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Editor: Jean-François Larivé, CONCAWE
Design and production: Words and Publications • words@words.co.uk

Foreword

Alain Heilbrunn, Secretary General, CONCAWE

At the beginning of 2007 the EU Commission launched a series of proposals that will have a profound impact on our industry and on European society in general.

The Energy Package, endorsed by the spring Council, proposes a set of bold targets for the 2020 horizon: 20% reduction in greenhouse gas (GHG) emissions compared to 1990, 20% renewable energy and 20% improvement in energy efficiency compared to a 'business-as-usual' scenario. The renewable energy goal includes a stipulation for 10% of the energy content of road fuels to be covered by biofuels. Fulfilment of this package would represent a massive change in the European energy landscape, in terms of both consumption and make-up. It opens a number of issues for our industry, particularly with regard to the uninterrupted supply of affordable and fit-for-purpose fuels. Direct consequences for the level of activity of the existing fuel production and distribution system could be very serious indeed and CONCAWE will play its part in evaluating the impact of these measures.

The Review of the Fuels Directive, originally due to be completed by the end of 2005, was finally published by the Commission early last January and will now be considered by the Parliament and Council. In general the recommendations follow CONCAWE's views that current road fuel specifications are appropriate for all foreseeable automotive technologies and do not call for further drastic changes. The surprise, however, came in the form of a proposal for the gradual and mandatory reduction of the 'life-cycle GHG emissions' of road fuels. This seemingly straightforward goal raises a large number of complex questions in terms of definitions, monitoring and measuring methodologies, possible links with other GHG reduction schemes, as well as real scope and opportunities for reduction. All these are currently the subject of heated debates, in which CONCAWE is of course fully involved and to which it contributes sound facts and figures.

When it comes to reduction of emissions, refiners are in the delicate situation of being both the enabler of lower overall emissions through improvement of their products, and the emitter of additional CO_2 to achieve these changes. There is no better illustration of this dilemma than the current debate on marine fuel quality discussed in our lead article. Like all other environmental issues, the evaluation of the impact of shipping on air pollution must be based on sound facts, and the Mediterranean ship emission study described in our second article is a good example of what is required to develop sound and cost-effective legislation.

'Clean' and 'Water' account for the C and the W of CONCAWE, illustrating our long involvement with water-related issues and our experience in this area. While we fully support continuous improvement of water quality through the establishment of Environmental Quality Standards, our third article highlights serious industry concerns over current proposals under the Water Framework Directive, which could lead to unjustifiably high compliance costs and even to unachievable targets.

Although environmental protection remains important, health issues are gradually taking centre stage for legislators in Europe as well as in the rest of the world. One of the reasons for this interest is that modern medical and biological science has gradually improved our ability to measure health effects. Human biomonitoring is one of the techniques which is gaining recognition and our fourth article gives an introduction to this subject.

Last but not least, preparations are in full swing for implementation of the REACH legislation that enters into force this June. Our final article explores the uncertainty surrounding authorisation under the new legislation.

Once again this issue of the *Review* endeavours to shed light on some of the most topical issues in the development of new European environmental legislation. I wish you good reading.

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Switching world shipping to marine diesel?

A wholesale shift to distillate fuel would have a momentous impact on the refining sector and fuel markets worldwide

In 2006 CONCAWE published the results of a techno-economic study analysing the impact of the reduction of the sulphur content of residual marine fuels (RMF) in Europe (CONCAWE report 2/06). The study contended that, when faced with a low sulphur limit on residual marine fuels, the most economically attractive alternative for refiners would be to exit that market and either convert or export the surplus residual material.

A new debate was sparked off by a recent proposal from one of the shipping associations for a wholesale shift from RMF to distillate fuel for all ships worldwide. Such a shift would undoubtedly have a momentous impact on the refining sector and fuel markets worldwide. In order to better understand the possible consequences for European refineries, CONCAWE has now extended the 2006 study to include this option. This article describes the new study and discusses its main results.

Table 1 shows the model cases considered in the discussion, all relating to 2015. In cases 0 to 2 the production of marine fuel is kept constant and fixed, and only the quality changes from a mix of low and high sulphur RMF (reference case 0), first to 100% low sulphur RMF (case 1) then to 100% marine diesel (MD, case 2). In case 3 no RMF production is allowed, nor are surpluses of any other products, but meeting the MD demand is now optional. In all the above cases the model is free to invest in any new plant. Finally in case 4, MD production is fixed again but export of various key products (heavy fuel oil (HFO), gasoline, LPG) is allowed to provide an outlet for surplus productions while investment in major conversion plants is blocked.

Production and margin

The projected 2015 production of marine fuels and other residual fuels in EU-25 is shown in Figure 1, together with the required crude oil intake. The net refinery margin (i.e. including capital charge), which drives the model, is shown in Figure 2. The margins shown are based on a price scenario representative of 2004, i.e. about 40 $/bbl and a moderate price differential of 10 $ per tonne and per percent sulphur.

Producing low sulphur RMF (case 1) does not generate a sufficient return to support the required investment (negative net margin). This is in line with the 2006 study which concluded that this option would only be attractive with a large increase in the LS-HS RMF price differential. Within this price scenario, production of MD generates a small positive margin (case 2). This is, however, not the economic optimum as a higher margin can be generated by 'not producing' the MD, and instead converting the surplus residual material into products to meet the core demand (case 3), thereby requiring less crude oil.

Table 1 Model cases under discussion for a shift from RMF to marine diesel

Case	Description
0 EU Directive (reference)	Reference case assuming provisions of MARPOL Annex VI and EU Directive 2005/33/EC are in place
1 RMF 0.5%	All RMF production at 0.5% sulphur
2 Marine diesel 0.5%	All RMF substituted by marine diesel (MJ per MJ) at 0.5% sulphur
3 Optional marine diesel	No RMF production and optional production of marine diesel at 0.5% sulphur
4 Marine diesel 0.5% + exports	All RMF substituted by marine diesel (MJ per MJ) at 0.5% sulphur, no investment in conversion, exports of key products allowed

Switching world shipping to marine diesel?

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Figure 1 2015 production of HFO and marine fuels, and crude oil intake (EU-25+N+CH)

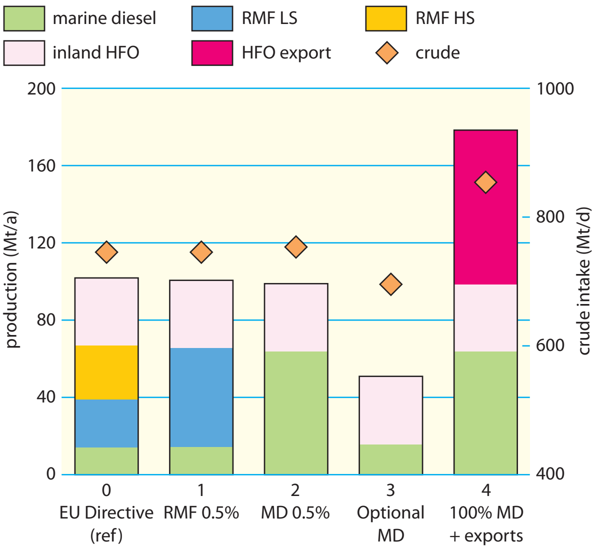

Figure 2 Cumulative net margin of European refineries (EU-25+N+CH)

