Proposal to the 47th Session of the Marine Environmental Protection Committee (MEPC 47) titled "Prevention of Air Pollution from Ships: Study on Estimation and Reduction of GHG Emissions from Ocean-Going Vessels"

PREVENTION OF AIR POLLUTION FROM SHIPS

Study on Estimation and Reduction of GHG Emissions
from Ocean-Going Vessels

1 Efforts of the Government of Japan in connection with the reduction of GHG emissions from ocean-going vessels

1.1 As for the greenhouse gas (GHG) emissions from ocean-going vessels, United Nations Framework Convention on Climate Change (UNFCCC) had requested the International Maritime Organization (IMO) to estimate the emissions quantitatively and study available options for its reductions. In MEPC46, we reached an agreement to deliberate on the details of GHG emissions reduction from MEPC47 in the newly established WG.

1.2 In Japan, the Ship & Ocean Foundation (SOF), a think-tank concerned with ships and oceans, has worked on this issue. Interim findings of the research study have been reported in MEPC44/INF.10, MEPC45/INF.27 and MEPC46/INF.33. This document presents a summary of the final findings of the study so as to facilitate the deliberations by the WG.

2 The present condition of GHG emissions from ocean-going vessels

2.1 CO_2, CH_4, N_2O, HFCs gases were addressed as GHGs from ocean-going vessels. Total GHG emissions in 1997 were estimated and a breakdown of the CO_2 emission by vessel type (tanker, bulk carrier, container ships), vessel size (DWT or TEU) and vessel age were also estimated.

2.2 According to the estimation, the total GHG emissions from ocean-going vessels were approximately 400×10^6 t (CO_2 equivalent value) as shown in Table 1. CO_2 covers 96 to 97% of the total amount of the 4 gases, of which a breakdown for each vessel type was 28% for tankers, 30% for bulk carriers and 36% for container ships (shown in Table 2). Also, a breakdown for vessel size and vessel age of each vessel type was calculated as shown in Figure 1. On the other hand, GHG emissions excluding CO_2 (CH_4, N_2O, HFCs) contribute 3 to 4 % of the total.

The issue on whether or not CH 4 emissions during loading and unloading of cargo and HFCs leakage from refrigerated/reefer containers during repair and maintenance be addressed as 'emissions from ocean-going vesselsf, must be deliberated by the WG.

Table 1 Breakdown of GHG Emissions from Ocean-Going Vessels (1997)

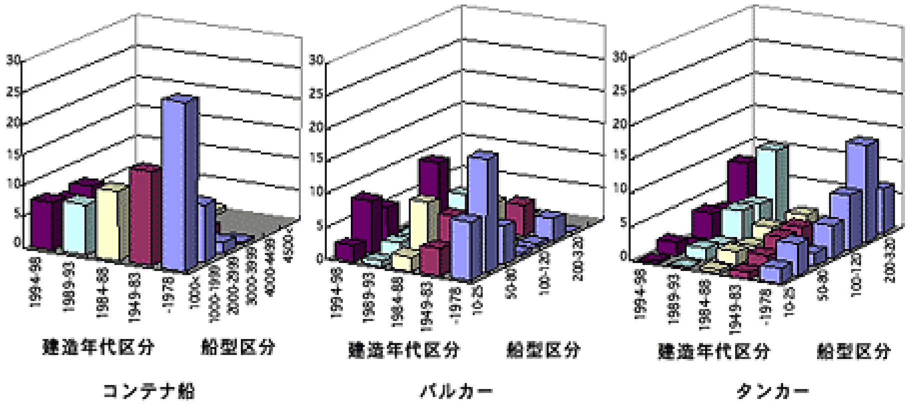
	CO_2	CH_4	N_2O	HFCs
Global Warming Potential (GWP)	1	21	310	1,700
Total Emission from Vessels (10^3t/yr)	386,800	175.2	10.0	3.1–5.1
CO2 Equivalent Value (10^6t/yr)	386.8	3.7	3.1	5.2–8.7
Total GHG Emissions (10^6t/yr)	398.8–402.3			
Emission Ratio	96.1–97.0%	0.9%	0.8%	1.3–2.

CO_2 conversion factor of 3,10^9 g-CO_2/kg-Fuel was used.

Table 2 Fuel Consumption and CO2 Emissions of Each Vessel Type (1997)

Division		Annual Total Volume of Transport (10^9 ton-mile)	Annual Fuel Consumption (10^6t-Fuel/yr)	Annual CO_2Emission (10^6t-CO $_2$/yr)	Ratio to Total Emissions
Tanker	Crude Oil	9,321	26	81	21%
	Oil Products	2,289	9	28	7%
	Sub Total	11,610	35	109	28%
Bulk Carrier	Iron Ore	2,520	16	50	13%
	Coal	2,359	17	53	13%
	Other Bulk	1,365	5	16	4%
	Sub Total	6,245	37	115	30%
Container Ship		$352x10^9$ TEU-mile	45	140	36%
Total		–	124	387	100%

Total includes 6% of unspecified amount of CO_2 emission, which cannot be identified to each of the above ship types.



