DIRECTORATE GENERAL FOR ENVIRONMENT

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

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CONTENTS

INTRODUCTION

Under its framework contract with the Directorate General for Environment (DG ENV) for technical support in relation to the quality of fuels, Beicip-Franlab was requested to provide advice on the impact of possible changes to the sulphur content specifications of marine fuels sold in the EU.

Specifically, DG ENV asked Beicip-Franlab to consider the following:

1. A survey of the marine fuels market providing information on quantities and qualities in terms of grade split and sulphur content and covering the following:

   - The amount of marine fuel sold annually in the EU as a whole
   - Breakdown of marine fuel sales by EU Member State and port
   - Amount of marine fuel sold offshore in Europe (beyond 12 miles from coasts; including dependent territories such as the Canary Islands) subject to information being available.
   - Amount of marine fuel sold in EU Candidate Countries
   - Amount of marine fuel sold elsewhere in the world, indicating major markets
   - Commentary on marine fuel sales and consumption – current and future trends assuming business as usual

2. Marine gas oils (MGO) – refinery cost implications of the following scenarios, expressed in terms of overall costs and in € per tonne fuel. Please also comment briefly on the cost implications of earlier or later dates for market switchover.

   - Raising the sulphur limit for DMC grade fuel from 0.2% to (i)1.5% ii)1% by 1/1/2005
   - Increasing supply of low S MGO (DMA, DMB or DMX) to: (i) 8.4 MT at 0.2%S by 1/1/2005; (ii) 8.4 MT at 0.1%S by 1/1/2008
   - Prohibiting the sale of MGO (DMA, DMB or DMX) over (i) 0.2%S by 2005 (ii) 0.1%S by 2008
   - Providing sufficient quantities of compatible (less alkaline) lubrication oil

3. Marine heavy fuel oils (HFO) – refinery cost implications of reducing the sulphur content of HFO sold in Europe, expressed in graphical format showing overall cost and cost premium in € per tonne fuel against the percentage of the EU HFO supply being produced. Comments on the following were requested:

   - the cost implications of providing sufficient quantities of compatible (less alkaline) lubrication oil
   - the cost implications of earlier or later dates for market switchover
   - the practicality of regulating on fuels “marketed in the EU and intended for use in EU waters”
   - the likely share of the refining cost burden between Member States
   - the likely impact on the global market of EU regulation on S content of fuels used and/or sold

1 SUMMARY

1.1 MARINE FUEL MARKET

- The two main 'oil fuel' classifications in the marine industry are distillates and residual fuel oils. Marine distillates divide into two broad types: marine gas oil (MGO) and marine diesel oil (MDO). Marine gas oils are generally used in the small, more highly rated diesel engines to be found on many types of ships. Fuel oil, also known as heavy fuel oil (HFO) or 'residual fuel oil', are the heaviest viscosity oil fuels. The most commonly used heavy fuel oil at sea are the Intermediate Fuel Oils, IFO180 and IFO380, fuel oils with a viscosity of 180 and 380 centistokes at 50°C. Unlike distillates, heavy fuel oils normally need pre-heating facilities.

- The predominant standard for marine fuels is the International Standard Organisation (ISO 8217). There are standards for distillate marine fuels (DMX, DMA, DMB and DMC) and for the most widely used intermediate fuel oils (180 and 380 cSt). DMX and DMA would normally be considered representative of MGO while DMB and DMC would normally be considered as MDO. The sulphur content, viscosity and density specifications in ISO 8217 are summarised below. MARPOL Annexe VI indicates a global sulphur content cap of 4.5%S and lower than the ISO specification of 5%S for the IFO grades.

ISO 8217: SELECTED SPECIFICATIONS						
Parameter	Distillates				IFO	
	DMX	DMA	DMB	DMC	RM E/F25	RM G/H35
Density @ 15 °C (kg/m3)	0.890	0.890	0.900	0.920	0.991	0.991
Viscosity @ 40 °C (mm2/s)	5.5	6	11	14	N/A	N/A
Viscosity @ 100 °C (mm2/s)	N/A	N/A	N/A	N/A	25	35
Sulphur % (m/m)	1	1.5	2	2	5	5

- The size of the bunker fuel market is determined by several factors, including changes in the volume of sea borne trade, particularly in terms of tonne-kilometres travelled; changes in the size and the composition of the world's merchant fleets; and advances in fuel efficiency and improvements in the design of marine machinery and vessel hulls.

- Prices of bunker fuels in Europe were estimated to have averaged around $100 per tonne for heavy fuel oil and around $180 per tonne for marine gasoil over the last five years.

- Demand for bunker fuels in the EU-15 reached 42 million tonnes (MT) in the year 2000. Of this amount, 34 MT were HFO. Since 1984, when demand hit a 30 year low of 19 MT, HFO bunker demand has grown at an average of 3.6% per year. Distillate bunker fuel has progressed more steadily until recent years. Demand grew in the nineties from 8.2 MT in 1990 to reach a peak in 1998 of 9.9 MT before falling back in the last two years to only 8.4 MT in the year 2000. Increased use of residual fuel on newer vessels is understood to have contributed to the recent decline.

- The European bunker market can be broadly divided into three regions: the Mediterranean, the North European, comprising the ARA region (Belgium-Netherlands) and the Baltic, and the Canary Islands. Netherlands, Greece, Spain, France and Belgium account for more than three quarters of the EU-15 bunker fuels sales (31 MT).

- The major European bunkering ports are Rotterdam, Antwerp, Gibraltar and Piraeus. Together, these four ports account for 17 MT of bunker fuels sales of which 9 MT were sold in Rotterdam. Las Palmas, Marseilles/Fos/la Vera, Amsterdam and Algeciras account for a further 6 MT.

- The average sulphur content of HFO bunkers sold in European ports is estimated to be 2.5%. The average quality in the Netherlands, the major European bunkering country is 2.6%. HFO bunkers sold in Ireland, Finland, Norway and the UK has a sulphur content of 2% or less, while HFO bunkers sold in Spain, Portugal, Greece and Italy averages around 3%S. The average sulphur content in North Europe was estimated to be 2.4% while the average in the Mediterranean was estimated at around 3%.

- Demand data for bunker sales in the 13 EU accession countries were less certain. Based on IEA data sales were estimated to total 1.3 MT. Poland accounts for nearly 50% of the total. The quality of the bunkers provided by the ports in these countries does not vary greatly from the quality supplied by EU-15 ports in the same regions.

- The world bunker market is estimated at 140 MT per year. With more than 25 MT, the US is the world leading country regarding bunker sales. Over the 1990-1999 period, world bunker sales have grown an average 3.4% per year. Nevertheless, they only reached their 1973 volume sales figures in 1997 (126 MT). 80% of the world bunker sales are HFO.

- The world's largest bunkering ports are Singapore, Fujairah, Rotterdam, Busan (South Korea), Hong Kong, Suez, Panama, and Houston. The leading bunkering ports are also refining centres or close to refining centres. The bunker market volume covered by 29 major world ports accounts for 68.5 MT/yr, equivalent to 50% of the world market. In 2000, bunker sales in Singapore alone account for over 20 MT/yr.

1.2 MARINE GASOIL/DIESEL SUPPLY

- The application of the EU sulphur content specification on MDO of 0.2%S versus the ISO 8217 specification of 2.0%S for DMC has meant that no heavy fuel oil can now be blended into DMC with a resulting increase in the cost of DMC to a level equivalent to heating gasoil. The ISO 8217 specifications for DMC grade fuel are such that refineries can produce such fuel by blending middle distillate with heavy fuel oil. The limitation on the amount of heavy fuel oil which can be blended into DMC is normally limited by the DMC viscosity specification, depending on the quality of the heavy fuel oil used for blending.

- Increasing the EU sulphur specification for DMC to 1%S allows the addition of 24wt% of HFO in the blend. The viscosity is still well below the DMC specification at under 8cst. Increasing the DMC sulphur content to 1.5%S allows the addition of 39wt% of heavy fuel oil. In this case, the viscosity of the DMC blend is now very close to the maximum specification of 14 cst. This means that no more high sulphur heavy fuel oil could be added even if the DMC sulphur content was higher than 1.5%S.

- DMC 1.5%S bunkers would be expected to sell for between €25 and €55 per tonne less than heating gasoil with an average of €39 per tonne based on prices over the last five years. The variations are due to the variation in the price spread between heating gasoil and heavy fuel oil. For the same period the premium for DMC 1.5%S bunkers would have been expected to be around €60 per tonne versus 3.5%S heavy fuel oil and €45 per tonne versus 1.5%S heavy fuel oil. The DMC 1%S bunkers would be expected to be more expensive moving in the range €15 to €34 Euro per tonne below heating gasoil, averaging €24 per tonne and €15 per tonne more costly than the DMC 1.5%S quality.

- Supply of 8.4 MT of MGO to a 0.2%S specification from 2005 and 0.1%S from 2008 was also considered. The 8.4 MT figure was considered as this has been estimated elsewhere as the in port consumption of vessels in the EU. DMA was considered as representative of MGO.

- To supply DMA to lower sulphur content specifications than the ISO 8217 specification of 1.5%S, the European refining industry would need to invest in additional middle distillate desulphurisation capacity. This capacity is already fully utilised due to the progressive reduction in sulphur content of on road diesel. Based on the cost of adding additional middle distillate desulphurisation capacity, the price premia for producing lower sulphur content DMA versus 1.5%S DMA has been estimated as follows:

LOW SULPHUR DMA PRICE PREMIUM	
% Sulphur	Premium versus 1.5%S DMA, €/tonne
0.2%S	12 - 19
0.1%S	14 - 21

- Prohibiting the sale of DMA or DMX with sulphur contents above 0.2%S in 2005 and 0.1%S in 2008 would be expected to result in price premia similar to those described above. As for DMC, the increase in price is likely to drive away the non-captive market for these products. The overall cost to the industry would be dependent on the amount of MGO still supplied to the captive market.

1.3 MARINE HEAVY FUEL OIL SUPPLY

- The supply of lower sulphur content marine heavy fuel oil could be achieved in two tranches. Firstly, based on a review of refinery HFO bunkers supply data provided by CONCAWE, a limited supply of lower sulphur content HFO bunkers could be made available by reblending of the HFO blending components to meet the lower sulpur content specification. Additional supply of low sulphur content HFO bunkers would require investment in refinery facilities for desulphurisation of the HFO.

- If it is assumed that the bunker fuel of less than 1.5%S currently produced can be blended with the next highest sulphur content production the amount of 1.5%S bunkers which could be made available would be extended. Using this approach suggests that around 4 MT of 1.5%S bunkers could be made available in North Europe and about 0.7 MT in the South. The sulphur content of the remaining high sulphur bunkers would increase to about 3.4 wt% in the North and 3.2 wt% in the South. These figures and those for a 1%S bunkers case are presented in the table below.

POTENTIAL LOW SULPHUR BUNKER PRODUCTION BY REBLENDING		
HFO Bunkers Sulphur content, wt%	Atlantic/NWE/Other (MT)	Mediterranean (MT)
< 1.0	1.2	0.4
< 1.5	4.0	0.7

- It should be noted that the segregation of low sulphur bunkers means that the sulphur content of the remaining bunkers will be increased. However, this higher sulphur content material is expected to be used for ship movements outside the SOx Emission Control Area, mostly on the high seas where it will have less environmental impact on acid-sensitive ecosystems and urban air quality.

- The costs of production of low sulphur bunkers will increase with the amount of bunkers produced. At low levels of production, costs will be relatively low as there is likely to be some flexibility within the current refinery production to free up some low sulphur bunkers as indicated above. As production increases and this flexibility is fully utilised, refinery investments will be needed to desulphurise the HFO blending components to meet the higher demand for low sulphur bunkers.

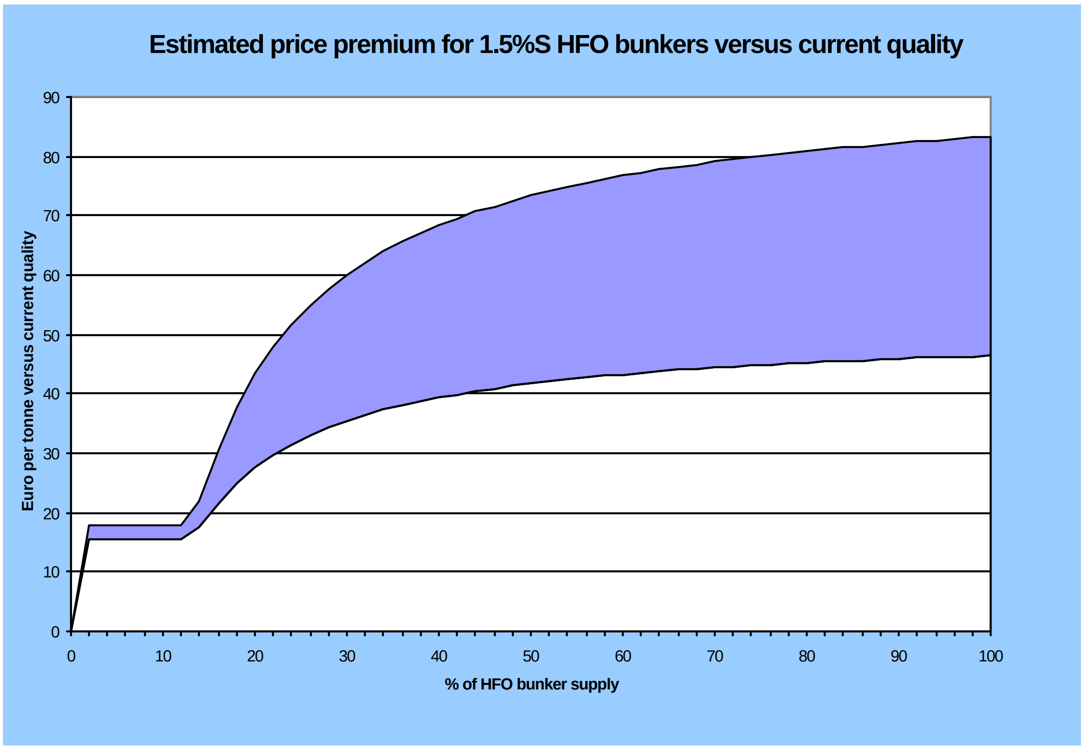
- The price differential between low sulphur fuel oil (1%S) and high sulphur fuel oil (3.5%S) averaged around $19 per tonne in both Northwest Europe and Mediterranean markets in the 1990 to 2001 period with an annual average high of $31 per tonne and a low of $8 per tonne. Differentials on other world markets were very similar indicating the global nature of the HFO market.

- The supply of low sulphur bunkers through reblending would be expected to result in a price premium in line with historial price differentials between low sulphur and high sulphur fuel oil. This is equivalent to around €16 to €18 per tonne.

- Additional supplies would require investment in facilites for desulphurisation of HFO. Refinery processes for desulphurisation of HFO are expensive due to the nature of the feedstock involved and the costs of these processes are far too high to justify construction of such a plant only to convert high sulphur residue to low sulphur residue. Most of the investments which have been made, and there are only a few plants in Europe, combine desulphurisation with some conversion of the residue to lighter products and this is usually the main driver in the economic justification. Demand for light products in Europe is growing and this is expected to continue in the future although probably at a lower rate than in the last ten years. At the same time heavy fuel oil demand is expected to continue to decline. Consequently, further addition of residue conversion capacity in Europe is required to meet the changing product slate.

- Based on a plant with a low level of conversion, and a capital cost of around €M480 (+/- 40%), the resulting price differential for 1.5%S bunkers versus the current level would be expected to be in the range of €50 to €90 per tonne. The wide range is due to the accuracy of the capital cost estimate and the range of assumption for return on the capital investment.

- The combination of the two tranches of production results in the cost versus production curve shown below.



2 MARINE FUEL MARKET REVIEW

2.1 BACKGROUND

2.1.1 Historical developments

1850s: Petroleum first used to propel ships at sea.

1910s: Liquid fuels seen as enhancing speed and operating flexibility. WW1 sees the beginning of the substantial use of fuel oil at sea (inspired by the efforts of W. Churchill's, Admiral Jackie Fisher of the British Navy and Marcus Samuel of the Shell company).

Early 1920s: Nearly 21% of the total merchant gross tonnage used fuel oil for steam raising. 72% used coal and the remainder sail.

Early 1970s: Large crude carriers utilise steam turbines (using low grade high viscosity fuel) or diesel propulsion plants (higher grade intermediate fuel oil). Fuel choice was solely a matter of operational performance.

Mid 1970s: World oil prices soar. Bunkers prices rose from $14/ton to $180-200/ton. MDO prices climb from $25 to $250-350/ton.

Early 1980s: Following the two major oil crises of the 70s, important improvements in engine efficiency. Constant reduction in world bunker demand.

1980s: Bunker market dominated by national oil companies. First international standards regulating bunker properties. Bunker consumption is cut significantly.

1990s: Steam turbines tend to disappear. Improvements in ship technology: coating (antifouling), reduction of water resistance, polished propellers. Stringent environmental constraints. World bunker sales recover their pre-1973 levels.

2.1.2 Definitions

There are several ways to classify the different types of marine fuels or bunker fuels. The term 'Oil fuel' describes any fuel manufactured from petroleum crude oil and can apply to gasoline (or petrol), jet kerosene or, in the marine world, gas oil, diesel oil or fuel oil. 'Fuel oil', refers to residual fuel oil manufactured at the 'bottom end' of an oil refining process, broadly the residue remaining after atmospheric distillation to 340°-370°C.

The two main 'Oil fuel' classifications in the marine industry are distillates and residual fuel oils. Marine distillates divide into two broad types: marine gas oil (MGO) and marine diesel oil (MDO). Both are used as fuels for the main engines of small vessels and auxiliary engines of larger vessels.

Marine gas oils are generally used in the small, more highly rated diesel engines to be found on many types of ships. It is a light distillate and is a clean oil containing no residual fuel oil. Marine diesel oil is a heavier distillate and may contain some residual fuel oil. It is sometimes called a blended distillate. Distillates are largely used by the fishing vessels that have less space for equipment targeted to treat high viscosity fuels.

Fuel oil, or ‘residual fuel oil’, are the heaviest viscosity oil fuels. The most common generic term for this fuel is Bunker C (or Heavy Fuel Oil, HFO, Marine Fuel Oil, or Bunker Fuel Oil). Fuel oil varies in viscosity, according to the port of supply, the supplier and even the time. It might be ‘straight run’ or ‘cracked’.

Residual fuel oils are identified by viscosity, and when necessary, are blended (or cut back) with distillate to produce the required viscosity. Such fuel oils, blended with the ‘Bunker C’, available at the time in a concerned port, are known as intermediate fuel oils (IFO) (or Interfuels, or Light Marine Fuels or Thin Fuel Oils). The most commonly used fuel oil at sea are the IFO180 and IFO380 which are intermediate fuel oils with a viscosity of 180 and 380 centistokes at 50°C.

