「日本国内における
低硫黄燃料供給の可能性」

"Potential for low sulfur fuel supply in Japan"

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1. 調査の背景と目的

・ 船舶からの硫黄酸化物（SOx）の排出規制は、マルポール条約付属書VIにおいて燃料油中の硫黄含有率基準が規定されている。Sox emissions from vessels are regulated with MARPOL Convention Annex VI according to sulfur content limit within fuel oil.

・ 条約には、一般海域において2020年に燃料油中の硫黄含有率0.5質量%以下の燃料油の供給がなされない場合には、2025年に延期すると規定されている。According to the MARPOL Convention, it is stipulated that the tightening of regulation will be postponed to the year 2020 in case the fuel with sulfur rate 0.5 mass % or below is not supplied in the general sea area within the of 2020.

・ 本調査は、2020年時点での日本関係船舶向けの規制適合燃料油の供給見通しとともに、規制強化に向けた課題等について調査を行うことを目的とした。This investigation aims for a research on the issues toward tightening of regulation, along with the outlook of the fuel supply matched to the regulation for Japanese vessels at the year of 2020.

・ 本調査は、国交省から海上技術安全研究所が請負契約書に基づいて実施したものである。（需給見通しは、JXリサーチ実施）This investigation was implemented by NMRI according to the contract with Ministry of Land, Infrastructure, Transport and Tourism.

2. 調査の内容

(1) 舶用燃料油供給の実態調査 Actual condition survey for vessel fuel supply

外航船、内航船、漁船に対する舶用燃料供給、消費の実態をIMO,IEA及び経済産業省、水産庁及び業界団体の文献等により調査 Investigation with the documents by IMO , IEA, Ministry of Economy, Trade and Industry, Fisheries Agency and the industry association concerning vessel fuel supply and it's actual consumption condition survey of ocean going vessel, domestic vessel and fishing vessel

(2) 2020年の舶用燃料供給量の予測 Predicted amount of vessel fuel supply for 2020

石油業界の動向を文献等により調査するとともに、スクラバー、LNGによる代替技術のヒアリングを実施し、(1)の結果を踏まえ、2020年の舶用燃料供給量を予測する。 Along with investigation with documents on the trends in the oil industry, the hearing on substitute technology by Scrubber and LNG should be carried out and then vessel fuel supply amount for 2020 should be planned according to the results of (1).

(3) 舶用燃料供給に関する技術的問題の調査 Survey for technical problems on vessel fuel supply.

舶用燃料油の低硫黄化にともなう性状の変化、代替技術開発に関する技術的課題を調査する。 Technical problems about the chemical property change along with low sulfurization of vessel fuel and it's alternative technical development will be investigated.

3. 石油製品(燃料油)内需見通し Outlook of the domestic demand for petroleum products(fuel oil)

政府経済見通し(2016.1内閣府試算)の経済再生ケース Economic reform case considered from the government's economic outlook (the cabinet's test calculation in Jan. 2016)

(2020年度までの経済成長率+2%/年)を前提とした場合。(On the assumption of +2%/year economic growth up to 2020)

unit : 10k KL, (%) ratio

	2012FY (achievement)	2015FY (expected achievement)	2012→ 2015 growth rate	2020FY (assumption)	2015→ 2020growth rate
gasoline・naphtha	9,938 [50%]	9,965 [50%]	0.30%	9,179 [50%]	▲ 7.9%
jet・kerosene	2,286 [12%]	2,086 [12%]	▲ 8.7%	1,836 [11%]	▲12.0%
gas oil・A-fuel oil	4,715 [24%]	4,528 [25%]	▲ 4.0%	4,249 [26%]	▲ 6.2%
B・C-fuel oil	2,838 [14%]	1,479 [8%]	▲47.9%	1,207 [7%]	▲18.4%
fuel oil total	19,777 [100%]	18,007 [100%]	▲ 8.9%	16,470 [100%]	▲ 8.5%

4. 船舶燃料油の需要実績

- 総合エネルギー統計数値と、全国漁業協同組合連合会（全漁連）の認識している数値との間に相当の乖離があったため、全漁連の数値を考慮した。The data of National Federation of Fisheries was given consideration since there was a big gap in data between overall energy statistical date and the one the association recognizes.