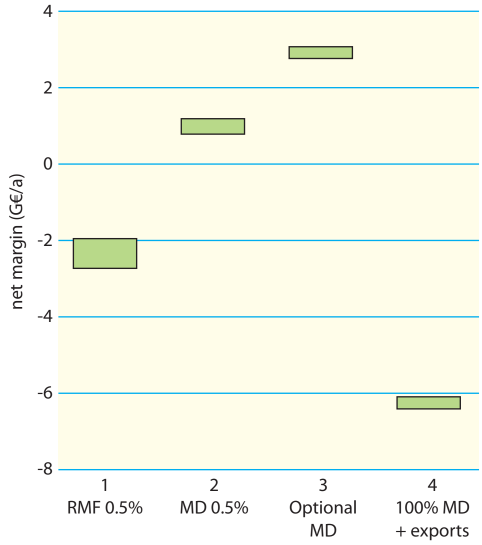

Figure 1
The scenario has a large impact on the production of marine fuels and other residual fuels as well as on crude intake.

Figure 2
The economics do not favour marine fuel production.

Case 4 produces a strongly negative margin as the lack of access to conversion capacity forces processing of 15% more crude oil (over 100 Mt/a) to produce the additional diesel in a very low conversion mode, while a large surplus of HFO (and smaller amounts of gasoline and LPG) needs to be exported.

It is worth noting that, although a different price scenario would lead to different margins, the ranking of the cases would essentially be unaffected.

Capital investment and new plant capacities

Figure 3 shows the capital investment required in the various cases. From the 2005 base case, around 13 G€ investment are needed to cover the evolution of the demand and fuel quality changes. Desulphurising RMF would entail another 7 to 12 G€[1], whereas converting residues to supply MD only would add as much as 30 G€. Although MD is not produced in case 3, significant investment is still required in order to convert the now unused residue into mainstream distillates. Note that case 4 also requires investment in crude distillation and thermal cracking, as well as various treating units.

It should be noted that these investment figures are based on typical numbers collected at the beginning of this decade. In recent months the high demand for new plants and the soaring cost of raw materials such as steel have lead to a substantial increase in the cost of new construction by factors of up to two compared to a few

Figure 3 Cumulative investment in European refineries (EU-25+N+CH)

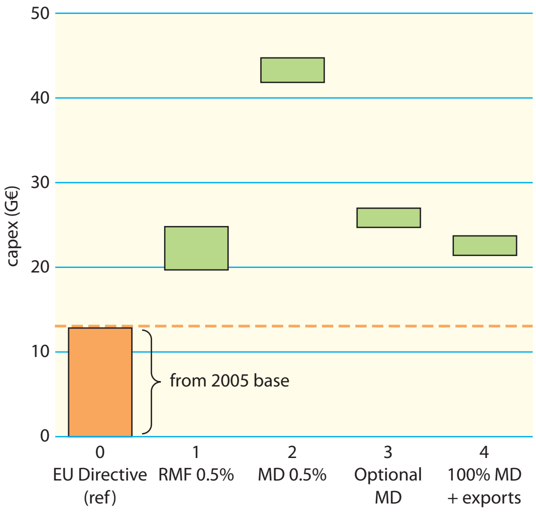

Figure 3
All cases will require significant additional investment beyond the 2005 base case.

[1] *The range of investment represents two extremes where there is either perfect foresight and no regret investment compared to the reference case or no foresight leading to maximum regret investment*

Switching world shipping to marine diesel?

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Table 2 Conversion intensity and gas oil/gasoline ratio

	Case 1 RMF 0.5%	Case 2 MD 0.5%	Case 3 Optional MD	Case 4 MD 0.5% + exports
Conversion intensity	83.5%	90.7%	90.0%	82.0%
Gas oil/gasoline ratio	2.6	3.1	2.6	2.7
Capex (no regret) *(G€)*	7.0	28.8	12.0	8.6

years ago. Whereas one cannot be sure how this will evolve, the general world economic outlook suggests that higher costs will be with us for the foreseeable future.

Table 2 illustrates the underlying reasons for these large differences in new process unit requirement and therefore investment. One of these reasons is the 'conversion intensity' defined here as the percentage of distillates produced relative to crude intake. The higher the conversion, the more plants required to achieve it. A second reason is that the gas oil/gasoline production ratio is strongly increased by the MD demand, which represents over 20% of the road diesel demand. In the European situation where there already is a serious imbalance between demands for gas oils and gasoline, any worsening of that ratio induces a need for major adaptation of the refineries.

An analysis of the extra capacities required for producing MD in case 2 reveals the full magnitude of the challenge (Table 3). Beyond the 35 Mt/a of hydrocracking capacity required to reach the reference case, another 100 Mt/a or so would be needed, as well as 64 Mt/a of residue conversion capacity (most of it being residue desulphurisation and mild conversion). We estimate that this would translate into between 50 and 70 new hydrocrackers and some 50 residue desulphurisation or conversion plants i.e. more or less one major conversion unit in each EU refinery. Even assuming financing was available, this is clearly not practically feasible in any foreseeable future scenario.

It may seem surprising that such a large amount of additional capacity be required to produce 'only' 50 Mt/a additional diesel. This has, however to be viewed in the prevailing context of an existing shortage of diesel. First, hydrocrackers do not produce 100% diesel or middle distillates. Second, they need feedstock which, in the model, is rerouted from the FCCs. FCC utilisation is reduced by 20% and the residue desulphurisation plants provide an alternative FCC feedstock. This is of course only one of many solutions and case 4 illustrates the fact that, with some flexibility in the demand, the requirement for new plants can be dramatically reduced (albeit at the expense of profitability and with higher use of crude oil resources).

Table 3 Requirement for new refinery plants

	0 EU Dir (ref)	1 RMF 0.5%	2 MD 0.5%	3 Optional MD	4 MD 0.5% + exports
(Figures in Mt/a)	Relative to 2005 Base	Relative to Reference			
Crude distillation	69.2	0.1	6.0	-41.7	106.2
Thermal cracking/coking	10.7	-6.6	-6.9	-6.4	39.6
Catalytic cracking	0.0	0.0	0.0	0.0	0.0
Hydrocracking	34.8	-27.8	98.7	45.6	11.2
Residual conversion	4.8	52.9	64.0	25.6	-4.8

Table 4 Refinery energy consumption and CO_2 emissions

	2005 base	0 EU Dir (ref)	1 RMF 0.5%	2 MD 0.5%	3 Optional MD	4 MD 0.5% + exports
Energy consumption *(toe/t crude)*	6.9%	6.8%	6.9%	7.5%	7.4%	7.0%
		Relative to 2005 Base	Relative to Reference			
CO_2 emissions *(Mt/a)*						
From site	138	18	5	33	13	33
Total	2046	121	3	21		

Energy and CO_2 emissions

All this extra activity in refineries would obviously have consequences on the energy consumption and CO_2 emissions, which are shown in Table 4.

