Reducing the sulphur content of residual marine fuels

What will be the consequences for refiners and for market prices?

The legislative context

Residual fuel is a commodity used by sea-going vessels the world over. The quality specifications of residual marine or 'bunker' fuels (RMF) result essentially from self-regulation of the industry and agreements between producers and consumers. Parameters such as carbon residue, density and stability are essential for the reliable and safe operation of ships.

The sulphur content of marine fuels is, however, regulated on a worldwide basis through the International Maritime Organization (IMO). The maximum allowable sulphur content of RMF is currently 4.5% m/m. An agreement under the International Convention for the Prevention of Pollution from Ships (MARPOL), known as MARPOL Annex VI, has introduced the concept of Sulphur Emission Control Areas (SECA) which are special sea areas where specific limits apply. The Baltic and North Sea have been designated as SECAs whereby emissions from ships sailing into these areas will be limited to a level consistent with a maximum fuel sulphur content of 1.5% m/m. Following its ratification in 2005, MARPOL Annex VI comes into force in May 2006 for the Baltic Sea and in November 2007 for the North Sea. A process for revision of that legislation was initiated by the IMO's Marine Environment Protection Committee in July 2005.

In addition, the EU has adopted Directive 2005/33/EC[1] (further referred to as 'the Directive') which extends the 1.5% m/m sulphur limit to all ferries operating from and to an EU port and which will also come into effect in August 2006. The Directive includes a review clause whereby the possibility can be envisaged of extension of the sulphur limit to all EU waters and its further reduction (levels of 0.5% m/m have been mentioned).

[1] *Directive 2005/33/EC of the European Parliament and of the Council of 6 July 2005 amending Directive 1999/32/EC as regards the sulphur content of marine fuels*

It has to be noted that the obligation under the Directive could also be met by appropriate reduction of the ship stack emissions. This can be achieved by sea water scrubbers, a number of which have been developed to full-scale demonstration stage.

In this context CONCAWE undertook a study focusing on the option of reduction of fuel sulphur content and aiming to:

- clarify the options open to European refiners facing these new constraints, including possible future ones; and
- analyse the impact of refiners' choices on the RMF market in terms of availability and prices.

The full results of the study will be published in a CONCAWE report. In this article we highlight the main findings and conclusions.

Refiner's business options

When faced with an additional constraint, a refiner will re-evaluate its entire operation to try to find the new economic optimum. Focusing on RMF sulphur reduction, the options would in principle be as follows:

Optimise residue streams segregation and residual fuel blending

This is a relatively soft option for the refiner, although it may require minor investments to make segregation possible. Clearly, however, the scope is limited to the volumes of low sulphur residual streams physically available and also by a number of practical considerations that could make segregation impossible. The current demand to cover the requirement of the Directive could partly be met through this mechanism.

Process more low sulphur crude

This option is of course in principle open to individual refiners. It must, however, be realised that the trend is for crude oil worldwide to become heavier and more sulphurous. Globally for Europe, it has been estimated that the current percentage of low-sulphur crudes (about 45%) can at best be maintained for the next 10–15 years but could not realistically be increased. From a European point of view this option is therefore not available.

Desulphurise residues

On paper, the simplest way to reduce sulphur in RMF is to desulphurise key residual components. Residue desulphurisation is technically feasible but is no trivial matter. It requires heavy processing, essentially high pressure/high temperature hydrotreatment. The processes involved are complex, the plants costly and delicate to operate. Blended fuel stability and mutual compatibility of finished fuels can cause problems, especially with the heavier, higher sulphur residues. The processes are similar in nature to hydroconversion (i.e. cracking to lighter material). They apply similar technologies but under somewhat milder conditions. Although several such processes are commercially proven, they are regarded as state-of-the-art technologies, particularly when it comes to treating heavy and high sulphur residues (e.g. from Middle Eastern crudes). None of the residue desulphurisation plants operating today actually produces low sulphur RMF components.