- 船舶比率は、軽油は1.5%，A重油は15~16%台になる。C重油は、電力用以外の一般C重油はボイラ用の内需が構造的に急減しているため、船舶用燃料が内需に占める割合は急増し、2014年度では35%に達している。The percentage of vessel use light oil and A-heavy oil in total fuel sales , is approximately 1.5% and the latter is 35%. Whereas C-heavy oil domestic demand reached 35% in the year of 2014 since domestic demand of general C-heavy oil for boiler use, other than power supply had structurally sudden decrease and the domestic demand of vessel fuel had sudden increase.

unit : 10k KL

	2012FY			2013FY			2014FY		
	gas oil	A-heavy oil	C-heavy oil	gas oil	A-heavy oil	C-heavy oil	gas oil	A-heavy oil	C-heavy oil
domestic	14	101	253	15	103	257	15	102	257
cargo	-	78	165	-	79	164	-	78	165
passenger	14	23	88	15	24	93	15	24	92
fishing boat	37	111	-	36	108	-	36	106	-
total	51	212	253	51	211	257	51	208	257
domestic total	3,339	1,376	899	3,409	1,344	748	3,358	1,236	734
ratio of vessel	1.5%	15.3%	28.2%	1.5%	15.7%	34.2%	1.5%	16.8%	35.0%

・The figures of C-heavy oil include those of B-heavy oil.

・The domestic demands totals show the general use of B・C-heavy oil except those of C-heavy oil for power supply.

4. 外航船の船舶燃料油の需要実績 The past record of marine fuel demand for ocean going vessel

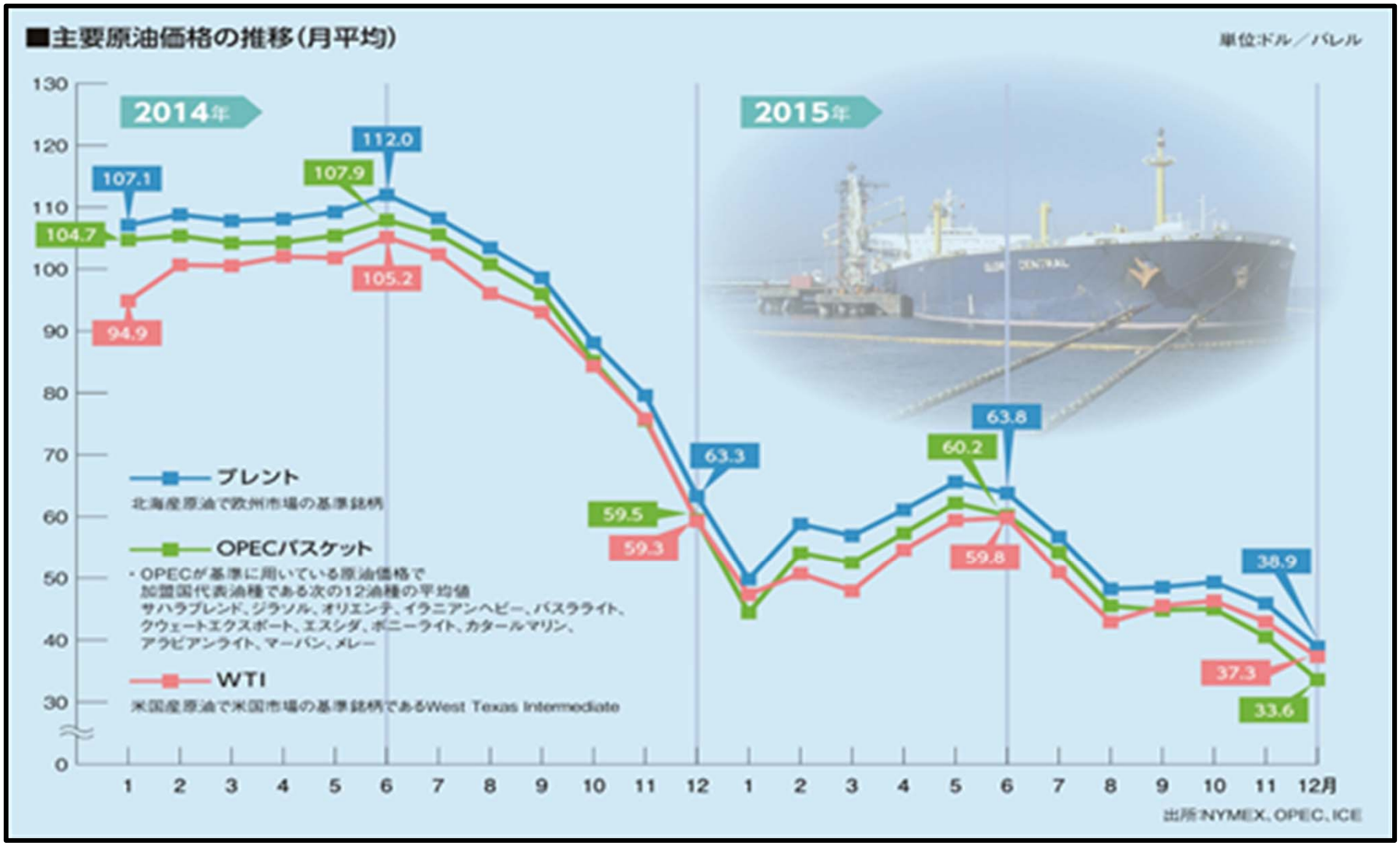
- 国内の外航船舶向けの燃料油は、保税（ボンド）扱いとなっている。Domestic marine fuel for ocean going vessels is treated as bonded fuel oil.
- 近年の外航船舶向けの保税重油については、A重油の保税輸入品は無く、C重油の保税輸入は少なく、ほぼ全量が生産品である。Concerning bonded fuel oil for ocean going vessels in recent years, they are mostly domestic products with no bonded A-fuel oil and very few bonded C-fuel oil.
- 今後も外航船舶向けの燃料油は、ほとんどが生産品によって供給されるものと考えられる。It is likely that domestic products will fulfill the demands of the fuel oil for ocean going vessels in the future as well.