In case 2, the specific energy consumption increases by 10% compared to the reference case. The increase in CO_2 emissions represents a higher percentage at 33 Mt/a because of the large process emissions related to hydrogen production, an increase of 20% at a time when refineries are under pressure to reduce total emissions! Even taking into account the lower emissions incurred when burning MD compared to RMF, the net effect is still an increase of CO_2 emissions by 21 Mt/a. This represents close to 15% of the refinery emissions in the reference case and more than 10% of the combustion emissions of the affected marine fuel.

It is worth noting that case 4 generates a similar increase in refinery CO_2 emissions because of the increased crude intake.

Conclusions and outlook

The above analysis demonstrates that a switch from RMF to MD would have momentous consequences for EU refining. Although Europe's circumstances are in many ways specific, this analysis can serve as a blueprint for the rest of the world. Many other regions do not have the same acute diesel shortage as Europe and may find it less onerous to increase gas oil production. However, finding such an additional amount of gas oil (the current worldwide RMF market is around 200 mt/a and inceasing) would still be a major challenge for world refining and would be likely to create a serious global shortage, with disruptive consequences on all middle distillate markets (diesel, heating oil, jet fuel). This would in turn limit the opportunities for imports to resolve the issue on a regional basis.

Meeting the new demand would involve major refinery adaptations, mostly increased residue conversion but also primary crude distillation capacity, which could not occur overnight. In all likelihood, this would generate additional crude processing. Based on the EU analysis (case 4) and scaling up to worldwide RMF demand figure, this could represent up to 400 Mt/a additional crude or 8 Mbbl/d (about 70% of the production of Saudi Arabia). The additional volumes of gasoline and HFO would have to find a home. In the case of the latter, the most likely scenario would be substitution of either gas or coal in power generation. The impact would therefore go beyond oil markets into energy markets in general.

This proposal has been put on the table on the basis of environmental benefits that are not clearly demonstrated. Even if these benefits were proven, there are other options to reduce the impact of shipping, such as on board flue gas desulphurisation, that should be considered on an equal footing. The proposal cannot practically be implemented in the near or medium term without creating major disruptions in the middle distillate markets and, more generally, the oil and energy markets. The real benefits of such a move should therefore be thoroughly considered in the light of potentially serious consequences.

Above: a commercial vessel being refuelled from the tanker moored alongside—an operation referred to as 'bunkering'.

New ship emissions inventory for the Mediterranean Sea

Recent study sheds new light on earlier work

In order to provide an up-to-date ship emission inventory for the Mediterranean Sea, a study (further referred to as the 'CONCAWE study') was recently completed for CONCAWE by the environmental and engineering consultancy Entec UK Ltd. Entec have been involved in a number of previous such studies and, in their own view, the CONCAWE study has resulted in a more robust inventory for the Mediterranean than was the case in their earlier work. A previous study carried out for DG Environment jointly by Entec, IIASA and the Norwegian Meteorological Institute and published in October 2006[1] (further referred to as the 'DG-ENV study') currently serves as a basis for input into the Integrated Assessment Modelling (using the IIASA GAINS model). This in turn, provides policy guidance for the revision of the National Emission Ceiling Directive (NECD). This article explores the key differences between the DG-ENV and CONCAWE studies.

Key features of the CONCAWE study

A key objective was to provide a more accurate, detailed and complete inventory than had hitherto been the case. The input data and methodology were specifically reviewed to achieve this. The key new elements were:

- Use of the 2005 vessel movements and characteristics data provided by Lloyds Marine Intelligence Unit (LMIU). This latest ship movement database includes some significant improvements over the 2000 LMIU database used by Entec in their previous studies, e.g. more accurate vessel arrival and departure times, and vessel-specific engine power data for main and auxiliary engines. In addition a full year of ship movements data was obtained from Lloyds rather than the 'four months' of data used in previous work.
- Manual addition of approximately 100,000 passenger vessel movements (mainly Greek port callings) using detailed company timetables. This was done to overcome the limitations of the LMIU database where multiple port calls within a single day are not recorded.
- Improved routing algorithms for individual point-to-point journeys based on the enhanced information in the latest LMIU database.
- Use of a much finer 'near shore' grid resolution (10x10 km) than the EMEP 50x50 gridding used in previous studies. A key reason for using finer resolution gridding near shore was to enable emissions within 'territorial waters' (12 nautical miles) to be determined accurately.
- Improved methodology for determining the time a ship spends in port based on the more detailed arrival/departure time data included in the latest LMIU database.
- Use of a more robust methodology for determining the relative percentages of gas oil and heavy fuel oil in the total fuel consumed, resulting in figures essentially in-line with studies carried out by the Beicip-Franlab consultancy for the EU Commission in 2002 and 2003[2]. In line with European legislation, the gas oil sulphur level was set at 0.2% for 2005 and 0.1% for 2010 and beyond.

Emission intensity map

To provide an overall perspective on the spatial distribution of emissions, the resulting emission intensity map (i.e. tonnes of SO_2 emissions/km^2) for the survey year of 2005 is shown in Figure 1. The high activity within coastal areas of the Mediterranean is readily

[1] *Interim report,* Analysis of Policy Measures to Reduce Ship Emissions in the Context of the Revision of the National Emission Ceilings Directive, *Janusz Cofala* et al., *October 2006.*

[2] *Advice on the costs to fuel producers and price premia likely to result from a reduction in the level of sulphur in marine fuels marketed in the EU (April 2002). Advice on marine fuels (October 2003). Contract EN.C1/SER/2001/0063*

seen in the finer near-shore grids. Also visible is the impact of the large number of 'transit' ships sailing between Suez and Gibraltar.

Current inventory and emission forecasts: comparison with the DG-ENV study

The results of both studies are shown in Table 1. Beyond establishing the inventory for the base year, both studies also included forecasts for 2010 and 2020. The CONCAWE study estimates SO_2 and NO_x emissions in 2005 at respectively 67% and 80% of the DG-ENV study numbers for 2000. The much decreased SO_2 emissions figure is due to the improved methodology used in the CONCAWE study for attributing gas oil or heavy fuel oil to individual ships, the overall effect of which is to increase the proportion of gas oil in the total ship fuel pool. This of course reduces the total SO_2 emissions for a given total fuel consumption. The SO_2 emissions are lower in 2010 than in 2005 because of the entry into force of the requirements for all EU ferries to comply with a maximum fuel sulphur content of 1.5% and for all ships in EU ports to utilise marine gas oil (0.1%S) while alongside. The reduction in SO_2 emissions resulting from these requirements more than offsets the growth in ship movements between 2005 and 2010.

It must also be noted that, as a result of the finer near-shore gridding, the CONCAWE study found that a higher fraction of the emissions occurs in the 12-mile territorial water zones than evidenced in previous inventories. The recent work attributes about 30% of emissions to the 12-mile zones, compared to an average of about 20% for all EU seas reported by IIASA in their October 2006 and March 2007 reports.