DWTUnit; 10^6t-CO_2/yr (ordinate axis), TEU(container ship) or 10^3DWT(bulk carrier and tanker) (vessel size-axis)

Figure 1 Breakdown of CO2 Emissions from ocean-going vessels by vessel type, size and age (1997)

3 Estimation on the GHG emissions from ocean-going vessels

3.1 Future trend to 2020 of CO 2 emissions, which constitute the majority of GHG emissions from ocean-going vessels, was estimated. Two cases of assumption, upper case and lower case, were made from information on global economic growth rate, a recent trend of cargo shipment, etc. to forecast cargo amount (ton-mile) transported by ocean-going vessels.

3.2 The results of the estimation are shown in Figure 2. The CO 2 emission is estimated to be 20-44% increase in 2010 and 38-74% increase in 2020, than the emission in 1997. Looking at each vessel type, increase in CO 2 emission from container ships is higher than that from tankers or bulk carriers and it will constitute nearly half of the emissions from all ocean-going vessels in 2020. The result indicates the importance of taking emission reduction measures to container ships in terms of the prevention of global warming.

	CO_2 Emission in 2020					
	at Lower Case			at Upper Case		
	10^6tCO_2/yr	% Growth 2020 / 1997	Component Ratio	10^6tCO_2/yr	% Growth 2020 / 1997	Component Ratio
Tanker	121	11%	23%	152	39%	23%
Bulk Carrier	152	33%	28%	152	33%	23%

Container Ship	230	64%	43%	326	134%	48%
Unknown	31	38%	6%	40	84%	6%
Total	535	38%	100%	675	74%	100%

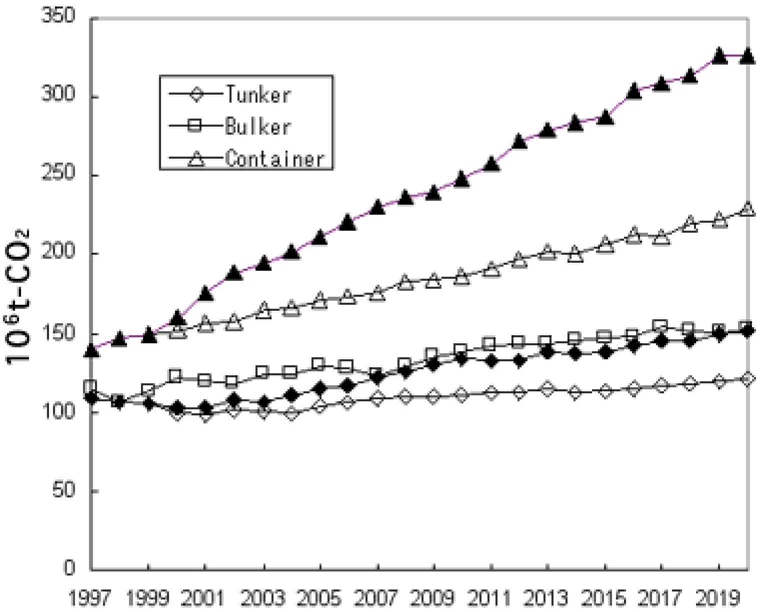


Figure 2 Future Estimates of CO_2 Emission, Percentage Growth and Component Ratio in 2020

3.3 Even though quantitative estimation on the future emission trends of GHGs other than CO 2 were not carried out, as to HFCs, if we consider the possibility of an increase in the distribution of refrigerated/reefer containers due to the increasing traffic of processed foodstuffs, the considerable increase in future HFCs leakage can be anticipated. It is conceivable that together with CO 2 emission reduction from container ships, HFCs leakage reduction from refrigerated/reefer containers will become a more important subject in the future.

4 The trend of reduction technology and assumed reduction scenarios

4.1 Practical and cost-available technologies and measures for reduction of each GHG emissions have been organized.

4.2 First of all, considerable studies have been done for the reduction of fuel consumption per transport unit of international shipping that is supposed to be the most cost-effective means of massive transport. Also taking into account future NOx restriction on ship engines, etc., it seems difficult to achieve additional large amount of CO_2 emission reduction in a short term by improvement of fuel consumption per transport unit. Under this circumstance, improvement technologies of propeller system shown in Table 3 can be considered as a relatively probable technology. Especially, Propeller Boss Cap Fin (PBCF) has an advantage of wider applicable scope for many type of vessels, possibility of retrofit, etc. As for mid-and long-term, CO_2 emission reduction technologies such as development of engines for alternate fuels (LNG, hydrogen, etc.) and modernized wind-powered ships, the viscous resistance reduction by micro-bubble technology, etc., can be considered.

