BeicipFranlab

Framework Contract for Technical Support in Relation to the Quality of Fuels

Advice on Marine Fuel

Potential price premium for 0.5%S marine fuel; Particular issues facing fuel producers in different parts of the EU; and Commentary on marine fuels market

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1 INTRODUCTION

The European Commission, through the DG-ENV, has requested Beicip-Franlab to provide advice on the main issues faced by fuel producers in relation to the quality of marine fuels. This report is a follow up of an earlier study completed in April 2002 (*Advice on the costs to fuel producers and price premia likely to result from a reduction in the level of sulphur in marine fuels marketed in the EU*, April 2002).

In addition of being an update of the main market aspects of marine fuels sold in the EU, this report seeks to answer further questions related to the consequences to fuel producers in case further sulphur specifications are imposed by the European Parliament to marine fuels.

In particular, this report:

- Calculates the potential price premium for 0.5%S marine fuel;
- Discusses about particular issues faced by fuel producers in different parts of the EU in case sulphur limits are tightened to 1.5%S for Heavy Fuel Oil (HFO) and 0.2%S for Marine Gasoils; and
- Comments on some of the practicalities and legalities oft the marine fuel market.

The second Chapter of this report presents a recall of the world bunker market, detailing the current trends in the EU. Subsequently, Chapter 3 provides a general estimate of the amount of very low sulphur marine fuel oil and marine distillates that could be produced in refineries across the EU and the rest of the world. An estimate of what would be the likely premium to provide 0.5%S HFO is presented in Chapter 4. These estimates were obtained by using the same methodology than in the April 2002 report.

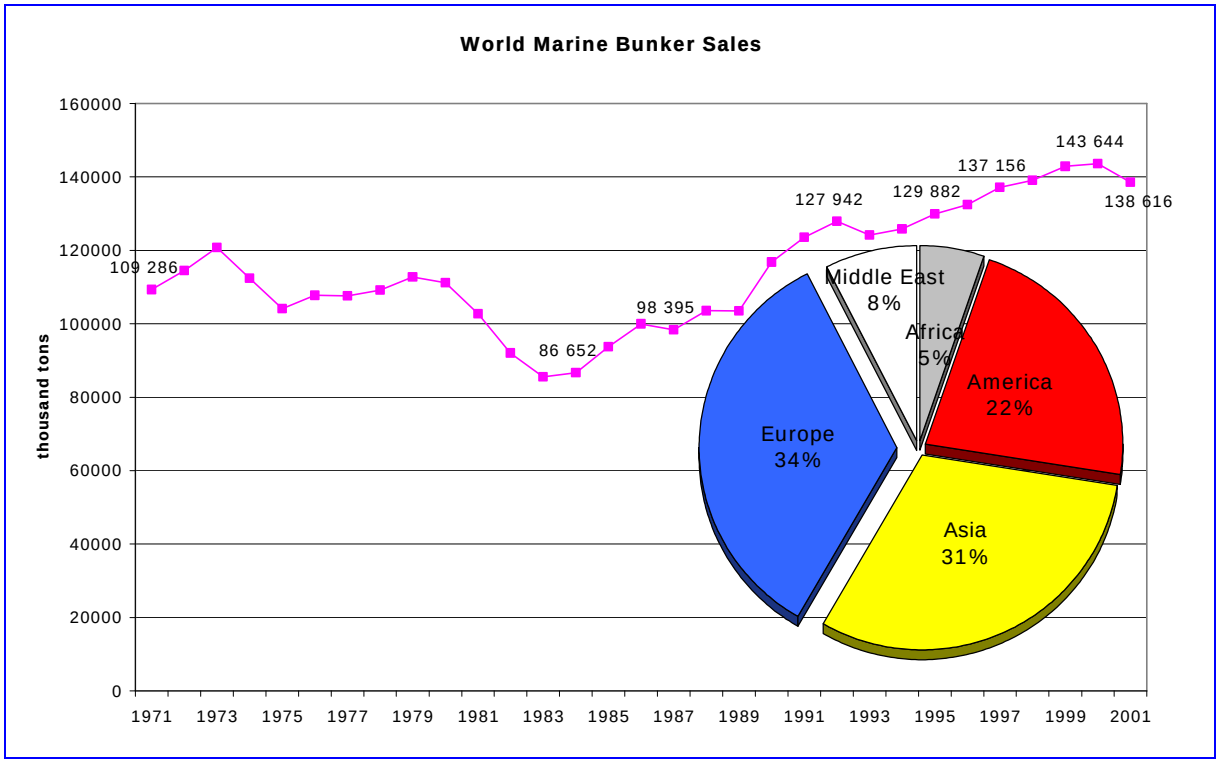
An approximation of the CO2 emissions that would result from the application of a 0.5%S limit is presented in Chapter 5. Although the increase in emissions is negligible by changing the crude slate in refineries, the opposite would occur if the very low sulphur HFO is produced through other methods, such as by residue desulphurisation.

Chapter 6 assesses the main technical and economic issues fuel producers are likely to face in order to reduce the levels of sulphur in marine fuels in Greece, the outermost regions (French overseas departments, the Azores, Madeira & the Canary Islands) and the 2004 accession countries to the EU.

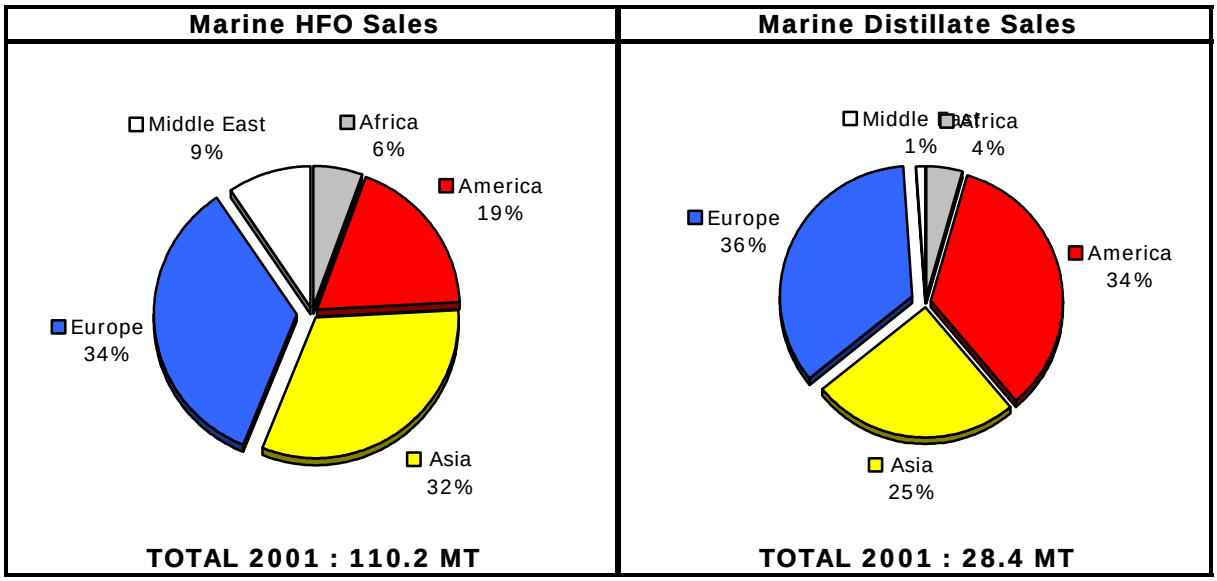
Finally, chapter 7 provides a discussion on the difference in effect between banning the « sale », « marketing », or « placing on the market » of higher sulphur marine diesel oils (over 1.5%S) and marine gas oils (over 0.2%S) in the EU.

