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**Marine Fuels: Composition, Quality and
Future Prospects**

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MANAGING RISK



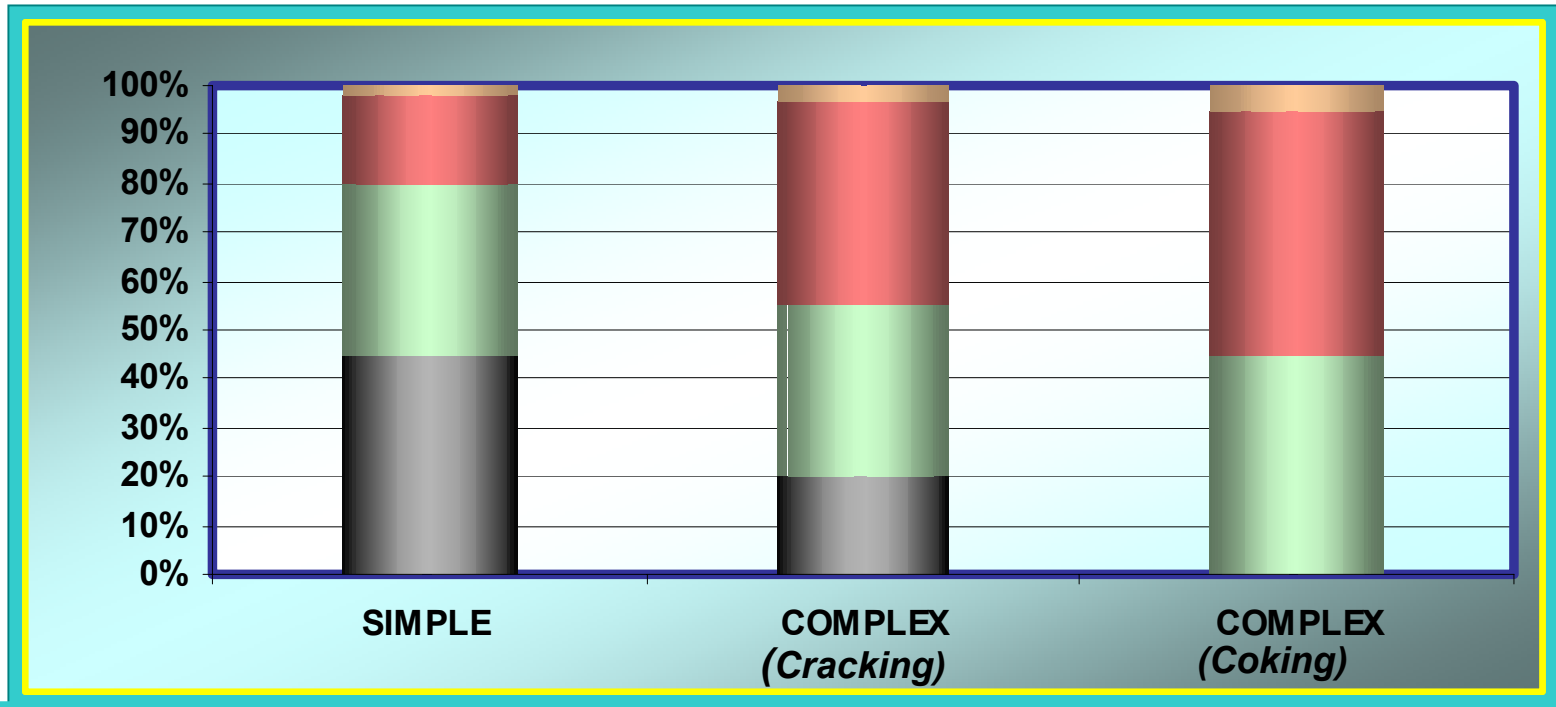
Marine Residual Fuel

Typical Composition

A mixture of Petroleum Residue (atmospheric or vacuum) and cutter stocks blended to meet specifications.

