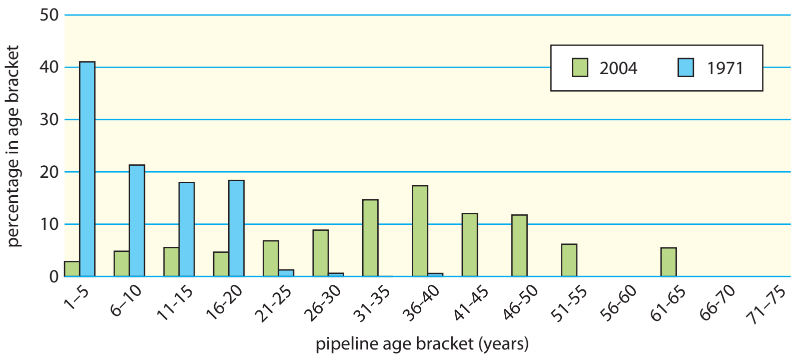
The question to ask is whether this matters or, more specifically, to what extent age affects the integrity of pipelines and/or other aspects of their operation.

There are two concerns associated with time: ageing/fatigue of the metal and welds (and consequent deterioration of the pipeline's structure and strength) and internal/external corrosion.

Metal deterioration is a slow process that depends on many factors related to quality of the original steel, design and operating conditions. Generally a steel pipeline operated within its original design window has a very long lifetime. It must also be pointed out that older lines were generally built with high safety margins in terms of e.g. wall thickness. From this point of view more modern lines designed in accordance with e.g. the API or national codes may be more vulnerable in the future. There must of course be a time limit but the general opinion is that we are still far from it in the case of oil pipelines. A parallel can be made with 19th century steel civil structures that are still being used and are still safe, often under conditions which exceed those for which they were originally designed.

The CONCAWE spill statistics provide some evidence that external/internal corrosion can be kept under control.

Figure 1 The age profile of the European cross-country pipeline network



In 1971 the average age of the European cross-country pipeline network was 8 years; in 2004 it was 34 years.

Pipeline integrity

Focus on pipeline ageing and third-party interference

Figure 2 Frequency of corrosion related spills for cold oil pipelines in the EU

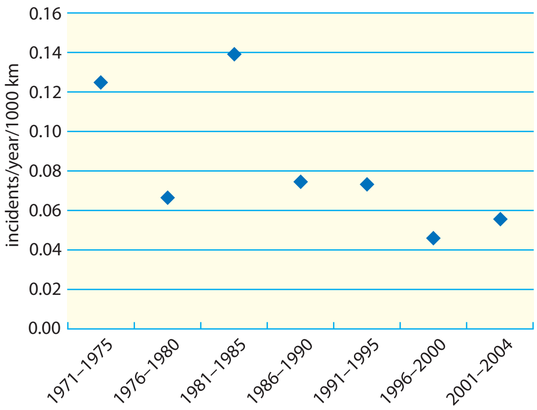


Figure 2 shows the frequency of corrosion-related spills over time for cold oil pipelines in the EU. There is clearly no increase with time and, if anything, the frequency has been on a downward trend over the years. We conclude that there is no direct correlation between age and corrosion-related failures. Indeed corrosion is usually the result of a specific set of conditions on a local line section and, if not well managed, can result in line failure within a relatively short time.

This favourable outcome is in part the result of continuous improvement in pipeline inspection and maintenance techniques which form an integral part of the pipeline integrity management system operated by the vast majority of all European pipeline operators.

Investigation techniques now routinely involve intelligence pigs which are becoming increasingly sophisticated in the range of data that can be collected and the portion of the pipeline surface that is effectively inspected. This is in addition to more traditional external and internal inspections of non-piggable sections, direct and indirect corrosion measurements and pressure tests (for obvious reasons this last method is certainly not preferred).

Excavating machinery can cause extensive damage to pipelines that does not always result in immediate failure.

Inspection data are used, together with historical operational data, for risk-based assessments by company and external experts to determine the need for repairs, preventive maintenance, passive and active corrosion mitigation (cathodic protection, corrosion inhibitors, etc.) and, where required, appropriate adaptation of operating conditions to take account of the state of the line.

All these activities have a cost but they are generally necessary on both new and older lines. There may come a time when signs of ageing on a line would increase the frequency of inspections and the instances of repairs, and force capacity reductions that would become unacceptable. In such a case replacement of a section of a line may have to be considered but this is viewed as an unlikely scenario.

Oil pipelines in Europe are indeed becoming older but this is not seen as a serious problem for the foreseeable future. Pipeline operators fully integrate this factor in the pipeline integrity management system.

Third-party interference

Pipelines run for long distances across rural and urban areas, crossing roads, railways and rivers. By their very nature they are less controllable by the operator than industrial sites and are therefore open to interference by third parties. Not surprisingly this has always been an important cause of incidents and near misses whereas, over the years, other causes of pipeline failure have progressively been brought under control through improved inspection and maintenance systems and generally improved pipeline integrity management systems.