A significant reduction of the sulphur content of a large proportion of the residual fuels would therefore change their very nature. They would become manufactured products having to support complex and expensive processing equipment. As a result their production would be in economic competition with other manufactured products such as distillates, and so refiners would inevitably consider alternatives.

Convert residual streams to distillate products

As the market has gradually moved towards more distillates and less residual fuels (a 'whiter demand barrel') while the average crude oil barrel on offer is slowly becoming heavier, the refining industry has adapted by installing 'conversion' capacity, i.e. plants that can turn residues into distillates such as diesel fuel, kerosenes or gasolines. Such plants are in fact very similar to those required to desulphurise residues, the difference being more in the degree of severity applied than in the process principles used. Conversion is likely to be more expensive than desulphurisation but not by a large margin. As a result, partial or full conversion will always be an option when desulphurisation is considered.

The economics of desulphurisation would rely on an expected price differential between low and high sulphur RMF. The magnitude and evolution with time of such a differential would be crucially dependent on the supply/demand balance of low sulphur material and the evolution and application of the legislation that created the demand in the first place. Compared with these uncertainties, conversion relies on the continued prospect of sustained distillate growth and decreasing demand for residues, offering a more reliable basis for justifying what would in any case be major investment decisions.

It must be noted that conversion is not the only technological option available to the refiner for dealing with residual streams. Residue gasification for heat and power production offers a further alternative which may be attractive under certain circumstances and would also be in competition with the desulphurisation option. Although our model is able to represent such processes we have not included this option in our study, as consideration of the relative economics of conversion and gasification would have required discussion of relative electricity and oil prices that would be beyond our scope.

Export surplus high sulphur residual fuel

The worldwide RMF market is set to grow steadily and, with no immediate prospects of additional sulphur restrictions outside Europe and limited parts of the USA and Japanese coastal areas, export is likely to remain an option. There may also be opportunities for export of high-sulphur heavy fuel oil (HS HFO) for other uses. This option might be considered where funding for the large desulphurisation or conversion investments is not available.

Cost of residue desulphurisation

Starting from a pre-SECA 'business-as-usual' case, the study considered two scenarios based on enacted legislation (MARPOL legislation alone, MARPOL + EU

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Figure 1 Desulphurisation cost per tonne of low sulphur RMF under different scenarios

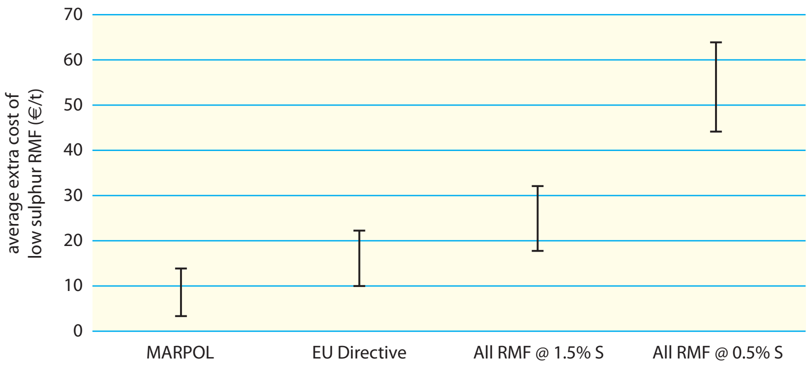


Figure 1
The average extra cost per tonne of LS RMF would be between 10 and 25 €/t to meet enacted legislation, increasing to 45 to 65 €/t in the 0.5% sulphur case.

