Assessment of Fuel Oil Availability

Jasper Faber, Tokyo, 29 November 2016

CE Delft

STRATAS ADVISORS
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UMAS

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PETROMARKET
RESEARCH GROUP

Presentation outline

- Context of the Fuel Availability Assessment
- Aim and scope and of the Assessment
- Methods, data and models
- 2012 fuel demand and supply
- 2020 fuel demand projections
  - Uptake of scrubbers and alternative fuels
- 2020 Refinery capacity
- 2020 Marine fuel supply
- Conclusions

Context of the Fuel Availability Assessment

- MEPC 58 (2008) amended MARPOL Annex VI, Regulation 14.
  - The sulphur content of any fuel oil used on board ships outside ECAs shall not exceed the following limits (14.1):
    - 3.50% m/m from 2012
    - 0.50% m/m from 2020
  - Regulation 4 specifies that these limits can also be achieved by alternative compliance methods that are 'at least as effective in terms of emissions reductions'
  - Regulation 14.8 specifies that the 0.50% limit shall be subject to a review to be completed in 2018, taking into account:
    - the global market supply and demand for compliant fuel;
    - trends in fuel oil markets; and
    - any other relevant issue.

Context of the Fuel Availability Assessment

- MEPC 68 (2015) approved terms of reference for the review of fuel oil availability
- MEPC 68 established a Steering Committee: 13 countries, EC, 6 NGOs
- IMO Secretariat and the Steering Committee selected a consortium led by CE Delft to conduct the study
- MEPC 69 (2016) agreed, in principle that a final decision on the date of implementation of the 0.50% sulphur limit should be taken at MEPC 70, so that maritime Administrations and industry can prepare and plan accordingly

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Aim and scope

- Overall objective:
  - To conduct an assessment of the availability of fuel oil with a sulphur content of 0.50% m/m or less by 2020.
- Specific objectives:
  - Develop quantitative estimates of the demand for fuel oil meeting the global 0.50% m/m sulphur limit, both globally and for different world regions;
  - Assess the ability of the refinery industry to supply the projected demand; and
  - Compare the demand and supply scenarios to assess their implications with respect to the availability of compliant fuels.

Study consortium

- CE Delft: overall lead
- Fuel demand team: CE Delft, UMAS, NMRI

- Fuel supply team: Stratas Advisors, Petromarket Research Group

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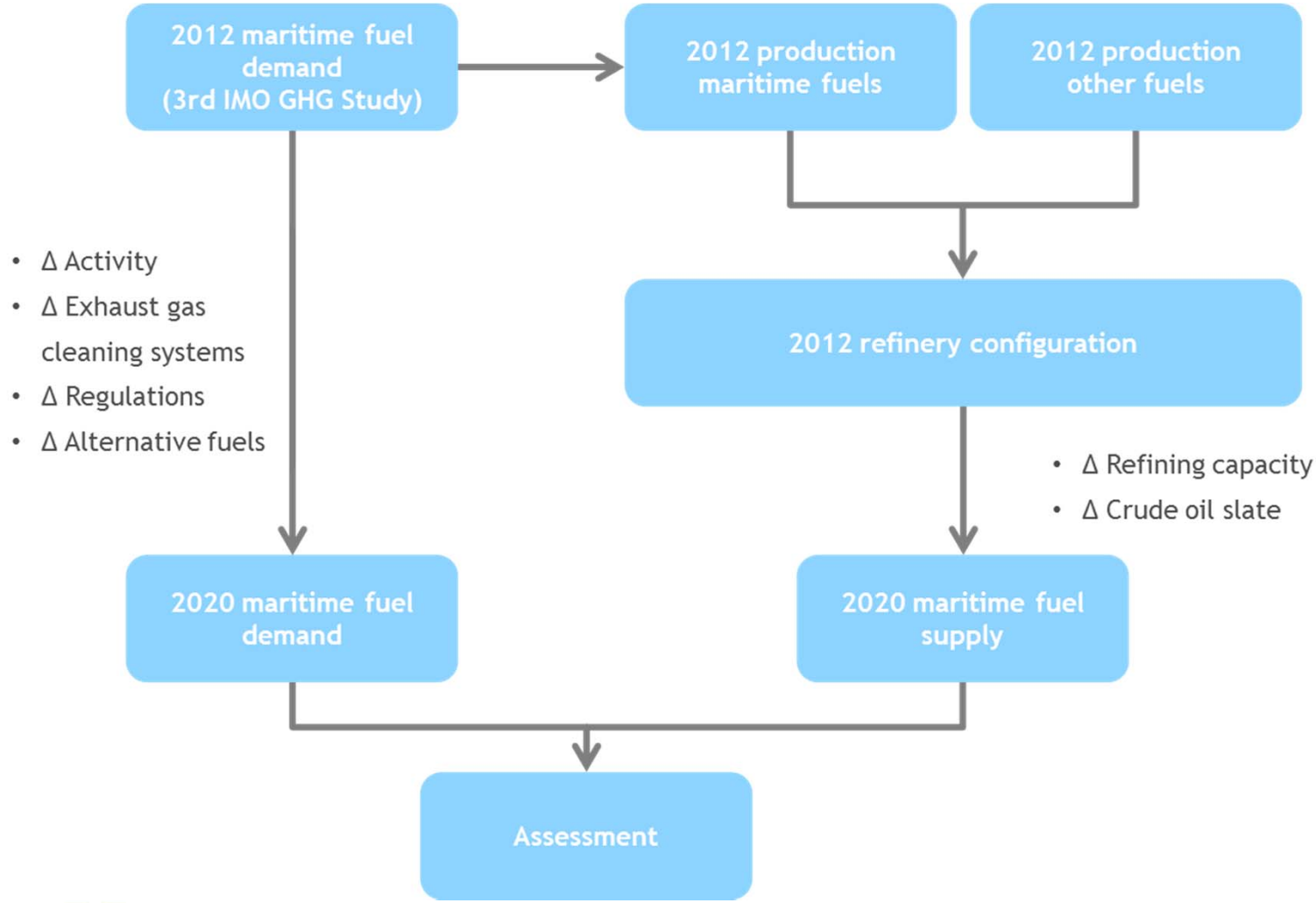
Methods, models and data sources