2.2 MARINE FUELS PRODUCTION

Modern refineries are designed to maximise the yields of their most valuable products. The lighter refined products tend to be more valuable, while the heavier products, such as fuel oil, are priced much lower. As discussed above, marine fuels are broadly categorised into MGO, MDO and fuel oil. MGO is produced from refinery middle distillate blending components which can also be used for the production of road diesel and heating gasoil with additional processing if required. The specifications for MDO are such that some heavy fuel oil can be blended with the middle distillate components.

Heavy fuel oil bunkers is produced from refinery streams also used for the production of heavy fuel oil sold for inland use in Europe. However, the higher sulphur content specification of bunkers than most inland heavy fuel oil product, allows the use of components produced from higher sulphur content crude oils. Crude oils typically contain between 35wt% and 50wt% of residue which remains after distillation of the crude oil at atmospheric conditions which is the first processing step in almost all refineries. However, as European demand for lighter products has grown and heavy fuel oil demand has declined, heavy fuel oil demand now represents less than 20wt% of overall European refined product demand. As a result, heavy fuel oil sells for less than crude oil so refineries always try to minimise heavy fuel oil production and would never process more crude oil to produce heavy fuel oil.

In response to this change in the demand barrel, European refiners have added additional processing plant to convert residue to lighter products. This has mainly been done using “cracking” processes. As the industry has gone deeper into the residue to convert more to light products, the quality of the heavy fuel oil produced has reduced in some respects important to bunker fuel oil quality.

2.3 MARINE FUELS PROPERTIES

2.3.1 Physical properties

Viscosity is traditionally the main and often the only characteristic quoted in the purchase of marine fuels. This property, the resistance of the oil to flow, is measured in centistokes (cSt) at a certain temperature. The higher the number, the more viscous is the oil, and the more resistant to flow.

In addition to viscosity, there are several physical properties important to marine fuels. These range from flash point, density, water content, carbon residue, asphaltenes, wax, sulphur, ash, sediment by extraction, aluminium, silicon and vanadium content, specific energy or calorific value, colour, sodium, additives, acids, ignition quality, stability, and compatibility.

The table below presents a summary of some of the main physical characteristics in distillates and residual fuel oils.

PHYSICAL PROPERTIES IN DISTILLATES AND RESIDUALS			
Property	**Units**	**Definition**	**Significance**
Viscosity	cSt	Resistance to flow	Amount of preheating needs to be known for pumping purposes. Higher viscosity, poorer ignition and combustion
Flash point temp.	°C	Temperature at which vapours ignites	Minimum temperature at which vapour is produced Safety measures The lower the value, the easier the oil fuel ignites.
Density	kg/m3	Relation between mass and volume	Less dense bunkers, higher energy/unit mass Prices are often quoted in $/tonne, and deliveries are measured in volume. Oil fuel purification processes in the ship use density differential (centrifuges).
Water content	% vol	Water content	The more water, the less calorific value in the fuel. Water can cause problems in the injectors. Forms emulsions, sludge that blocks filters interrupting flow.
Carbon residue	% wt	Carbon left after total combustion	Leads to late burning and high exhaust temperatures (damage moving parts) Indicator of the carbon depositing tendency and the combustion properties.
Asphal-tenes	% wt	High molecular weight hydrocarbons	They play a role in the stability and compatibility of a fuel. They are slow burning material.
Wax	°C (Cloud Point)	Amount of wax in the fuel	With high wax bunkers can not be easily pre-heated Even if it has good calorific value, it can cause problems for pumping and for storage.
Sulphur	% wt	Amount of sulphur in the fuel	Higher sulphur content fuels tend to have lower energy content. Forms corrosive acids to the engine and exhaust emissions.
Ash, silicon and metals	% wt	Inorganic material in the fuel	Residue that damages moving parts High abrasive material that cause engine damage. Material that forms salts resulting in deposits.
Calorific value	Cal/gram	Heat released	
Ignition quality	Cetane N°	Ease of ignition	The higher the number the more 'easily' the engines can be started.
Stability		Phase changes	Suspension or sludge formation, incompatibility with other fuels.

2.3.2 Fuel standards

There are several world regulatory bodies in charge of establishing quality standards for the bunker fuels. The most widely used are the ASTM, British Standards Institution, CIMAC (Conseil International des Machines a Combustion, an entity that safeguards the interests of engine manufacturers and users), and the International Organisation for Standardisation, the ISO.

2.3.2.1 British Standards

The BS MA 100 was the first standard for marine fuels, distillates and residual fuel oils. It subdivides fuel oils into twelve groups, each group containing threshold values for the properties of the fuel. The main groupings in the BS MA 100 range from M1 to M12, ranging from the lowest viscosity distillate (M1), to the higher viscosity residual fuel (M12). Nevertheless, the BS had several limitations, providing no information regarding important properties such as:

- mixability
- ignition characteristics
- contents of solid particles or contaminants.

The ISO standards were therefore designed to cover a range of physical properties for both marine distillates and residual fuel oils.

2.3.2.2 ISO Standards

For the past 15 years, both the BS and the CIMAC have been losing popularity in favour of the ISO 8217 standard, which is the predominant standard nowadays. The next tables present the ISO standard (ISO 8217) for distillate marine fuels (DMX, DMA, DMB and DMC) and for the most widely used intermediate fuel oils (180 and 380 cSt).

ISO 8217: FUEL QUALITY STANDARD FOR DISTILLATE MARINE FUELS						
Parameter	Limit	Category ISO-F				Test method reference
		DMX	DMA	DMB	DMC	
Appearance		Visual		--	--	
Density @ 15 °C (kg/m3)	Max	0.89		0.9	0.92	ISO3675/ISO12185
Viscosity @ 40 °C (mm2/s)	Min	1.4	1.5	--	--	ISO3104
	Max	5.5	6	11	14	ISO3104
Flash Point °C	Min	43	60	60	60	ISO2719
Pour Point (upper) °C -- Winter quality	Max	--	-6	0	0	ISO3016
-- Summer quality	Max	--	0	6	6	ISO3106
Cloud Point °C	Max	-16	--	--	--	ISO3015
Sulphur % (m/m)	Max	1	1.5	2	2	ISO8754
Cetane Number	Min	45	40	35	--	ISO5165
Carbon Residue (Micro method) 10% (v/v) distillation bottoms	Max	0.3	0.3	--	--	ISO10370
Carbon Residue (Micro method) % (m/m)	Max	--	--	0.3	2.5	ISO10370
Ash % (m/m)	Max	0.01	0.01	0.01	0.05	ISO6245
Sediment % (m/m)	Max	--	--	0.07	--	ISO10307-1
Total Existing Sediment % (m/m)	Max	--	--	--	0.1	ISO10307-1
Water % (V/V)	Max	--	--	0.3	0.3	ISO3733
Vanadium mg/kg ppm	Max	--	--	--	100	ISO14597
Aluminium+Silicon mg/kg ppm	Max	--	--	--	25	ISO10478

ISO 8217: FUEL QUALITY STANDARD FOR IFO180 AND IFO380 cSt BUNKER FUELS						
Parameter	Limit	Category ISO-F				Test method reference
		RM E25	RM F25	RM G35	RM H35	
Density @ 15 °C (kg/m3)	Max	0.991		0.991		ISO3675/ISO12185
Viscosity @ 100 °C (mm2/s)	Max	25		35		ISO3104
Flash Point °C	Min	60		60		ISO2719
Pour Point (upper) °C -- Winter quality	Max	30		30		ISO3016
-- Summer quality	Max	30		30		ISO3106
Carbon Residue % (m/m)	Max	15	20	18	22	ISO10370
Ash % (m/m)	Max	0.1	0.15	0.15	0.2	ISO6245
Water % (V/V)	Max	1		1		ISO3733
Sulphur % (m/m)	Max	5		5		ISO8754
Vanadium mg/kg ppm	Max	200	500	300	600	ISO14597
Aluminium+Silicon mg/kg ppm	Max	80		80		ISO10478
Total Sediment Potential (TSP) % (m/m)	Max	0.1		0.1		ISO10307-2

2.4 MARINE FUEL USES

Depending on the engine type, different grades of marine fuels are used. During most of the 60s and 70s, steam turbines preferring low grade high viscosity fuel (HVF) were the trend. Steam turbines implied higher fuel consumption but lower maintenance costs.

Diesel engines use higher grade intermediate fuel oil (IFO), while generators (electrical load for both engines) use the lighter fuels, marine diesel oil (MDO). All vessels, even those powered with steam, use generators or auxiliary equipment that are driven by the main shaft when the ship is in sea and by a diesel (MDO) when the vessel is not under way.

Traditionally fuel choice was a matter of operational performance, but the evolving technology and price increases have recently had much influence on the selection of the bunker for a specific vessel. While in large cargo vessels there is a trend for switching to HFO even to propel generators and auxiliary machinery, fishing fleets are still constrained by the space needed to process HFO prior to its combustion.

Other type of vessels, such as high speed ferries that are constrained by the engine weight penalties, may keep on using distillates. Similarly, the decision on whether to use HFO or distillates in cruise ships is not straightforward. The newer generations of these vessels can be driven by compact and powerful gas turbines engines that would allow more space on board ship (i.e. for more passenger cabins).

The following table presents the classification made by ISO on the four types of distillate marine fuels and comment on the possible uses for these fuels.

DISTILLATE MARINE FUEL USES BY GRADE			
ISO 8217	**Fuel type**	**Viscosity @ 40°C (max.)**	**Uses/Notes**
DMX	MGO	5.5	Suitable for use when the ambient temperature is low. High cetane number and reduced flash point. Used for emergency machinery external to main machinery spaces. In the merchant marine its use is limited to lifeboat motors and emergency generators.
DMA	MGO	6.0	High quality distillate generally used for auxiliary engines.
DMB	MDO	11.0	Distillate mixed with some residual oil. Intended for use in diesel engines which are not designed for combustion of residual oil.
DMC	MDO	14.0	Higher viscosity diesel oil. Largely used by fishing fleets. Not suitable for machinery and oil treatment plants that are not designed for residual fuel.

Similarly, the ISO 8217 and CIMAC describe thirteen categories of residual grades. The standards are arranged with the viscosity of the oils as starting point. The table below describe the qualitative properties of each of the residual types.

RESIDUAL MARINE FUEL USES BY GRADE		
ISO 8217	**Viscosity @ 50°C (max.)**	**Uses/Notes**
RM A10	40	Suitable for operations at low ambient temperatures in installations without preheating facilities in the storage tank, where a pour point lower than 240 - 300°C. is necessary. RM A10 has generally the lower specific density and a minimum viscosity to improve ignition properties.
RM B10	40	
RM C10	40	Fuel oils requiring on board treatment/purification in ordinary purifier/ clarifier extraction systems.
RM D15	80	
RM E25	180	
RM F25	180	
RM G35	380	
RM H35	380	
RM H45	500	
RM H55	700	
RM K35	380 – 700	Fuel for use in installations with separators specially designed for the treatment of fuel oils with higher specific densities.
RM K45		
RM K55		

2.5 MARKET STRUCTURE

2.5.1 Market determinants

A set of factors, ranging from the volume of sea trade, the fleet of marine vessels to technical factors determine the consumption of marine fuels. In summary, the worldwide bunker consumption is primarily a result of the following:

- Changes in the volume of sea borne trade, particularly in terms of tonne-kilometres travelled;
- Changes in employment conditions, and the growth of idle tonnage;
- Changes in the size and the composition of the world's merchant fleets;
- Advances in fuel efficiency and improvements in the design of marine machinery and vessel hulls;
- Improved monitoring and maintenance of ship's machinery, as well as ship operations;
- Reduced fuel consumption brought about by practices such as slow-steaming (prevalent amongst the large tanker fleet);
- Re-engineering of existing ships to achieve improved fuel efficiency.

In the past three decades, the first three factors have provided both positive and negative stimuli to bunker consumption. The latter four factors, however, have generally led to fuel saving.

2.5.2 Sellers

In the past, major oil companies used to have 85% of the bunker market (distribution network, technical support). The major oil companies' share has eroded to 40%. They are looking to recover some of the lost market share, partly due to the fact that refiners have to look for markets for the fuel oil no longer used for electricity generation, and other inland uses.

There is an increasing number of independent and state owned companies (now about 500), participating in the bunker business. Companies operate on a regional basis and compete against the major players on price.

The large amount of companies has fostered the number of bunker brokers and traders. Brokers receive commissions for arranging a sale to an operator (generally they do not charge buyers). Traders sell bunkers to operators who do not have an established account with a supplier.

2.6 BUNKERING DECISIONS

In addition to the product quality and availability, the port and the price are major determinants when selecting a place to load. Not all the ports offer bunkering options, and not all bunkering ports are final destinations. For instance, according to the type of service they provide, ports can be divided into:

- Full service ports: load/unload, bunkering;
- Bunker only call ports: only bunkering.

Therefore, after deciding on the itinerary, ship operators select the place where they bunker according to the following criteria.

- Bunker at the load port for the round trip: decreasing cargo intake.
- Bunker at the load port only to reach the discharge port: maximising cargo intake.
- Bunker at intermediate point of voyage: lengthens the voyage (time and distance).

Similarly, bunkering activities can be divided into:

- Onshore: ship is at the port.
- Offshore: fuel delivered by barge.

The third important factor in the decision on where to bunker is cost. Bunkers are a major expense item for a ship owner. They are both burnt at sea and at ports (used for loading and unloading activities). Bunker costs range from 60% to 95% of the vessel operating costs, the high end of the range being more typical of old VLCC with fuel inefficient engines.

2.7 ESTIMATED BUNKER FUEL PRICES

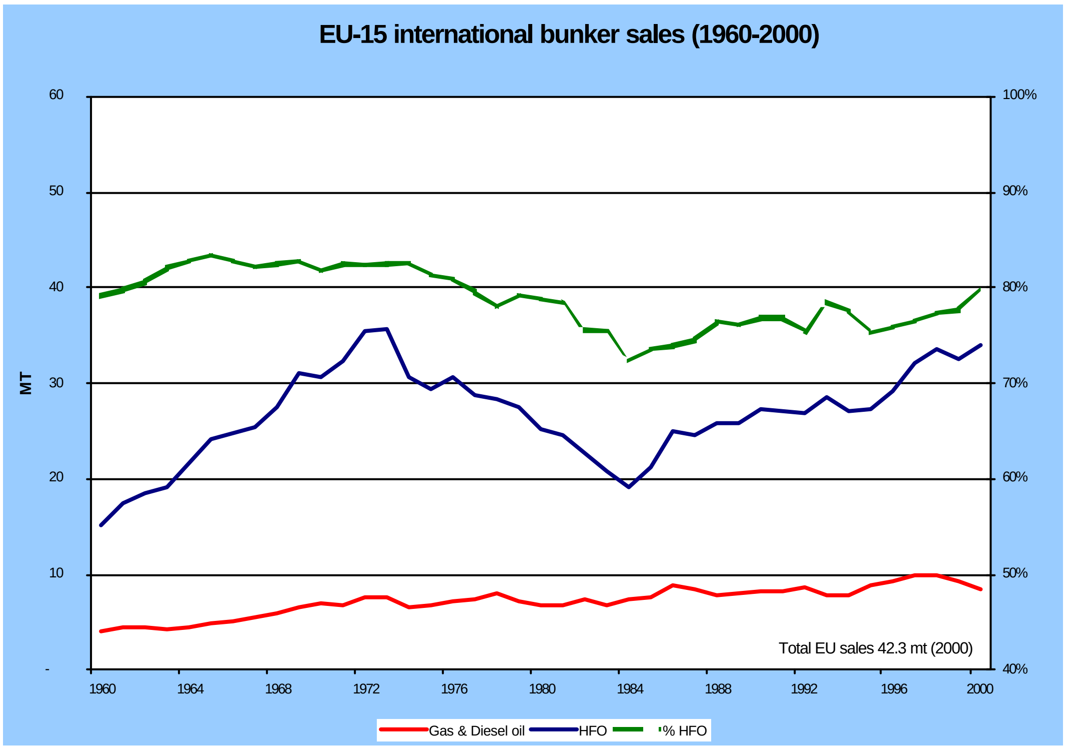
Average prices for the different ISO grades of bunker fuel have been estimated for the 1997 to 2001 period for the ARA (Amsterdam Rotterdam Antwerp) region. Mediterranean prices would not be expected to be significantly different.

ESTIMATED BUNKER FUEL PRICES 1997 - 2001	
Grade	**$/tonne**
DMX	190+
DMA (0.2%S)	186
DMB (2%S)	156
DMC (2%S)	151
IFO 180	105
IFO 380	97

2.8 EUROPEAN MARKET

2.8.1 EU-15 Bunker Sales

The figure below shows the development of international marine bunker sales in the EU-15 countries since 1960.



Sales of international HFO bunkers reached a peak in 1973 of nearly 37 MT (million tonnes). The large increase in bunker fuels prices due to the crude oil price shocks in 1973 and 1979 led to a strong energy efficiency drive and reduced demand for oil and shipping. Demand fell steadily to 19 MT in 1984 before demand started to increase again. Since then HFO bunker demand has grown at an average of 3.6% per year through 2000.

The growth of distillate bunker fuel has progressed more steadily until recent years. Demand grew in the nineties from 8.2 MT in 1990 to reach a peak in 1998 of 9.9 MT before falling back in the last two years to only 8.4 MT in the year 2000. Increased use of residual fuel on newer vessels is understood to have contributed to the recent decline.

Since the mid 1980s, the split between HFO and distillates has increased steadily in favour of HFO. Partly due to the fact that the general policy is a move toward the use of and conversion to the cheaper heavy fuels at sea. Nevertheless, the shift towards HFO is counterbalanced by the fact that more distillate is being used to cut back the heavier grades of fuel oil obtained by more sophisticated refining processes. The increasing demand for distillates may also be due to the greater proportional operation of small craft with trunk-type diesels compared to vessels with larger crosshead marine diesel engines.

As a result of the changes described above, the proportion of HFO in the bunkers sold fell to just under 75% in 1984 before increasing again to 80% by 2000.

2.8.2 EU-15 sales by member state

Historical bunker fuel sales by EU member state are shown in the table below. Total international bunker sales in 2000 were 42.3 MT of which 33.9 MT was HFO bunkers. The Netherlands dominates sales with nearly one third of total EU-15 sales. Belgium is the second largest seller with a share of around 14% followed by Spain and Greece with 12% and 9% respectively.