Source: Major petroleum company Manufacturers Safety Data Sheets (MSDS)

Impact of Refinery Type on Product Barrel

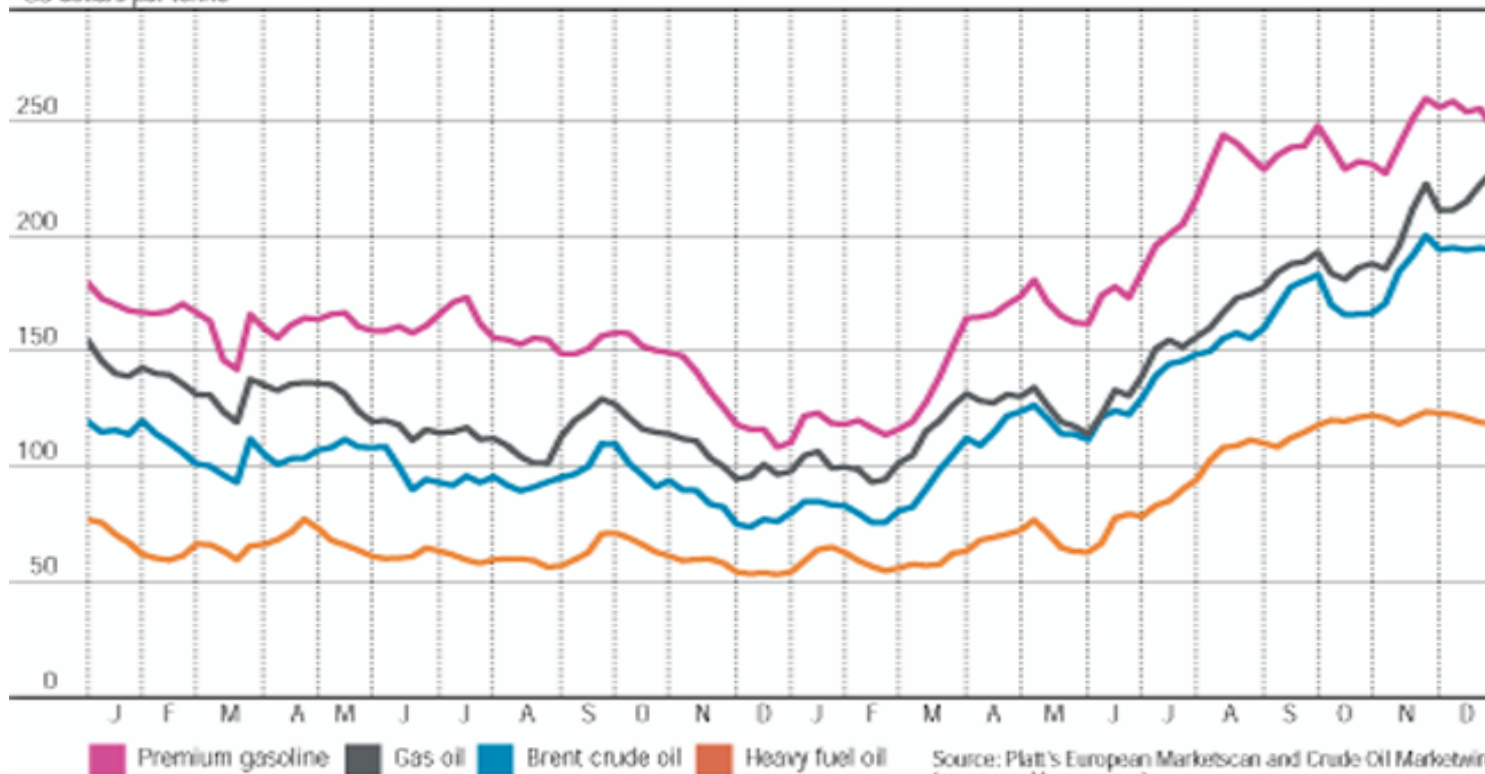


- GASES
- GASOLINE
- MIDDLE DISTILLATES
- RESIDE

**2 Year
Average**

Spot crude and product prices 1998 and 1999

US dollars per tonne



Source: Platt's European Marketscan and Crude Oil Marketwire [mean weekly averages].