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Methods, models and data sources

- We have used data from reputable organisations and models that have been subject to public scrutiny
  - Fuel demand model and data
    - Third IMO GHG Study 2014
    - CE Delft emissions projection model
  - 2012 refinery data
    - IEA
  - Refinery capacity data
    - Oil and Gas Journal, Hart Energy
  - Refinery model
    - Aspentech PIMS (used by 75% of refineries worldwide, and used in >60 peer-reviewed articles in academic journals)

2012 supply and demand of marine fuels

- Bottom up results from the Third IMO Greenhouse Gas Study were used as a basis for the estimate of the global 2012 marine fuel market.
- QA/QC based on newly available IEA top-down data confirmed the plausibility of the results.

- Global shipping fuel consumption 2012 (million tonnes):

	HFO	MDO/MGO	LNG
Main engine	188	18	7
Auxiliary	33	42	1
Boiler	7	5	0
Total	228	64	8

2012 supply and demand of marine fuels

- Marine MDO/MGO accounted for 5% of global middle distillate production.
- Marine HFO accounted for 46% of global HFO production.

- Global refinery production 2012 (million tonnes):

Refinery production		Sulphur (% m/m)
Gasoline	963	
Naphtha	256	
Jet/Kerosene Fuel	324	
Middle Distillate Oil	1316	
of which Marine MGO	64	0.14
Marine Heavy Fuel Oil (HFO)	228	2.51
LPG	113	
Other	784	
Total	3984	

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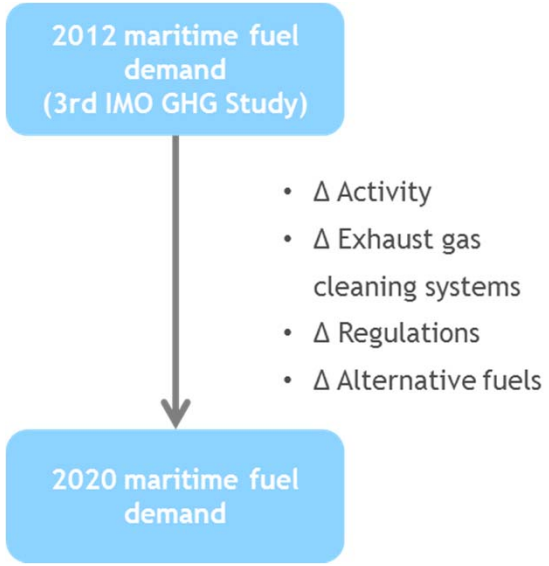
2020 fuel demand projections

- Energy demand model from Third IMO Greenhouse Gas Study.
- High/low cases take economic cycle into account through speed changes.
- Results checks for plausibility:
  - UNCTAD transport work data;
  - IMF global GDP forecasts;
  - Clarksons WFR fleet renewal rates.
- Energy use increases by 8% in the base case.
- Energy use in 2012 and 2020 (PJ):



