Impact of marine fuels quality legislation on EU refineries at the 2020 horizon

Momentous changes are afoot in the marine fuels world

Background

Over the years the oil refining system in the EU has developed and adapted to meet the evolving demand, in both qualitative and quantitative terms, while coping with an ever-changing supply of crude oils. The combination of changes in demand and crude supply requires constant adaptation of the refining tool, taking all factors into account, including the availability of dependable import and export opportunities to 'balance the books' under acceptable economic terms. Supported by a sophisticated linear programming model representing the entire European refining industry, CONCAWE regularly endeavours to quantify the changes that might be required in terms of new/modified process units, resulting refining costs, energy consumption and CO_2 emissions.

In recent years there has been increased focus on the quality of marine fuels, culminating in the adoption by the International Maritime Organization (IMO), in October 2008, of a timetable for the progressive but drastic reduction of sulphur oxides emissions from ships. This article presents the main findings of a recent CONCAWE report (3/09) which considers the potential impact of these measures on the EU refining industry.

Momentous changes to the world's marine fuels quality

Emissions from international shipping are regulated by the IMO, established in 1948 under a United Nations Convention. Air emissions measures are covered in Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). This Annex entered into force in May 2005, and more specifically its Regulation 14, which aims to limit SO_x emissions by limiting the sulphur content of any fuel oil used on board ships to 4.5% m/m. The regulation also allows the creation of so-called Sulphur Oxide Emission Control Areas (SECAs), where SO_x emissions have to be consistent with a maximum fuel sulphur content of 1.5%, by using either such a fuel or emission abatement equipment to reduce flue gas SO_x concentration.

The Baltic Sea became the world's first SECA in May 2006, followed by the North Sea and the English Channel in November 2007. No further SECAs have been established since, but very recently the USA and Canada submitted an application for Emission Control Areas on their East and West Coasts.

Following intense debates at the IMO, a revision to Annex VI was adopted in October 2008 and will enter into force on 1 July 2010. This will trigger momentous changes to marine fuels specifications in the next decade and beyond. Firstly, the sulphur level in SECAs will be reduced to 1.0% as of July 2010 and to 0.1% as of January 2015. Secondly the global sulphur cap will be reduced to 3.5% as of January 2012 and to 0.5% as of January 2020, subject to a 2018 review of fuel availability, on the basis of which the deadline could be postponed to January 2025. In all cases, approved emission abatement equipment may be used to achieve equivalent emissions.

In addition to the IMO regulations, the European Union has established its own requirements in a revision of the Sulphur in Liquids Fuels Directive (2005/33/EC) which imposes the use of 1.5% sulphur fuel by all ferries calling at European ports when sailing in territorial seas, exclusive economic zones and pollution control zones as of August 2006. From January 2010 marine fuels for inland waterway vessels and for all ships at berth may not contain more than 0.1% sulphur. In line with the IMO convention, emission abatement technology may be used by ships to achieve equivalent emissions, subject to authorisation. A revision of this Directive by the EU Commission, originally due in 2008, has been postponed pending the completion of the IMO deliberations.

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Consequences for EU refineries

These effective and potential changes to the quality of marine fuels have to be seen in the context of numerous other changes affecting refineries in Europe both in terms of quality and of supply/demand. The analysis of the compounded impacts of these various constraints was developed in CONCAWE report 8/08.

Using the framework established in that work in terms of supply/demand forecast and product quality changes, CONCAWE has recently completed a separate report (3/09) focusing specifically on the impact of marine fuels quality changes on EU refineries at the 2020 horizon. The analysis assumes that all SO_x emission reductions will be achieved through fuel desulphurisation (rather than on-board abatement equipment) and that EU refineries continue to satisfy the total EU demand for all products in terms of quantity and quality without changes in the current level of import/export.

Although this is not included in the measures adopted by IMO, there have also been calls for a wholesale migration of marine fuels from residual to (low sulphur) distillate fuels, and this case has been included in the analysis.

A number of cases were considered, all based on a common reference 2020 scenario and in order of increasing severity (see Table 1). The starting point assumes no changes to the historical 4.5% sulphur cap.

The increasing level of desulphurisation requires significant changes in the refinery toolkit. The total capacity required in Europe for the most relevant process units is shown in Figure 1.

Up to the current situation (3.5% global cap) and 1.5% in SECAs, the existing configuration can essentially cope, i.e. the new limits can be met by extra segregation of existing low sulphur material[1] (the investments of nearly 50 G$ shown in Figure 2 for this case are required to meet other changes occurring between today and 2020). Beyond this, a large increase in residue desulphurisation capacity is required, partly compensated for by a small decrease in distillate hydrocracking utilisation (because residue desulphurisation provides a measure of conversion). The hydrogen requirement also increases. It should be noted that these cases rely heavily on deep desulphurisation of residual streams and produce fuels of a very different composition compared to traditional ones. Whether this will turn out to be feasible in terms of the quality of the final fuels remains to be confirmed, and it could well be that the distillate route is a more realistic option.

In the distillate fuel (DMB) case both distillate hydrocracking and residue desulphurisation increase further with a large increase in hydrogen demand, mostly on account of the already very tight middle distillate supply situation in Europe.

The increased capacity requirements translate into new plants and corresponding investments, as well as additional energy consumption and CO_2 emissions, the latter caused in no small part by the increased hydrogen consumption. This is illustrated in Figure 2.