Figure 3 shows the frequency of spills for five groups of causes. All frequencies have steadily decreased over the years but third-party interference has been at best static in the past 15 years. It is now by far the most important cause of spills from European oil pipelines, representing more than 50% of all spills in the past 5 years.

It must be noted that this is an issue not only for oil pipelines but also for all other buried infrastructure such as other pipelines and underground cables, for which similar statistics apply.

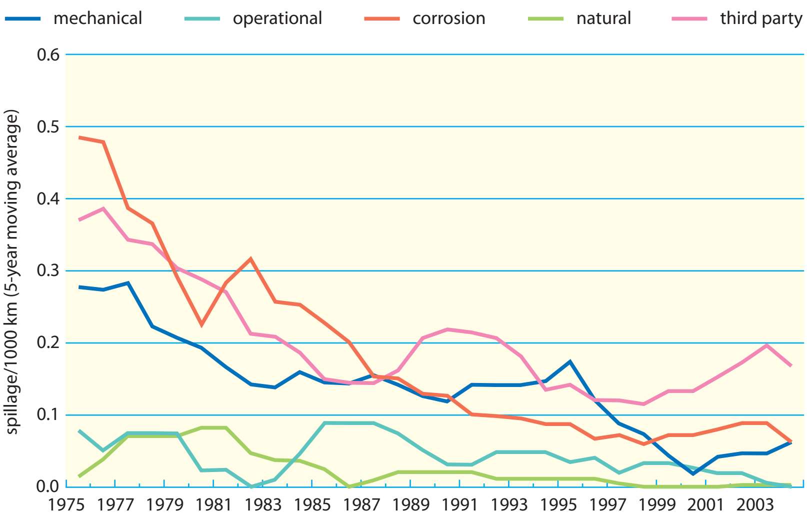
Interference by third parties can take many forms, including attempted theft, although most cases are linked to excavation activities by either farmers and landowners or civil works contractors. Freak incidents also occur as illustrated by a recent case where an electric pylon fell and punctured a pipeline. In many cases damage is done to the pipeline by some form of machinery without resulting in an immediate leak. Failure occurs later (sometimes years later) through metal fatigue or as a result of a minor operational upset such as a pressure surge.

Pipeline operators have been well aware of this problem for many years. It is, however, a multi-stakeholder issue that has proven to be a 'difficult nut to crack'.

Operators have a number of options at their disposal to protect the lines and limit the consequences of incidents. Passive protection of a pipeline in particularly risky areas can include greater burial depths and concrete covers. Warning strips running above the pipeline are also commonly used. Active protection involves surveillance by air patrol, CCTV, car and foot patrols. In addition various mitigation systems can be installed such as leak detection and location systems, and remotely operated isolation valves.

However useful all these may be, they will not serve to prevent all incidents. Involvement of the other stakeholders, particularly regulating and permitting authorities and civil contractors, is essential. A number of countries or provinces have put 'one-call' systems in place to ensure proper and centralised communication between those whose job it is to excavate, and operators of pipelines and other buried infrastructure. The Dutch KLIC system and the ALIZ scheme in operation in North Rhine Westphalia are examples of such systems. In a recent UK project a database of 'infringements' (i.e. including near-misses, undeclared work, etc.) was collected. This showed that some companies (often large utilities) are the most repeated offenders, and it provided an objective tool to confront such companies

Figure 3 Frequency of pipeline spills for five groups of causes



and trigger corrective action. These systems are effective up to a point but still have to rely on minimum discipline by those who are about to dig. The problem is compounded by the fact that civil works often involve several layers of contractors and sub-contractors, making communication between the pipeline operator and the man holding the pickaxe particularly difficult.

It is essential that authorities are involved to provide an official framework for such 'one-call' systems and a certain level of regulation and enforcement. No amount of legislation will, however, definitely solve the problem. Overly complex and prescriptive regulatory systems could even be counter-productive. The onus must be on communication and training, the lack thereof being at the root of most incidents. Here too, operators have an important role to play in keeping regular contact with land owners, farmers and all contractors who are likely to be involved in excavation activities near a pipeline.

Members of the CONCAWE Oil Pipelines Management Group are fully aware of their responsibilities in this matter and have decided to take a leading role towards improvement. A working group has been formed and is currently working on the definition of operator's best practices and the development of recommendations and guidelines for operators, authorities and potential third parties.

The frequency of spills for all five groups of causes has decreased steadily over the years. The most important cause of spills is third-party interference which represents more than 50 per cent of all spills in the past five years.

In memoriam

Neville D. Thompson
15.8.1955 – 29.8.2006

Our colleague, Neville Thompson passed away on 29 August, after battling bravely against cancer for just over a year.