EU-15 TOTAL BUNKER SALES (HFO, DO, GO) (INTERNATIONAL) -MT

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Yearly growth 91-00
Austria	-	-	-	-	-	-	-	-	-	-	-	
Belgium	4.20	4.30	4.27	4.40	4.21	4.00	4.62	5.23	5.60	4.52	5.00	1.9%
Denmark	0.98	0.86	0.92	1.36	1.51	1.63	1.52	1.50	1.40	1.31	1.30	3.3%
Finland	0.58	0.55	0.70	0.55	0.42	0.34	0.38	0.41	0.53	0.57	0.56	-0.3%
France	2.57	2.67	2.58	2.46	2.18	2.56	2.77	3.01	2.91	2.94	3.05	1.8%
Germany	2.51	2.11	1.76	2.22	2.05	2.06	2.04	2.17	2.06	2.10	2.21	-1.2%
Greece	2.57	2.36	2.71	3.16	3.36	3.61	3.18	3.18	3.56	3.16	3.65	4.2%
Ireland	0.02	0.03	0.02	0.05	0.04	0.12	0.16	0.15	0.16	0.17	0.15	72.8%
Italy	2.70	2.55	2.45	2.44	2.36	2.44	2.30	2.40	2.64	2.43	2.48	-0.8%
Luxembourg	-	-	-	-	-	-	-	-	-	-	-	
Netherlands	11.10	11.38	11.49	11.91	11.36	11.49	11.70	12.42	12.51	12.94	13.65	2.3%
Portugal	0.62	0.63	0.62	0.52	0.50	0.49	0.51	0.50	0.39	0.60	0.62	0.0%
Spain	3.72	3.94	3.99	3.50	3.16	3.25	4.74	5.85	6.17	6.02	6.15	6.6%
Sweden	0.68	0.81	0.92	0.93	1.09	1.07	1.14	1.35	1.61	1.55	1.39	10.5%
UK	2.54	2.49	2.55	2.48	2.31	2.47	2.67	2.96	3.08	2.33	2.08	-1.8%
Total	34.78	34.68	34.96	35.97	34.55	35.52	37.71	41.14	42.59	40.63	42.29	2.2%

EU-15 MARINE DISTILLATE SALES (INTERNATIONAL) -MT

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Yearly growth 91-00
Austria	-	-	-	-	-	-	-	-	-	-	-	
Belgium	0.64	0.66	0.73	0.65	0.59	0.71	0.65	0.68	0.72	0.57	0.68	0.7%
Denmark	0.27	0.28	0.40	0.45	0.54	0.65	0.64	0.71	0.73	0.61	0.50	8.1%
Finland	0.12	0.11	0.13	0.14	0.15	0.15	0.15	0.16	0.16	0.16	0.16	3.2%
France	0.31	0.34	0.35	0.28	0.25	0.27	0.31	0.42	0.44	0.42	0.48	5.6%
Germany	0.55	0.45	0.44	0.49	0.46	0.48	0.65	0.64	0.52	0.48	0.50	-0.8%
Greece	0.51	0.51	0.66	0.72	0.80	0.97	0.78	0.77	0.76	0.71	0.75	4.7%
Ireland	0.01	0.01	0.01	0.03	0.02	0.07	0.10	0.10	0.11	0.12	0.11	116.7%
Italy	0.57	0.56	0.57	0.56	0.55	0.57	0.57	0.66	0.79	0.79	0.71	2.4%
Luxembourg	-	-	-	-	-	-	-	-	-	-	-	
Netherlands	2.08	2.12	2.14	1.87	1.95	2.30	2.12	1.96	2.05	2.01	2.06	-0.1%
Portugal	0.21	0.22	0.21	0.19	0.18	0.20	0.20	0.19	0.11	0.18	0.14	-3.2%
Spain	1.21	1.18	1.30	0.74	0.61	0.78	1.18	1.53	1.14	1.15	0.97	-2.0%
Sweden	0.15	0.15	0.18	0.17	0.19	0.20	0.21	0.25	0.28	0.22	0.17	1.1%
UK	1.14	1.20	1.24	1.16	1.20	1.11	1.20	1.16	1.40	1.15	1.14	0.0%
Total	7.77	7.80	8.35	7.45	7.48	8.44	8.74	9.23	9.21	8.57	8.36	0.8%

EU-15 HFO SALES (INTERNATIONAL) -MT												
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	Yearly growth 91-00
Austria	-	-	-	-	-	-	-	-	-	-	-	
Belgium	3.57	3.64	3.54	3.75	3.62	3.30	3.97	4.54	4.88	3.95	4.32	2.1%
Denmark	0.71	0.58	0.52	0.92	0.97	0.98	0.88	0.80	0.66	0.70	0.81	1.4%
Finland	0.46	0.44	0.56	0.40	0.28	0.18	0.23	0.26	0.37	0.41	0.40	-1.3%
France	2.26	2.33	2.23	2.18	1.93	2.30	2.46	2.59	2.47	2.52	2.56	1.3%
Germany	1.96	1.66	1.32	1.73	1.59	1.59	1.39	1.53	1.53	1.61	1.71	-1.3%
Greece	2.06	1.85	2.05	2.44	2.56	2.64	2.40	2.41	2.80	2.45	2.90	4.0%
Ireland	0.01	0.02	0.01	0.02	0.02	0.05	0.06	0.05	0.05	0.05	0.04	28.9%
Italy	2.13	1.99	1.88	1.89	1.81	1.87	1.74	1.74	1.85	1.63	1.77	-1.7%
Luxembourg	-	-	-	-	-	-	-	-	-	-	-	
Netherlands	9.02	9.25	9.35	10.04	9.41	9.19	9.59	10.46	10.46	10.93	11.60	2.9%
Portugal	0.41	0.41	0.40	0.33	0.32	0.29	0.31	0.31	0.28	0.42	0.48	1.7%
Spain	2.51	2.76	2.69	2.76	2.56	2.47	3.56	4.32	5.03	4.87	5.18	10.7%
Sweden	0.53	0.66	0.74	0.75	0.90	0.87	0.93	1.10	1.33	1.34	1.23	13.2%
UK	1.40	1.29	1.31	1.32	1.12	1.35	1.46	1.81	1.68	1.18	0.94	-3.3%
Total	27.02	26.87	26.61	28.52	27.07	27.08	28.97	31.91	33.39	32.06	33.93	2.6%

2.8.3 Sales breakdown

A more detailed break down of bunker sales by member state for 1999 is shown in the table below. This table shows both distillate and HFO bunker sales for international and internal use. The data for 2000 were not available at the time of writing.

BUNKER DEMAND IN EU-15 COUNTRIES - 1999									
Country **MT**	**International navigation**			**Domestic navigation (inland and coastal)**			**Total**		
	GO/DO	**HFO**	**TOTAL**	**GO/DO**	**HFO**	**TOTAL**	**GO/DO**	**HFO**	**TOTAL**
Austria	N/A	N/A	N/A	0.00	-	0.00	0.00	-	0.00
Belgium	0.57	3.95	4.52	0.08	0.19	0.27	0.65	4.14	4.79
Denmark	0.61	0.70	1.31	0.08	0.04	0.12	0.69	0.74	1.43
Finland	0.16	0.41	0.57	0.08	0.05	0.13	0.24	0.46	0.70
France	0.42	2.52	2.94	0.49	0.01	0.49	0.90	2.53	3.44
Germany	0.48	1.61	2.10	0.30	-	0.30	0.78	1.61	2.39
Greece	0.71	2.45	3.16	0.29	0.59	0.88	1.00	3.04	4.04
Ireland	0.12	0.05	0.17	0.02	0.02	0.04	0.14	0.07	0.21
Italy	0.79	1.63	2.43	0.22	-	0.22	1.02	1.63	2.65
Luxembourg	N/A	N/A	N/A	-	-	-	-	-	-
Netherlands	2.01	10.93	12.94	0.66	-	0.66	2.67	10.93	13.60
Portugal	0.18	0.42	0.60	0.04	-	0.04	0.22	0.42	0.64
Spain	1.15	4.87	6.02	1.35	0.23	1.58	2.50	5.10	7.60
Sweden	0.22	1.34	1.55	0.10	0.04	0.14	0.32	1.37	1.69
UK	1.15	1.18	2.33	0.92	0.07	0.99	2.07	1.25	3.32
Total EU-15	8.57	32.06	40.63	4.63	1.23	5.86	13.20	33.29	46.49
% split (EU-15)	21%	79%		79%	21%		28%	72%	

HFO bunker demand used for domestic navigation was just over 1 MT and relatively small compared to international bunkers. MGO/MDO use is more significant totalling 4.6 MT and representing over one third of total MGO/MDO bunker sales in the EU-15.

2.8.4 Main EU-15 bunkering ports

The main bunkering ports in the EU and estimated bunker sales are shown in the table below.

BUNKER SALES IN MAJOR EU-15 PORTS (1999)		
Main EU-15 ports	**Country**	**MT/yr**
ROTTERDAM	NL	9.00
ANTWERP	B	3.60
GIBRALTAR	Sp	2.50
PIRAEUS	Gr	2.00
LAS PALMAS	Sp	1.62
MARSEILLE/FOS/LAVERA	F	1.60
AMSTERDAM	NL	1.50
ALGECIRAS	Sp	1.42
TENERIFE	Sp	0.90
VALETTA	Mal	0.90
ISTANBUL	Tk	*0.83*
GENOA	It	0.80
HAMBURG	D	*0.65*
CEUTA	Sp	0.54
COPENHAGEN	Dk	*0.40*
DUNKERQUE	F	0.38
AUGUSTA	It	*0.36*
LE HAVRE	F	0.36
ZEEBRUGGE	B	*0.35*
GOTHENBURG	Sw	*0.33*
NANTES-ST-NAZAIRE	F	0.26
LISBON	Por	*0.25*
BREMEN	D	*0.22*
BARCELONA	Sp	0.20
LEGORNO	It	*0.20*
THESSALONIKI	Gr	*0.20*
TURKU	Fi	*0.20*
BERGEN	No	*0.19*
OPORTO	Por	*0.17*
VIGO	Sp	0.16

Notes: figures in Italics are estimates

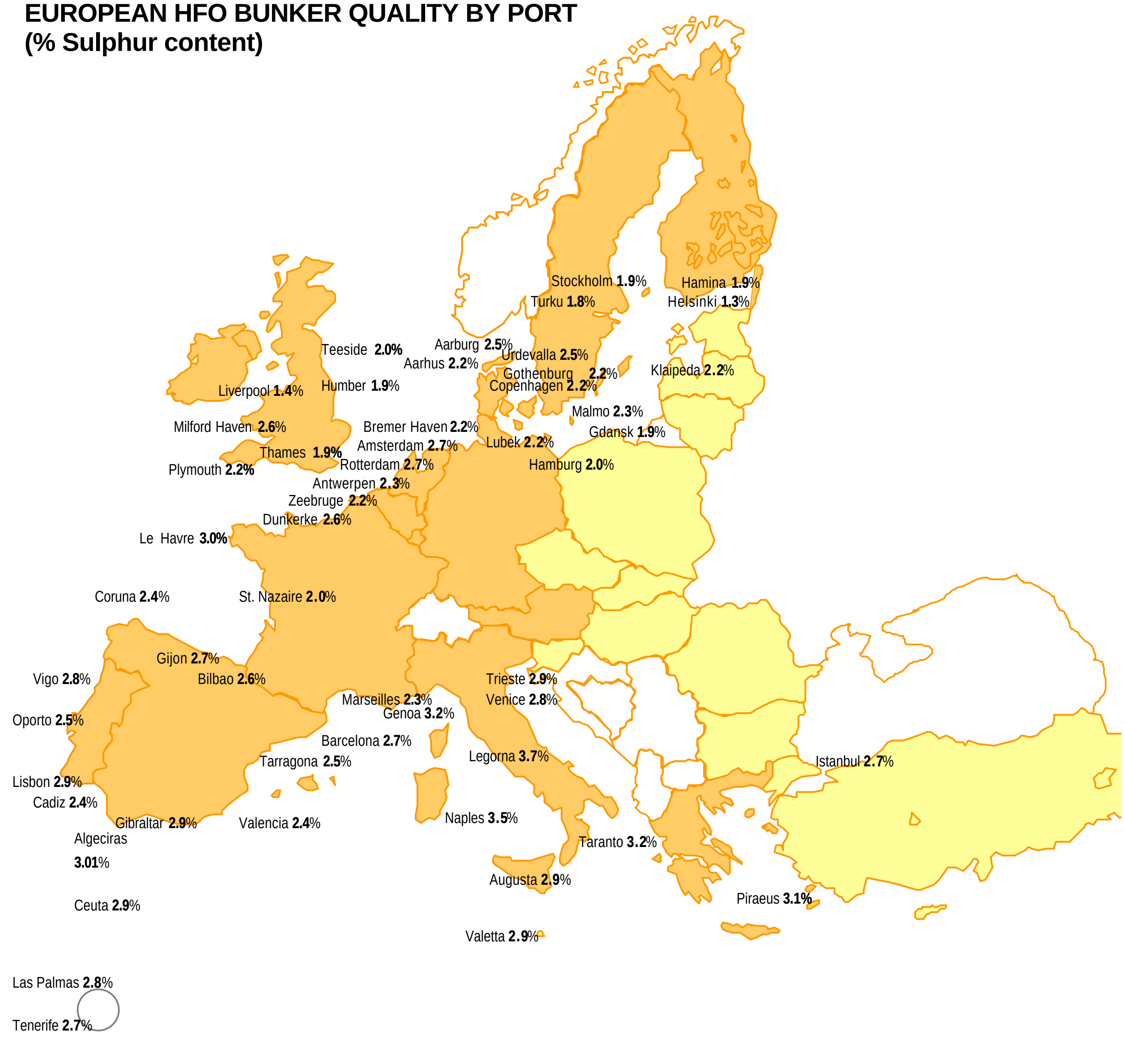
The Rotterdam, Amsterdam and Antwerp (ARA) ports total around 14 MT and around one third of EU-15 sales. The ports in and around Spain namely Gibraltar, Las Palmas, Algeciras and Tenerife also account for a significant share. The major bunker location in Greece is

Piraeus which ranks fourth with sales of around 2 MT per year. The major bunker ports are described in more detail later in this section.

2.8.5 HFO bunker quality

The following map shows the major bunker locations in the Europe and estimated HFO bunker quality. The quality data are based on all samples of HFO bunkers taken in 2001 by Det Norske Veritas (DNV). DNV are understood to carry out around 70% of bunker fuel testing. However, only around 25% of bunkers are believed to be tested.

EUROPEAN HFO BUNKER QUALITY BY PORT
(% Sulphur content)



Source: Det Norske Veritas

BUNKER SALES IN MAJOR EU-15 PORTS (1999)			
Port	**MT/yr**	**Port**	**MT/yr**
ROTTERDAM	9.00	TENERIFE	0.90
ANTWERP	3.60	VALETTA	0.90
GIBRALTAR	2.50	ISTANBUL	*0.83*
PIRAEUS	2.00	GENOA	0.80
LAS PALMAS	1.62	HAMBURG	*0.65*
MARSEILLE/FOS/LAVERA	1.60	CEUTA	0.54
AMSTERDAM	1.50	COPENHAGEN	*0.40*
ALGECIRAS	1.42	DUNKERQUE	0.38

Using the data provided by DNV, we have estimated the average HFO bunker sulphur contents for each member state and for the EU-15 as a whole. The estimates were based on a weighted average of the sulphur contents for each port taking account of the number of samples tested in each port.

HFO BUNKER FUEL SULPHUR CONTENT	
Country	**Average wt % S**
Belgium	2.3
Denmark	2.2
Finland	1.6
France	2.5
Germany	2.1
Greece	3.0
Ireland	1.3
Italy	3.1
Netherlands	2.6
Norway	2.0
Portugal	2.9
Spain	2.9
Sweden	2.3
United Kingdom	1.9
TOTAL EU-15	2.5

The overall weighted average sulphur content for EU sales of HFO bunkers is just over 2.5 wt% using this approach. This is a little lower than previous estimates of 2.7%S. However, it is likely to be within the range of error given that the samples tested probably represent a relatively low proportion of overall HFO bunkers sold.

As expected, the sulphur content of bunkers sold in the southern states is higher than in the north due to the higher sulphur content crude slate processed. Greece, Italy and Spain are all at or around the 3%S level. Netherlands averages 2.6%S while all the other northern countries are lower than this level. The average sulphur content for the northern states was estimated to be 2.4% while the average in the south was estimated at around 3%.

Surprisingly, the sulphur contents above are a little lower than the sulphur content of HFO bunkers produced by European refineries surveyed by CONCAWE (Section 3.1.3). The discrepancy could be due to the small proportion of DNV sampling in the overall context but more likely is due to the fact that the CONCAWE data is for 1998 while the DNV data is for 2001. It would be informative to request CONCAWE to ask their members to provide data for 2001.

2.9 EU ACCESSION COUNTRIES

2.9.1 Sales by candidate state

Bunker sales data for the EU accession countries is provided below for the 1990 to 1999 period.