The growth rate assumptions of 2.5% per annum for cargo vessels and 3.9% for passenger vessels used in the DG-ENV study were also used in the CONCAWE study. The emissions implied by these growth rates in a 2010

Figure 1 Base case 2005 SO_2 inventory

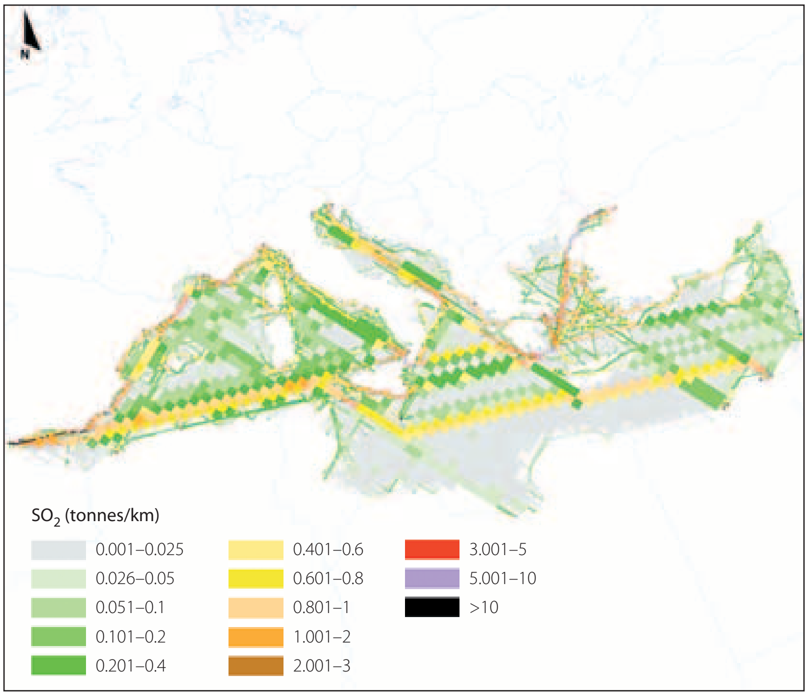

Figure 1
The map shows the level of SO_2 emissions per square kilometre for the base year of 2005. The high activity within coastal areas is readily seen in the finer near-shore grids, and the impact of the large number of 'transit' ships sailing between Suez and Gibraltar can also be observed.

Table 1 Emissions in the Mediterranean: 2006 DG-ENV study vs. CONCAWE Study

	SO_2			NO_x		
(Figures in kt/a)	**DG ENV**	**CONCAWE**	**Ratio**	**DG ENV**	**CONCAWE**	**Ratio**
Reference year	2000	2005	%	2000	2005	%
Mediterranean total 2000/05	1278	862	67%	1818	1448	80%
Mediterranean total 2010	1602[b]	840	52%	2383[a]	1461	61%
Mediterranean total 2020	2082[c]	1088	52%	3095[b]	1771	57%

[a] Addendum to CONCAWE—Ship Emission Inventory—Mediterranean Sea, February 2007, Entec Limited; Entitled: *Ship Emissions in the Mediterranean Sea—Approach to CONCAWE Ship Emissions Study, with Comparisons against Entec's Earlier Work for the European Commission.*
[b] Data used by IIASA for IAM RAINS modelling in the CAFE programme.
[c] Cost-optimised reductions of air pollutants emissions in EU Member States to meet the environmental targets of the Thematic Strategy on Air Pollution-NEC Scenario Analysis Report Nr 3 Part 1, Table 3.2. IIASA March 2007 (Derived from October 2006 Entec Study).

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and 2020 time horizon (current horizon years for the NECD and the Thematic Strategy on Air Pollution respectively) are also given in the table.

Over the past several years, Entec have been contracted by DG-ENV for a number of shipping-related studies. In their view, 'Port callings are likely to be the most appropriate overall proxy for the growth in movements (compared to the total number of movements that would include port callings plus vessels passing through the Mediterranean Sea without calling)'[3]. According to the CONCAWE study there were 249,819 port callings in 2005 within the Mediterranean Sea. The 2006 DG-ENV study indicated a number of 239,308 in 2000. Lloyds have confirmed that the underlying method of reporting and including port calls into the database has not changed between 2000 and 2005, which indicates that ship activity within the Mediterranean Sea has only grown by some 4% over this period, i.e. somewhat less than 1% annually. This is very different from the growth rate assumptions of 2.5% for cargo vessels and 3.9% for passenger vessels used in the DG-ENV study.

This very different perspective on growth has a profound influence on the 'emissions multiplier' used to generate 2010 and 2020 'uncontrolled' baseline emissions for use in IIASA Integrated Assessment Modelling (IAM). Over a ten-year period (2010 horizon) growth rates of 2.5% for cargo vessels and 3.9% for passenger vessels result in multipliers of 1.28 and 1.47 respectively. With a 1% growth rate, over the same period the multiplier would drop to 1.11. The emissions of SO_2 and NO_x in Table 1 reflect these multipliers together with the changes in legislative requirements over the period and the penetration rate of new vessels meeting the NO_x emission limits required by IMO.

Based on the new CONCAWE study, projected 2020 emissions for both SO_2 and NO_x would be almost halved compared to those currently used by IIASA in their IAM assessment work associated with the NECD review. Aside from the essential issue of cost-effectiveness, this large reduction has important implications for the potential contribution that Mediterranean ship emissions can make to delivering further improvements in human health or the environment at the 2020 horizon and therefore for related policies. CONCAWE believes it is essential that this more up-to-date and accurate data set for the Mediterranean Sea be taken into account in the NECD review work. Although the CONCAWE study was confined to the Mediterranean Sea, it would also be prudent to test the robustness of Entec's earlier work on other European Sea areas against the latest (2005) Lloyds database by suitably designed sensitivity scenarios.

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[3] *Addendum to CONCAWE—Ship Emission Inventory—Mediterranean Sea, February 2007, Entec Limited; Entitled:* Ship Emissions in the Mediterranean Sea—Approach to CONCAWE Ship Emissions Study, with Comparisons against Entec's Earlier Work for the European Commission.

Water Environmental Quality Standards

Requirements must fit the objectives

In July 2006, the EU Commission published a proposal for a Directive on Environmental Quality Standards (EQS) as required under article 16 of the Water Framework Directive (2000/60/EC) (WFD). Specifically, the Commission has now identified a list of 33 substances of concern (Table 1—from Annex 2 of the Directive), for which measures should be taken for '… the progressive reduction and, for priority hazardous substances, … the cessation or phasing out of discharges, emissions and losses.'

Table 1[1] Priority Substances (PS) and Priority Hazardous Substances (PHS)

Alachlor	Naphthalene
Anthracene	Nickel and its compounds
Atrazine	Nonylphenol
Benzene	*(4-(para)nonylphenol)*
Brominated diphenylether	Octylphenol
Cadmium and its compounds	*(Para-tert-octylphenol)*
Chloroalkanes, C10-13	Pentachlorobenzene
Chlorfenvinphos	Pentachlorophenol
Chlorpyrifos	Polyaromatic hydrocarbons
1,2-Dichloroethane	*(Benzo(a)pyrene)*
Dichloromethane	*(Benzo(b)fluoranthene)*
Di(2-ethylhexyl)phthalate (DEHP)	*(Benzo(g,h,i)perylene)*
Diuron	*(Benzo(k)fluoranthene)*
Endosulfan	*(Indeno(1,2,3-cd)pyrene)*
(Alpha-endosulfan)	Simazine
Fluoranthene	Tributyltin compounds
Hexachlorobenzene	*Tributyltin-cation*
Hexachlorobutadiene	Trichlorobenzenes
Hexachlorocyclohexane	*(1,2,4-trichlorobenzene)*
(Gamma-isomer, Lindane)	Trichloromethane
Isoproturon	*(Chloroform)*
Lead and its compounds	Trifluralin
Mercury and its compounds	

Where groups of substances have been selected, typical individual representatives are listed as indicative parameters.