Ship type	2012	Base case	High case	Low case
Dry bulk	2,109	2,422	2,663	2,108
Liquid bulk	2,893	2,482	3,031	2,218
Unitized	4,371	5,448	6,132	4,826
Passenger	981	939	1,042	846
Miscellaneous	1,523	1,523	1,691	1,373
Total	11,877	12,814	14,559	11,370

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2020 fuel demand projections

- Projections of EGCS use based on:
  - Literature review;
  - Stakeholder in-depth interviews;
  - Stakeholder internet survey.
- Model takes into account:
  - Costs and benefits;
  - Regulatory, technical and operational constraints;
  - Availability of scrubbers and installation capacity; and
  - Other barriers.
- Base case: 3,800 ships will have EGCSs in 2020, 36 million tonnes of fuel (11% of energy)
- High case: 1,200 ships, 14 million tonnes of fuel (4% of energy)
- Low case: 4,100 ships, 38 million tonnes of fuel (13% of energy)

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2020 fuel demand projections

- Projections of LNG use based on:
  - Literature review;
  - Stakeholder interviews;
  - Projected number of LNG carriers;
  - Model that projects LNG use as fuel market taking into account:
    - Input assumptions derived in this study (e.g. fuel price, transport demand, costs of scrubbers);
    - Technology and operational interventions;
    - Regulatory, technical and operational constraints;
    - Costs and benefits of any combination of fuel and machinery.
- Estimated LNG use in million tonnes (Table 22), and % of the energy:

	2012	2020 base	2020 high	2020 low
LNG carriers	8	9.76	10.85	9.70
LNG as a fuel market (global fleet)	0	3.22	3.00	3.66
Total	8	13.0	12.7	14.5
Percentage of the total energy demand (%)	3.6%	5.4%	4.7%	6.8%

2020 fuel demand projections

- Marine fuel demand will increase from 300 million tonnes in 2012 to 320 million tonnes in 2020 in the base case.
- 76% of petroleum fuels will have a sulphur content of 0.10% - 0.50%.
- 13% of petroleum fuels will have a sulphur content of 0.10% or less.

	Petroleum derived fuels			LNG
Sulphur (% m/m)	<0.1%	0.1%-0.5%	>0.5%	
	In ECAs and MGO used in small engines	Outside ECAs	Globally in combination with a EGCS	Globally
	Million tonnes per year			
Africa	2	12	1	0
Asia	18	110	15	4
CISS & Russia	1	7	1	0
Europe	9	54	8	4
Latin America	3	21	3	1
Middle East	1	5	4	1
North America	4	26	3	3
Global	39	233	36	12

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2020 fuel supply projections

Supply modelling methodology

The calibrated model developed for 2012 was updated with the following information for base case of 2020.

- Regional refinery capacities were updated.
- Fuel specifications were updated for 2020.
- The price for 2020 was updated.
- Based on 2020 demand numbers the maximum and minimum of refinery products and refinery inputs range were updated.

Conservative assumptions:

- The utilization of hydroprocessing units was limited to 90% or less.
- The sulphur removal in hydrodesulphurization units was limited to 90% or less depending on the grade of oil being processed.
- The MDO/MGO/HFO sulphur specification was further tightened by 10%.

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2020 refinery capacity

	2012	2020	Change
	Million tonnes per year		
Crude Distillation	4630	5020	8%
Light Oil Processing			
Reforming	610	626	3%
Isomerization	94	122	30%
Alkylation/Polymerization	117	118	1%
Conversion			
Coking	312	421	35%
Catalytic Cracking	862	916	6%
Hydrocracking	388	532	37%
Hydroprocessing			
Gasoline	148	204	38%
Naphtha	759	810	7%
Middle Distillates	1109	1306	18%
Heavy Oil/Residual Fuel	439	507	15%

2020 refinery capacity: sulphur and hydrogen plants

- Hydrotreatment requires hydrogen and generates hydrogen sulphide (H_2S) which can either be burnt (generating sulphur oxides, SO_x) or turned into elemental sulphur in a sulphur plant.
- Hydrogen can be generated in a refinery (e.g. in a reformer) but can also be bought commercially.
- Statistics on sulphur plant capacity are of a lower quality than statistics about other refinery units.
- Investments in sulphur plants are one or two orders of magnitude smaller than investments in hydrotreatment units, and expansions of existing plants often require even less capex.
- Hence our assumption that refineries that have invested in hydrotreatment or hydrocracking units, have also invested in sufficient sulphur plant capacity.