Source: "BP World Energy Outlook"



MANAGING RISK

World Average Residual Marine Fuel Quality, 2004

"IF 180 GRADE"

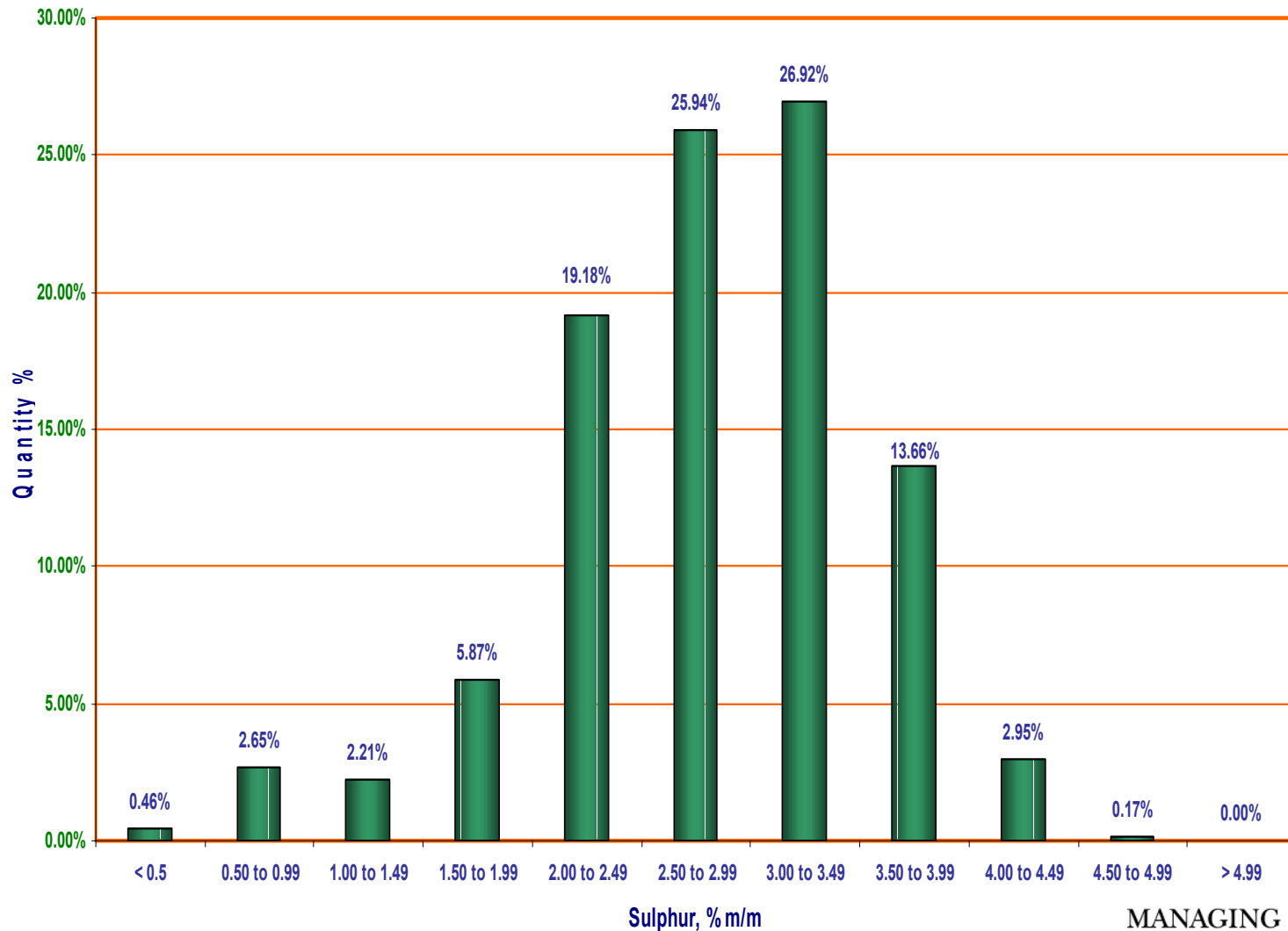
	<u>DENS</u>	<u>VISC</u>	<u>H2O</u>	<u>MCR</u>	<u>S</u>	<u>TSP</u>	<u>ASH</u>	<u>V</u>	<u>Al</u>	<u>Si</u>	<u>MJ/Kg</u>	<u>CCAI</u>
World Avg	974	177	0.2	11.7	2.64	0.02	0.04	92	8	11	40.48	845
US	985	190	0.2	13.0	2.67	0.02	0.05	133	11	15	40.31	853
World* (ex. US)	972	175	0.2	11.6	2.64	0.02	0.04	88	8	10	40.51	842