2 WORLD BUNKER MARKET

In 2001, total international bunker sales reached 136 million tonnes (MT). This represents a 3.4% decline from 2000 mainly due to the fall in sales of heavy fuel oil. Meanwhile, the distillate bunker fuel market recovered to reach 28.4 MT, representing about 20% of total bunker fuel sales. Europe and Asia remain the main world consumers with 48 and 42 MT respectively.

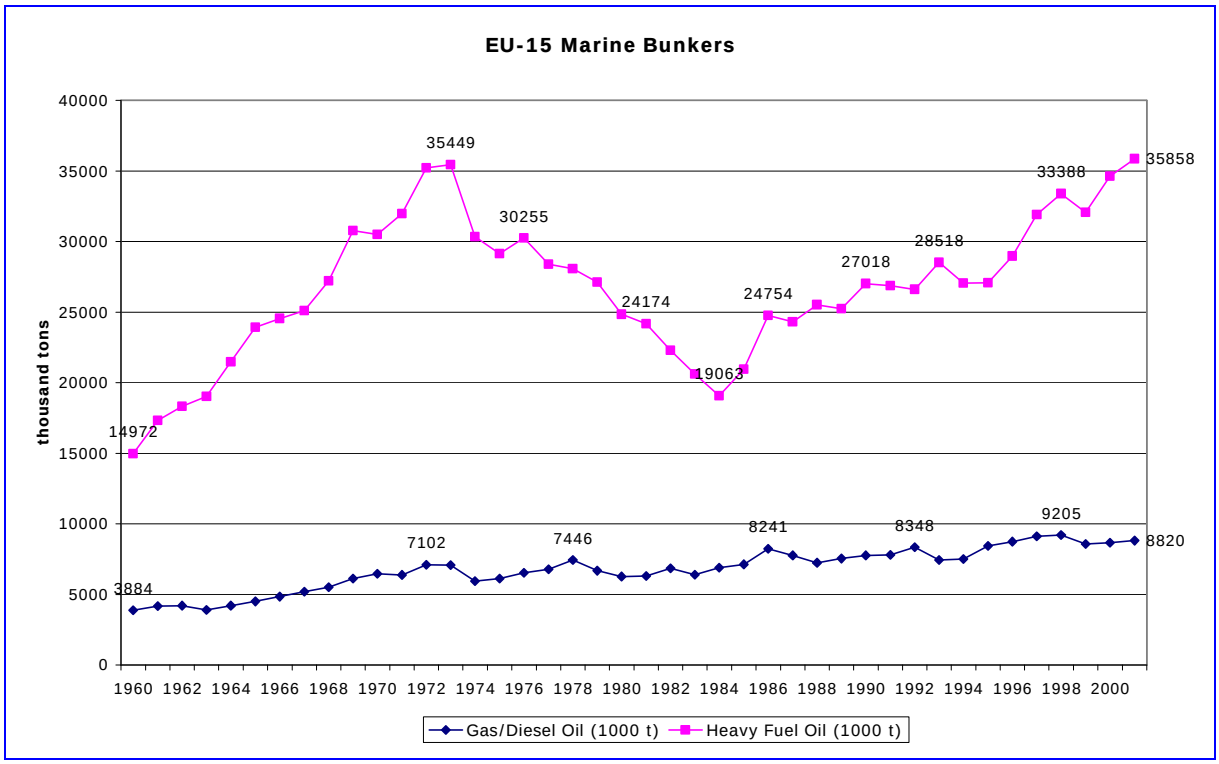


Regional consumption patterns for heavy fuel oil and distillates are quite different as presented in the following figure.



2.1 EU-15 market

EU-15 bunker sales reach 45 MT in 2001 of which 80% are heavy fuel oil.



During the year 2001, total bunker fuels consumption in EU-15 kept increasing by more than 3% per year.

Historical bunker fuel sales by EU member state are shown in the following tables. The Netherlands dominate the market with 36% of EU-15 marine HFO sales and 25% of EU-15 marine distillates sales. Spain and Belgium are the next larger sellers of bunker fuels with respectively 15% and 12% of total EU-15 market.

EU-15 Marine Distillate Sales (Marine Gasoil and Marine Diesel oil) ('000 tonnes)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	YEARLY GROWTH RATE
Austria	0	0	0	0	0	0	0	0	0	0	0	0	
Belgium	635	662	725	649	586	706	652	684	717	570	787	773	1.6%
Denmark	272	295	395	448	565	626	638	593	732	611	536	501	5.4%
Finland	121	114	132	144	147	153	150	155	160	160	188	142	2.2%
France	311	337	352	282	250	266	305	420	441	419	483	561	5.2%
Germany	548	452	444	491	459	475	650	639	524	483	501	458	0.1%
Greece	510	514	657	718	801	966	776	771	758	706	750	612	1.8%
Ireland	9	12	5	34	19	67	100	102	108	122	114	125	26.4%
Italy	569	558	572	555	552	566	566	659	792	794	771	722	2.6%
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	
Netherlands	2083	2124	2138	1874	1952	2332	2116	1964	2051	2009	2055	2193	0.3%
Portugal	212	222	213	187	180	199	201	193	109	183	205	153	-3.7%
Spain	1206	1182	1300	740	606	778	1178	1531	1135	1147	967	998	-1.7%
Sweden	150	149	176	172	193	198	208	245	282	216	166	149	0.0%
U.K.	1138	1195	1239	1155	1199	1111	1204	1157	1396	1151	1141	1433	1.8%
Total EU-15	**7764**	**7816**	**8348**	**7449**	**7509**	**8443**	**8744**	**9113**	**9205**	**8571**	**8664**	**8820**	**1.2%**

EU-15 HFO Bunker Sales ('000 tonnes)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	YEARLY GROWTH RATE
Austria	0	0	0	0	0	0	0	0	0	0	0	0	
Belgium	3565	3636	3544	3746	3624	3297	3965	4544	4879	3951	4752	4641	2.5%
Denmark	707	581	520	916	966	978	878	798	663	702	816	617	0.6%
Finland	458	438	564	401	277	182	230	258	369	407	494	442	0.1%
France	2262	2333	2227	2177	1930	2298	2462	2590	2469	2523	2561	2170	-0.7%
Germany	1960	1657	1317	1725	1586	1588	1393	1531	1533	1613	1705	1790	0.8%
Greece	2063	1846	2052	2444	2557	2641	2399	2413	2798	2452	2898	2933	4.7%
Ireland	9	22	12	20	20	50	58	49	50	50	37	36	5.0%
Italy	2129	1994	1880	1889	1811	1872	1738	1738	1847	1634	1956	2120	0.6%
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	
Netherlands	9019	9251	9352	10035	9408	9186	9585	10455	10458	10926	11582	12775	3.3%
Portugal	407	405	402	334	316	292	306	311	280	416	471	330	-2.0%
Spain	2510	2760	2692	2755	2557	2470	3563	4315	5031	4870	5183	5886	7.9%
Sweden	530	658	743	753	898	874	928	1102	1327	1337	1227	1277	6.9%
U.K.	1399	1291	1307	1323	1115	1354	1461	1805	1684	1179	938	841	-4.2%
Total EU-15	**27018**	**26872**	**26612**	**28518**	**27065**	**27082**	**28966**	**31909**	**33388**	**32060**	**34620**	**35858**	**2.9%**

3 LOW SULPHUR MARINE HEAVY FUEL OIL SUPPLY

In April 2002, Beicip-Franlab presented an analysis of the marine heavy fuel oil supply in Europe. This analysis was based on the 1998 Concawe survey on the distribution of sulphur in the heavy bunker fuel oil produced in the main European Refineries, DNV reports and our own estimates on recent trends in the development of this market.