After a career of more than 20 years with Esso/ExxonMobil in England, Neville joined CONCAWE in September 2000 as Technical Coordinator for Fuels Quality & Emissions. His expertise, professionalism and personality quickly gained him the recognition, respect and esteem of all those with whom he had dealings, both within our industry and beyond. Neville's mastery of the fuels and vehicles field allowed him to successfully champion and advance the relevant issues within CONCAWE. He was also a driving force in enhancing working relationships, mutual understanding and cooperation between key stakeholders in Europe (automotive industry, EU Commission, etc.) and in North America.

Neville was not only a true professional in his field, but also a valued colleague and a good friend to all the staff at CONCAWE, as well as to members of the various groups that he coordinated. He will be sorely missed.

Abbreviations and terms used in this CONCAWE *Review*

ALIZ	A company which proposes a 'one-call system' as a link between pipeline operators and civil contractors in part of Germany (www.aliz.de)
API	American Petroleum Institute
BCF	Bioconcentration Factor
CAFE	Clean Air For Europe
CAP	Common Agricultural Policy
CBA	Cost Benefit Analysis
CCTV	Closed Circuit Television
CLE	Current Legislation
COPEX	CONCAWE Oil Pipeline Operators Experience Exchange
COR	Call on refineries
CTLBB	Critical Target Lipid Body Burdens
Defra	UK Government Department for Environment, Food and Rural Affairs
EP	European Parliament
ExternE	Externalities of Energy. A Research Project of the European Commission for the Assessment of External Costs from Energy Technologies
G	Gasoline
GO	Gas Oil
IAM	Integrated Assessment Modelling (Model)
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
KLIC	Cable and Pipeline Information Centre (www.klic.nl)
K_{MW}	Membrane-water partitioning coefficient
K_{OW}	Octanol-water partitioning coefficient
LC50	Median Lethal Concentration. A statistically derived concentration that can be expected to cause death in 50% of animals exposed for a specific time.
MTFR	Maximum Technically Feasible Reductions
NECD	National Emissions Ceilings Directive
NewExt	New Elements for the Assessment of External Costs from Energy Technologies: Project financed by the European Union, DG Research, Technological Development and Demonstration (RTD)
NTLM	Narcosis Target Lipid Model
PM	Particulate Matter
PNEC	Predicted No-Effect Concentration
RAINS	Regional Air Pollution Information and Simulation model (A tool developed by the International Institute for Applied Systems Analysis (IIASA) for analysing alternative strategies to reduce acidification, eutrophication and ground-level ozone in Europe)
REACH	Registration, Evaluation and Authorisation of Chemicals
SETAC	The Society of Environmental Toxicology and Chemistry
Stage I	Vapour Recovery: system used to reduce hydrocarbon emissions during the refuelling of gasoline storage tanks. Vapours in the tank, which are displaced by the incoming gasoline, are routed through a hose back into the cargo tanker, instead of being vented to the atmosphere.
Stage II	Vapour Recovery: system used to reduce hydrocarbon emissions during the refuelling of vehicles at service stations. Special nozzles and hoses at the pump capture the displaced gasoline vapours from the vehicle's fuel tank and route them back to the service station's storage tank
TGD	Technical guidance document
TU	Toxic Unit
TPH	Total Petroleum Hydrocarbon
TSAP	Thematic Strategy on Air Pollution
2D-GC	Two-Dimensional Gas Chromatography
UFIP	Union Française des Industries Pétrolières
VOC	Volatile Organic Compounds
VOLY	Value of a Life Year
VPF	Value of a Prevented Fatality
VSL	Value of a Statistical Life
WAF	Water Accommodated Fraction
WTP	Willingness To Pay

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We would like to welcome Ken Rose who joined CONCAWE on 1 September as Technical Coordinator for Fuels Quality and Emissions. Ken has worked for ExxonMobil Research and Engineering (USA) and for Esso Petroleum (UK), having responsibilities for fuels quality, refinery and marketing support, and fuels research and development.

CONCAWE publications

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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
9/05R	Air pollutant emission estimation methods for EPER and PRTR reporting by refineries (revised)
10/05	European downstream oil industry safety performance—statistical summary of reported incidents—2004
2006	
1/06	Human exposure information for EU substance risk assessment of gas oil
2/06	Techno-economic analysis of the impact of the reduction of sulphur content of residual marine fuels in Europe
3/06	Performance of European cross-country oil pipelines—statistical summary of reported spillages—2004
4/06	Analysis of the CAFE cost benefit analysis
5/06†	Motor vehicle emission regulations and fuel specifications—Part 1—2004/2005 update
6/06† *(included on CD with Report 5/06)*	Motor vehicle emission regulations and fuel specifications—Part 2—historic review (1996–2005)

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†Not published on the CONCAWE website; copies may be ordered from the Secretariat.

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