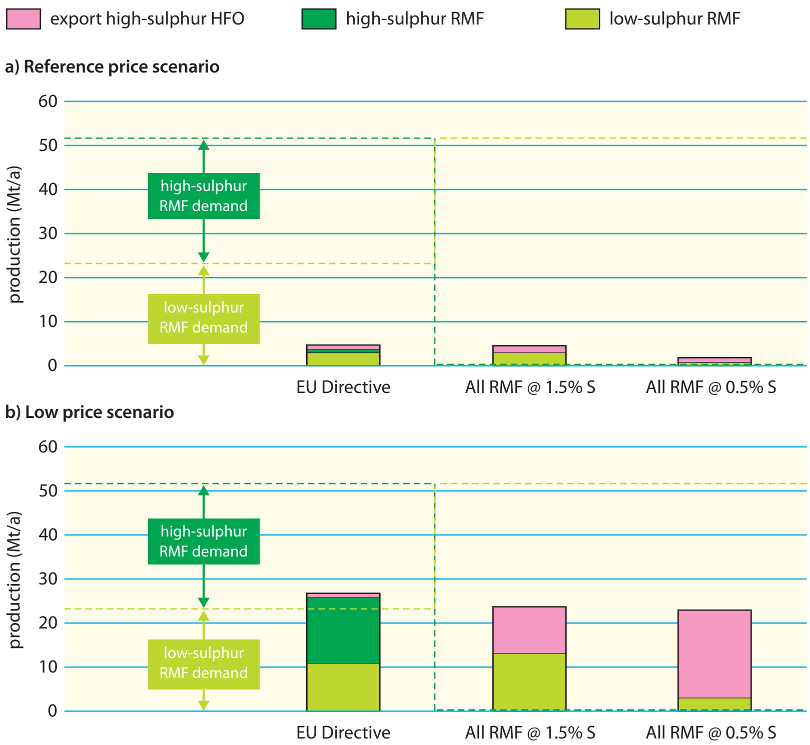
Figure 2
Under both scenarios studied, conversion or export would be more attractive than desulphurization.

Directive) and two further prospective scenarios in which the sulphur content of all RMF sold in the EU would be limited to either 1.5 or 0.5% m/m. Demand figures were based on a 2015 forecast.

In a first part we estimated the cost to EU-27 (EU-25 + Norway and Switzerland) refineries of reducing RMF sulphur to the required level while meeting the RMF demand.

As already highlighted in studies by others, residue desulphurisation has a high cost. Meeting already enacted legislation will require investments of up to 2 G€ in EU-27 for an annual cost in the order of 0.5 G€. Reducing the sulphur content of all RMF sold in Europe to 0.5% m/m would require an additional investment of between 7 and 13 G€ for an annualised cost of 2.2–3.2 G€. The average extra cost per tonne of LS RMF (Figure 1) would be between 10 and 25 €/t to meet enacted legislation increasing to 45 to 65 €/t in the 0.5% sulphur case.

Figure 2 Optimum economic production of RMF under two price scenarios



These costs, however, do not reflect the impact of the RMF sulphur limits on its likely market price. From an economic point of view desulphurisation relies on the price differential between low and high sulphur residual fuels, which is only the consequence of legislated sulphur limits. Conversion also requires complex and costly plants but delivers distillate products that are inherently more valuable than residues. Its economic prospects are therefore much better than desulphurisation.

The consequences of realistic economic mechanisms

In reality refiners will always have the choice to supply only the portion of the market which is economically attractive. In a second part of our study we therefore considered the relative merits of residue desulphurisation (for LS RMF production), conversion to lighter products or export outside the EU. In addition to the reference price scenario (around 40 $/bbl) we also used a low price set (around 25 $/bbl) in order to test the sensitivity of the results to this essential economic driver.

As shown in Figure 2, our key finding is that, under both price scenarios **conversion or export would be more attractive than desulphurisation.**

The LS RMF price increase required to make desulphurisation attractive would be very high. In order to re-establish the full LS RMF production in our reference price scenario, differentials between HS and LS RMF in the order of 90 €/t would be required in the EU Directive case and up to 140 €/t in the 0.5% overall sulphur limit case. This would bring the price of LS RMF close to that of heating oil, which would then make LS RMF an unattractive customer choice.