It resulted from this analysis the following:

- the average sulphur content of HFO bunkers produced in Europe is around 2.91%wt, with an average for the Atlantic/NEW/Other region of 2.89%wt and 2.95%wt in the Mediterranean;
- Total HFO Bunker fuel produced in Europe (EU-15) amount to 25 MT;
- Total sales HFO Bunker fuel in the EU-15 is 34 MT.

The analysis of the distribution of sulphur in bunker fuels produced in European refineries shows that the spread of sulphur content ranges from 0.1%wt to 4.3%wt.

The following table summarises the sulphur distribution by region.

Average Sulphur content of HFO bunker production (MT)		
Sulphur content, wt%	Atlantic/NWE/Other	Mediterranean
< 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

Based on this table, Beicip-Franlab report has derived the potential production of low sulphur fuel oil assuming blending of different sulphur content cuts.

Potential Low Sulphur HFO bunker production by re-blending (MT)		
Sulphur content, wt%	Atlantic/NWE/Other	Mediterranean
< 1.0	1.2	0.4
< 1.5	4.0	0.7

From this analysis, around 4 MT of 1.5%S bunkers could be made available (without investment in desulphurisation facilities) in North Europe and about 0.7 MT in the South. Figures for 1%S bunkers are 1.2 MT in North Europe and 0.4 MT in the South.

Regarding 0.5%S bunkers, the supply is limited to 0.16 MT of which 0.04 MT in North Europe and 0.12 MT in Mediterranean as no re-blending of cuts is possible.

They are no statistics available on the production of 0.5%S bunker fuel oil as this product, when manufactured, is used as a feed for the fuel oil / distillate pools of the refinery. Only few refineries do sell this product directly in some very specific market. Today, in Europe, the main consumers of low-sulphur bunkers with a maximum of 0.5

per cent sulphur content by weight are the large ferry companies in the Kattegatt, the Sound and in the Baltic Sea.

In order to assess the current production capacity of 0.5%S bunker fuel oil in Europe and outside, it would be necessary to make a survey similar to the one made by Cocawe in 1998. However, it is possible to derive an estimate for this production figure considering the requirements in terms of processing / treatment units and crude slates for the refineries to manufacture this product.

There are mainly two types of Refineries which can manufacture 0.5%S bunker fuel oil:

- Refineries equipped with residue upgrading facilities such as VRDS (vacuum residue Desulphurisation unit)
- Refineries (with conversion) processing very light crude oil (<0.2%S wt.)

3.1 Low sulphur fuel oil from hydrotreating of residue

Hydrotreatment of residue (VRDS) is a catalytic refinery process which is used to upgrade heavy oils to clean-burning distillates. This process allows achieving maximum Desulphurisation . Typically, a Residue Hydrotreating unit removes 90-95% of feed sulphur content. It is therefore possible to produce from heavy crude oil residual fractions with very low sulphur content. However, due to high capital and operating costs, those units are primary used as a feed treatment for conversion units and not for the production of low sulphur fuel oil.

Worldwide VRDS capacities are presented in the following table.

Region	VRDS capacity kbbl/d	% of world capacity
Western Europe	92 000	8%
Asia	731 200	62%
Middle East	209 700	18%
USA	142 100	12%
TOTAL	**1 175 000**	

Most of the capacity of VRDS is therefore installed in Asia and mainly in Japan. In Europe the biggest units are installed in Belgium and the United Kingdom. There is one of such units in Slovakia.

Based on this installed capacity, it is estimated that total potential production of low sulphur fuel oil is around 52-55 MT. Only a limited amount (around 10 MT) could be made available for the marine fuel oil market.

3.2 Low sulphur fuel oil from processing sweeter crude oil

The use of low-sulphur crude oil is the most cost-effective method to produce low-sulphur fuel. To produce 0.5%S fuel oil in a typical European Refinery it is necessary to process crude oil of less than 0.2%S. The world production of light and sweet crude oil amounts to 14 000 kbbl/d[1].

[1] Equivalent to about 18% of the world production.

The following table shows how the low sulphur crude production is spread by region :

Region	Main Countries	Production Low sulphur crude kbbl/d	% of light crude world production	Total refinery Capacity M bbl/d
Europe	Denmark	108		
	Norway	2 172		
	Russia	160		
	United Kingdom	1 774		
Total Europe		**4 214**	**29.6%**	**22.0**
Central Asia	Kazakhstan	119		
	Turkmenistan	30		
Total Central Asia		**151**	**1.1%**	**3.2**
Middle East	Qatar	160		
	Saudi Arabia	192		
	Yemen	158		
Total Middle East		**510**	**3.6%**	**6.3**
Africa	Algeria	1 521		
	Angola	283		
	Congo	128		
	Egypt	114		
	Libya	1 255		
	Nigeria	1 218		
Total Africa		**4 601**	**32.6%**	**3.2**
Asia	Australia	542		
	Brunei	114		
	India	565		
	Indonesia	706		
	Malaysia	485		
	Thailand	130		
	Vietnam	340		
Total Asia		**3 034**	**21.5%**	**20.2**
Americas	Argentina	121		
	Canada	785		
	Colombia	243		
Total Americas		**1 612**	**11.4%**	**26.9**
TOTAL WORLD		**14 122**		**81.9**

The main regions where light and sweet crude oils are produced are: Africa (mainly Algeria, Libya and Nigeria) and Europe (North Sea crude oil producing regions).

Based on these production figures, refineries capacities and typical yield on 350°C+ cut, it is possible to estimate the world potential production of low sulphur fuel oil at 185 MT of which only a small share could be used as bunker fuel (around 40 MT).

In the Mediterranean region, the most important producer of low sulphur fuel oil is Algeria. For a total refining capacity of 21.3 MT, Algeria could produce around 5.5 MT of low sulphur fuel oil ranging from 0.26 to 0.39%S wt.

Finally the following table summarises the current potential production of Low Sulphur Bunker Fuel oil.

World production of LS FO/LS BFO (2000)	Total Production LS FO (MT)	Total Production LS BFO (MT)
LS FO from residue conversion	54	10.0
Of which Northern Europe		*0.9*
LS FO from direct processing of sweet crude oil	185	40.0
Of which Northern Europe		*10.0*
TOTAL Production of Low Sulphur BFO		**50.0**
Of which Northern Europe		*11.0*
Total World Market of BFO		110.0 (of which 34 for EU-15)

This analysis tends to show that around 50MT of low sulphur bunker fuel oil could be made available and around 11MT in Northern European ports. It is based on the assumption that only a small part of the current production of Low Sulphur Fuel oil will be re-directed from land-use. Importantly, this analysis does not consider that additional desulphurisation units are installed and crude slate of major refineries modified.

Therefore, supply of low sulphur fuel oil (<0.5%Swt) for the bunker market is today constrained as refiners have no incentive to sell this fuel on the bunker fuel market. Most of the production of low sulphur fuel oil is today dedicated to the inland market (electricity and industrial consumers) where a price premium applies.