Table 1 Analysis of potential changes to marine fuels quality

Residual fuel cases	
Cap 4.5%	Reference case. Global sulphur cap at 4.5%, no SECAs. *Representative of pre-2006 legislation.*
Cap 3.5% S+F 1.5%	Global sulphur cap at 3.5%. SECAs sulphur limit at 1.5% (North and Baltic seas, as per MARPOL Annex VI), same limit applicable to 'passenger ships on regular service to or from an EU port' (i.e. 'Ferries', as per Directive 2005/33/EC). *Representative of current situation, based on typical sulphur levels of residual fuels.*
Cap 0.5% SECA 0.1%	Global sulphur cap at 0.5%. SECAs sulphur limit at 0.1% (North and Baltic seas, as per MARPOL Annex VI). No specific limit for Ferries. *Representative of situation in 2020 under IMO proposal.*
Cap 0.5% S+F 0.1%	As previous with Ferries subject to SECA sulphur limit. *Not formally proposed.*
Distillate fuel (DMB) case	
100% DMB 0.1/0.5%	Substitution of 100% of each residual marine fuel grade by distillate (DMB grade) at 0.5% sulphur (0.1% in SECAs and for Ferries).[a]

[a] This was simulated as a single distillate grade with specifications as per DMB and 0.3% sulphur content

[1] *Note that our model tends to over-optimise by assuming perfect liquidity in each broad region, so that this outcome may be somewhat over-optimistic.*

The EU refining sector is already facing potential investments of nearly 50 G$ to meet other demand and quality changes in the same time period. The new sulphur limits imposed by the IMO will increase this by at least another 10 G$. Actual investments may well be significantly higher should the distillate route be preferred over residue desulphurisation. A complete switch to distillate fuel would be much more onerous, up to some 65 G$ additional investment. Refinery CO_2 emissions follow a similar pattern with an increase of about 15 Mt/a (approximately 10%) to meet IMO specifications, reaching over 40 Mt/a in the case of a switch to distillate fuel.

The necessary investments would require a massive effort from the industry, especially when seen in the context of other calls for new installations in order to meet quality specifications of other products, adapt to changes in supply/demand and comply with other regulatory constraints such as implementation of the IPPC and Large Combustion Plant Directive. Beyond the all-important financial and economic aspects, the ability of the industry to mobilise sufficient material and human resources for such massive investment must be considered.

Faced with the need to desulphurise residual streams, refiners could choose instead to stop production of residual marine fuels and convert the residues into higher value products, primarily diesel and motor gasoline. The investments required for conversion of residual streams are indeed higher than for desulphurisation but the reward in terms of product value is also much higher. Indeed for the 2007 price set that we have used the model confirmed that the conversion alternative is economically attractive. We were also able to confirm previous findings (see CONCAWE report 2/06) according to which economics would favour conversion unless the price of low sulphur residual fuels approached that of gas oils. This suggests that the real-life impact of imposing very low sulphur marine fuels may be higher than what could be anticipated purely on the basis of the desulphurisation needs. It also highlights the fact that there is likely to be a cost trade-off for ship operators between using low sulphur fuel and installing on-board flue gas scrubbing facilities.

CONCAWE report 3/09 also considers the contribution of marine fuels to the total energy consumption and CO_2 emissions of refineries, showing it to be a strong function of their required quality and of the relative demand for the different grades. For Europe, decreasing marine fuel demand can either decrease or increase energy consumption and CO_2 emissions, depending whether the required grades are high sulphur residual fuels or low sulphur distillate fuel. These findings are further discussed in the previous article, which considers the more general issue of evaluating the carbon footprint of fossil fuels.

Figures 1 and 2: Increased capacity requirements translate into new plants and corresponding investments, as well as additional energy consumption and CO_2 emissions, the latter caused in no small part by the increased hydrogen consumption.

Figure 1 Extreme marine fuel specifications require major changes in the refining toolkit

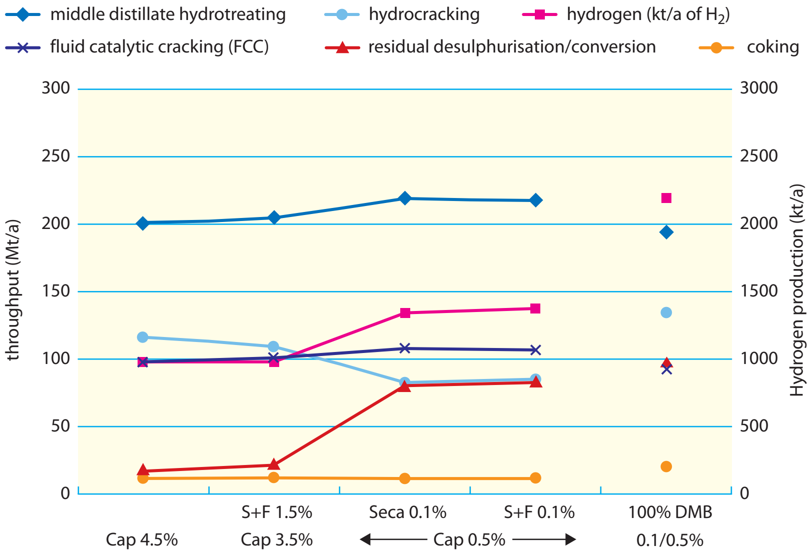

Figure 2 Such changes trigger new investments and additional CO_2 emissions