unit : 10k/KL

		2010FY	2011FY	2012FY	2013FY	2014FY	2015FY (market price)
A-heavy oil	production	8.6	7.0	8.0	6.5	7.3	12.6
	import	0.0	0	0	0	0	0
	demand	8.6	7.0	8.0	6.5	7.3	12.6
C-heavy oil	production	445.5	391.5	415.8	394.8	357.5	370.0
	import	0.0	0	0	7.1	1.5	3.5
	demand	445.4	391.3	415.7	401.9	369.9	373.5

source : Petroleum Association of Japan

4. 船舶燃料油の価格



source: Petroleum Industry Today 2016(Petroleum Association of Japan)

4. 船舶燃料油の価格 the prices of marine fuel oil

		May, 2014	January, 2015	March, 2016
bunker fuel oil(S:3.5%or below)	RMG-380	605 $/t	285 $/t	178 $/t
LSfuel oil(S:0.1%or below)		sold in Europe （slightly cheaper than DMB)		
MGO(S:0.1%or below)	DMA	990 $/t	570 $/t	—
MDO(S:0.1%or below)	DMB	—	—	340 $/t
crude oil price in Dubai		105.5$/barrel (659$/kℓ)	46～52$/barrel (288～325$/kℓ)	35$/barrel (215$/kℓ)
domestic vessel	A-heavey fuel	￥92,300/kℓ	￥69,500/kℓ	￥58,800/kℓ
domestic vessel	C-heavy fuel	￥76,650/kℓ	￥50,100/kℓ	￥42,300/kℓ
domestic (street price)	gas oil	￥144,000/kℓ	￥120,000/kℓ	￥97,000/kℓ

・import crude oil : petroleum and coal tax (¥2,290/kl), gas oil : gas oil delivery tax (¥32,100/kl)

・バンカー重油価格は、原油価格に連動し、原油価格より安価。The cost of bunker fuel oil is lower than that of crude oil which is linked to.

・MGOやMDO価格は、留出油(軽油相当)で硫黄分が少ないために
製造コストが高くなり、300$/トン程度の格差がある。There is a big price gap between MGO and MDO ,– about $300/ton because of the one tends to be production cost wise more expensive than the other as it has fewer sulfur contents, called distillate fuel (estimated as fuel oil) , therefore becomes more costly.