Issues

There are several areas of concern for the refining industry and the first is the concept of cessation. According to the current proposal, mercury, cadmium and polycyclic aromatic hydrocarbons (PAHs) will have to be eliminated from refinery effluents—even though these substances occur naturally in receiving waters and in crude oil. Therefore, emitters will be required to continually reduce emissions until complete phase out over a 20-year period. At the endpoint, phase out and cessation is considered to be absolute zero and not a discharge level below a detection limit or a negligible load.

We believe the cessation concept, as defined above, is fundamentally flawed. Ever more sophisticated analytical techniques can detect chemical compounds at extremely low levels that the best available and most comprehensive treatment schemes cannot be expected to match. Even if a refinery could install a complete water recycling and reuse system, there would still be some release of concentrated materials which, while volumetrically lower than discharges from a conventional wastewater treatment system, would still not achieve an absolute zero emission. Furthermore, any reduction in effluent concentrations simultaneously increases the amount of waste produced and requires an increase in the amount of energy needed for additional treatment. In certain site-specific circumstances, this trade-off may in fact be more detrimental to the environment.

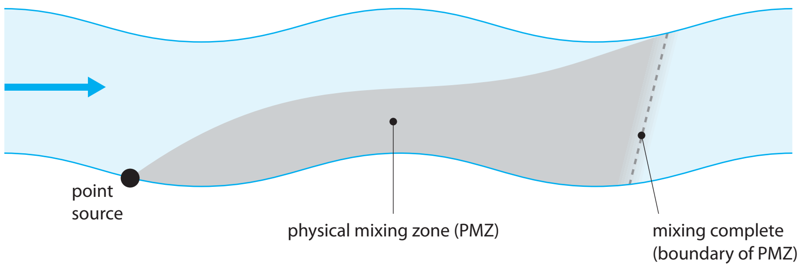
Some already appear to be taking a more pragmatic approach to this matter and recognise that it is impossible to prevent all emissions of naturally occurring substances, and to distinguish between their natural occurrence and man-made discharges where they overlap. Consequently, some Members of the European Parliament (MEPs) as well as several Member States have proposed amendments to this effect. They acknowledge

[1] *Proposal for a Directive of the European Parliament and of the Council on environmental quality standards in the field of water policy and amending Directive 2000/60/EC, Annex 2, pages 23–25, Brussels, 17.7.2006*

Water Environmental Quality Standards

Requirements must fit the objectives

Figure 1[2] Point discharge mixing zone



the fact that the complete phase out of naturally occurring substances, such as cadmium, mercury and polyaromatic hydrocarbons, is impossible. But it is important for all Member States to recognise this, so that the original WFD requirements are translated into feasible objectives, which are not disproportionately costly and which achieve real environmental benefits.

A second issue is the use of transitional areas of exceedance (TAEs), also known as mixing zones (i.e. the area where the effluent mixes with the receiving water). Emission Limit Values (ELVs) are set according to what the receiving water can naturally assimilate, so that, although discharges may have a higher substance concentration, final concentrations in the water body comply with the established EQS levels and the integrity of the water body as a whole is not impaired (Figure 1).

The Commission has proposed the use of TAEs, but there is significant pressure by some MEPs and several Member States to eliminate them. If they are eliminated, refineries will have to meet the EQS at the discharge point—which effectively makes the ELV permitted for the site equal to the EQS. This 'end of pipe' requirement would result in a significant increase in treatment costs, since dischargers would have to reduce their emissions by a factor of 10 to 100. Refineries may be required to install equipment that goes beyond current Best Available Techniques (BAT), as currently outlined in the Best Available Techniques Reference Documents (BATREFs) for the Integrated Pollution Prevention and Control Directive 96/61/EEC.

These reduced effluent emissions would provide little environmental benefit since discharges would be below the natural background concentration of the receiving water. This is potentially the case for metals and PAHs since both of these substances occur naturally. If achieving these discharge limits became cost prohibitive or not technically feasible, a refinery may be able to obtain a derogation at Member State level. This would, however, be issued on a case-by-case basis so that the onus would be on refiners to conduct both technical and economic research in order to generate the information necessary to make their case. Furthermore, different criteria for acceptance of derogations between Member States could result in an un-level playing field for industry throughout Europe.

To illustrate this point, CONCAWE reviewed the European Commission's EQS numerical values versus the World Health Organization's Guidelines for Drinking Water Quality. In all cases, the proposed EQS values are set equal to or well below concentration levels that are considered safe for human consumption (Table 2).

For cadmium, benzo(a)pyrene (a polycyclic aromatic hydrocarbon) and mercury the EQS is respectively 12, 14 and 120 times lower than the WHO recommended value. This means that, if TAEs are not permitted, a refinery would be required to discharge water with substance concentrations 10 to 100 times better than drinking water quality. This would require sophisticated treatment schemes, such as granulated activated carbon, ion exchange or membrane filtration systems to polish the effluent water prior to discharge. The World Health Organization indicates that for mercury, 'It should be possible to achieve a concentration below 1 µg/litre …'[3] but this is still 20 times higher than the proposed EQS. So even with the most advanced treatment systems, facilities may not be able to meet EQS values at the discharge point, nor should they, since there would be little environmental benefit from such stringent discharge standards. This also illustrates the technical infeasibility of the cessation concept.

[2] After *Colorado Department of Public Health and Environment, Water Quality Control Division, Colorado,* Mixing Zone Implementation Guidance, *page 6, April 2002.*

[3] *WHO* Guidelines for Drinking-water Quality, *First Addendum to Third Edition, Volume 1, Recommendations, Annex 4. Chemical Summary Tables, page 402, 2006.*

CONCAWE activities

In response to the proposed legislation, CONCAWE has undertaken a series of actions to help its members assess the full impact of this Directive.

A refinery effluent survey launched in October 2006 was an important first step. Though this questionnaire was primarily developed to gather information for the CONCAWE risk assessment programme in connection with the REACH regulation, it will also allow us to understand the current gap between refinery ELVs and the proposed EQSs. This information can then be used to inform CONCAWE members and assist them in preparing for future issues (e.g. by making necessary changes to their site analytical capabilities, developing monitoring regimes, and/or developing risk management plans in order to help them meet the EQS requirements).

A project is also being considered to review the economics associated with additional wastewater treatment options. The need for this information stems from the EU Commission's impact assessment which states that 'Approximately 40% of the costs identified are associated with the refineries sector.'[6] The Commission estimates it will cost the refining industry between 1–14 billion Euros (scenario dependent) over the next 20 years to meet EQS requirements[7]. The wide range of costs is directly related to the choice of discount factor and implementation timeline, but the message is clear: European refineries will have to install additional equipment or take operational measures to reduce their emissions of PS and PHS.