4 PRICE PREMIUM FOR LOW SULPHUR BUNKER FUELS

The April 2002 Beicip-Franlab report provided indicative costs per tonne of production of low sulphur HFO marine bunkers (1.5% and 1.0%). In that report, cost ranges for three potential sources of low sulphur HFO marine bunkers were mentioned:

- Re-blending very low sulphur HFO
- Processing of sweeter crudes
- Desulphurisation of residue

The April 2002 report stated that the re-blending option was the lowest cost option for producing low sulphur HFO bunkers, although it is the option that could treat the lowest quantity of material. This alternative implies nearly no major costs, other than relatively small costs associated to the logistics for the re-blending of the different categories of HFO currently being produced by the European refineries.

The next alternative by increased cost is the processing lower sulphur crude oils. It was argued that this option would be achieved by replacing high sulphur content crudes, such as Arabian Light, which contains 1.8%, by a lower sulphur crudes (for instance by African crudes such as Bonny Light which contain 0.14% sulphur by weight). The estimated incremental costs for HFO marine bunkers incurred by this alternative were estimated in the range of 40 to 45 €/tonne, due to the higher price per barrel of Bonny Light when compared to Arabian Light.

Finally, the third most expensive option for the production of low sulphur HFO (LS HFO) bunkers mentioned in the April report was the desulphurisation of vacuum residue (VRDS). It is important to notice, however, that as opposed to the degree of desulphurisation required for petrol or diesel, hydro-treating of the bottom of the barrel (residue desulphurisation) is not a process that refiners are currently considering to implement per se, that is if it is not coupled with some conversion of residue to lighter products. Nonetheless, if VRDS was pursued for the sole objective of desulphurisation of vacuum residue, the costs of this alternative were likely to fall in the range of 80 to 95 €/tonne.

Likely price premium for producing low sulphur HFO marine bunkers

Option	Estimated price premium range (2002 €/tonne)
Re-blending	13 – 16
Supply of lower S crude	40 – 45
Desulphurisation of residue	80 – 95

The present report follows the same methodology to calculate the price premium of producing 0.5%S HFO marine bunkers.

4.1 Price premium of producing 0.5%S HFO marine bunkers

HFO marine bunkers containing 1.5% or less sulphur could be produced using any of the methods described above. The April 2002 report estimated that around 1.63 MT of low sulphur HFO (<1.5%) are produced in Europe, of which 0.64 MT are less than 1.0%S and 0.16 MT are less than 0.5%S.

By re-blending this material (<1%S HFO) with higher content sulphur HFO, the April 2002 report found that refiners could produce approximately 4.7 MT of 1.5%S marine bunkers.

Estimated quantity of LS HFO that could be supplied by re-blending

Sulphur content	HFO supplied by re-blending (MT)
<0.5% S	0.16*
<1.0% S	1.5
<1.5% S	4.5 – 4.7

Note: *in the 0.5%S case these marine bunkers are not re-blended. 1998 data.

The fact that there is very little production of <0.5%S, the production of 0.5%S HFO by re-blending is negligible. Thus, this material will have to be produced by either the supply of lower sulphur crudes or by the more costly option, residue desulphurisation. The price premium of producing 0.5%S HFO marine bunkers would range between €43 to €93 per tonne, the latter figure reflecting the estimated costs per tonne of residue desulphurisation.

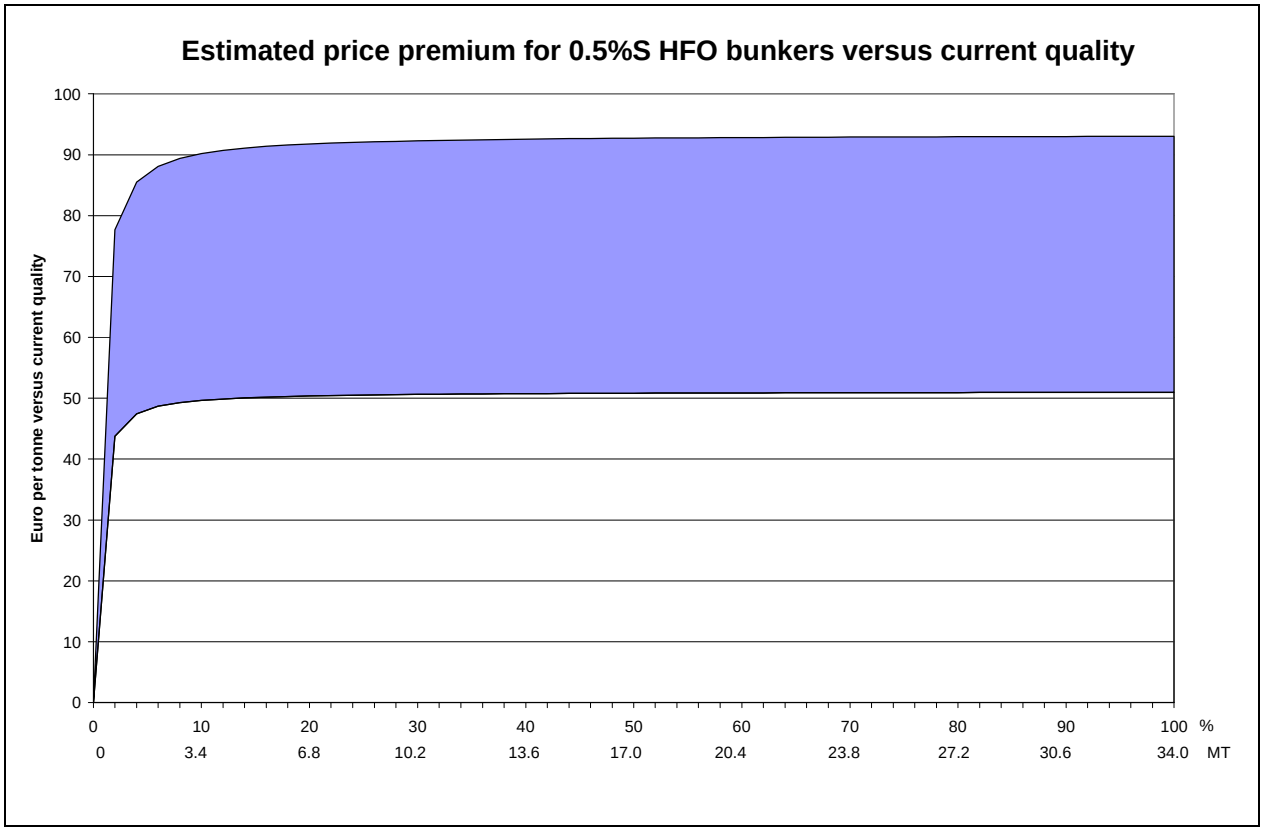
Because the costs of supplying low sulphur marine bunkers increase due to the higher costs of low sulphur crude oil and the investment costs of residue desulphurisation units, the production of low sulphur marine bunkers increase as the quantity supplied increases.

The next table summarises the results of the April 2002 report, and includes the likely costs of the production of 0.5%S HFO marine bunkers.

Estimated price premium of providing low sulphur HFO marine bunkers

Supply price premium range (2002 €/tonne)	25%	50%	75%	100%
1.5% S	22 – 52	32 – 73	35 – 80	37 – 83
1.0% S	35 – 81	39 – 87	40 – 90	41 – 92
0.5% S	42 – 92	42 – 93	43 – 93	43 – 93

The rapid rise to the higher cost range indicates that there is no 0.5%S HFO bunkers that could be supplied by re-blending, and that the low sulphur material could only be supplied by processing lower sulphur crude oils or by implementing further residue desulphurisation.