2020 refinery capacity

- Although crude distillation capacity increase lags the demand increase between 2012 and 2020, hydrocracking, middle distillate and residual hydrotreatment capacity increases are higher than demand increases.
- This creates capacity to produce low sulphur marine fuels, provided that:
  - The sulphur content of the crude does not increase too much; and
  - The road diesel and road gasoline sulphur limits are not tightened more than in current legislation.
- These fuels can be hydrotreated residual fuels, unconverted oil from hydrocrackers, and lighter oils.

2020 maritime fuel supply: base case

Million tonnes/year	2020	2012
LPG*	110	113
Gasoline	1,086	963
Naphta*	305	256
Jet fuel and kerosene	331	324
Middle distillate	1,521	1,316
of which marine MGO	39	64
Marine heavy fuel oil	269	228
of which ≤0.50% S	233	0
of which >0.50% S	36	228
Other heavy fuel	194	272
Other*	343	512
Total (refinery only)	4,159	3,984

2020 maritime fuel supply: base case

Different regions have different blends of 0.50% S marine fuels, e.g.

Europe

Europe HFO blending (2020)				
Component to Blend	Volume (barrels/day)	Vol%	SUL % (m/m)	Viscosity cSt@50°C
SR DIESEL	224,083	23.05	0.552	-
FCC LCO	113,224	11.65	0.587	-
TR LT DIST	27,316	2.81	0.044	-
TRT AGO 85%	351,048	36.12	0.148	-
TRT PURCH GASOIL	5,404	0.56	0.015	-
H-OIL BTMS	152,943	15.73	1.000	-
TRT ATRES	97,981	10.08	0.250	-
Total	972,000	100.00	0.450	17.2

Asia

Asia HFO blending (2020)				
Component to Blend	Volume (barrels/day)	Vol%	SUL % (m/m)	Viscosity cSt@50°C
ATRES	114,489	6.06	2.103	-
TR LT DIST	291,104	15.4	0.030	-
H-OIL BTMS	241,080	12.76	1.000	-
TRT ATRES	1,243,327	65.78	0.263	-
Total	1,890,000	100	0.450	110.7

2020 maritime fuel supply: sensitivity analyses

1. Low Flash Point- Reducing minimum flash point to 52° C, will help increase HFO volume, but not needed for base case, Case 1.
2. High Demand Case – Asia and Middle East supply additional HFO.
3. Low Demand Case Asia is able to reduce the supply meeting other fuel demands.
4. Maximum amount of compliant fuel: Asia and Middle East increases the supply, other regions stays at the base case. 296 million tonnes (27% higher than base case.
5. High Sulphur Crude – Middle East, Africa, Asia, and Europe will be able to use 10% higher Sulphur relative to 2012.
6. Increasing low viscosity blend stock in HFO – The supply is available from kerosene pool.
7. Maximum refinery utilization – North America increased Hydrocracker utilization, other region stays at maximum.

2020 maritime fuel supply: fuel quality

- The viscosity ranges between 10-180 CST.
- The density ranges between 908-934 kg/m^3.
- The CCAI ranges between 821-858.
- The flash point ranges between 94-118°C.

Region	Viscosity, CST	Density, kg/m^3	CCAI	Flash pt, C	ISO grade
Africa	10	911	853	97	RMB
Asia	110.7	926	826	111	RME
North America	14.7	925	858	110	RMB
Latin America	52.1	911	821	97	RMD
Middle East	180	934	828	118	RME
Europe	17.2	908	838	94	RMB
Russia	66.4	932	839	116	RMD

Assessment of fuel availability

- The base low and high case are plausible projections of fuel demand.
  - However, unexpected economic developments (positive or negative) could lead to demand outside the range analysed in this report.
  - Unexpectedly high or low investment in EGCSs and LNG ships would have to coincide with much higher or lower transport demand to result in fuel demand outside the range projected by our cases.
- Sufficient amounts of fuel oil of the required quality can be produced for both the base cases, the low case and the high case.
  - Production capacity is higher than the high case.
  - However, delayed or aborted expansion projects, delayed upgrading of hydroprocessing catalysts, unavailability of low sulphur crude as a result of geopolitical tensions, and new regulations on road diesel could result in a lower supply.

Assessment of fuel availability

- We find global shortages improbable.
- Situations of regional oversupply and shortages, which cancel each other out on a global level, are likely to occur.
  - In several scenarios, oversupplies occur in Latin America, Europe, and the Middle East, while Africa, Asia and North America produce less than is sold there.
- Regional supply and demand can be balanced by:
  - Transport of products.
  - Changes in bunkering patterns.

Conclusion

In all scenarios, the supply of marine fuels with a sulphur content of 0.50% m/m or less and with a sulphur content of 0.10% m/m or less is projected to meet demand for these products.

Thank you for your attention!

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