This economic assessment project is still being defined, but CONCAWE intends to review facilities with various treatment schemes and determine both the capital and operational costs associated with more advanced treatment or management options. The cost range in the Commission's assessment indicates a worst case scenario, but it will be prudent to verify their results to have a better understanding of the real financial impact on refinery operations.

Table 2 Comparison of EU EQS values versus WHO drinking water guidelines

Substance	WHO (drinking water guidelines, µg/l)[4]	EQS (EU Directive for inland surface waters, µg/l)[5]	Factor of difference
Alachlor	20	0.3	67
Atrazine	2	0.6	3.3
Benzene	10	10	equal
Benzo[a]pyrene	0.7	0.05	14
Cadmium	3	0.25	12
Chloroform (Trichloromethane)	300	2.5	120
Chlorpyrifos	30	0.03	1000
1,2-Dichloroethane	30	10	3.0
Dichloromethane	20	20	equal
Hexachlorobutadiene	0.6	0.1	6.0
Isoproturon	9	0.3	30.0
Lead	10	7.2	1.4
Mercury	6	0.05	120
Nickel	70	20	3.5
Pentachlorophenol	9	0.4	22.5
Simazine	2	1	2.0
Trifluralin	20	0.03	667

Note: the WHO guidelines are published in milligrams per litre (mg/l). These values were converted to micrograms per litre (µg/l) to ensure proper comparison with the EQS values (annual average), which are listed as µg/l in the EU proposal. Also, for cadmium, a range from < 0.08–0.25 µg/l depending on water hardness is listed in the EQS tables and 0.25 µg/l is used above since it calculates the lowest factor of difference between WHO and EQS values.

CONCAWE has also begun participating in an EU Commission Working Group that will manage which PS and which PHS will be placed on the future EQS list. Currently CONCAWE is involved at management level, but has offered to participate on the technical level as well. The technical working group will be jointly managed by the Commission and the European Chemical Bureau and they have planned their first meeting in May 2007. A group of experts will recommend the specific criteria for additional substances to go on the EQS list that the Commission must deliver by 2009.

What the future PS/PHS list will consist of is not well understood at this stage. The major issue CONCAWE

[4] *Ibid [3], pages 491–493*

[5] *Proposal for a Directive of the European Parliament and of the Council on environmental quality standards in the field of water policy and amending Directive 2000/60/EC, Annex 1, Column 4, pages 18–21. Brussels, 17.7.2006.*

[6] *Commission Staff Working Document, Impact Assessment; Proposal for a Directive of the European Parliament and of the Council on environmental quality standards in the field of water policy and amending Directive 2000/60/EC, Brussels, 17.7.2006, page 25.*

[7] *Ibid, page 26.*

Water Environmental Quality Standards

Requirements must fit the objectives

Refinery effluents may contain a complex mixture of organic and inorganic compounds.

envisages is the practicality of adding 30 to 40 more substances, as indicated by the Commission Working Group, to the existing list of 33. Today, it is very difficult to sample and analyse for individual substances at the sub-microgram per litre level in refinery effluents, because many current laboratory techniques do not provide the necessary level of detection. Adding substances to the list will only compound the problem. To close this gap, CONCAWE is considering a comprehensive study of laboratory testing and analysis of refinery effluents. The information gathered will help determine the shortfall in current procedures compared to what may be required under the EQS Directive and help CONCAWE member companies understand the issues associated with testing substances that traditionally may not be on an effluent permit, especially at very low concentrations.

Additionally, CONCAWE has studied the biological effects of refinery effluents and has done significant analysis of Whole Effluent Assessment (WEA) techniques. This research has provided great insight into the toxicity and biodegradation of refinery effluents. WEA is more cost-effective and looks at the actual environmental impact of an effluent, regardless of its constituents. CONCAWE contends that it is a preferred alternative to adding more individual substances to the EQS list. The EQS substance-by-substance approach will be costly, unmanageable and never really indicate what the potential environmental effects of these substances may be.

The way forward

It is vitally important that the outcome of the proposed Directive allows industry to take proportionate measures to reduce pollutants in effluent water where it is environmentally beneficial. While EQSs are intended to provide an indication of the environmental status of a water body, they may now become ELVs, which will require a great deal of investment in an attempt to meet more stringent discharge requirements. It is not pragmatic to reduce substances to levels well below drinking water guidelines, as this becomes very expensive and provides questionable environmental benefits.

Additionally, if it is not possible or pragmatic to reduce emissions below drinking water standards, then the concept of absolute cessation becomes futile. While the Water Framework Directive clearly establishes this concept, it does not define it and it would be prudent for any future legislation to clearly define that cessation is not absolute. Otherwise, emitters will be subject to a provision that is not achievable and the law will then fail to meet its intended objectives.

To this end, national and European-wide trade associations need to ensure that these messages are sent to decision makers, so that they develop any forthcoming legislation in a sensible manner. Refiners should also be aware that if the legislation passes in its current form, meeting more stringent emissions targets will be difficult if facilities have not done the proper analysis beforehand. Therefore, CONCAWE suggests that its member companies begin risk planning now rather than wait until the Directive is finalised (projected for 2008). While CONCAWE is doing its part by researching general topics that will help all member companies, individual facilities will have to understand site-specific gaps between current discharge levels and future emissions limits, so that they are not subject to undue higher costs and additional regulatory pressures at the last minute. The Water Framework Directive mandates that EQSs must be established for compounds selected by the Commission. Although full details are not finalised, it is better to be prepared for a possible step change in emissions targets by planning today.

Human biomonitoring

A sophisticated technique which requires an equally sophisticated interpretation framework

It has long been known that certain chemicals are toxic to humans. Obviously they can only exert this toxic effect insofar as they are absorbed in the body. Scientific advances have made it possible to detect minute quantities of man-made chemicals in complex media such as human blood, urine and hair. This type of analysis is often referred to as human biomonitoring.

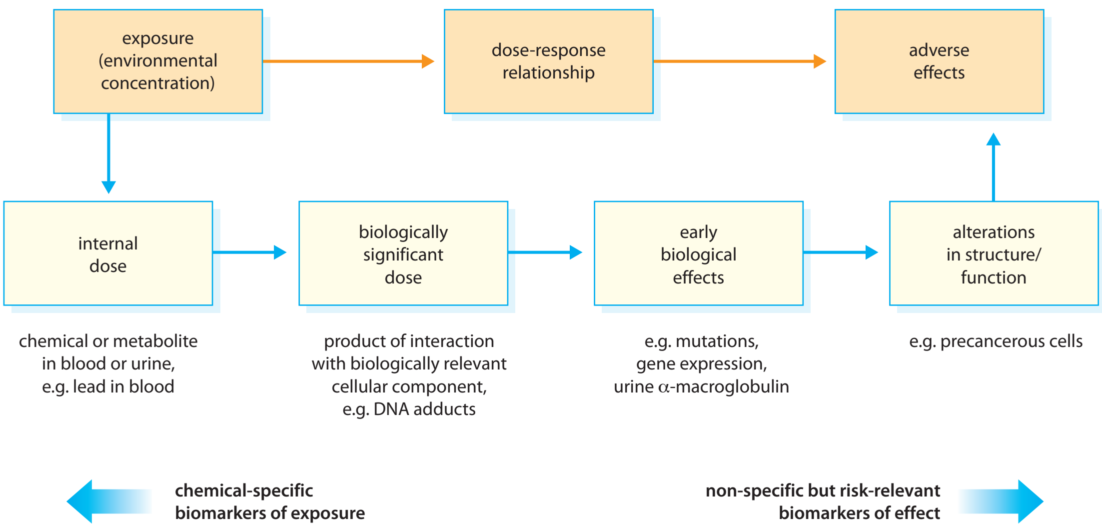
'Chemicals' can be released into the environment from many sources, both man-made and natural. Uptake of 'chemicals' in the body can occur via inhalation, through food and drinking water or through direct contact with the skin and indeed, exposure to some chemical compounds can occur through more than one of these routes. One of the attractions of biomonitoring lies in its ability to account for the combination of the different exposure routes through a single measurement.