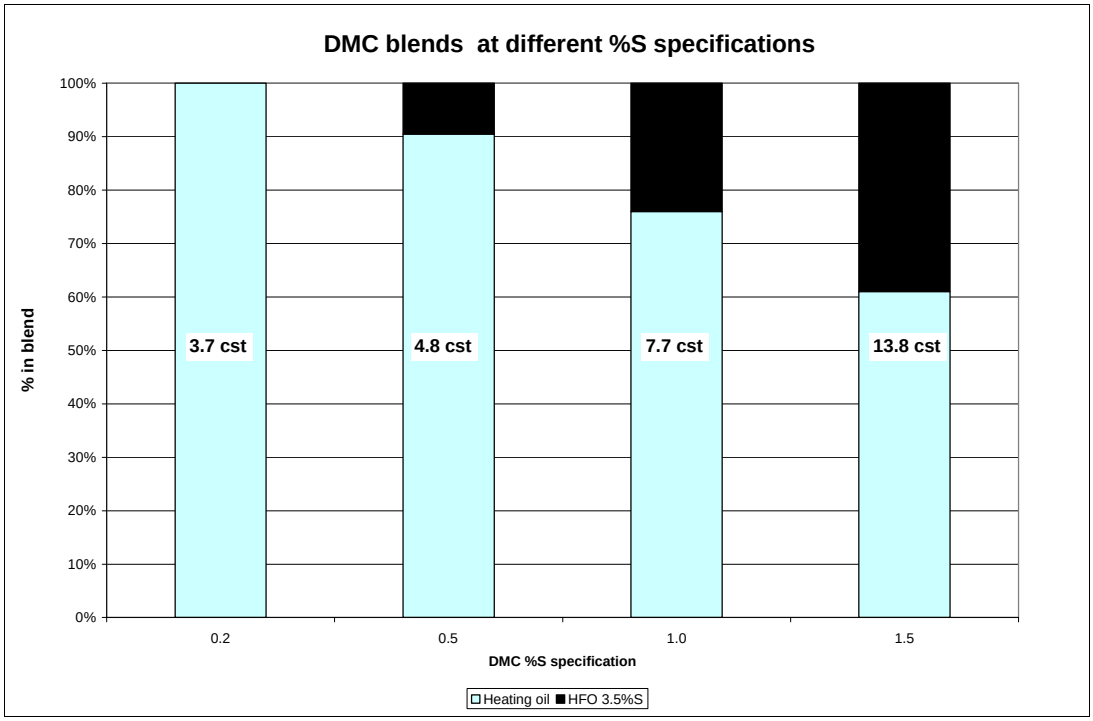


4.2 Price premium of producing 0.5%S marine distillates

DMC grade fuel is taken as a representative of marine distillates. DMC is produced in refineries 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 both the maximum sulphur content and the DMC viscosity specification, depending on the quality of the heavy fuel oil used for blending.

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.

The figure shows the maximum allowable quantity of HFO depending on the quality of DMC desired. As discussed previously in the April 2002 report, the resulting price premium will be a function of the quantity of HFO that could be blended.

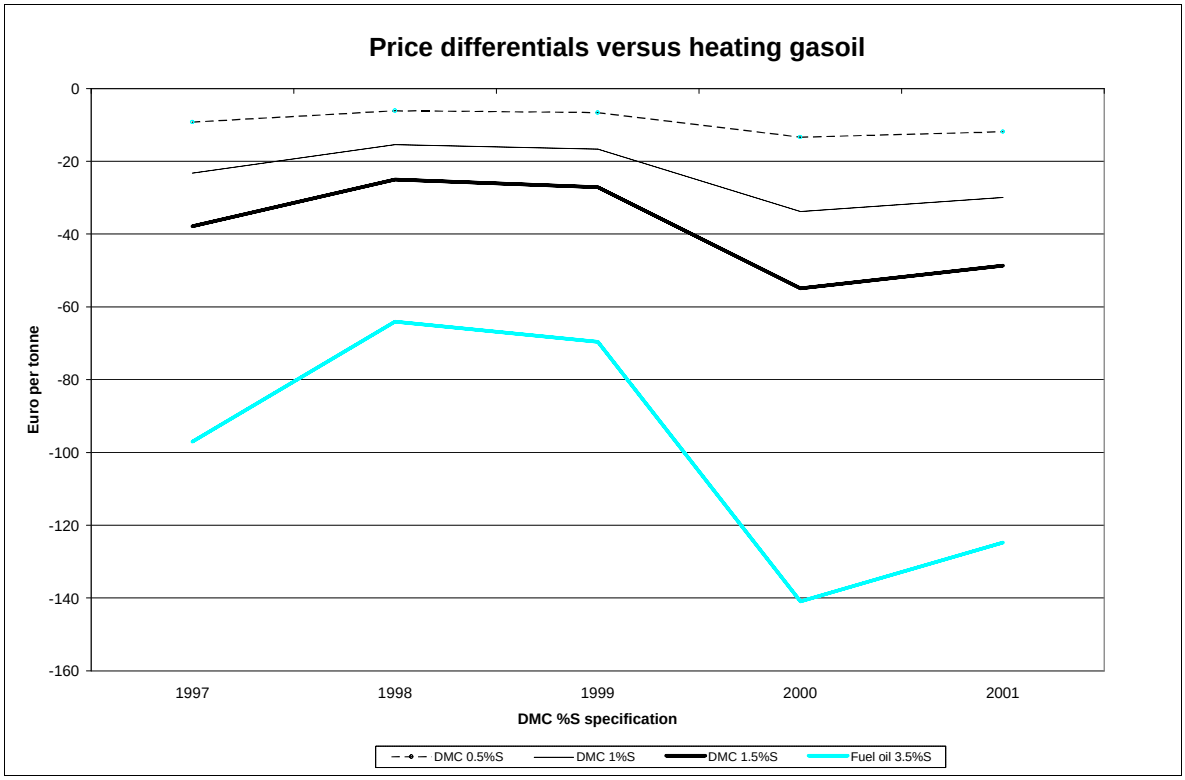


The column on the left side shows that the reduction of the sulphur content of DMC to 0.2%S from the prior specification of 2.0%S has meant that no HFO can now be blended into DMC with a resulting increase in the cost of DMC to a level equivalent to heating gasoil.

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 0.5%S allows the addition of 10wt% of heavy fuel oil. In this case, the viscosity of the DMC blend is around 4.8 cst.

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 0.5%S bunkers would be expected to sell for between €9 and €17 per tonne less than heating gasoil with an average of €10 per tonne for the five year period (1997–2001). The variations are due to the variation in the price spread between heating gasoil and heavy fuel oil. As argued in the April 2002 report, the DMC 1%S and DMC 1.5% bunkers would be expected to less costly than the DMC 0.5%S quality.

5 LIKELY CO2 EMISSIONS RESULTING FROM THE 0.5%S LIMIT

The production of low sulphur marine bunkers can cause an important increase of airborne emissions, notably of carbon dioxide (CO2) emissions, depending on what option is implemented to supply them, whether it is by re-blending, switching crude oils, increasing hydrotreating or by residue desulphurisation.

It can be assumed that re-blending material or changing the crude slate virtually does not increase CO2 emissions, both hydrotreating (HDT) and residue desulphurisation units and their associated hydrogen plants are high energy consumers.

While CO2 emissions increase is closely related to the type of plant and the quantity of HFO to be produced, the tables below show the CO2 emissions of a typical 1.2 MT vacuum residue desulphurisation (VRDS) plant. In summary, emissions of a complete unit (VRDS + H2 plant) are in the range of 0.75 million tonnes per year.