・国内のC重油は、原油処理費と輸入原油(石油石炭税）等の
関税がかかり、原油価格より高くなっている。Domestic C –heavy fuel is more expensive than crude oil because the former comes with processing fee and import tax for crude oil(tax on crude oil and coal)

5. 2020年の舶用燃料油の供給量予測 The expected amount of marine fuel for 2020

内航船舶及び漁船向けの需要見通し the demand outlook of domestic vessels and shipping boats

＠前提条件＠ Precondition；

- 足元の需要をベースに、政府経済見通しを勘案して、2020年時点の船舶燃料の需要を想定した。This is an assumed marine fuel demand for the year of 2020, on the basis of the recent demand as well as considering government's economic outlook,

- また、内航船および漁船のLNGやバイオ燃料の油種転換は、流通上の問題等から、2020年時には、普及しないと予測した。Also , changing oil type of LNG and bio fuel for domestic vessels and fishing boats is not expected to be diffused for the reason of problem in distribution.

- スクラバー対応についても小型船のために設置スペースがないためにほとんど普及しないと予測した。Also, scrubber application is estimated not to be diffused for there's not enough space in smaller vessels.

したがって、国内の船舶燃料油は低硫黄燃料油での対応となる。Therefore, low sulfur fuel is more applicable to the domestic vessels.

5.内航船舶及び漁船向けの需要見通し Demand outlook for domestic vessel s and fishing boats

unit ：10k/KL

	2015 (achievement)			2020 (expected achievement)			yearly growth rate(2015→2020)		
	gas oil	A-heavy oil	C-heavy oil	gas oil	A-heavy oil	C-heavy oil	gas oil	A-heavy oil	C-heavy oil
domestic vessel	15	101	254	14	96	237	-1.0%	-1.1%	-1.4%
cargo	—	78	164	—	74	153	—	-1.0%	-1.3%
passenger	15	24	91	14	22	84	-1.0%	-1.4%	-1.5%
fishing boat	35	104	—	32	92	—	-2.0%	-2.3%	—
total	50	205	254	45	188	237	-1.7%	-1.7%	-1.4%
domestic total	3,359	1,169	633	3,306	943	482			
ratio of vessels	1.5%	17.5%	40.2%	1.4%	19.9%	49.3%			

・The figures in C-heavy oil include those of B-heavy oil. The domestic totals show the total of B・C-heavy oil for general use.

2020年度に向けて、経済成長は年率2%程度の堅調な経済成長を前提としても、Even on the assumption that there will be robust yearly 2% economic growth toward the year of 2020, however

・重量物の輸送量は減って、内航貨物の輸送量は漸減し、旅客船の乗客数も減る。Heavy goods freight traffic and domestic cargo will reduce and the number of passenger on passenger ships will also reduce.

・漁業に従事する人口は減る傾向であり、漁船向けの燃料需要も減っていく。The population engaged in fishing industry tends to be reducing and so does the fuel demands for fishing boats.

・この結果、C重油（電力用以外）需要に占める内航船舶のシェアは、
2020年には50%に迫るものと想定される。As a result , the market share of C-heavy oil (excluding power supply use) demand for domestic vessels is expected to become up to 50% in the year of 2020.

5. 外航船の需要見通し Outlook of marine fuel for oceangoing vessels

・ 外航船舶向けの保税重油については、世界の主要な供給地ごとの価格差により、どの港で補油をするか、ユーザー（船舶）側に選択権がある。As for bond fuel oil for ocean going vessels, they have options to decide where to refuelfor there is a price difference in each country's main supply center

・ 日本積みは一般に価格競争力での優位性は無いので、2020年時点の日本積み需要は、近年の実績のうち、A重油7万KL，C重油370万KL程度と想定する。Demands for shipment in Japan for the year of 2020 is estimated about 700000/KL for A-heavy oil and 3700000/KL for C-heavy oil according to the achievement in the recent years for they do not have advantage in general price competitiveness.