ACCESSION CTS. TOTAL BUNKER SALES (HFO, DO, GO) (INTERNATIONAL) -MT

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Estonia	-	-	0.13	0.15	0.13	0.09	0.09	0.10	0.11	0.19
Latvia	-	-	-	-	-	-	-	-	-	-
Lithuania	-	-	0.30	0.16	0.16	0.14	0.13	0.06	0.05	0.07
Slovenia	-	-	-	-	-	-	-	-	-	-
Romania	-	-	-	-	-	-	-	-	0.11	-
Bulgaria	0.06	0.30	0.27	0.26	0.27	0.28	0.24	0.01	0.07	0.01
Malta	0.03	0.04	0.05	0.03	0.03	0.05	0.08	0.08	0.05	0.05
Cyprus	0.06	0.06	0.06	0.05	0.06	0.07	0.09	0.10	0.10	0.15
Czech Rep	-	-	-	-	-	-	-	-	-	-
Hungary	-	-	-	-	-	-	-	-	-	-
Poland	0.43	0.18	0.29	0.10	0.09	0.20	0.23	0.15	0.27	0.55
Slovak Rep	-	-	-	-	-	-	-	-	-	-
Turkey	0.12	0.13	0.11	0.10	0.11	0.19	0.13	0.16	0.16	0.28
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
Total	0.70	0.71	1.21	0.86	0.84	1.00	0.99	0.66	0.91	1.30

ACCESSION COUNTRIES MARINE DISTILLATE SALES (INTERNATIONAL) -MT

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Estonia	-	-	0.04	0.07	0.06	0.04	0.04	0.03	0.03	0.05
Latvia	-	-	-	-	-	-	-	-	-	-
Lithuania	-	-	-	-	-	-	-	0.01	0.02	0.02
Slovenia	-	-	-	-	-	-	-	-	-	-
Romania	-	-	-	-	-	-	-	-	0.03	-
Bulgaria	-	0.08	0.06	0.06	0.05	0.06	0.06	0.01	0.07	0.01
Malta	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cyprus	0.02	0.02	0.02	0.01	0.01	0.02	0.03	0.03	0.04	0.05
Czech Rep	-	-	-	-	-	-	-	-	-	-
Hungary	-	-	-	-	-	-	-	-	-	-
Poland	0.15	0.07	0.10	0.06	0.02	0.05	0.04	0.02	0.07	0.11
Slovak Rep	-	-	-	-	-	-	-	-	-	-
Turkey	0.07	0.08	0.07	0.06	0.07	0.12	0.08	0.09	0.07	0.15
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
Total	0.27	0.27	0.32	0.28	0.23	0.30	0.25	0.20	0.35	0.41

ACCESSION COUNTRIES HFO SALES (INTERNATIONAL) -MT										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Estonia	-	-	0.08	0.08	0.07	0.05	0.06	0.07	0.08	0.13
Latvia	-	-	-	-	-	-	-	-	-	-
Lithuania	-	-	0.30	0.16	0.16	0.14	0.13	0.06	0.03	0.05
Slovenia	-	-	-	-	-	-	-	-	-	-
Romania	-	-	-	-	-	-	-	-	0.08	-
Bulgaria	0.06	0.22	0.21	0.21	0.21	0.21	0.18	-	-	0.00
Malta	0.01	0.02	0.03	0.01	0.01	0.03	0.06	0.06	0.03	0.03
Cyprus	0.03	0.04	0.04	0.04	0.05	0.05	0.07	0.07	0.06	0.11
Czech Rep	-	-	-	-	-	-	-	-	-	-
Hungary	-	-	-	-	-	-	-	-	-	-
Poland	0.28	0.11	0.19	0.04	0.08	0.15	0.19	0.14	0.20	0.44
Slovak Rep	-	-	-	-	-	-	-	-	-	-
Turkey	0.05	0.05	0.04	0.04	0.05	0.07	0.05	0.07	0.09	0.14
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
Total	0.43	0.44	0.89	0.58	0.61	0.70	0.74	0.46	0.56	0.90

Note that the bunker sales reported by the IEA, the main source of data used, vary from year to year. These data may be somewhat unreliable therefore. For example, Bulgaria shows close to 0.3 MT per year of bunker sales through 1996 but then drops to close to zero in later years which seems unlikely. We have not been able to confirm these data. However, in the context of the overall European bunker market the sales are very small in any case.

2.9.2 Sales breakdown

BUNKER DEMAND IN EU ACCESSION COUNTRIES – 1999									
Country MT	International navigation			Domestic navigation (inland & coastal)			Total		
	GO/DO	HFO	TOTAL	GO/DO	HFO	TOTAL	GO/DO	HFO	TOTAL
Bulgaria	0.01	0.00	0.01	-	0.00	0.00	0.01	0.00	0.01
Cyprus	0.05	0.11	0.15	-	-	-	0.05	0.11	0.15
Estonia	0.05	0.13	0.19	0.01	-	0.01	0.06	0.13	0.19
Latvia	-	-	-	0.01	0.00	0.02	0.01	0.00	0.02
Lithuania	0.02	0.05	0.07	0.00	-	0.00	0.03	0.05	0.08
Malta	0.02	0.03	0.05	-	-	-	0.02	0.03	0.05
Poland	0.11	0.44	0.55	0.02	-	0.02	0.13	0.44	0.57
Romania	-	-	-	0.06	0.16	0.22	0.06	0.16	0.22
Turkey	0.15	0.14	0.28	0.11	0.10	0.21	0.25	0.24	0.49
Slovenia	-	-	-	-	-	-	-	-	-
Czech Republic	N/A	N/A	N/A	-	-	-	-	-	-
Hungary	N/A	N/A	N/A	-	-	-	-	-	-
Slovak Republic	N/A	N/A	N/A	-	-	-	-	-	-
Total	0.41	0.90	1.31	0.21	0.26	0.48	0.62	1.16	1.78

As in the EU-15, bunker sales for internal use are lower than international sales but represent a higher proportion of total sales than for the current EU states.

2.9.3 HFO bunker quality

Some limited quality data were available for the bunkering ports in the accession countries. The data are shown on the European map provided above. The quality of the bunkers provided by the ports in accession countries does not vary greatly from the quality supplied by EU-15 ports in the same regions. For example, sulphur contents of 1.9 wt% and 2.2 wt% respectively are reported for Tallinn, Estonia and Klaipeda, Lithuania respectively. These sulphur contents are similar to the bunker sulphur contents reported for many of the ports in Sweden. Similarly, a sulphur content of 2.9%S is reported for Valetta, Malta and 2.7%S for Istanbul which are also in line with values reported for Greece, Italy and Spain.

2.10 EUROPEAN BUNKER MARKET

The European bunker market can be broadly divided into the following regions:

- South Europe: Mediterranean
- North Europe: ARA (Belgium-Netherlands) and the Baltic.
- Other: Canary Islands

2.10.1 Mediterranean market

There are over 250 ports in the Mediterranean. The Mediterranean ports are a large set of niche markets. Three of the main determinants of the Mediterranean bunker market are:

- The running of East-West traffic lanes.
- High number of cruise ships
- Prices generally lower than in the ARA region.

With more than 6 MT Spain dominates the Mediterranean market, followed by Greece, France and Italy. Spain holds the largest share of the fishing fleet in the EU (nearly 30% by tonnage). Spain also holds 3 of the 4 largest bunkering centres in south Europe.

France and Greece both have a similar-sized bunker market (3 MT), while Italy's sales accounted for 2.4 MT. The major bunkering port in Greece (and in the Mediterranean) is Piraeus, with nearly two thirds of the Greek market (2 MT).

The major bunkering port in France is Marseilles/Fos, with sales of 1.2 MT. In Marseilles, the sales of HFO account for 92% of the bunker sales. Out of the 3 MT of bunker sales in France, in 2000, 84% were HFO, while 16% were distillates.

In Italy, of the total bunker sales volume, approximately 70% is fuel oil and 30% distillates. Out of the total volume sales in 1999, IFO 380 sales were about 1.5 MT while IFO 180 about 1 MT. Augusta and Genoa (both with around 0.75 MT) account for most of the Italian sales.

In the Mediterranean, there are three main bottlenecks ideal for 'bunker-only' calls:

- West Med: Algeciras – Gibraltar – Ceuta
- Eastern Med: Piraeus and the Bosphorous strait.
- Suez Canal

2.10.1.1 Suez Canal

More than 17,000 ships transit the Suez Canal every year, and its strategic position as a entry to the Mediterranean make it an ideal location for bunkering. Suez holds sufficient captive demand, oil and enough refining capacity.

Bunker sales in the Suez Canal, including fuel oil and gasoil (MGO), are estimated at nearly 3 MT/yr. All companies in the Suez area deliver fuel by barge.

Regarding availability, port authorities claim that fuel oil from 30 cSt and up to 380 cSt is available. Marine diesel oil (MDO) is not available in this area. All residual fuel oil is sourced from Egyptian refineries owned by the EGPC, whereas distillates (MGO) are a mix of imported and local product.

2.10.1.2 Gibraltar strait

Gibraltar Strait is one of the leading world bunkering centres, with a combined sales of 4.8 MT/yr. Around 80,000 potential customers pass by the region's every year.

The three ‘bunker-only’ ports that are located strategically on the strait are the Spanish port of Algeciras, the British-owned Gibraltar; and the Spanish enclave of Ceuta on the north African coastline. Gibraltar bunker sales were estimated at 2.5 MT in 2000, while Algeciras recorded sales of 1.4 MT in the same year. A decade ago, Algeciras was supplying 0.72 MT compared to Gibraltar’s 0.52 MT.

Bunkering activities have increase significantly in Gibraltar. For instance, in 1989, only 932 of the deep-sea merchant ships arriving in Gibraltar listed bunkering as their main purpose for calling. By 1996, more than 2,500 ships were calling at Gibraltar primarily to lift bunkers.

CEPSA's Refineria Gibraltar 205,000 B/D refinery in Campo de Gibraltar is the centre for the regions bunkering operations, providing fuel for all the three markets.

2.10.1.3 Las Palmas and Tenerife

The Canary Islands, a group of 7 islands that are under Spanish jurisdiction, are strategically situated for 'bunker only' calls. The two best known bunker ports in the Canary Islands are Las Palmas on Gran Canaria and Santa Cruz de Tenerife, known just as Tenerife. In the year 2000, the two ports recorded sales of 2.5 MT.

Las Palmas has an annual bunkers turnover of roughly 1.6 MT, out of which distillates account for around 1 MT due to the many fishing vessels calling at the port.

Traditionally, the major group of bunker buyers at Las Palmas are fishing fleets operating in the Atlantic - both Spanish and several Far Eastern fleets. However, this trend is reversing, and the fuel oil is gaining share at the distillates expenses. The principal reason is the reduction of fishing activities in the area.

The main source of bunker fuels is the Tenerife refinery operated by Compania Espanolas de Petroleos SA (CEPSA). Shell, an important distributor, obtains most of its gasoil from its own refineries in Rotterdam and Sicily, and only supplies gasoil with maximum 0.5% sulphur content.

2.10.1.4 Valleta and Istanbul

Two ports of growing bunker market participation in the Mediterranean are Valletta in Malta (0.9 MT in 2000) and Istanbul (0.8 MT). Both ports are bunkering only calls. Malta's market share increase has been mostly due to the deregulation process in port activities, and to the constant opening of offshore bunkering facilities. Although prices in Malta are higher than elsewhere (there is no refinery in the island), its location is of particular interest to shipowners. This has resulted in some of Malta's market share been taken away from the Sicilian port of Augusta.

On the East Mediterranean, Istanbul has being gaining market share at Greece's ports expenses. A higher transit of ships crossing the Bosphorous strait

2.10.1.5 North Africa

The north coast of Africa is rarely considered as a bunkering zone. Outside Egypt (Suez) and Ceuta, involvement in bunkers is negligible. Morocco lacks of a proper bunker port on its Mediterranean coast, while although Libya is currently the most significant development on the north African coast, its bunker sales are to date been negligible probably as the indigenous Libyan crude is low in sulphur content and so low priced high sulphur bunkers would not be available unless imported.

2.10.1.6 Future outlook

- Markets at the bottlenecks either end of the Mediterranean are the most stable and should grow in line with traffic volumes.
- Higher growth potential lies along the south rim.
- Cruise shipping is on the rise in the Mediterranean, increasing the scope for bunker sales.

2.10.2 North European market

After Singapore, the second world bunker supply centre is the ARA (Antwerp-Rotterdam-Amsterdam) region. ARA bunker sales account for nearly 50% of total European sales. Its success as a bunkering centre is based on its role as the European hub for international shipping in addition of being a major refining and distribution centre for oil. Similarly some of Europe's biggest refineries are located in ARA region.

2.10.2.1 Rotterdam

Rotterdam is one of the largest ports in the world with a throughput of more than 300 MT of cargo annually. Some 30,000 seagoing vessels call at the port every year, and 110,000 to 120,000 inland vessels. Bunker only calls are not frequent in Rotterdam because it is not a natural deviation route for vessels.

Although Rotterdam is a major European refining centre (4 refineries with a capacity of nearly 1 million B/D), due to the modernisation of the refineries they now produce less of the 3.0-3.5% sulphur fuel oil which is typically sold in the bunker market. As a result, the local refinery production can no longer cover bunker demand in the so-called ARA region, and the market relies on imported fuel oil cargoes from Russia (normally in the summer) and Venezuela.

Fuel quality

IFO380 is the most widely sold product, followed by IFO180, then MDO, with MGO accounting for the smallest share of bunker turnover.

ROTTERDAM BUNKER SALES (1995 - 2000) -MT						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
MGO	0.43	0.29	0.34	0.33	0.25	0.32
MDO	0.64	0.67	0.62	0.43	0.25	0.22
HFO/IFO	6.76	6.33	7.01	6.84	6.70	7.29
TOTAL	7.83	7.30	7.97	7.60	7.20	7.82

2.10.2.2 Antwerp

In addition to Rotterdam, Amsterdam and Antwerp are the other two main ports in the so-called ARA region. Notably smaller than Rotterdam, the size of the Antwerp bunker market is in the region of 3-4 MT/yr. The vast majority of fuel deliveries in Antwerp are made by barge, although there are occasional truck deliveries.

Five refineries in the Antwerp region (TotalFinaElf 270,000 barrels per day (B/D)), Flushing 150,000 B/D, ExxonMobil refinery 246,000 B/D, the 80,750 B/D Belgian Refining Corporation NV, 15,000 B/D Nynas Petroleum NV and 65,000 B/D Petroplus) supply most of the marine heavy fuel oil to the Belgian bunker market, although bunker suppliers may also rely on imports from other sources, including Russia.

2.10.2.3 Amsterdam

Although Amsterdam ranks as Europe's sixth bunkering port, its deliveries are significantly smaller than those in Rotterdam or Antwerp. Bunker sales are estimated at 1.5 MT annually, and the quality of sales can be compared to that sold in Rotterdam and in Antwerp.

2.10.2.4 Scandinavian and Baltic ports

The total market for bunkers in the Scandinavian countries is less than 5.0 MT/yr. Denmark, Sweden and Norway hold strategic positions on the entrance to the Baltic Sea, and enjoy a high volume of traffic on route to the rapidly growing ports in Russia, Poland, Estonia, Latvia and Lithuania.

In Sweden, where the bunker market is around 1.7 MT/yr, the port of Gothenburg on the west coast and the offshore waters around Gothenburg are the key bunkering centres. The port itself is a major terminal for tankers, dry bulk carriers, general cargo vessels and car carriers, and the biggest refining centre in Scandinavia. Bergen and Oslo are the leading bunkering centres in the relatively small Norwegian bunker market. Copenhagen and Aarhus lead the 1.4 MT Danish bunker market.

Scandinavian ports hold several advantages: sheltered waters, reliable suppliers, flexible operations. Similarly, ports in the region are increasingly 'environmentally' aware, through the provision of low-sulphur marine distillates.

Nevertheless, during the last five years, the sales volume in Scandinavia is said to have greatly decreased, mostly due to continuously increasing competition from the Baltic ports, notably Tallinn in Estonia, ice-free and navigable all year round, Ventspils, in Latvia, the largest crude oil and oil product terminal on the Baltic Sea, and Kaliningrad and St Petersburg in Russia.

2.11 EUROPEAN BUNKER SALES PROJECTION

2.11.1 International bunkers

World bunker fuel demand has grown steadily in the nineties at around 2% per year on average with growth somewhat stronger in the second half of the decade than in the first half. EU bunker demand grew at a similar rate but with very little growth in the first half of the decade and stronger growth in the second half. Overall bunker demand can be expected to continue to grow as world trade continues to increase. However, the replacement of older ships is gathering pace and more efficient ships are taking their place. These efficiency gains are likely to offset to some extent the increases in trade. Overall it is expected that bunker demand in total will grow in the 1.5% to 2% per year range over the next ten years.

More uncertain is the relative growth rates of HFO compared to marine distillates. Marine distillate growth in Europe has been weak, and actually fell in the second half of the nineties. This compares to steady growth of 3% per year on a worldwide basis. This suggests that Europe may have been losing some of the marine distillate market to other regions. In addition, the practice of switching fuels from HFO to MDO for manoeuvring in ports is not necessary with newer vessels which can operate on HFO all the time due to the installation of fuel heating systems.

Two of the main determinants for the uptake of marine distillates are the move towards lighter and faster vessels and the growth of the cruise ship industry to provide for increasing numbers of tourists. However these growth trends may be offset by increased efficiency of the fishing fleets, leading to lower demand for marine distillates from this sector.

These trends are likely to continue and it is expected that growth for HFO bunkers will be in the 1.5% to 2% range annually while marine distillate growth will be closer to 1% annually. This results in international HFO bunkers increasing to just over 40 MT in 2010 and marine distillate increasing to just over 9 MT by 2010.

2.11.2 Marine fuels for domestic use

The marine fuel demand trends for domestic use in inland waterways and coastal shipping within the EU-15 have been rather different from the international bunker trends. HFO bunkers grew by just over 1% per year through the nineties with stronger growth in the early nineties and little growth in the second half of the decade. Marine distillate meanwhile declined steadily throughout the decade with demand falling by an average 1.7% per year. A continuation of these trends is expected resulting in HFO demand just under 1.4 MT and marine distillate demand of just under 4 MT in 2010.

2.12 WORLD BUNKER MARKET

2.12.1 World market

The world bunker market is portrayed in the next paragraphs. The section describes the leading bunkering centres and briefly explains why they have reached this position.

The world bunker market is estimated at 140 MT per year, equivalent to $15 billion[1]. With more than 25 MT, the US is the world leading country regarding bunker sales. Over the 1990-1999 period, world bunker sales have grown an average 3.4% per year. Nevertheless, they only reached their 1973 volume sales figures in 1997 (126 MT).

Most of the world bunker sales are HFO. The market share of sales of HFO is 80%, from a 89% in the early 70s. This can be explained by the increase of smaller type of vessels, the fishing fleet, and the fact that modern engines are less constrained by the type of fuel they burn.

2.12.2 Major world ports

The world's largest bunkering ports are Singapore, Fujairah, Rotterdam, Busan (South Korea), Antwerp, Hong Kong, Suez, Panama, Houston and Gibraltar. Leading bunkering ports are also refining centres or close to refining centres. From the table below, it can be seen that the bunker market volume covered by 29 major world ports accounts for 68.5 MT/yr, equivalent to 50% of the world market.

In 2000, bunker sales in Singapore alone account for over 20 MT/yr, while the bunkers supplied in the ARA region reached 14.1 MT/yr. South Korea is the world's third bunkering region, with over 12 MT/yr. The west entry to the Mediterranean, Gibraltar-Algeciras-Ceuta, reached over 5.0 MT/yr.

2.12.2.1 Singapore

The Port of Singapore is the world's busiest port in terms of shipping tonnage. In terms of vessel arrivals, the port attracted more than 146,000 calls in 2001. Singapore's dominance as a bunker market is guaranteed by the combination of its vast maritime trade and its role as a global refining and cargo centre, with a capacity of refining 1.2 million B/D of crude oil. The result is that a total of 20.4 MT of bunkers were sold in Singapore in 2001 (around 15% of the global bunker market).

SINGAPORE BUNKER SALES (1998 – 2001) -MT				
	1998	**1999**	**2000**	**2001**
MGO	1.36	1.34	1.26	1.68
MDO	0.42	0.40	0.30	0.25
IFO 180 cst	3.66	3.66	3.18	3.21
IFO 380 cst	11.82	12.75	13.24	14.67
Others	0.80	0.74	0.68	0.55
TOTAL	18.06	18.89	18.65	20.35

[1] This figure only includes 'international' sales of both distillates and heavy fuel oils.