Table 3 Example Application Figures of Various Technologies in Propeller Systems

Technology	Percentage Rise in Energy Efficiency at Full Load (%)	Percentage Rise in Energy Efficiency during Ballast Navigation (%)	Conversion Cost (Million Yen)	Docking Period for Conversion (Days)	Cost Recovery Period (Year)
PBCF	6	5	35	2	4
Duct Propeller	10	8	86	15	9
Contra-Rotating Propeller	9	8	143	25	10
Controllable Pitch Propeller	3	4	52	15	15

Example application figures for a tanker (L=240m, Cb =0.80)

4.3 Although GHGs other than CO_2 have comparatively low emissions, there is a possibility to reduce these emissions relatively easier than that of CO_2 with the appropriate measures. For example, considerable amount of reduction could be expected for CH_4 emitted from crude oil tanker during loading operation by combusting CH_4 at land facilities. Moreover, for HFCs, it is considered that an adequate amount of emission could be reduced by completion of operating control when refrigerated/reefer containers are re-filled up with cooling medium.

For mid- and long-term, technological development such as environment friendly cooling medium (ammonia, propane, butane, carbon dioxide, etc.), recovering technique of CH_4 from tankers at sea, etc. can be expected.

4.4 Next, a number of reduction scenarios regarding CO_2 gas were assumed based on the direction of reduction policies and technology, and the effects were quantitatively evaluated (Table 4).

Base Case: This is the case when no countermeasure is taken. This case is equivalent to the estimations indicated in Figure 2. Only the lower cases in Figure 2 are shown in Table 4.

Case 1: This case strives to reduce CO_2 gas through the promotion of replacement of obsolete fleets by newly built ships with improved energy efficiency (kg-Fuel/ton-mile). In this case, calculations were made on the assumption that a similar phase out schedule to that of tankers, based on revised Regulation 13G of Annex I of the MARPOL, will also be applied to bulk carriers and container ships.

Case 2: This is the case when reduction technologies that can be introduced within a short-term (for example, PBCF and other improvement technology of propellers) are applied to all vessels. In this calculation, a 5% reduction in the amount of fuel consumption from the said technologies was assumed. Also, a 10-year transitional period is set regarding its application to existing vessels.

Case 3: This case is when low-speed navigation is assumed. In this calculation, a speed reduction of 20% for container ships, and 10% for tankers and bulk carriers were assumed.

Case 4: This case is when new reduction technologies that can be introduced over a mid-term are applied only to newly built vessels. In this calculation, a 15% reduction in the amount of fuel consumption from the said technologies and an implementation to newly built vessels starting the year 2008 was assumed.

Table 4 The Efficiency of Reduction Measures of CO_2 Emission from Ocean-Going Vessels

Assumed Case	Rate of Increase of CO_2 Emission (2020/1997)	Improvement Range of the Energy Efficiency (kg-

		Fuel/ton-mile) (2020/1997)
Base Case (lower case shown in Figure 2)	38.3%	0.2%
Case 1: Early Replacement of Obsolete Fleets	37.7%	0.7%
Case 2: Reduction Technologies that can be Introduced within a Short-Term are Applied to All Vessels	31.4%	3.8%
Case 3: Low-Speed Navigation	1.3%	26.9%
Case 4: Reduction Technologies that can be Introduced over a Mid-Term are Applied Only to Newly Built Vessels	32.4%	4.5%

4.5 The results from calculations are shown in Table 4. By the year 2020, a 26.7 x 10 6 t (5%) of annual CO_2 emission reduction as compared to the base case becomes possible from the reduction technologies available for introduction in a short term, such as PBCF etc. However, the improvement of energy efficiency due to these reduction technologies will be cancelled out by surpassing the increase of the international shipping volume with the growth of the world economy, and the total amount of CO_2 emission will increase by 31.4% as compared to that of 1997. On the other hand, the CO_2 emission reduction effect of low-speed navigation is very large, and it is theoretically possible to control the amount of CO_2 emission in 2020 to the 1997 level. However, low-speed navigation will clearly bring about deterioration in the transportation service, and will also impose a change in the production/distribution system and in human lifestyle. Moreover, it will bring about a slowdown in the world economy. It remains questionable whether this measure can be effectively implemented without incentives on low-speed navigation. Thus, careful investigation into this is needed.

5 Conclusion

5.1 From the results mentioned above, IMO is requested to take necessary steps as soon as possible to establish a feasible international framework for the reduction of GHG emission from ocean-going vessels. For this end, MEPC is requested first to evaluate objectively the reduction effects, applicable types of vessel, costs, etc. for available reduction technologies in the short-term and subsequently to identify a priority agenda for the international framework. MEPC is also requested to discuss the establishment of an international framework, which accelerates the development of new technologies for GHG reduction. Within these discussion, it is necessary to take account not only CO 2 but also other GHGs.

5.2 Moreover, the promotion of the elimination of substandard vessels engaged by IMO is also important because it has a secondary effect to stimulate the substitution of obsolete vessels, which have less energy efficiency.