・ 需給状況がC重油の過剰な局面では、これに追加されるものと想定される。These figures would be added when reaching the excessive situation of supply and demand. for C-heavy oil.

unit：10k/KL

	2012FY (achievement)		2015FY (expected achievement)		2020FY (estimate)	
	A-heavy oil	C-heavy oil	A-heavy oil	C-heavy oil	A-heavy oil	C-heavy oil
domestic vessels	115	253	116	254	110	237
fishing boats	147	—	138	—	124	—
export (ocean going vessels)	8	416	13	370	65	370

・A-heavy oil includes gas oil. Also, C-heavy oil includes B-heavy oil

6. 国内の船舶燃料油の供給能力 fuel oil supply capability for domestic vessels

エネルギー供給構造高度化法（2009年7月1日成立）

Structural upgrading law for energy supply (established on July 1, 2009)

・原油など化石エネルギーの有効利用 Effective utilization of fossil energy including crude oil

・非化石エネルギーの利用拡大 Utilization expansion of non-fossil energy

2016年度までに日本全体の重質油分解装置装備率を
45%から50%程度に引き上げることを目標 Objective of raising the current equipment rate of heavy fuel cracking process from 45% up to approximately 50% before the year of 2016.

「装備率向上により、C重油が分解されガソリン・灯油・軽油等が増産され、供給能力が向上」 Total supply capacity has improved along with the improvement of equipment rate of C-heavy fuel cracking process, resulting production increase of gasoline, kerosene and diesel fuel.

重質油分解装置装備率 Equipment rate of heavy fuel cracking process

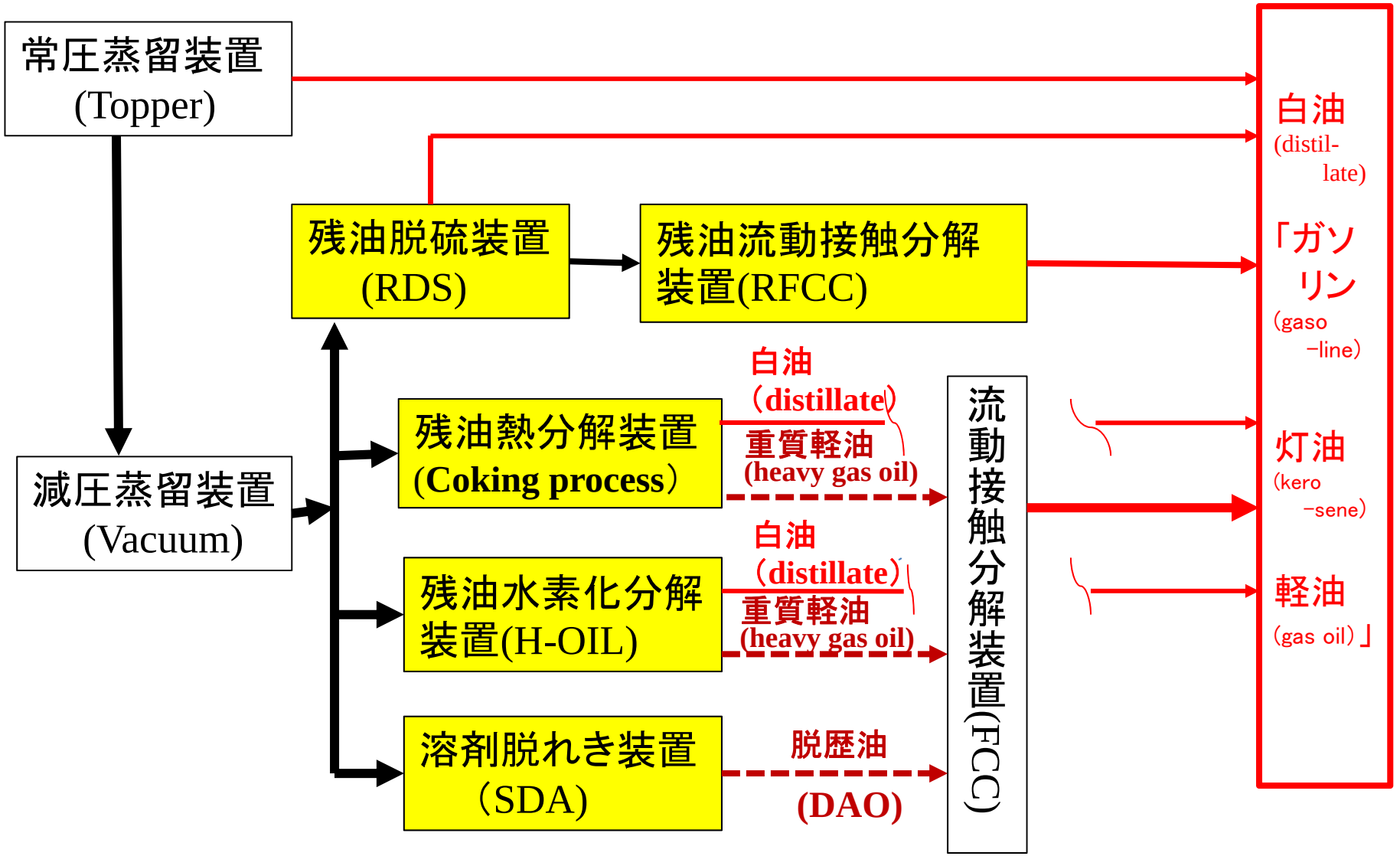
$$\text{重質油分解装置装備率} = \frac{\text{重質油分解装置の処理能力}}{\text{常圧蒸留装置の処理能力}}$$