Regarding sulphur content, because of the availability of domestic sweet crudes in countries such as China, Indonesia, and Malaysia, average fuel sulphur levels are often lower than the maximum specifications. However, as production of sweet crude in the region is stagnating, dependence on mid and high-sulphur crudes from the Middle East is likely to increase. Singapore has become a party to Annex VI of the International Maritime Organisation's (IMO's) International Convention for the Prevention of Pollution from Ships.

2.12.2.2 Fujairah

Fujairah in the United Arab Emirates is the world fourth largest bunkering area. Tankers transport bunkers from Arabian Gulf and Red Sea refineries to the port of Fujairah. From there, bunkers are delivered to tankers by barges and small bunkering tankers. The port is known for tankers awaiting loading instructions prior to entering the Arabian Gulf. Tankers are the dominant buyer group. Around 95% of the supplies are made off-shore.

Fujairah has been one of the cheapest and of the fastest growing bunkering centres. This market came into prominence as a result of the Iran/Iraq war in the 1980's. Three United Arab Emirates ports of Khor Fakkan, Fujairah and Kalba, and their off-shore sector, constitute "the Fujairah bunker market". Sales at Fujairah are estimated at 11.5 MT/yr, but it is unclear whether this volume includes export figures to nearby countries such as Pakistan.

There is no bunker fuel indigenously available at Fujairah, thus product has to be imported from refineries in the Gulf region, i.e. from Bahrain National Oil Co’s, Aramco’s Saudi refineries and from Iran’s NIOC. The products available in the port are generally 280 cSt and a DMA gasoil (MGO). In order to obtain lighter grades, it is necessary to blend down the 380 cst fuel oil.

Concerning marine diesel sales, there is generally no DMB available. The MDO marketed is a DMC grade, and is usually an MGO blended with fuel oil. In general MDO is not a popular product in Fujairah, as the blending of good quality gasoil with good quality fuel oil does not necessarily produce a good quality diesel oil.

Sulphur content in the crude oil processed in the refineries supplying Fujairah is high: fuel oil derived from Kuwait oil has a sulphur content ranging from 3.5 to 3.9%. As a result, HFO bunkers loaded in Fujairah are likely to be approaching the 4.5wt% sulphur content limit.

2.12.2.3 US ports

The US is the world leader in bunker sales (26 MT). There are three main bunkering regions in the US: the West Coast, the Gulf of Mexico and the East Coast.

The total East Coast bunker market is estimated to be around 4 MT/y. The market in this region is dominated by the ports of New York and Philadelphia, which have estimated annual bunker sales of 1.5 MT and 1.2 MT respectively. Regarding the HFO/MD split in New York, the demand for heavy fuel oil bunkers is rising, while the market for marine gas oil and diesel has been stationary for a number of years.

Refining capacity is ample, with around 15 refineries currently in operation in the region. Nonetheless, insufficient volumes of HFO are produced to meet local demand. Product has to be imported from abroad, and in particular from Venezuela.

On the US Gulf coast the bunker market is dominated by hubs centred around Houston (the leading US bunker port) and New Orleans, which account for annual sales volumes of around 2.7 MT and 2.5 MT respectively.

Both in Houston and in New Orleans, no local refineries produce material for the bunker market, forcing suppliers have to blend their own. The main producer of source material is the Marathon Ashland refinery, which provides between 50% and 60% of the market's requirement. Other refineries involved in the market are the ExxonMobil's Chalmette refinery and the Motiva's Convent plant.

The West Coast market is dominated by Los Angeles, with 2.5 MT/yr, followed by San Francisco (1 MT/yr). One of the main supply issues in California is that refining capacity has been reduced over the last decade in the wake of strict state air-pollution legislation.

At the northern end of the US West Coast, the key bunker centre is Seattle, with 1.5 MT/yr. At the end of the 1990s, demand along the northern ports of the US suffered harshly following the Asian economic crisis. Bunker sales dropped in line with fewer vessel calls. Now that the recovery is well and truly under way on the opposite side of the Pacific, things are expected to improve again.

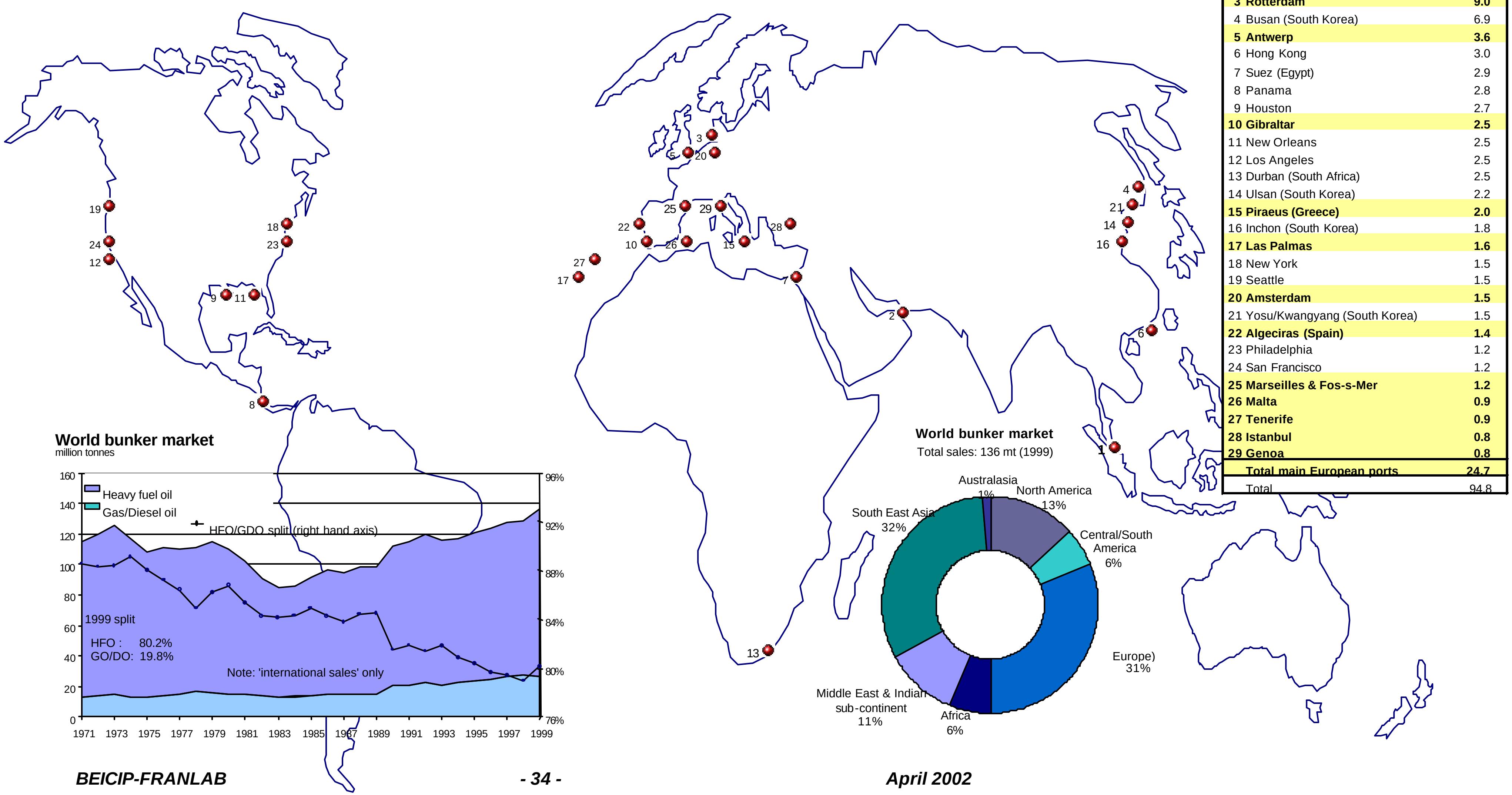
Product for the northern West Coast bunker market comes mainly from refining capacity operated in Washington state by Tesoro and Texaco-Shell west-US refining.

2.12.2.4 South Korean ports

After Singapore and the ARA region, the Korean bunker market is the third largest bunker market in the world, with sales reaching more than 12 MT per year. The leading bunkering port is Busan, with more than 50% of the market share (6.9 MT).

Busan is followed by Ulsan and Inchon, each with around 15% of the total South Korean market (2.2 MT and 1.8 MT respectively). The fourth port, Yosu/Kwangyang supplies over 1.5 MT.

World bunker market



World major bunkering ports	mt/year
1 Singapore	20.4
2 Fujiarah/Khor Fakkan/Kara (UAE)	11.5
3 Rotterdam	**9.0**
4 Busan (South Korea)	6.9
5 Antwerp	**3.6**
6 Hong Kong	3.0
7 Suez (Egypt)	2.9
8 Panama	2.8
9 Houston	2.7
10 Gibraltar	**2.5**
11 New Orleans	2.5
12 Los Angeles	2.5
13 Durban (South Africa)	2.5
14 Ulsan (South Korea)	2.2
15 Piraeus (Greece)	**2.0**
16 Inchon (South Korea)	1.8
17 Las Palmas	**1.6**
18 New York	1.5
19 Seattle	1.5
20 Amsterdam	**1.5**
21 Yosu/Kwangyang (South Korea)	1.5
22 Algeciras (Spain)	**1.4**
23 Philadelphia	1.2
24 San Francisco	1.2
25 Marseilles & Fos-s-Mer	**1.2**
26 Malta	**0.9**
27 Tenerife	**0.9**
28 Istanbul	**0.8**
29 Genoa	**0.8**
Total main European ports	**24.7**
Total	94.8

3 MARINE GASOIL/DIESEL SUPPLY

As discussed above, in this study marine gasoil/diesel is considered to cover fuels supplied meeting the ISO specifications DMX, DMA, DMB and DMC. DMA is generally considered to be the main grade supplied as MGO while DMC is usually supplied for MDO. DMX is higher in quality than DMA and can be considered in the MGO category. DMB has a higher viscosity than DMA and a lower cetane specification which may allow a small amount of residual fuel oil components to be used in its production. We have considered DMA and DMC grades for the subsequent analysis in this section.

The following options have been considered:

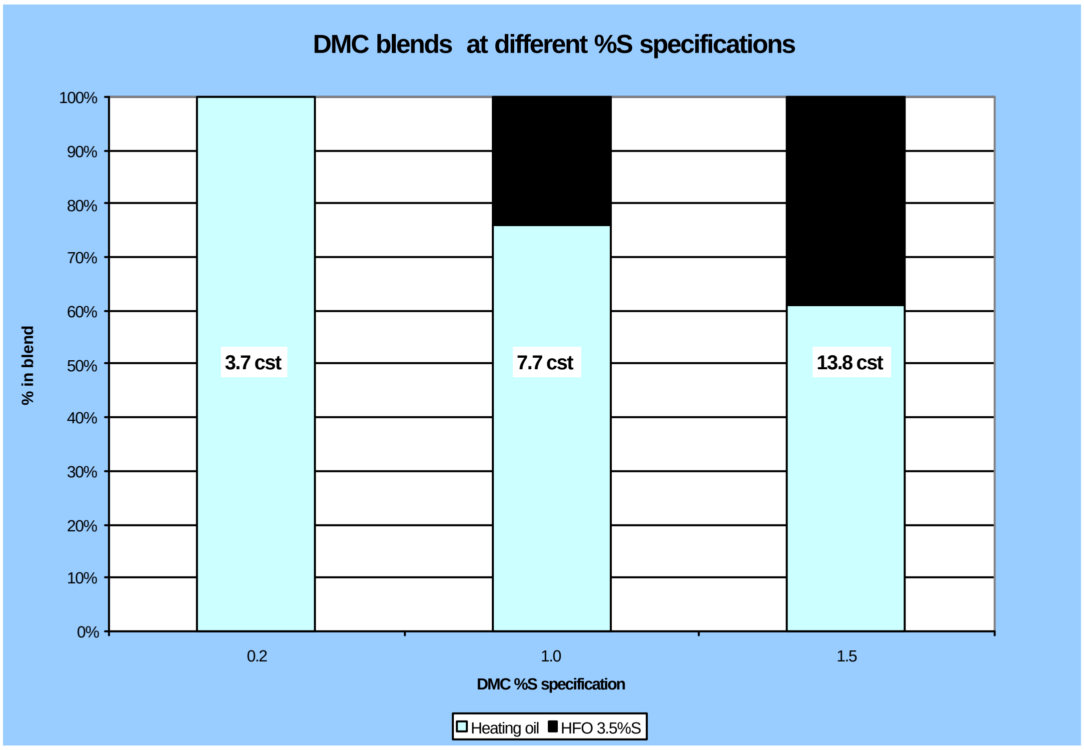
- Increasing the sulphur content limit for DMC grade from 0.2wt% to 1.5wt% or 1wt%.
- Supply of 8.4 MT of MGO at 0.2%S from 1st January 2005 and 0.1%S from 1st January 2008.
- Prohibiting the sale of MGO of above 0.2%S by 2005 and 0.1%S by 2008.

Each of these items is discussed in turn below.

3.1 CHANGE IN DMC GRADE SULPHUR CONTENT

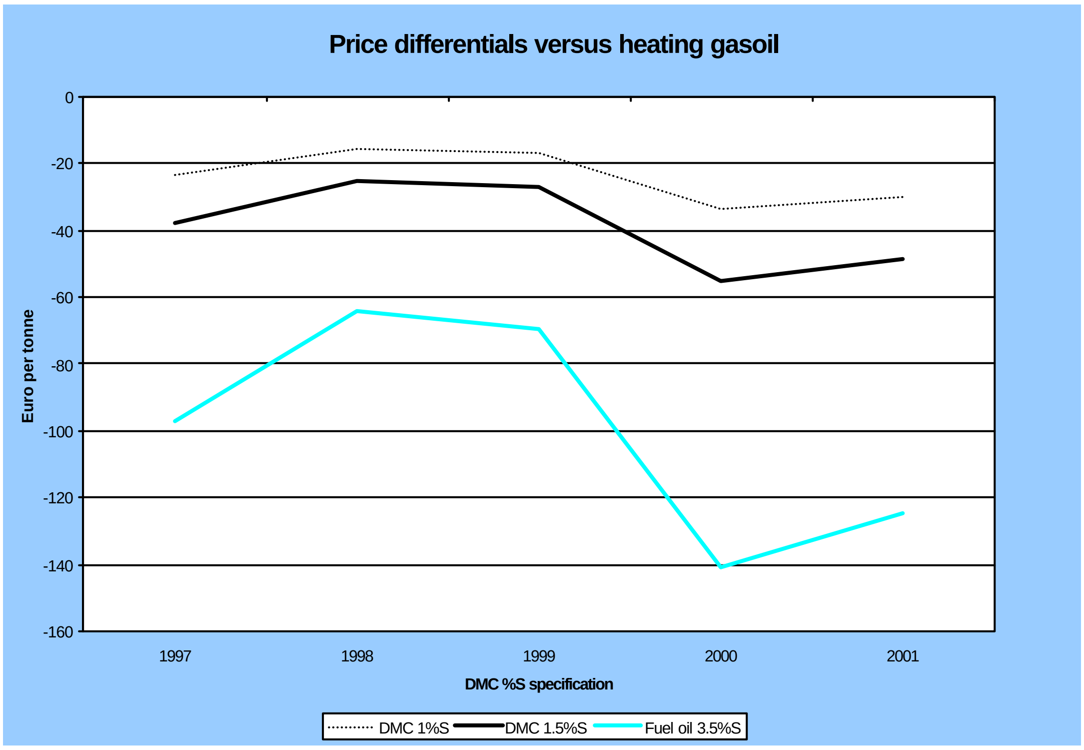
The ISO 8217 specifications for DMC grade fuel are such that refineries can produce such fuel by blending middle distillate with heavy fuel oil. The limitation on the amount of heavy fuel oil which can be blended into DMC is normally limited by the DMC viscosity specification, depending on the quality of the heavy fuel oil used for blending. The reduction of the sulphur content of DMC to 0.2%S from the prior specification of 2.0%S has meant that no heavy fuel oil can now be blended into DMC with a resulting increase in the cost of DMC to a level equivalent to heating gasoil

To estimate the costs of producing DMC, we have developed blends of DMC considering the viscosity specification and sulphur content specifications using heating gasoil and high sulphur fuel oil. The results are summarised in the figure shown below.



A 0.2%S specification on DMC prevents the addition of any heavy fuel oil since the heating gasoil is already at 0.2%S. The viscosity of the material is below 4 cst and well below the DMC specification of 14 cst @ 40°C. Increasing the DMC sulphur specification to 1%S allows the addition of 24wt% of HFO in the blend. The viscosity is still well below the DMC specification at under 8cst. Increasing the DMC sulphur content to 1.5%S allows the addition of 39wt% of heavy fuel oil. In this case, the viscosity of the DMC blend is now very close to the maximum specification of 14 cst. This means that no more high sulphur heavy fuel oil could be added even if the DMC sulphur content was higher than 1.5%S.

Using these blends of heating gasoil and high sulphur fuel oil the prices of the DMC blends were estimated using prices over the last 5 years. Since the 0.2%S case does not allow any addition of heavy fuel oil, the price of the 0.2%S DMC would be expected to be equivalent to the price of 0.2%S heating gasoil. For comparison purposes, the figure below shows the estimated price differential for the DMC 1%S, DMC 1.5%S and heavy fuel oil 3.5%S versus the heating gasoil price.



DMC 1.5%S bunkers would be expected to sell for between €25 and €55 per tonne less than heating gasoil with an average of €39 per tonne for the five year period. The variations are due to the variation in the price spread between heating gasoil and heavy fuel oil. The DMC 1%S bunkers would be expected to be more expensive moving in the range €15 to €34 Euro per tonne below heating gasoil, averaging €24 per tonne and €15 per tonne more costly than the DMC 1.5%S quality.

The bunker fuel market is very price sensitive and any increase in price of bunker fuel is likely to drive the non-captive EU market elsewhere. The above analysis shows that a 1.5%S limit on DMC is not likely to result in any major price difference between this quality and the ISO specification of 2%S since the viscosity limit on DMC is likely to limit the addition of any more heavy fuel oil to the blend. However, imposing a limit of 1%S will limit the addition of heavy fuel oil in the DMC and result in a significant increase in price due to the higher gasoil content required. This increase in price is expected to drive the non-captive DMC market outside of the EU where ships would be able to continue to buy DMC of higher sulphur content.

3.2 CHANGE IN MGO SULPHUR CONTENT

For the purposes of this analysis, we have considered the DMA grade as representative of MGO quality. DMA is produced from refinery middle distillate blending components. These same components are used for the production of on road diesel and heating gasoil. For a typical European catalytic cracking refinery the main blending components and indicative properties are shown below with the DMA and EN590 road diesel specifications for comparison.