"IF 380 GRADE"

World Avg	983	343	0.2	13.3	2.73	0.02	0.04	110	9	12	40.35	845
US	987	334	0.2	13.8	2.72	0.02	0.05	140	11	16	40.27	850
World* (ex. US)	982	344	0.2	13.2	2.74	0.02	0.04	104	8	11	40.37	844

*World Average fuel quality minus US average fuel quality

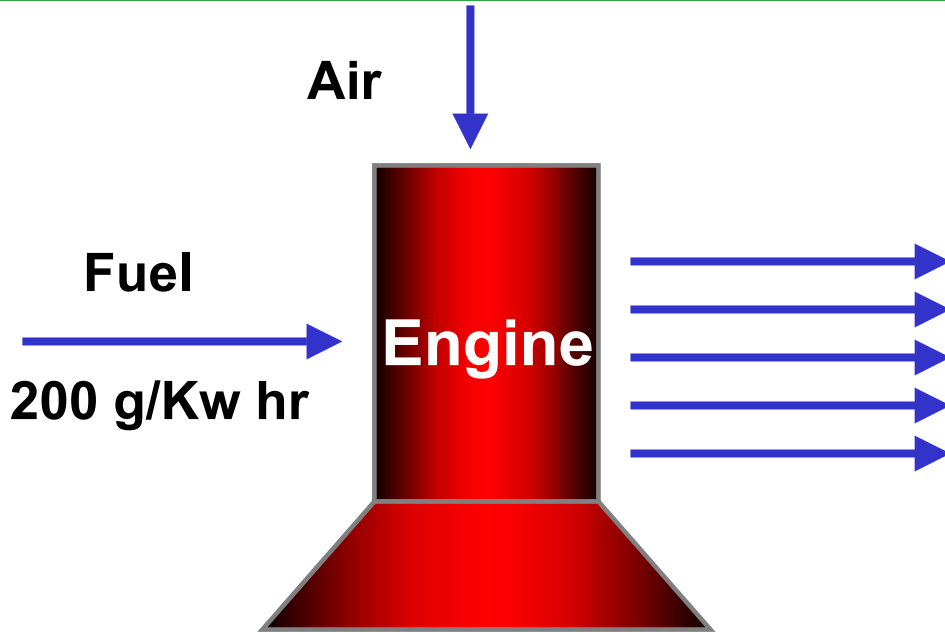
Marine Fuel Distribution by Sulfur Content 2004



ENVIRONMENTAL CONCERNS

SO_x
 NO_x
 $PM_{2.5}$
VOC
 CO_2

Marine Exhaust Emissions



Fuel Derived Emissions, g/Kw hr

CO ₂	634
H ₂ O	187
SO _x	11.1
NO _x	1.75
Particulates	N/A
Nitrogen	4740
Oxygen	626

MEMO:

Fuel Composition

% C	86.5
% H	10.4
% S	2.7
% N	0.4

Ratio's

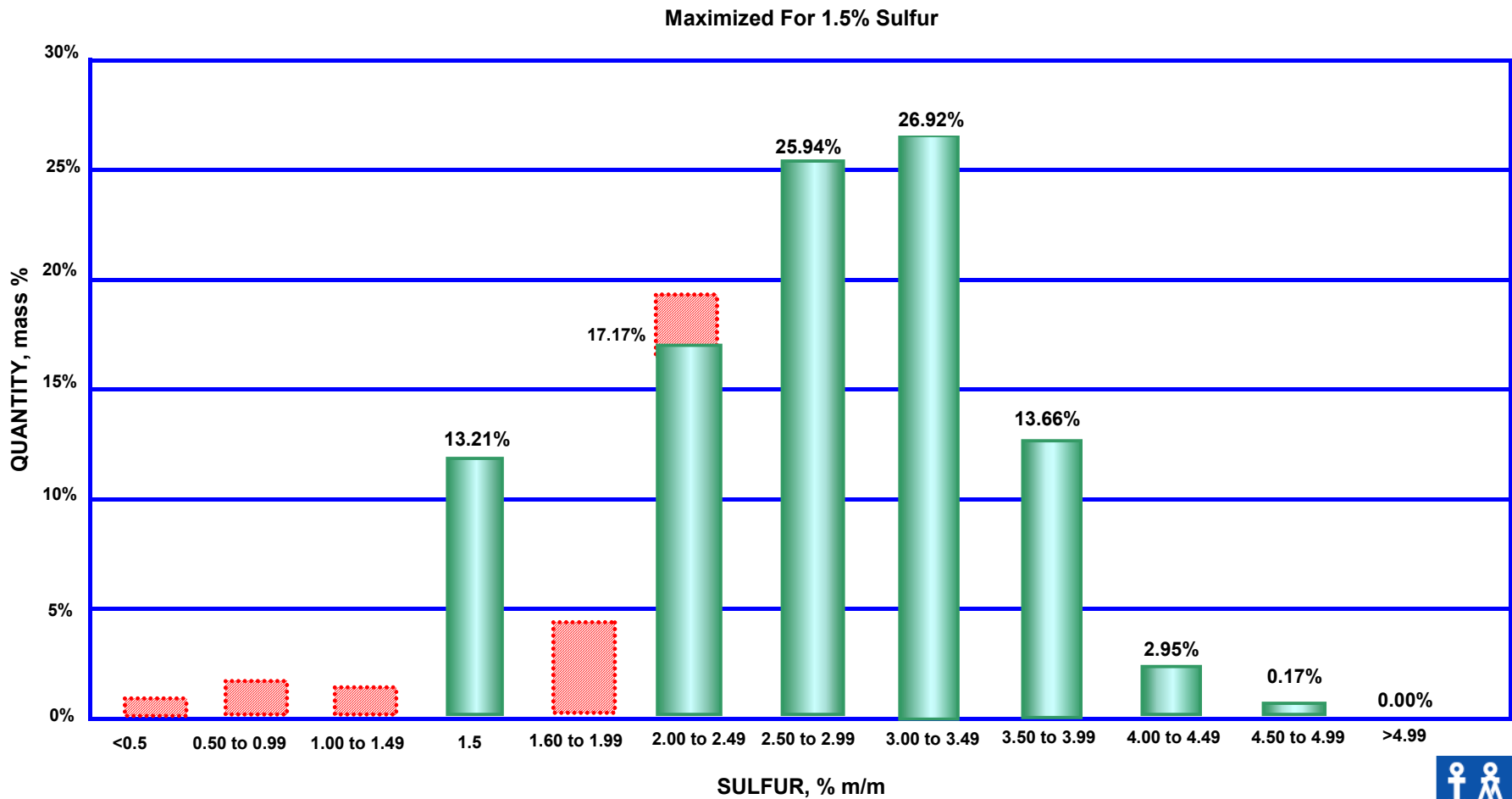
H/C	1.44
C/S	89
C/N	202
SO ₂ /SO ₃	90/10
NO/NO ₂	96/4
Air/Fuel	30/1

Low Sulfur Fuel (1.5%)

How will this demand be met?

- Low % Sulfur IFO from low % Sulfur crude
 - FACTS:
 - World Average Sulfur 2.7%
 - ~5% of DNVPS samples are low S ($\leq 1.5\%$)
 - Low % Sulfur fuels concentrated in few locations:
Brazil, Argentina, North Africa, Indonesia
- Repositioning of low % Sulfur residue (LSFO)
- Stack scrubbing
- Sulfur credits Trading
- Residue desulfurization
- Blending
 - LSFO/IFO: limited potential
 - IFO/MGO: feasible today but expensive

Marine Fuel Distribution by Sulfur Content



Conclusions

- SO_x Restrictions are inevitable
 - When, Where, How Low?
- Solution will be expensive
 - How many SECA's