Processing capacity of heavy fuel cracking process / Processing capacity of atmospheric distillation unit

残油流動接触分解装置、**残油**熱分解装置、**残油**水素化分解装置

Fluid catalytic cracking process for residue / Thermal cracking process for residue / Hydrogenation cracking process for residue

【参考】エネルギー供給構造高度化法



6. 国内の船舶燃料油の供給能力

Supply capacity of domestic marine fuel

・ 常圧蒸留装置の能力を現状よりも▲10%削減した場合でも、2020年度時点の燃料油需給バランスを試算すると、常圧蒸留装置稼働率は84.5%にしかならない。The operating ratio of atmospheric distillation unit will be only 84.5% when doing a trial calculation of the fuel supply and demand at the year of 2020, even in the case of reducing 10% of capacity of atmospheric distillation in the current state

・ 製品別の生産得率は、残油処理装置の装備率が高くなり、2015年実績と比べて、中間留分の生産割合が+1.4%アップ、C重油割合▲1.0%と見込んだ。The yield of products on each item, along with the rise of equipment ratio of distillate cracking is estimated that the ratio of middle distillate rises 1.4% whereas those of C-heavy fuel drops 1.0% comparing the actual achievement in 2015.

		gasoline	naphtha	JET・kerosene	gas oil・A-heavy oil	C-heavy oil
production	1k BD	818	351	510	900	364
	10k KL/year	4,777	2,050	2,978	5,256	2,126
	(ratio in 2015)	-27.30%	-11.70%	-17.00%	-30.00%	-9.00%
	(ratio in 2020)	-28.70%	-10.10%	-16.60%	-29.00%	-10.00%
domenstic demand	1k BD	818	763	316	733	208
	10k KL/year	4,770	4,298	1,845	4,282	1,215
import and export(NET)	1k BD	0	▲412	+194	+167	+156
	10k KL/year	0	▲2,248	+1,133	+974	+911
bonded fuel oil	1k BD	0	0	132	min.1	min.64
	10k KL/year	0	0	771	min.10	min.374

・As for import and export, plus signs indicate NET export, whereas naphtha depends on import so far.
・Crude oil treatment amount- 3 M BD（3.55M BD processing capacity, 84.5% operating ratio）

6. 国内の船舶燃料油の供給能力 The supply capacity (feed capability) of domestic marine fuel

【2020年時の供給能力のまとめ The summary of the supply capacity for the year 2020】

(1)　軽油留分(軽油・A重油)およびC重油は大幅な供給超過状況であり、特に軽油のアジア、豪州などへの輸出が確保できないと、一段の原油処理削減を余儀なくされる。

Gas distillate(gas oil・A-heavy fuel)including C-heavy fuel is already excessively oversupplied at present and will have no other choice than further reduction of crude oil treatment without securing the gas oil export to Asia and Australia.