MIDDLE DISTILLATE BLENDING COMPONENTS			
	Indicative Properties		
	Sulphur content, wt%	Cetane	Density, kg/m3
Straight run, low sulphur	0.3	51	847
Straight run, high sulphur	1.1	54	847
Light cycle oil	1.8	25	942
Kerosene	0.2	45	798
EN 590 Diesel	0.035	51	845
DMA – ISO 8217	1.5	40	890

Refineries would typically produce DMA from a blend of high sulphur straight run gasoil and light cycle oil. The cetane and density of the light cycle oil is such that very little can be used to produce EN590 diesel. However, it can be used to produce DMA due to its lower cetane and higher density specifications. Blending of these components would produce DMA with sulphur content at or close to the 1.5%S specification.

The sulphur content of middle distillates in refineries is reduced using desulphurisation processes. These processes have been widely used in the industry for many years. The reduction in diesel and heating oil sulphur content through the nineties and again in 2000 has resulted in full utilisation of the desulphuristion capacity in European refineries. Further reduction in the diesel sulphur content to 50ppm in 2005 and 10ppm later and the reduction in heating gasoil sulphur content in 2008 will result in the need for further addition of desulphurisation capacity and increase in severity. Any reduction in the sulphur content of other products produced from middle distillates, such as DMA, will require further addition of desulphurisation capacity in European refineries.

Using our European Index refineries we have simulated a typical blend of DMA consisting of high sulphur straight run gasoil and light cycle oil blended to the density and cetane limit. The resulting sulphur content of this DMA blend was 1.45% and close to the ISO 8217 specification. Current refinery desulphurisation processes remove in the range of 90% to 98% of the sulphur in the feed. This means that around 91% of the DMA blend would need to be desulphurised to produce a 0.2%S DMA product and around 98% would need to be desulphurised to produce a 0.1%S DMA product.

Based on this approach we have estimated the additional desulphurisation capacity which would be needed to produce 8.4 MT of DMA for the two cases. To produce 0.2%S DMA, additional hydrotreating capacity of 7.6 MT/yr would be required and 8.2 MT/yr would be required to meet 0.1%S. Using a typical size for desulphurisation unit of 1.5 MT/yr and a capital cost of €M95 along with appropriate operating costs we have estimated the price premium for low sulphur DMA compared to the current specification.

LOW SULPHUR DMA PRICE PREMIUM	
% Sulphur	Premium versus 1.5%S, €/tonne
0.2%S	12 - 19
0.1%S	14 - 21

The range is mainly a reflection of the assumption for the capital charge applied to the refining investments. The high end of the range represents a capital charge of 20% and is close to the level which oil companies have indicated they aim to achieve while the low end of the range is close to the level historically achieved by the refining industry.

The overall cost to the industry has been estimated based on the approach used in previous work for the European Commission and in Auto Oil 1. This approach estimates a Net Present Value (NPV) based on capital expenditure plus 9.75 times the annual operating cost. Total costs on this basis would be around €1.1 billion for the 0.2%S case and €1.2 billion for the 0.1%S case.

3.3 PROHIBITING THE SALE OF HIGH SULPHUR MGO

Prohibiting the sale of DMA or DMX with sulphur contents above 0.2%S in 2005 and 0.1%S in 2008 would be expected to result in price premia similar to those described above. As for DMC, the increase in price is likely to drive away the non-captive market for these products. The overall cost to the industry would be dependent on the amount of MGO still supplied to the captive market.

4 MARINE HEAVY FUEL OIL SUPPLY

As discussed earlier, marine heavy fuel oil (HFO) is generally considered to mean bunkers in the IFO 180 and IFO 380 categories. These HFO grades are currently produced by processing relatively high sulphur content crude oils, due to their relatively high sulphur content specification. However, the sulphur content of the bunker fuel produced in Europe is lower than the 4.5% global cap proposed by the IMO under MARPOL Annex VI, because the average sulphur content of the crude oil processed in Europe is relatively low. This is due to Europe's proximity to two major sources of low sulphur crude oil production namely the North Sea and North Western Africa. In addition, these low sulphur crude oils are also relatively low in density and so produce a relatively high yield of light products which is required for the European market.

The selection of crude oils processed by refineries is very complex and varies from refinery to refinery. The most important factors underlying the choice are the market for products from the refinery, the refinery configuration and location. Changing the crude slate of a given refinery will change the yields of the products produced. As a result, there is always some flexibility to change refinery product yields to meet changing market demand patterns by changing the crude slate.

Of course, changing the crude slate processed by any given refinery will change the feedstock costs for that refinery which in turn will affect the profitability of the refinery. The overall market structure of crude and product prices will not be affected by a change in one refinery's operation, however. If the overall market is changed, by a change in product specification for example, then it is possible that many refineries will see an incentive for changing their crude slate. A large change in demand for a particular type of crude can change the price of that quality of crude relative to other crudes due to the increased demand.

In the context of reducing sulphur content of HFO bunkers to 1.5% or below, it could be argued that European refineries could adjust their crude slates to produce the lower sulphur content HFO. As discussed below, low sulphur North Sea crude oil is exported outside of Europe so in theory there is some excess available. If this was not enough, additional imports from West Africa might be possible. However, the oil market is a global one and if Europe needed to buy additional low sulphur crude it would need to pay more than the price currently paid by the buyers of that crude oil who currently buy it for its low sulphur content and its relatively high content of light products.

If crude slate adjustment could not be used to produce the additional bunkers, the lower sulphur fuel would need to be produced by desulphurisation of the high sulphur residue. This represents the high cost end of the range but would ultimately be needed since crude supply may not be adjusted sufficiently. The lower the sulphur content of the bunker fuel needed to be supplied, the less potential there would be to use the crude slate adjustment option and consequently the harder it would be to avoid high cost desulphurisation investments.

These issues are discussed in more detail below. Firstly, information provided by CONCAWE on the current sulphur content of HFO produced in European refineries is discussed. Secondly, the crude oil supply to Europe is reviewed. Finally, the cost implications of supply of bunkers of lower sulphur content are discussed.

4.1 REFINERY SULPHUR CONTENT SURVEY

CONCAWE provided updated information for 1998 on the sulphur content of crude oil processed and heavy fuel oil produced from European refineries. The data were based on responses to a survey sent to CONCAWE members. Comparison of the reported crude oil processed in the CONCAWE survey with IEA data indicates that the CONCAWE data represents close to 80% of refinery capacity in terms of crude oil processed in 1998 in the region concerned.

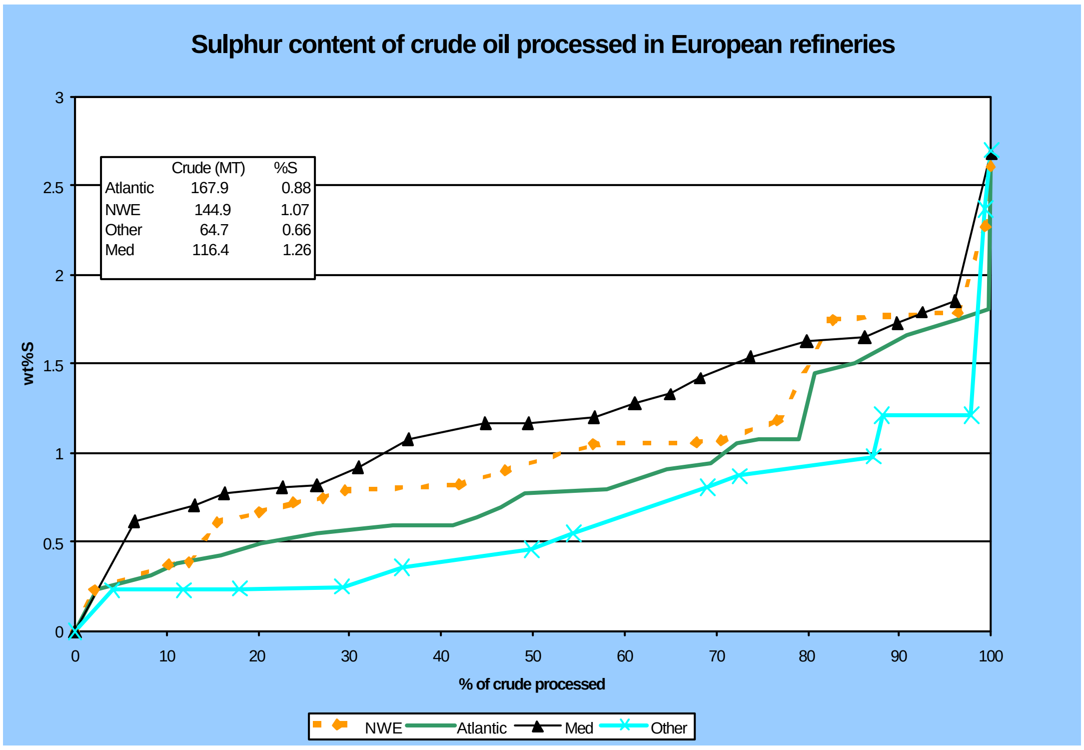
Information was collected from refineries operating in the following countries and arranged in the supply regions shown below.

CONCAWE SULPHUR CONTENT SURVEY SUPPLY REGIONS			
North West Europe	**Atlantic**	**Mediterranean**	**Other**
Belgium Denmark Germany Netherlands	Atlantic France Ireland Portugal Atlantic Spain UK	Greece Southern France Italy Other Spain	Austria Finland Hungary Norway Sweden Switzerland

The combination of the North West Europe, Atlantic and Other regions can be considered to represent Northern Europe. The sulphur content of the crude oil and other feedstocks processed, domestic HFO for non-marine use and bunker fuel produced was presented in tranches of production and on an overall average basis for each region.

4.1.1 Crude oil sulphur content

The data for the sulphur content of the crude oil processed in each region is presented graphically below.



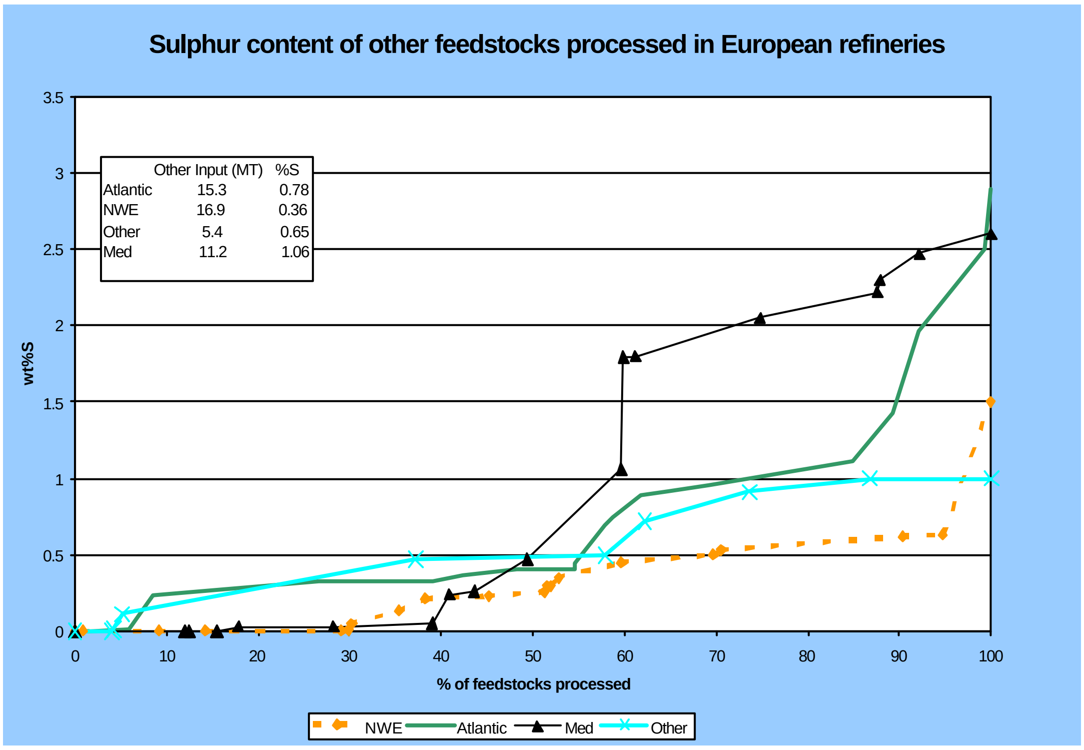
Typically, in order to produce heavy fuel oil with less than 1% sulphur content in a typical European refinery with catalytic cracking configuration, a crude oil feedstock with sulphur content in the 0.3% to 0.4% range is required. This is typical of North Sea crude oil quality. Inspection of the CONCAWE data indicates there is a number of refineries which process crude oil with average sulphur content of less than 0.4% in the Atlantic, North West European and Other zones but none in the Mediterranean. The total crude oil processed by these refineries represents 60 MT. The average heavy fuel oil yield in the same regions is just under 13% which would equate to production of around 7.8 MT of heavy fuel oil of less than 1%S. Taking a similar approach for 0.5%S and 1.5%S heavy fuel oil, crude oil of less than 0.2%S and 0.7%S would be required in each case. There are no refineries which report average sulphur content of crude processed of less than 0.2%. Around 120 MT of crude oil with average sulphur content of less than 0.7%S is processed in refineries in the Atlantic, NWE and Other regions, and around 7 MT is processed in the Mediterranean. Based on the average heavy fuel oil yields in each region, this would suggest about 15 MT of 1.5%S HFO might be produced in Northern Europe and around 1 MT in the Mediterranean. This production has to meet all needs and not just bunker fuel.

Of course, these refineries will be processing a blend of crude oils, some with sulphur content higher than the average and some lower than the average. It is possible that some additional segregation of crude oils, and the resultant heavy fuel oil production, could be achieved to increase the production of lower sulphur content heavy fuel oils but this cannot be guaranteed.

The crude oil processed in the refineries which responded to the CONCAWE survey totals 493.9 MT. This figure can be compared to the total crude oil intake reported by the IEA for the same countries of 638.2 MT for the same period. The reporting refineries therefore represent 77% of the crude oil processed in the region.

4.1.2 Refinery Feedstocks

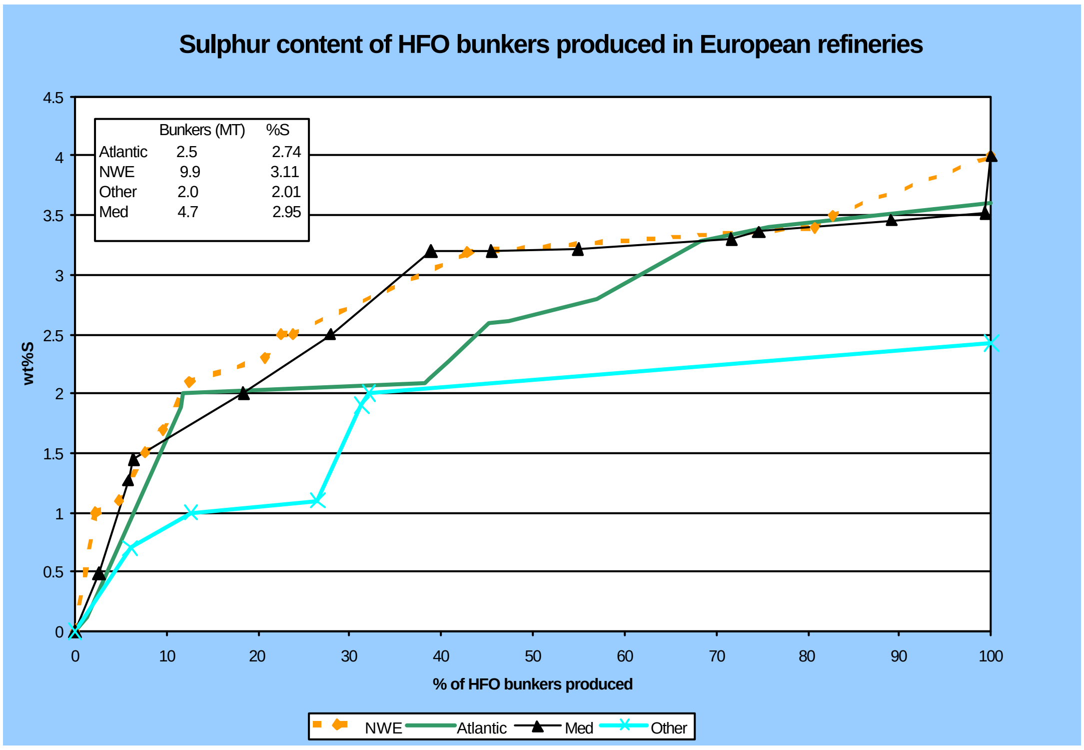
The data on the sulphur content of other refinery feedstocks is summarised below. The range of sulphur contents of other feedstocks is very wide. At the low and of the scale there are substantial quantities of feedstocks reported with sulphur contents of less than 0.1%S. These feedstocks are condensates or natural gas liquids which are very light and produce almost no heavy fuel oil. The feedstocks with higher sulphur contents will be straight run residues imported by refineries for further processing usually as feedstocks for residue upgrading units.



Some other indicative figures can be obtained through inspection of the sulphur content data for the bunker fuel and heavy fuel oil for inland uses themselves. Total bunker heavy fuel oil production was reported to be 19 MT in these countries. Norway is included in these data but represents only 0.4 MT of sales so any adjustment required is minimal. If the total bunker HFO production is pro-rated based on the 77% of crude oil proportion discussed above, a figure of around 25 MT of bunker fuel oil production in the EU-15 countries is obtained. Total sales of heavy fuel oil bunkers in the EU-15 were just over 33 MT in 1998 as discussed. This implies significant net imports of heavy fuel oil bunkers of around 8 MT for subsequent sale from EU countries. This is somewhat higher than the imports of 5 MT indicated in the BMT study.

4.1.3 HFO Bunkers

The sulphur contents of HFO bunkers sold from the refineries in the survey are summarised in the figure below.



The average sulphur content of HFO bunkers produced from these refineries overall in 1998 was 2.91wt% with an average for the Atlantic/NWE/Other of 2.89 wt% and 2.95 wt% in the Mediterranean. There is therefore a considerable quality margin between the sulphur content of the actual bunkers produced and the IMO specification of 4.5%.

In 1998, the quantity of bunkers produced broken down by sulphur content can be summarised as follows.