CO2 emissions from a typical VRDS plant

Utilities	Utilities/bbl resid.		Utilities/ T of resid.	For a 1.2 MT residue plant		Tonnes of CO2 per TEO	CO2 emissions
	kWh	MMBTU	MMBTU	MMBTU	MM TOE		MM T
Fuel gas		0.017	0.11	128 302	0.03	3.26	0.10
Electricity	6.35		0.14	163 518	0.04	3.26	0.13
Steam		0.04	0.25	301 887	0.08	3.26	0.25
TOTAL				**593 707**	**0.15**		**0.48**

Notes: TOE = Tonne of oil equivalent.

CO2 emissions from a typical H2 plant

Utilities	units/tonne H2		For 1.2 MT residue plant		Tonnes of CO2 per TEO	CO2 emissions
	MJ	MMBTU	MMBTU	MM TOE		MM T
Fuel gas	35 000-80 000	18.96	263 526	0.07	3.26	0.21
Electricity	200-800	0.47	6 588	0.0004	3.26	0.01
TOTAL			**204 233**	**0.05**		**0.26**

Notes: Utilities for the H2 plant calculated on the basis of 20000 MJ of fuel gas, 500 MJ for electricity, and a generation of 5000 MJ of steam. Hydrogen needs calculated on the basis of H2 needs equal 1.2% wt of residue (14400 tonnes of H2 for 1.2 M tonnes of residue).

In the unlikely situation that the European market of Low Sulphur HFO (34 MT of 0.5 or 1.0% S) were supplied only by HFO from such units, a maximum of 28 of such units would be required across Europe. The next table illustrates CO2 emissions for 8.5 and 17 MT of HFO.

Increase on CO2 emissions of providing 0.5%S HFO marine bunkers (MT)

0.5%S HFO supply	25%	50%
HFO (MT)	8.5	17.0
Number of VRDS	7	14
CO2 (MT)	5.35	10.7

6 TECHNICAL AND ECONOMIC ISSUES FACED BY FUEL PRODUCERS IN GREECE, OUTERMOST REGIONS AND ACCESSION COUNTRIES

The following section reviews the technical and economic issues fuel producers are likely to face in order to reduce the levels of sulphur in marine fuels to:

- 1.5% S for heavy fuel oils and/or marine fuel oils and
- 0.2% S for marine gas oils

in Greece, the outermost regions (French overseas departments, the Azores, Madeira & the Canary Islands) and the 2004 accession countries to the EU.

6.1 Main technical and economic issues

There is, to a certain extent, scope for fuel producers in Greece, the Canary Islands (Tenerife) and elsewhere in accession countries to treat sweeter crudes, and hence to produce lower sulphur products.

Each refinery, however, may have its own problematic: either they do not have enough hydrotreating capacity or they are limited because of more logistical and operational reasons. For instance, some refineries are partly owned by international crude producers and committed to a single source of supply. Similarly, a given refinery may have been designed to treat one single type of crude oil.

About a quarter of the refineries located in Greece and in the accession countries (about 16 refineries) are of the hydroskimming sort (simple configuration). Some of the refineries however, own cracking facilities, which enable the flexibility of operations, and consequently could be capable to adapt to a vast choice of sweeter crude oils, albeit by paying a premium[2].

The April 2002 report argued that the cost per tonne of HFO bunkers endured by refiners by switching from Arabian Light to lower sulphur Bonny Light could be around €40 per tonne, including any side benefit obtained from the production of lighter products.

The costs likely to be supported by the refiners in the countries surveyed will vary depending on the nature of the crude switched. On one extreme, the Tenerife refinery could endure the highest costs, as it processes considerable quantities of Maya (Mexico crude oil, 3.56%S wt). It would be very likely forced to switch part of its Maya supply to higher cost West African sweeter crudes.

On the other extreme, most refineries located in accession countries process Urals (FSU crude, 1.3%S wt), which produces a lower sulphur HFO than Arabian Light. A priori, they would have fewer constraints because they would need less sweet crude to switch to produce lower sulphur bunkers. On practice, this could be more problematic: the nature of the supply system and infrastructure in most of these countries, (existing crude import pipelines, such as the Russian system Friendship Pipeline and the refinery configuration), makes them structurally dependent on Urals (Russian crude oil, 1.3%S wt).

Except for the Petrola Hellas refinery which has long term contracts with Saudi Aramco, Greek refineries could also be in a position to process lower sulphur crude oils. The Petrola Hellas refinery will enhance its production of lighter and sweeter fractions by 2004, when the hydrotreater-hydrocracking complex facilities will be in operations.

[2] As an example, we illustrated in the April 2002 study the differential between Arabian Light (Saudi Arabian crude, 1.79%S wt) and Bonny Light (Nigeria, 0.36%S wt).

More detailed studies could be performed on a case-by-case basis to assess how much of the sweeter crude oils would be realistically needed for producing the lower sulphur HFO. In addition, in case there is a constant growing demand for lower sulphur crude oils, the current price differential between crude oils may increase unexpectedly. The next paragraphs detail the situation in each of the refineries surveyed.

6.2 Greece

There are four refineries in Greece. Greek four crude oil refineries totalled a 400 kbbl/d capacity as of January 1, 2002. Two are owned by the state company Hellenic Petroleum (HP), one owned by the independent company Petrola Hellas and one owned by Motor Oil Hellas (MOH). The largest and more complex refinery is the Aspropyrgos refinery. This refinery has a crude distillation capacity of 130 kbbl/d, including a catalytic cracker of 36 kbbl/d with feed hydrotreating, which increases its capability to process high sulphur crude oils. There is also an asphalt unit.

The two private refineries, owned by MOH and Petrola Hellas, that are export-oriented, refine 100 kbbl/d each. The MOH refinery includes a catalytic cracker and imports most of its material from Saudi Arabia. On the other hand, the Petrola refinery is on the last steps to put on stream an hydrocracking unit that will enable to increase the crude processing flexibility of the refinery and help to meet future demand and quality.

Finally, the HP second refinery is the Thessaloniki refinery. This refinery is a hydroskimming refinery (simple) with a capacity of 68 kbbl/d. It had been initially designed to process indigenous heavy Greek crude oil in the past.

Greek refineries (2002)

Refinery	Type	Capacity kbbl/d	Main crude supply	Crude Sulphur content (%wt)	Approximate supply (%)
Hellenic Petroleum (Aspropyrgos)	CC	130	Urals	1.31	46
			Arabian light	1.79	10
			Iranian light	1.50	10
			Arabian ext. lt	1.19	9
Hellenic Petroleum (Thessaloniki)	HS	68	Iranian heavy	1.77	9
			Sarir	0.16	9
			Kirkuk	1.97	2
			Other	-	5
Petrola Hellas	HC (2004)	100	Saudi Arabia	1.19 – 2.75	100
Motor Oil Corinth	CC	100	n/a	n/a	n/a

Note: HS hydroskimming, CC: catalytic cracking, HC: hydrocracking

6.3 Outermost regions (French OD, the Azores, Madeira & the Canary Islands)

There are two refineries in the Outermost regions (French overseas departments (OD), the Azores, Madeira & the Canary Islands) that may have economic or technical consequences due to the reduction of sulphur in marine fuels. The first is the Tenerife

Refinery owned by CEPSA and TOTAL, and the Fort-de-France located in Martinique, owned by TOTAL and SHELL.

6.3.1 Canary Islands

The CEPSA refinery in the Canary Islands has a 85 kbbl/d capacity. The feed is processed into two distillation units. The main distillation unit can operate into two modes depending on whether it is fishing season: fuel oil and bunkers. The second unit is designed to produce asphalt. The feed for the asphalt unit is mostly Maya crude (3.56% wt S), while the feed for the main distillation unit is made from a mix of Maya and West African crudes such as Escravos or Kole.