A chemical which has entered the body is eliminated at a certain rate. Long-term exposure leads to an equilibrium level between uptake and elimination. Often chemicals are transformed via enzymatic processes into 'metabolites' which are then excreted. An example of this is cotinine which can be measured in urine and is derived from nicotine in inhaled cigarette smoke or from the use of nicotine patches on the skin.

The advances in the analytical field have not yet been followed by full scientific insights about possible health risks associated with the detected levels of chemicals. For a chemical substance to present a risk to health it needs somehow to interfere with the body's systems and it needs to be present in sufficient quantity to overcome the body's defence (i.e. de-toxification) capability.

Figure 1 describes the chain of events necessary for a chemical to have an effect. Upon exposure to a chemical, uptake occurs, followed by other internal transformation processes. The resulting concentration of the chemical or a close metabolite, e.g. in blood, urine or exhaled air, is known as a biomarker of exposure. Other events further down the chain are called biomarkers of effect. The latter may often result from exposure to more than one chemical compound. Biomarkers of

Figure 1 Biomarkers in the assessment of risks from toxic environmental chemicals
(courtesy of S. Kyrtopoulos, National Hellenic Research Foundation)



Human biomonitoring

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exposure are of course indicative of chemical exposure but not necessarily of a possible health effect. Biomarkers of effect indeed indicate that a biological effect process is taking place, but they are often not specific to a single chemical.

In recent years a number of human biomonitoring campaigns have been reported in rather emotional terms by the press. In most cases these reports referred to biomarkers of exposure. While there is a widespread public perception that it would be preferable for no man-made chemicals to enter our bodies, their mere presence may not be construed as a health risk and should be viewed in perspective.

As is the case in all areas of sound science, application of novel scientific concepts for societal risk management needs to be preceded by validation studies. Several organisations have recently published guidance for the interpretation of results of human biomonitoring campaigns (ECETOC, CEFIC, US National Academy of Sciences). Human biomonitoring should be considered as one of the tools to manage human health risk, not as a goal in itself. If the theoretical basis is insufficient for a risk-based interpretation of the results, the only possible use of biomonitoring data is for descriptive purposes, for instance to establish:

- Who is most/least exposed?
- How does an individual's exposure compare with the entire population?
- Is this a new or a long-standing exposure?

Descriptive data can be used to track trends, for example in response to a policy measure. Currently, under the EU's Environment and Health Action Plan 2004–10, a working group is developing proposals for pilot projects in several EU Member States. The principal purpose is to improve standardisation of survey protocols and associated communication programmes. The experience with and attitude towards human biomonitoring is quite diverse in different EU Member States. Whereas in some countries (e.g. Germany) large population surveys have already been conducted, in others there is no experience and consequently no infrastructure of laboratories and scientific expertise to support this type of programme. CONCAWE's toxicologists provide support to the European working group, building on experience gained with biomonitoring applications to identify and control exposures to hazardous substances in the industrial work environment, such as benzene and polycyclic aromatic hydrocarbons for which analytical methods to measure their metabolites in urine have been established and validated.

Remarkable advances in chemical analytical techniques now make human biomonitoring possible. It is essential that the data thus generated are supported by an equally sophisticated interpretation framework. This must include thorough validation studies to ensure that human biomonitoring leads to sound and efficient environmental policy making. It is a promising development but, like all tools, it needs to be used expertly and sensibly if it is to help improve management of environmental health risks.

The authorisation of substances under REACH

What is the process?

The main elements of the REACH regulation (EU Official Journal L396, Vol 49, 30.12.2006) which enters into force on 1 June 2007, are the registration, evaluation, restriction and authorisation of chemical substances. With the exception of crude oil, which is regarded as a naturally occurring substance, all other petroleum substances will be subject to registration. After a volume band dependent deadline (30 November 2010 for practically all petroleum substances), a registration will be required to manufacture a substance in the EU or to import it from outside the EU, hence the slogan 'No data, no market!'

Whereas the registration of substances and their safe use is the sole responsibility of industry, evaluation, restrictions and authorisations are tasks for the new European Chemicals Agency (ECHA), the Member States and/or the Commission. This includes identifying exactly which substances are to be subject to an authorisation procedure. The decision whether certain uses of a substance identified for an authorisation procedure will be granted authorisation is the sole responsibility of the Commission.

The most immediate priority for CONCAWE and its member companies is the assessment of petroleum substances and the demonstration of their safe use throughout the supply chain so that they can be pre-registered by 1 December 2008 and subsequently registered by the volume-specific deadlines. However, it is also important to understand whether petroleum substances will, or could be, subject to authorisation and if so, what the process would be.

Which substances are affected?

Article 57 of REACH defines which substances could be subject to an authorisation procedure:

1. Substances meeting the criteria for classification as carcinogenic, mutagenic or toxic for reproduction (CMRs) category 1 or 2 in accordance with Directive 67/548/EEC.
2. Substances which are persistent, bioaccumulative and toxic (PBTs) or substances which are very persistent and very bioaccumulative (vPvBs) in accordance with the criteria set out in REACH itself.
3. Substances, such as those having endocrine disrupting properties or those having persistent, bioaccumulative and toxic properties or very persistent and very bioaccumulative properties, which do not fulfil the criteria under 1 and 2, and for which there is scientific evidence of probable serious effects to humans or the environment which give rise to an equivalent level of concern to those of other substances described above and which are identified on a case-by-case basis in accordance with the procedure set out in REACH.

These substances are also referred to as substances of very high concern (SVHCs).

Whereas the criteria for SVHCs in the first two groups, i.e. CMRs, PBTs and vPvBs will, in principle, be well-defined and sufficiently transparent, and the consequences therefore predictable, the criteria for substances in the third group, often referred to as 'substances of an equivalent level of concern', are more obscure and will leave room for interpretation by the authorities. This has already become apparent in the Technical Guidance Document that is currently in preparation.

Known CMRs category 1 or 2 already have mandatory 'Community harmonised' classifications under existing law, and restrictions for their marketing and use are already in place. This includes a number of petroleum substances, for example gasoline.

However, there are exemptions from the need for authorisation. For the petroleum industry the most important exemptions are in Article 56(4):

- use as motor fuels covered by Directive 98/70/EC of the European Parliament and of the Council; and

The authorisation of substances under REACH

What is the process?