AVERAGE SULPHUR CONTENT OF HFO BUNKER PRODUCTION		
Sulphur content, wt%	Atlantic/NWE/Other (MT)	Mediterranean (MT)
< 0.5	0.04	0.12
< 1.0	0.52	0.12
< 1.5	1.33	0.30
Over 1.5	13.49	4.40

The table shows that there is just over 1.3 MT of HFO bunkers currently being produced at a sulphur content of below 1.5%S in the North of Europe. However, only 0.5 MT of production is below 1%S and a negligible amount is produced below 0.5%S. In the South, only 0.3 MT of HFO bunkers is produced at a sulphur content below 1.5%.

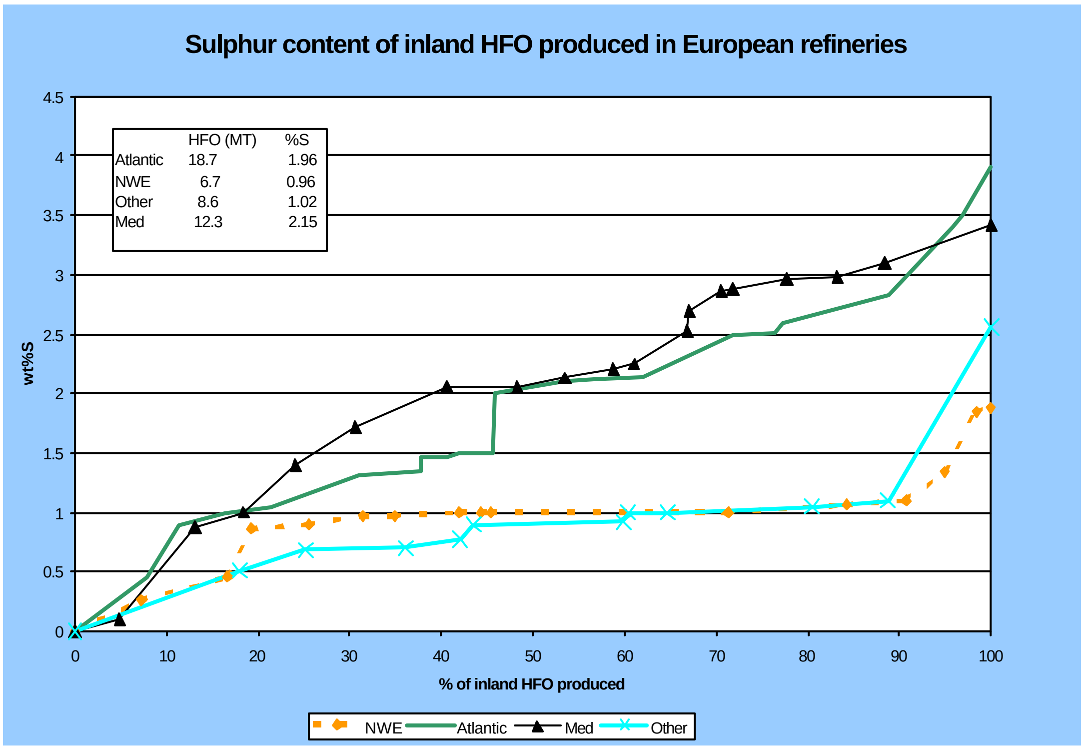
If it is assumed that the bunker fuel of less than 1.5%S currently produced can be blended with the next highest sulphur content production the amount of 1.5%S bunkers which could be made available would be extended. Using this approach suggests that around 4 MT of 1.5%S bunkers could be made available in North Europe and about 0.7 MT in the South. The sulphur content of the remaining high sulphur bunkers would increase to about 3.4 wt% in the North and 3.2 wt% in the South. These figures and those for a 1%S bunkers case are presented in the table below.

POTENTIAL LOW SULPHUR HFO BUNKER PRODUCTION BY REBLENDING		
HFO Bunkers Sulphur content, wt%	Atlantic/NWE/Other (MT)	Mediterranean (MT)
< 1.0	1.2	0.4
< 1.5	4.0	0.7

It should be noted that the segregation of low sulphur bunkers means that the sulphur content of the remaining bunkers will be increased. However, this higher sulphur content material is expected to be used for ship movements outside the SOx Emission Control Area, mostly on the high seas where it will have less environmental impact on acid-sensitive ecosystems and urban air quality..

4.1.4 HFO Inland

The data provided by CONCAWE also included information on inland heavy fuel oil sulphur content. These data are summarised in the figure below.



Inland heavy fuel oil production in the NorthWest Europe region averaged just under 1%S for the refineries surveyed. As the figure above shows, close to 90% of production in the region was below or very close to the 1%S level reflecting the widespread 1%S limit already applied in the region in 1998. However, production was under 7 MT. Similarly, in the Other region, mainly Scandinavia, nearly 90% of production was below or close to 1%S on average. Total production in this region is a little higher at nearly 9 MT.

The refineries in the Atlantic region produced nearly 19 MT of heavy fuel oil for inland use. The average sulphur content was much higher at nearly 2wt%S and only around 21% of production averaged below or close to the 1%S level. The spread of sulphur content was wide reflecting the continued use of high sulphur content fuel oil for inland use in countries such as Portugal and Spain while mainly 1%S was used in the UK and France.

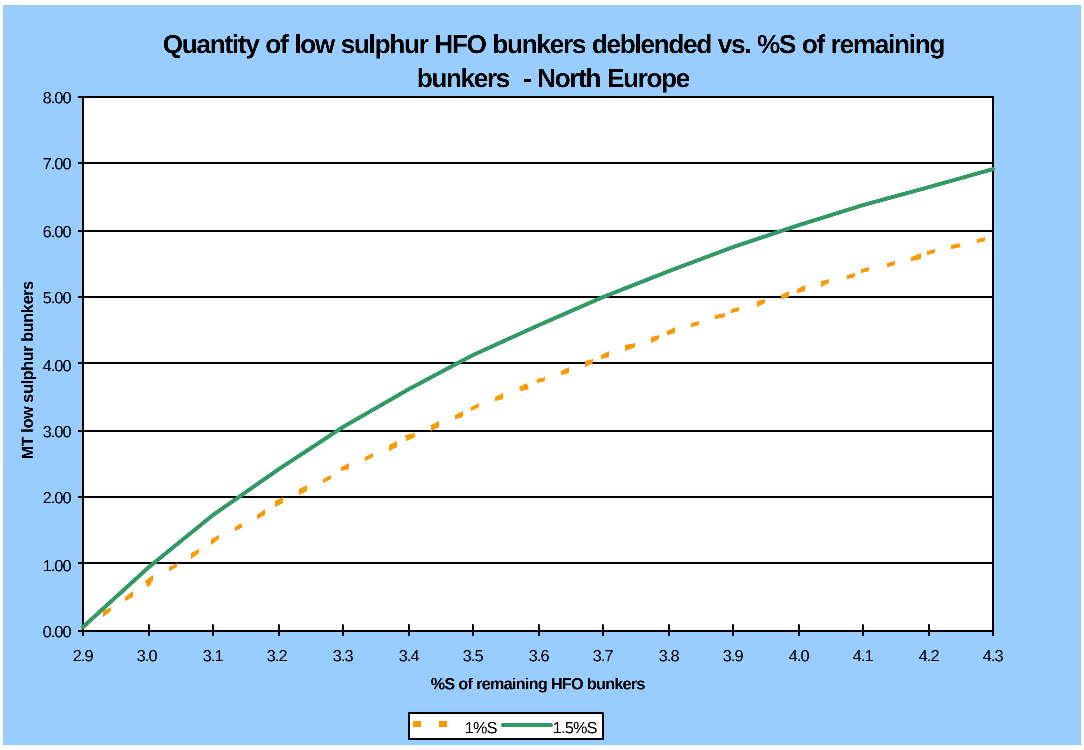
In the Mediterranean region, total production of inland heavy fuel oil for the reporting refineries was just over 12 MT. Only 18% of this production, representing around 2.3 MT was below 1%S on average. This is despite Europe's largest HFO market being in Italy where 1998 demand totalled around 23 MT of which nearly 12 MT was low sulphur fuel oil. The Italian statistics report imports of low sulphur fuel oil of around 7 MT in 1998 which implies production of low sulphur fuel oil in Italy of about 5 MT.

4.1.5 HFO Blending flexibility

Although production of low sulphur fuel oil for inland use in the EU-15 countries is significant, this does not imply that any of this material would be available for use as lower sulphur content bunker fuel. Indeed in the regions where inland HFO specifications are already at the 1%S level, the NWE and Other regions, nearly all the HFO production is made at or very close to this level. It is reasonable to assume that the inland HFO produced from EU-15 refineries is at or close to the specification limits. Any routing of 1.5%S material to the bunker fuel market from current inland HFO production is unlikely to be an option.

However, since the overall quality of the HFO bunkers produced is below the IMO specification there is likely to be some flexibility in the bunker fuel oil blending pool to segregate some 1.5%S, or lower, HFO bunkers. The quality of the HFO bunker blending components used in refineries will cover a range in sulphur contents. Thus to produce the overall average HFO bunkers sulphur content of 2.89wt% in the North Europe, blending components with sulphur contents higher and lower than this average would be used. Details of the blending components and their sulphur contents are not included in the CONCAWE data. However, at the high end of the scale it is unlikely that significant volumes of heavy fuel oil blending components with sulphur contents much above 4 wt% are likely to be available as most of the crudes processed in Europe would not produce fuel oil blending components with sulphur contents much higher than 4wt%. For example vacuum residue is one of the highest sulphur blending components used in heavy fuel oil blending. Vacuum residue produced from a Middle East crude oil such as Arabian Light, commonly processed in European refineries, would have a sulphur content of around 4.1wt% while vacuum residue produced from the Russian crude Urals, also widely processed, would be around 3.2 wt%.

Even if the highest sulphur components were segregated from 1.5%S bunkers, the remaining bunkers would still likely be below the 4.5%S IMO specification. This is important as the higher the sulphur content of the remaining high sulphur content bunkers, the more 1.5%S bunkers can be segregated from the blend. The figure below illustrates the point.

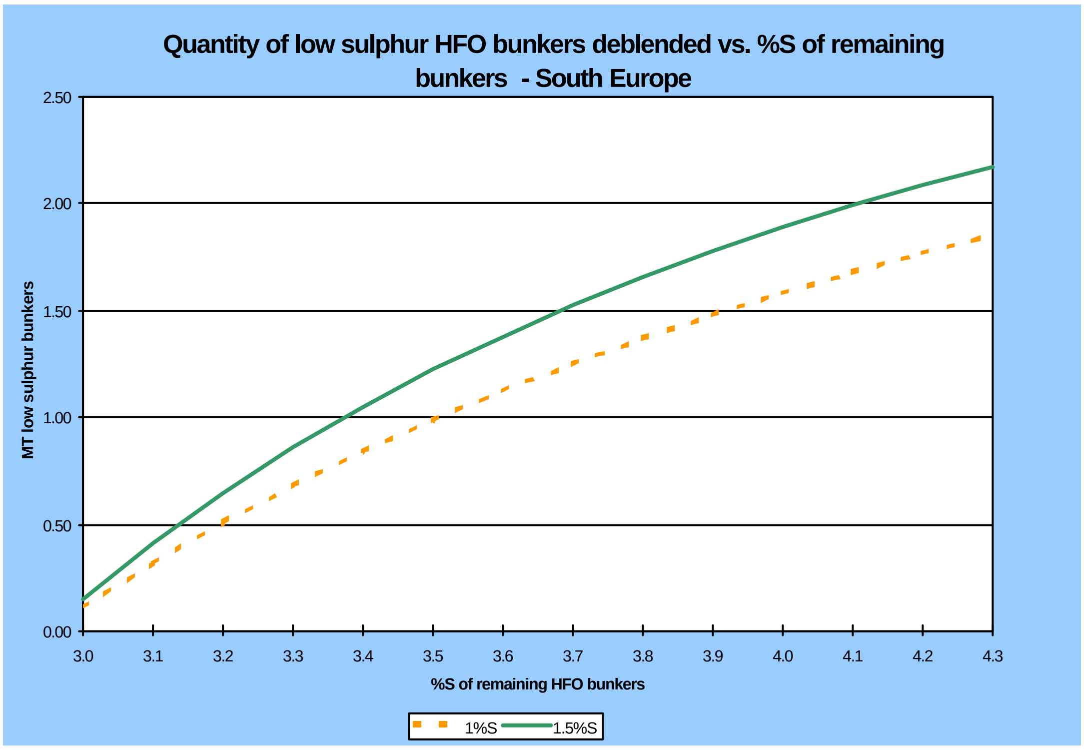


The figure shows that if 7 MT of 1.5%S bunkers could be segregated from the HFO bunker pool, the remaining HFO bunkers would have a sulphur content of around 4.3 %S, just within the IMO specification. As discussed above, most of the blending components in the HFO bunker blending pool are likely to have sulphur content of less then 4% so this case is unlikely to be achievable. Segregation of up to 4 MT of 1.5%S bunkers is more likely to be achievable which would leave the remaining pool at around 3.5%S. This compares to the similar figure obtained through reblending of the refinery production tranches discussed above.

It should be noted that although the amount of 1.5%S bunkers which can be segregated is calculated, the sulphur content of the remaining bunkers which can be achieved in practice is qualitative. More information on the range of sulphur contents used in bunker fuel blending components in refineries would be needed to confirm the achievable level. CONCAWE may be able to provide this information. However, the alternative approach of reblending of the tranches of refinery output discussed earlier supports this figure.

A similar plot is shown for the production of 1%S bunkers. In this case, the same issues apply but are stronger in that it is more questionable whether there would be the blending components available to produce the amount of 1%S bunkers indicated.

In the Mediterranean, the average sulphur content of the HFO bunkers produced was a little higher at 2.95 wt%. A similar plot was developed for South Europe as shown below.



If the same assumption is made in South Europe that the high sulphur bunkers are allowed to increase to 3.5%S, then it may be possible to release just over 1 MT of 1.5%S bunkers in the region. This compares to the actual 1998 figure of 0.3 MT of refinery HFO bunker production with average sulphur content below 1.5 wt%. The production of 1%S bunkers is even more questionable in the case of South Europe due to the lower proportion of low sulphur content crudes processed and the current import of low sulphur fuel oil to meet inland low sulphur demand in Italy.

4.2 CRUDE OIL SUPPLY TO EU REFINERIES

As discussed earlier EU refineries, particularly in North Europe, are located close to the North Sea, a major producing area of generally low sulphur content crude oil. Imports of crude to the EU are shown in the table below.

MAIN SUPPLIERS OF CRUDE OIL FOR THE EU						
MT	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Norway	101.3	110.5	113.0	113.2	106.0	113.2
FSU	57.2	64.6	65.0	67.9	78.8	88.9
Saudi Arabia	82.4	77.7	88.8	86.0	61.0	65.5
Libya	48.0	47.5	47.8	50.7	46.6	45.3
United Kingdom	42.7	50.4	50.9	49.7	49.2	45.0
Iran	52.4	49.3	42.8	46.5	42.0	35.3
Iraq	-	0.1	13.0	32.5	35.1	31.3
Nigeria	28.5	34.3	28.5	22.3	19.7	22.2
Algeria	12.5	14.4	12.9	13.6	12.9	16.5
Denmark	3.9	4.7	6.0	7.0	9.3	11.3
Kuwait	12.1	12.4	9.8	10.9	7.7	10.1
Mexico	7.2	6.5	8.5	10.1	9.1	9.8
Venezuela	9.9	7.8	8.6	8.5	8.3	7.0
Other Middle East	15.0	14.5	14.1	13.9	15.0	13.3
Total SWEET	237.0	261.8	258.9	256.5	243.7	253.4
	50.1%	*52.9%*	*50.8%*	*48.2%*	*48.7%*	*49.3%*
Total SOUR	236.4	233.0	250.5	276.2	256.9	261.0
	49.9%	*47.1%*	*49.2%*	*51.8%*	*51.3%*	*50.7%*
Total	473.4	494.8	509.4	532.7	500.6	514.4
	95.0%	*95.6%*	*96.4%*	*95.9%*	*95.5%*	*94.8%*
Total EU imports	498.1	517.4	528.3	555.5	524.5	542.6

It could be argued that it may be possible for EU refineries to process more North Sea crude oil to produce low sulphur HFO bunkers. The table below summarises recent production from the North Sea and imports to the EU.

NORTH SEA CRUDE OIL DISPOSITION					
MT	**1996**	**1997**	**1998**	**1999**	**2000**
Total Production	287.0	286.3	283.5	290.2	291.8
Norway	152.8	152.5	146.2	145.8	154.4
UK	121.9	120.3	124.2	128.3	118.4
Denmark	10.1	11.4	11.4	14.5	17.6
Netherlands	2.2	2.1	1.7	1.6	1.4
Own Use	65.2	63.3	60.9	60.3	49.5
EU Imports	165.6	169.9	169.9	164.5	169.5
Net Available	56.2	53.1	52.7	65.4	72.8

North Sea production has been relatively steady in the last five years with some decline in the UK being offset by increases in Norway and Denmark. Total production was nearly 292 MT (around 6.0 MB/D) in 2000. Consumption in refineries in these countries was around 60 MT in the 1996 to 1999 period but fell to 50 MT in 2000. The EU imports of North Sea crude oil were very steady in the 164 to 170 MT range.

The North Sea crude oil being exported outside of the EU has increased from the 50 to 60 MT range in 1996 to 1998 to nearly 73 MT in 2000. Most of this crude oil was exported to North America.

If this crude oil had all been processed in EU refineries around 9 MT of additional low sulphur fuel oil would be made available assuming an average fuel oil yield of around 13% based on the CONCAWE data.

It is generally accepted that North Sea crude production has reached its peak. Certainly the production levels in recent years tend to support this view. The question is how quickly will production levels decline. The UK is more mature in terms of development and this is perhaps reflected in the decline in production in 2000 and a further decline based in preliminary data for 2001. A decline rate of 3% per year would be required to eliminate the excess of 73 MT of crude oil by 2010. This decline rate is lower than many projections being put forward at the current time. It is therefore unlikely that an excess of North Sea crude oil would be available beyond 2010.

In any case, the processing of this additional North Sea crude to produce low sulphur bunkers would have an impact on the price of low sulphur crudes. Although under this scenario, the European industry would not incur the costs of capital investments, the sudden increase in demand for low sulphur crude would have an impact on the price of these types of crudes and European refiners would need to pay the increased price to ensure they secured the supplies. Ultimately, as the oil market is global, the increased demand for low sulphur crude in Europe would result in a shortage elsewhere in the world. Ultimately, refinery investments would be required somewhere in the world refining system to rebalance the supply of products. Until these investments are made, prices of low sulphur crude would reflect this change in the balance.

Looking further afield additional imports of low sulphur crude from West Africa could be considered. Again, the same issues arise regarding the impact on the price of low sulphur crudes.