The refinery produces road diesel at current European specifications (0.035%S), marine gasoil at 0.6%S in addition to smaller quantities of marine gasoil at 1.0%S (which is mostly sold in Africa).

There are three types of fuel oils produced in the refinery: Fuel oil, low sulphur FO and, since 2001 a very low sulphur FO (<0.6%).

Tenerife refinery (2002)

Refinery	Type	Capacity kbbl/d	Main crude supply	Crude Sulphur content (%wt)	Approximate supply (%)
Tenerife (CEPSA)	HS	84	Escravos	0.12	36
			Maya	3.56	26
			Kole Marina	0.33	19
			Cabina exp	0.07	6
			Other	n/a	11

Note: HS hydroskimming

It would be technically feasible to reduce sulphur content in HFO produced in the Tenerife refinery by choosing the second option by cost, ie by changing the crude slate, by switching some of the input material from Maya crude to sweeter crudes such as West African ones. The specific quantities of low sulphur HFO that could be produced, and the costs which would be incurred by the Tenerife refinery are beyond the scope of this study.

6.3.2 French Overseas Departments and Territories

There is one small refinery in the Martinique, which treats North Sea and Venezuelan crude and which produces for domestic consumption.

Martinique refinery (2002)

Refinery	Type	Capacity kbbl/d	Main crude supply	Crude Sulphur content (%wt)	Approximate supply (%)
Fort-de-France (SARA)	HS	17	Flotta, Brent	0.4	50
			Santa Barbara	-	50
			Kirkuk	1.97	-

Note : HS hydroskimming

6.3.3 Azores and Madeira

There are no refineries in the Azores and Madeira islands.

6.4 Accession countries

6.4.1 Quality of marine fuels in accession countries

Marine distillates HFO bunker quality in accession countries is relatively similar to that sold in ports of the EU. Sulphur contents of 1.9 wt %S and 2.2 wt %S respectively were reported for Tallinn (Estonia) and Kaipeda (Lithuania). These sulphur contents are similar to the bunker sulphur contents reported for many of the ports in Sweden.

Sulphur content of 2.9%S is reported for Valetta (Malta) and 2.7% for Istanbul, which are also in line with the values reported for Greece, Italy and Spain.

Bunker fuel sulphur content (weighted average) –Accession countries

Country	Main Port	Avg. Sulphur in BFO
Estonia	Tallinn	2.34
Latvia	Riga	2.06
	Ventspils	2.41
Lithuania	Klaipeda	2.17
Malta	Valetta	2.93
Poland	Gdansk	1.93
	River Oder	2.09
Romania	Constanza	2.21
Turkey	Istanbul	2.66
	Izmir	2.78
	Mersin	2.72

Note: No data available for Slovenia, Bulgaria, Romania, Turkey, the Czech Republic, Hungary and the Slovak Republic.

6.4.2 Fuel producers in accession countries

There are nine major crude oil refining centres in the 10 accession countries[3], totalling around 1.11 million bbl/day (roughly equivalent to Spain's or the Netherlands capacity, and compared to an EU-15 total capacity of 13 million bbl/d).

Crude oil refining centres in accession countries

Region	Country	Number of refineries	Type	Combined capacity kbbl/d	Main crude supply	Sulphur content (%wt)
North Europe	Poland*	2	CC/HS	360	Russia	1.31
	Lithuania	1		263	Russia	1.31
	Latvia	-	-	-	-	-
	Estonia	-	-	-	-	-
Central Europe	Czech Rep	3		198	Russia	1.31
	Hungary	1		161	Russia	1.31
	Slovakia	1	RHC	115	Russia	1.31
	Slovenia*	-	-	-	-	
Mediterranean	Cyprus	1	HS	17	Iraq, Russ, NAfrica	0.5 - 1.31
	Malta	-	-	-	-	
TOTAL		9		1,114		

Notes: HS hydroskimming, CC: catalytic cracking, HC: hydrocracking, RHC: residue hydrocracking. In Poland there are 5 further small refineries with combined crude distillation capacity of 31 kbbl/day. There is one 13 kb/d refinery in Slovenia currently not in use. In addition, there are five refineries in Turkey, ten in Romania, and one in Bulgaria.

Three of the refineries are located in the Czech Republic and two in Poland. In addition, there are around seven further installations which are either not in use or treat less than 15 kbbd/d. Except for the Cyprus refinery and one of the Czech Republic's refineries, the major crude oil refining centres in accession countries are complex refineries, with high degrees of conversion.

6.4.3 Central Europe

Central European refineries are amongst the most modern in Europe. For instance, the Slovnaft refinery (Slovakia) has one of the highest degrees of conversion across Europe. In 2001 the start up of major upgrading units, including a residue hydrocracker (LC-Finer), resulted in the refinery producing only 3% of Fuel Oil (0.15 MT), against 23% before 1999. As of today, the hydrocrack of heavy crude oil fractions with the process of hydro cracking in a boiling bed is operated only by three refineries. The Slovnaft refinery currently exceeds the diesel sulphur content EU specification, with 280 – 300 ppm.
Hungary has one refinery in operation, the 161 kbbl/d the Szazhalombatta (Duna) refinery. Along with the Slovnaft refinery, the Duna refinery has also one of the highest desulphurisation indexes Europe.

[3] This paragraph does not include refineries in Turkey (6), Romania (10) and Bulgaria (1) refineries.

In the Czech Republic the Ceská Rafinérská is the largest crude oil refining company, it owns and operates two refineries: Litvinov and Kralupy. These two refineries have a combined capacity of 178 kbbl/d. Slovenia has one small simple refinery currently shut down (12,000 bbd/d).

Although this study did not surveyed the detailed quantities of marine bunkers (HFO) produced by each of these refineries, it can be assumed that minor quantities of this material are produced in Central European refineries because of demand constraints.

6.4.4 North Europe

There are three major refining centres in North European accession countries, located in Lithuania and in Poland. Although Poland holds seven refineries, two of them have around 10 kbbl/d of crude distillation capacity, and three hold around 3 kbbl/d. The remaining two are major refineries, the 270 kbbl/d Plock refinery, owned by PKN ORLEN and the Gdansk refinery 90 kbbl/d. Lithuania's only refinery is the 263 kbbl/d-capacity Mazeikiu Nafta.

In August 2000, the Gdansk refinery began production of a low-sulphur gas oil with a sulphur content of 50 ppm (0.005%). Gasoils meet also European standards. The starting up in 2000 of an Hydrocracking Complex allowed to reduce the sulphur content in gasoils to 0.005%. In 2002 the refinery completed a further up-grading of the gasoils HDS unit, which further reduced sulphur content in the gasoil pool. There are ongoing works to produce a new “ecological gasoil” with an ultra-low sulphur content of 0.001%. In 2002 the Gdansk refinery began the production of an ecological light heating oil with a sulphur content of 0.1%.

6.4.5 Mediterranean

The Cyprus refinery is a simple hydroskimming refinery, that treats about 17 kbbl/day of Urals, North African and Kirkuk crude oils. It produces about 5000 tonnes per year of HFO and BFO for local consumption.

7 COMMENTARY ON THE DIFFERENCE IN EFFECT BETWEEN BANNING THE « SALE », « MARKETING », OR « PLACING ON THE MARKET » OF HIGHER SULPHUR MARINE DIESEL OILS (OVER 1.5%S) AND MARINE GAS OILS (OVER 0.2%S) IN THE EU.

It has been tried in this very short commentary to gather elements on bunker delivery operations (especially marine distillates) in the European Union. However, it was not possible within this survey to answer directly the question raised in the title. The few elements collected may nevertheless help to improve the understanding of this issue.