(2) C重油についても、ボンド輸出を行ってもなお供給超過状況である。As for C-heavy fuel, it is still excessively supplied with or without the export of bonded oil

したがって、需給面から言えば、**日本積みの船舶燃料油(A重油、C重油)の供給不足の可能性は考えられない。** Thus as far as 'demand and supply' concern, there will be no possibility of short supply of Japanese marine fuel oil (both A-heavy fuel and C-heavy fuel)in the future.

(4) IMOによる一般海域での硫黄分規制が2020年から実施された場合、**直接脱硫装置の能力には余裕があるので、採算さえ合えば、硫黄分:0.5質量%以下のバンカー重油を日本積みで供給するか、あるいはｼﾝｶﾞﾎﾟｰﾙ向けなどに輸出することも考えられる。** Either the supply shipment to Japan of bunker fuel oil with sulfur rate 05% or below, or the export of those to Singapore will be possible since the direct sulfur cracking process has more capability than estimated when the sulfur limit in the general sea area designated by IMO is implemented in 2020.

7. 低硫黄燃料油に対応する潤滑油 Lubricate oil workable (applicable) for low sulfur oil

船舶用潤滑油の品質（アルカリ価）The quality(base number) of lubricate oil

・アルカリ価は、清浄分散剤の酸中和性、清浄性などを示す尺度として
エンジン油の評価や使用油の管理面で使用されている。The base number is used as the scale for acid neutralization and /or detergency of detergent dispersant when evaluating engine fuel and for it's management.

・硫黄分の多い燃料を使用する船舶のシリンダー油では、高塩基価の金属
系清浄分散剤を添加して高い酸中和性を持たしている。As for marine cylinder oil with high sulfur, highly alkaline metallic detergent dispersant is usually added for a higher acid neutralization.

・表に示す通り燃料油中の硫黄分が少なくなる場合は、アルカリ価の
少ないエンジン油を使用する。As shown in the table below, low alkaline engine oil should be used when sulfur rate in the fuel decreases.

	current alkalinity value	alkalinity value when controlling (S:0.5%) in 2020
lubricating oil for fishing boat(4stroke engine)	10～20(S≦1.0%)	⇦
lubricating oil for domestic vessel(4stroke engine)	30or40mainly(S≦3.0%)	20or30(varies in engine)
lubricating oil for ocean going vessel(2stroke engine)		
general sea area	70～100(S≦3.5%)	15～40(S≦0.5%)
ECA	15～30(S≦0.1%)	⇦

今後の課題 Future issues

（1）2020年時の国内需要に係る詳細な検討 Detailed examination regarding domestic demand in 2020

2020年時の国内のガソリン、灯油、軽油、重油等の需要見通し量から国内全体の船舶用燃料油を含む最適生産量と製造コストを確認する必要がある。It is necessary to confirm the optimum production quantity and cost including those of domestic marine fuel considering the year 2020's demand outlook of domestic gasoline, kerosene, heavy fuel and so forth.

（2）2020年時の低硫黄船舶燃料油品質の懸念対応調査の実施について Regarding the implementation of the countermeasure research against quality concern for low sulfur marine fuel in the year22020

現状を把握して、2020年開始予定の低硫黄燃料油使用時に関する懸念事項について検討・整理する必要がある。Those concern matters when using low sulfur fuel which is planned to be enforced in 2020 need to be examined and outlined understanding the current situation.

（3）トラブルの無い船舶燃料油品質の確保 Securing the troubleless quality for marine fuel

現在のA重油とC重油のJIS規格（JIS K2205-2006版）は、ボイラ用とエンジン用が一緒になった規格であり、船舶用としては不十分な規格となっている。

そのため、JIS K2205-2006版の改定もしくは船舶用燃料油品質規格の新設について検討する必要があると考える。The current JIS standard(the version of JIS K2205-2006) for A-heavy fuel and C-heavy fuel is the combinational standard for engine and boiler use. Thus either an amendment of the version of JIS K2205-2006 or establishing a new quality standard for marine fuel is required as the current standard is not sufficient for marine fuel.

NMRI

ご清聴ありがとうございました。

Thank you very much for your attention.

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