- use of mineral oil products as fuel in mobile or fixed combustion plants and in closed systems.

The term 'combustion plant' is defined in Directive 2001/80/EC, article 2(7) as 'any technical apparatus in which fuels are oxidised in order to use the heat thus generated' and includes home heating appliances.

Petroleum substances that are known CMRs category 1 or 2 will not become subject to an authorisation procedure as long as they are exclusively used as fuel.

Whether petroleum substances are PBTs or vPvBs in the definition of REACH will be established in the mandatory PBT assessment, which is part of the registration dossier that registrants will have to submit. This is currently work in progress and it is too early to say whether the application of the REACH criteria will lead to the identification of PBTs or vPvBs among the petroleum substances.

The identification of substances of equivalent concern is not an obligation for industry. This will be done by the authorities. In view of the wide margin for interpretation of the criteria, the outcome of the evaluation by the authorities is totally unpredictable.

Petroleum substances identified as PBTs, vPvBs or substances of an equivalent level of concern will not be affected by authorisation if used exclusively as fuel, as the exemption discussed above would still apply.

What triggers an authorisation dossier?

The decision making process, which triggers an authorisation dossier, can be summarised as follows:

- The registrant, a member state (MS) or the ECHA identifies or suspects that a substance is a CMR 1/2, PBT vPvB or of equivalent concern.
- An MS selects such substance and prepares an Annex XV dossier.
- The MS submits the Annex XV dossier to the Agency.
- The ECHA informs stakeholders, including registrants, that an Annex XV dossier has been submitted. It should be noted that the registrants have no access to the Annex XV dossier.
- If they wish to do so, the stakeholders formally submit comments to the Agency.
- The ECHA includes the substance in the candidate list, which will be published.
- The ECHA recommends priority substances (priority criteria are: PBTs, vPvBs, wide dispersive use, high volume), selects substances for its work programme and informs the stakeholders. The capacity of the ECHA to handle authorisations will be taken into account.
- If they wish to do so, the stakeholders formally submit comments to the Agency.
- The ECHA finalises its recommendations.
- The Commission amends Annex XIV (the list of substances which will then need to undergo an authorisation procedure) and sets a sunset date, i.e. the date after which a substance may no longer be manufactured/imported and put on the market without an authorisation.
- The registrant(s) submit(s) an application for authorisation at least 18 months before the sunset date.

What is the process by which an authorisation is granted?

Substances for which exposures are below their 'Derived No Effect Level' (DNEL) and their 'Predicted No Effect Concentration' (PNEC) are deemed to be adequately controlled. For these cases an authorisation will be granted.

To obtain an authorisation for substances where it is not possible to establish a DNEL, as well as those identified as PBTs and vPvBs (i.e. substances for which adequate control cannot be shown) it will have to be demonstrated that their socioeconomic benefits outweigh the risk.

All authorisations will be time limited. Before an authorisation expires the manufacturer/importer may apply for an extension. However, already in the first authorisation round the applicant is obliged to submit a substitution plan as part of his application for an authorisation.

Abbreviations and terms used in this CONCAWE *Review*

BATREF	Best Available Techniques Reference Documents
CAFE	Clean Air For Europe
CEFIC	European Chemical Industry Council
CMR	Carcinogenic, Mutagenic or toxic for Reproduction
DNEL	Derived No Effect Level
ECETOC	European Centre for Ecotoxicology and Toxicology of Chemicals
ECHA	European Chemicals Agency
ELV	Emission Limit Value
EMEP	UN-ECE's cooperative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe
EQS	Environmental Quality Standard
FCC	Fluid Catalytic Cracking
GAINS	Greenhouse Gas and Air Pollution Interactions and Synergies
HFO	Heavy Fuel Oil
HS	High Sulphur
IAM	Integrated Assessment Modelling (Model)
IIASA	International Institute for Applied Systems Analysis
IMO	International Maritime Organization
LMIU	Lloyds Marine Intelligence Unit
LPG	Liquefied Petroleum Gas
LS	Low Sulphur
MARPOL	1973 International Convention for the Prevention of Pollution from Ships
MD	Marine Diesel
MEP	Member of the European Parliament
NECD	National Emission Ceilings Directive
PBT	Persistent, Bioaccumulative and Toxic
PHS	Priority Hazardous Substance
PNEC	Predicted No Effect Concentration
PS	Priority Substance
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, Authorisation and Restriction of Chemicals—Regulation (EC) 1997/2006
RMF	Residual Marine Fuel
SVHC	Substances of Very High Concern
TAE	Transitional Area of Exceedance
vPvB	very Persistent and very Bioaccumulative
WEA	Whole Effluent Assessment
WFD	Water Framework Directive
WHO	World Health Organization

CONCAWE contacts

Secretary General

Alain Heilbrunn
Tel: +32-2 566 91 66 Mobile: +32-475 90 40 31
E-mail: alain.heilbrunn@concawe.org

Technical coordinators

Air quality
Lourens Post
Tel: +32-2 566 91 71 Mobile: +32-494 52 04 49
E-mail: lourens.post@concawe.org

Fuels quality and emissions
Ken Rose
Tel: +32-2 566 91 69 Mobile: +32-499 97 53 25
E-mail: ken.rose@concawe.org

Health
Jan Urbanus
Tel: +32-2 566 91 63 Mobile: +32-485 75 72 31
E-mail: jan.urbanus@concawe.org

Petroleum products • Risk assessment
Bo Dmytrasz
Tel: +32-2 566 91 65 Mobile: +32-485 54 41 12
E-mail: bo.dmytrasz@concawe.org

REACH implementation
Lothar Kistenbruegger
Tel: +32-2 566 91 85 Mobile: +32-495 57 17 50
E-mail: lothar.kistenbruegger@concawe.org

Safety • Oil pipelines • Refinery technology
Jean-François Larivé
Tel: +32-2 566 91 67 Mobile: +32-485 75 73 73
E-mail: jeanfrancois.larive@concawe.org

Water, waste and soil
George Stalter
Tel: +32-2 566 91 83 Mobile: +32-495 26 14 34
E-mail: george.stalter@concawe.org

Office management and support

Office manager
Sophie Bornstein
Tel: +32-2 566 91 18
E-mail: sophie.bornstein@concawe.org

Documentation/library
Office administration
Annemie Hermans
Tel: +32-2 566 91 80
E-mail: annemie.hermans@concawe.org

Virginie Baumard
Tel: +32-2 566 91 78
E-mail: virginie.baumard@concawe.org

Marleen Eggerickx
Tel: +32-2 566 91 76
E-mail: marleen.eggerickx@concawe.org

Sandrine Faucq
Tel: +32-2 566 91 75
E-mail: sandrine.faucq@concawe.org

Anja Mannaerts
Tel: +32-2 566 91 73
E-mail: anja.mannaerts@concawe.org

Barbara Salter
Tel: +32-2 566 91 74
E-mail: barbara.salter@concawe.org

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CONCAWE

Boulevard du Souverain 165, B–1160 Brussels, Belgium

Telephone: +32-2 566 91 60 • Telefax: +32-2 566 91 81

info@concawe.org • www.concawe.org

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