The sources have been a few studies carried out in the past, elements collected from a few internet sites and phone calls to some operators (mainly brokers).

7.1 The issue

It can be interpreted as follows: is it possible to distinguish different markets for marine diesel and gas oils according to the type of customer (inland vessel, coastal/domestic vessel, international vessel) and the location of fuel delivery (port, territorial waters, international waters)

In that purpose, it would be necessary to have information on the respective volumes of these “markets” (at least in relative terms) in main EU ports, and on the supply procedures, national or EU-wide.

The procedures encompass the regulations such as mandatory or effective reporting of sales, fiscal treatment (duties, taxes), etc.

Particularly, can the sales be estimated with a distinction between sales in the ports, sales offshore but inside the territorial waters, and sales offshore outside the EU territorial waters.

Can the offshore sales outside the territorial waters be controlled so that an EU legislation on fuel specifications be applied also to these offshore sales or is it unavoidable to restrict the more severe EU specs, similar to those for Marpol-VI SECA’s or more stringent, to the only sales in ports or in coastal areas.

In this latter case, this would then let offshore sales subject to the sole worldwide regulations if any such as those of Marpol-Annex VI for residual fuel oil.

7.2 Market and delivery practices

The EU already prohibits the use of marine gasoil, including DMA, DMB, DMC and DMX grades, with sulphur content exceeding 0.2%. Ships coming from third countries are exempt from the limit until they first stop in an EC member country port, after which they must use the cleaner fuel if they burn gasoil. Sweden and Belgium already ban the sale of higher sulphur marine gasoil.

It is very difficult to see how any requirements for more stringent specifications can be effectively policed and enforced either in ports or at sea, except in respect of ships that operate more or less exclusively in a single area or two or more adjacent areas such as SECA’s, or of ships that can be clearly demonstrated to operate only on low sulphur fuels.

Absent a sufficiently fail-safe global system of bunker delivery notes which (together with bunker receipts, both backed up ultimately by the sulphur content calculation system) constitute reliable evidence of the quantities and sulphur content of bunker fuel taken on board and/or of reliable ship's logging of where and when change-over procedures between high and low-sulphur fuels kept in different tanks take place, it is impossible to determine whether or not a vessel is in compliance (source: BMT report, Study on the Economical, Legal, Environmental and Practical Implications of an European Union System to Reduce Ship Emissions of SO2 and NOx, August 2000).

While, for example, several EC/EEA coastal states have marine pollution legislation prescribing standards for foreign ships in their internal waters(or ports), territorial seas and in some cases, jurisdictional waters, fewer provide for at-sea enforcement and most exhibit a strong preference for in-port enforcement.

The UK in particular opposes any other option, and consistently with this, its 1996 Pollution Regulations do not provide for enforcement at sea (source: BMT report).

In that respect, it would be interesting to determine, from the amounts of the international sales supposed to go to coastal (for intra EU trade) and international(for extra EU trade) vessels, what is the split between sales in ports, offshore sales within territorial waters and offshore sales outside territorial waters.

According to IEA statistics, consumption of gas/diesel oil in the EU countries as bunker fuel averages 13 to 14MT/Y. About 65% of these quantities, or about 8.5 to 9MT/Y are classified as international bunkers, therefore excluded from the domestic consumption.

It can be safely assumed that all sales to inland uses (5MT) are carried out in EU ports (sea ports or river ports).

The remaining 9MT are sold in ports, in territorial waters and possibly outside territorial waters as international bunkers.

These sales are not subject to taxes or duties and prices are fixed exclusively on a commercial basis.

Regarding the relative share of the fuel consumption in territorial waters in the total consumption: if taking all bunker fuels into account, it is believed a significant share is bunkered and consumed during international voyages hence a significant part of the sales represents "export" for consumption outside European waters. However, it seems that when considering marine diesels and marine gas oils only, the share is much smaller.

In any case, it appears that statistics on sales splitted by type of customer or location of delivery, if they probably exist within main suppliers and perhaps within port authorities, are not published.

It appears nevertheless that the volumes of marine diesel and gasoil delivered offshore outside territorial waters are very limited. This essentially concerns fishing fleets in Northern seas (north of Norway, Baltic) and around the Canary Islands.

Regarding the quality aspects, it appears that the trend for ship operators is to more and more systematically buy and use 0.2%S gasoil, which is mandatory for use in territorial waters, even for ships going outside the EU. Indeed, very few EU ports at present continue to market higher sulphur content gasoils, all are located in Southern Europe.

7.3 Offshore bunkering

Offshore bunkering has the advantage of avoiding calling costs, agency fees and port dues, minimal or no deviation from route and generally it is reliable and professional. The only disadvantage is time consumption for the ship operator and environmental concern on possible bunker spills incidents.

Many European ports operate bunkering at the anchorage, that is to say at a maximum distance of 3 to 4 miles from the coast.

As stated hereabove, the fishing fleets are among the biggest buyers of both marine diesel and marine gasoil, whether in territorial waters or outside territorial waters. In international waters, fleets are supplied on the fishing areas. Bunkers delivered outside territorial waters are provided by a very small barge fleet not believed to exceed 4 or 5 units in North Europe.

Offshore prices are sometimes cheaper than in ports. This is the case in Denmark for example.

7.4 Overview of main bunkering locations

In the case of the Rotterdam port, “bunker only” calls are not frequent because it is not a natural deviation route for vessels, despite reduced harbour dues.

More than 90% of bunkers are delivered by barge, with a total barge fleet around 80-100 vessels in a wide range of sizes. Pipeline deliveries are not common, although this may be offered to cargoes calling at refineries/storage facilities.

These barges operate within the Europoort or other ports part of the port of Rotterdam.

Most suppliers, including the independents and oil majors, do not own or operate their barges. They have specially dedicated barges or barges on exclusive time charter. Among independents, it is common practice to pool barge transportation services.

Most important, offshore deliveries are not allowed by Dutch law, so that all deliveries take place inside port limits.

This is not so in Denmark where offshore bunkering is well developed. It accounts for an estimated 80% of a total Danish market totalling approximately 1.5MTons. The majority of bunker buyers in Denmark consist of international vessels passing the country on their way into or out the Baltic sea. The main areas for offshore bunkering are in the Great Belt region and offshore Copenhagen/the Sound. Deliveries are done by a fleet of small sea-going bunker tankers, varying in size from 1,500 to 6,000 dwt. They generally have in-line blending facilities and offer the full range of marine fuels. Gothenburg in Sweden has also an active offshore operation.

These operations however take place within the territorial seas.

Falmouth in the UK is a major bunkering location and operates bunkering near the coast (at anchorage). In France, it is similar for Cherbourg which is in fierce competition with Falmouth.

Belgium used to operate offshore bunkering at West Ender, but there is no more delivery barge in this location. Ostende continues to sell bunkers near the coast.

In the Med area, Gibraltar, Fos/Lavera, Malta, Piraeus, Augusta, Crete, Cyprus, are major bunkering location where bunkering at the anchorage constitute the great majority of sales.

There is no bunkering outside territorial waters in the Med.

This is probably different in the Canary Islands for offshore sales to international fishing fleets operating off Morocco and Mauritania.

Both in the Med and in the Canary Islands, marine gasoil having a high sulphur content continues to be marketed (0.6%S in the Canary Islands), but 0.2% grade is available everywhere. More than 0.2% grade can be found in Southern France (1%S grade sold to international vessels), Gibraltar and the Canary Islands and probably in areas such as Greece and Malta.