Low sulphur crude oils are also relatively light with a higher yield of light products than heavier high sulphur crude oils and this is reflected in their higher prices. An important factor in crude oil selection considered by European refiners is the need to meet the required demand for valuable light products by making full use of the most profitable refinery units. The most profitable refinery units are those which convert fuel oil blending components to light products like cat crackers and hydrocrackers. If European refiners were forced to replace heavier high sulphur crudes with light sweet crude just to produce low sulphur bunkers the conversion units would be short of feed assuming the production of other products is not changed. This lower utilisation of the conversion facilities would result in a loss of refining margin.

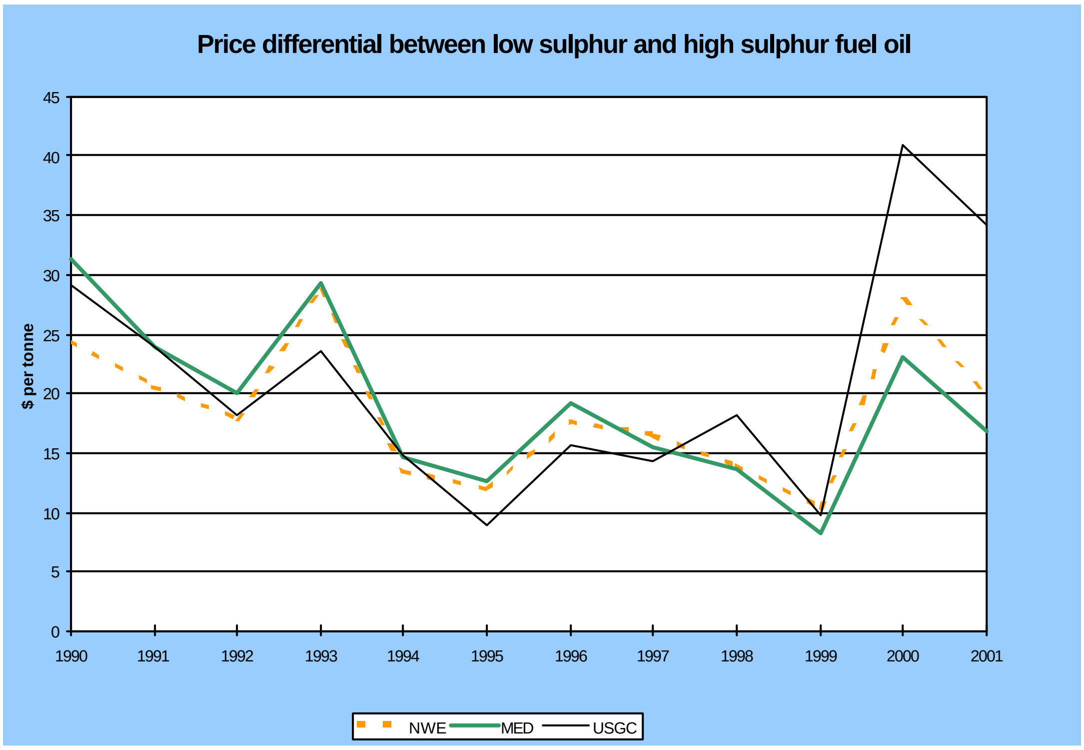
4.3 INDICATIVE COSTS OF PRODUCTION OF LOW SULPHUR BUNKERS

The costs of production of low sulphur bunkers will increase with the amount of bunkers produced. At low levels of production, costs will be relatively low as there is likely to be some flexibility within the current refinery production and possibly crude slate to free up some low sulphur bunkers. As production increases and this flexibility is fully utilised, refinery investments will be needed to desulphurise the HFO blending components to meet the higher demand for low sulphur bunkers.

Before addressing these costs, a brief historical perspective on the price differentials between low sulphur and high sulphur fuel oil is provided.

4.3.1 Low sulphur/high sulphur fuel oil price spreads

Bulk prices for both low sulphur (1wt%S max) and high sulphur (3.5wt%S max) fuel oil are reported for both the NorthWest European and Mediterranean markets. The annual average price differentials are summarised in the figure below.



The price differentials in the two regions have generally moved together ranging from a high of $31 per tonne in the Mediterranean caused by the Gulf crisis to a low of only $8 per tonne in the Med in 1999. The average over the period is $18.6 per tonne in NorthWest Europe and $19.0 per tonne in the Mediterranean.

To illustrate the global nature of the market we have also shown the differential in the US Gulf Coast market. The high sulphur grade in the USGC is actually 3%S so the differentials are not exactly comparable. The differential has tracked the European differentials closely until the last two years when differentials have been much higher due to the increased demand for low sulphur fuel oil in the US for power generation and due to a shortage of natural gas. This high differential was one of the reasons for the higher exports of low sulphur crude from the North Sea to North America in 2000 and illustrates how a change in demand for low sulphur fuel oil can affect the market and prices. The average differential in the USGC in the period was $21.0 per tonne.

4.3.2 Costs & price differentials for low sulphur bunkers

Based on the review above, there are three potential sources of low sulphur HFO bunkers with progressively increasing costs.

- Reblending within the current refining system

  This option represents the lowest cost option. It is expected that around 4 MT of 1.5%S bunkers in North Europe might be made available and around 0.7 MT in the South. The cost of producing this material would be reflected in the higher price of the bunker fuel.

Based on the average price spread between low sulphur and high sulphur fuel oil for the last five years of $17.7 per tonne in NorthWest Europe and $15.5 per tonne in the Mediterranean, the premium for 1.5%S bunkers versus current quality would be expected to be around $14 per tonne in North Europe and around $12 per tonne in South Europe.

In addition to the sulphur premium, production of two grades of bunker fuel may require segregation of tankage in refineries to provide the two qualities but in most cases this segregation would be expected to be achievable through tankage reallocation.

- Increased processing of low sulphur crude oil

The increased processing of low sulphur crude oil may be possible in the near term due to the current excess of North Sea production. However, European refiners will need to pay a premium to bid this crude away from the North American market. Ultimately the low sulphur crude supplied to the North American market will need to be replaced by other low sulphur crude supplies and the price premium for low sulphur crude will increase and reflect the costs of desulphurisation. In practice, this means that European refiners will not pay the extra premium to process the additional lower sulphur crude only to make bunker fuel, and bunker sales will move outside of Europe.

We have considered the loss of refining margin which would result if heavier high sulphur crude oil was replaced by light sweet crude from West Africa. To obtain an indication of the cost, we have used the catalytic cracking Index Refinery model processing a mix of 60% Brent, 20% Urals and 20% Arab Light crudes. In the base case, high sulphur bunker fuel was produced with a sulphur content of 2.9% close to the European average. The bunker specification was then reduced to 1.5%S and Arab Light crude was then replaced with Bonny Light (Nigerian crude) to meet the bunker specification. The production of all other major products was kept unchanged. Yield differentials between the two cases were then calculated.

Using the yield differences and average crude oil and product prices for the 1997 to 2001 period, the additional cost of producing the 1.5%S bunkers was estimated. The additional cost is attributable to processing a higher priced crude, Bonny Light compared to Arab Light. On a delivered Rotterdam basis, Bonny Light cost $2.70 per barrel more than Arab Light in the period considered. Allocating the loss in margin to the 1.5%S bunkers results in a cost of between €40 and €45 per tonne of bunkers.

- Desulphurisation of residue

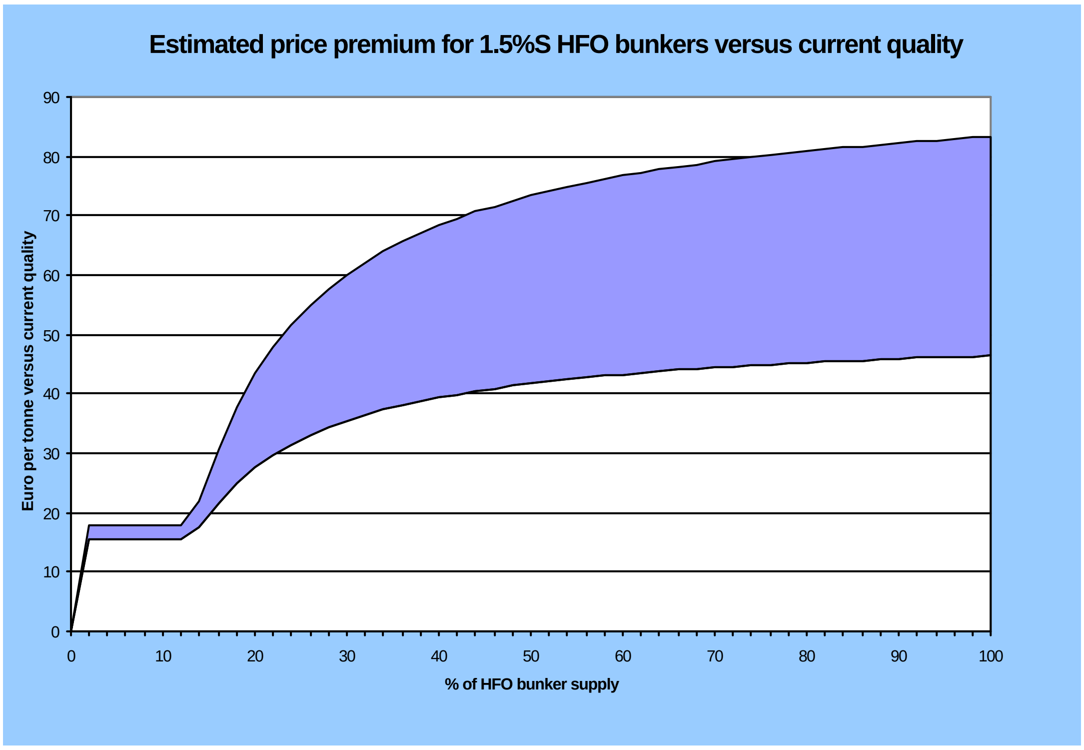
Refinery processes for desulphurisation of residue are expensive due to the nature of the feedstock involved. The costs of these processes are far too high to justify construction of such a plant only to convert high sulphur residue to low sulphur residue. The price differential between high and low sulphur fuel oil has never been anywhere near high enough to support such an investment. Most of the investments which have been made, and there are only a few plants in Europe, combine desulphurisation with some conversion of the residue to lighter products and this is usually the main driver in the economic justification. Demand for light products in Europe is growing and this is expected to continue in the future although probably at a lower rate than in the last ten years. At the same time heavy fuel oil demand is expected to continue to decline. Consequently, further addition of residue conversion capacity in Europe is required to meet the changing product slate.

As a result, we have considered such processes which combine residue desulphurisation with some conversion. There are a few of these plants built in Europe including those at TFE Antwerp, Shell Pernis and Agip/KPC Milazzo. The products produced from such plants normally require further processing. For example, the diesel produced is normally low in cetane and the sulphur content would not meet current specifications. These plants are also large consumers of hydrogen and a hydrogen plant would normally be required. The investment required is very site specific. We have assumed a plant capacity of 1.2 MT/yr with 15% conversion of vacuum residue to light products. Total costs including hydrogen plant and downstream facilities have been assumed to be $M430. Investment costs would typically have an accuracy of +/- 40% at the scoping stage of a project before any engineering work has been undertaken even for a specific plant.

We have used product prices based on the averages for the last five years.

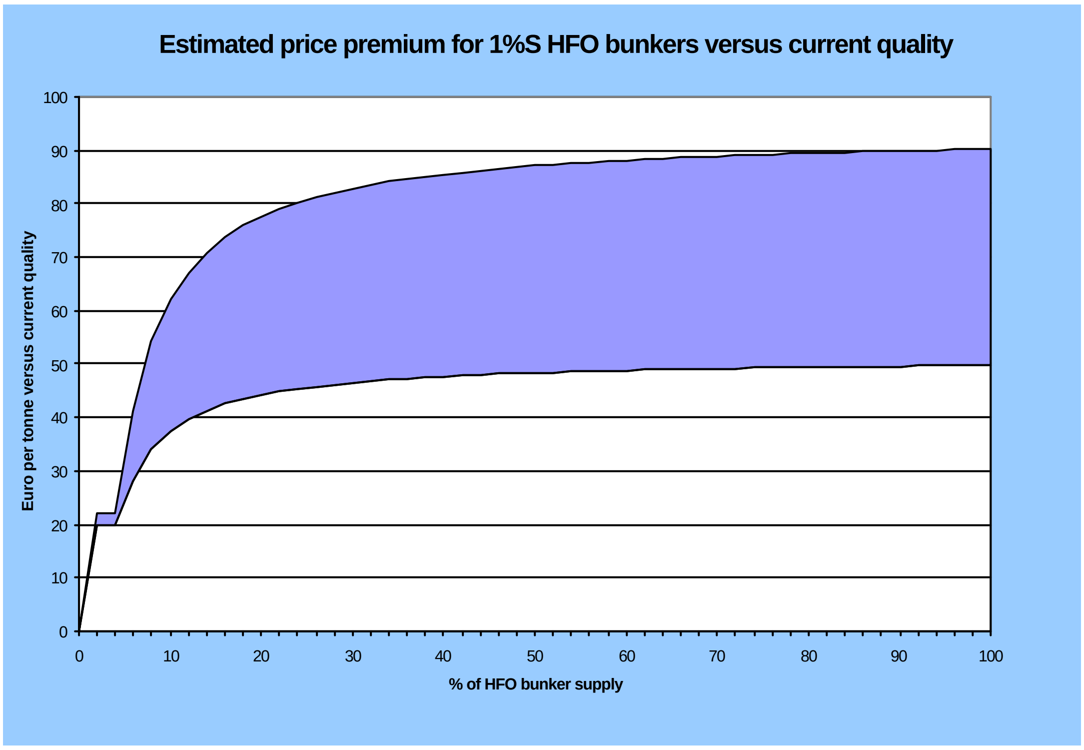
It should also be mentioned that these plants are relatively high energy consumers. In addition, hydrogen plants produce carbon dioxide as a by-product. Overall the addition of desulphurisation and associated plant would significantly increase carbon dioxide emissions.

We have assumed that 4.7 MT of 1.5%S bunkers can be supplied through reblending within the current refining system. Additional bunker fuel must then be supplied through refinery investments in residue desulphurisation/conversion facilities. The cost of these facilities, net of any yield benefits, has then been allocated to the low sulphur bunkers. As the amount of bunkers produced from desulphurisation increases, the premium tends towards the cost of desulphurisation as shown below.



The range shown mainly reflects the rate of return on capital assumed for the desulphurisation facility investments. The high end of the range represents a return on capital broadly in line with oil companies stated target levels while the low end of the range approximates to the relatively low return achieved historically in the European refining industry. The range also reflects uncertainty in the range of investment costs for the desulphurisation and associated facilities.

In the case of production of 1%S bunkers, the amount of low cost production is reduced and the premium rises more quickly to reflect the costs of desulphurisation/conversion. It is assumed that the costs for desulphurisation down to 1%S are not significantly different to the costs for production of 1.5%S bunkers.



For 0.5%S bunkers the amount of low cost supply is negligible and the cost would reflect the desulphurisation/conversion costs. In fact, the severity of desulphurisation required to produce 0.5%S material is higher than the usual design basis for these types of plants and the resulting price premium would therefore be expected to be higher. The price premium range would therefore be expected to somewhat higher than the €50 to €90 per tonne range.

The marine bunker market is highly cost sensitive. An increase in the price of bunkers well below even the low cost supply based on reblending would be enough to encourage shipowners to bunker outside of the EU. Consequently, the price premia indicated above only have practical relevance for intra EU movements and bunkers burned within EU waters if such legislation could be imposed.

4.3.3 Additional Comments

4.3.3.1 Date of market switchover

The impact of the date of a change to low sulphur HFO bunkers is dependent on the legislation put in place. If the legislation is such that the bunker sales affected are expected to be at or below the level which can be supplied by reblending, then the timing is not a major issue. In this case, mainly operational changes would be required at the refineries although some lead time would be required if new tankage to supply two bunker qualities is required in some refineries.

If the legislation was such that desulphurisation/conversion investments were required then timing would be important. These major refinery investments would require three to four years from the start of project analysis to start up.

4.3.3.2 Practicality of regulation

The practicality of regulation on HFO bunkers marketed in the EU and intended for use in EU waters appears to be mainly related to shipping issues. There should be no reason why "EU grade" bunker quality should not be certified by bunker suppliers in the same way that other fuels meeting EU specifications are supplied. Refineries always carry out their own testing on product tanks and the material in those tanks would not be released for sale to the market before the results of the tests confirmed that the quality meets the specification. In many instances, a certificate of quality is provided to the vessel carrying the cargo. This certificate of quality can be from the refinery's own quality control laboratory or from an independent laboratory. A similar system of certification might be considered for bunkers such that when the bunkers are delivered a certificate of quality is provided.

However, after the bunkers are delivered to the ship, the material may be mixed with other quality on the ship. The resulting blend may not meet the EU specification.

4.3.3.3 Refining cost burden

The refining cost burden would vary considerably between EU Member States. The refineries located in those Member States with major bunkering locations would be affected most significantly. The Amsterdam Rotterdam Antwerp (ARA) area provides around one third of bunker sales in Europe. Clearly, the refining industries in the Netherlands and Belgium will be among the most strongly affected of the industries in the Member States. Spain and Greece would also be very strongly affected. Spain supplies nearly 5 MT of HFO bunkers while Greece supplies 2.5 MT but from much lower refining capacity.

4.3.3.4 Global impact of EU regulation

EU sales of HFO bunkers of around 34 MT represent a significant share of the world HFO bunker market of around 110 MT. As discussed above, the bunker market is very price sensitive. A general ban on sales of bunker fuels in the EU of above 1.5%S would mean that bunker prices in the EU would become significantly higher than elsewhere in the world. EU bunker sales would fall as a result and it is likely that sales would only be made to vessels working only in EU waters. Offshore bunkering would be likely to increase. If only the sale of high sulphur bunkers is banned and not the use, then ships moving into EU waters from outside would continue to use low priced high sulphur bunkers purchased elsewhere. The overall effect would be only a limited reduction in sulphur dioxide emissions while the EU refining industry would need to invest to convert the unwanted residue into light products at considerable costs.

If the use of high sulphur bunkers in EU waters is banned then emissions will be reduced assuming the regulation can be enforced. High sulphur bunker sales could still be made for use outside of EU waters. Low sulphur bunkers would then be sold for use within EU waters. In this scenario any costs incurred by the EU refining industry would be associated with the benefit of a reduction in sulphur dioxide emissions.

4.3.3.5 Lube oil alkalinity

It is understood that use of lower sulphur content bunker fuels will require the use of lower alkalinity lubricating oils. Based on limited discussions with oil industry representatives, it was not envisaged that the supply of lower alkalinity lube oil would be associated with a higher cost. There may be higher costs associated with the ship operation if two qualities of lube oil must be carried for operation on both low and high sulphur fuels.