INTERNATIONAL MARITIME ORGANIZATION

IMO

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INTERSESSIONAL MEETING OF THE GREENHOUSE GAS WORKING GROUP
2nd session
Agenda item 2

GHG-WG 2/2/18
6 February 2009
ENGLISH ONLY

CONSIDERATION OF THE ENERGY EFFICIENCY DESIGN INDEX FOR NEW SHIPS

Technical consideration of baselines for Energy Efficiency Design Index (EEDI)

Submitted by Japan

SUMMARY	
Executive summary:	This document provides the technical consideration of the EEDI baselines, which are derived from the data of existing ships, as an analytical basis for drawing appropriate baselines to make the EEDI requirements practical and enforceable
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.1 and 7.3.1.3
Action to be taken:	Paragraph 24
Related documents:	MEPC 57/INF.12; GHG-WG 1/2/1; MEPC 58/4; MEPC 58/4/8; MEPC 58/4/34; MEPC 58/4/38 and MEPC 58/23

Introduction

1 The Energy Efficiency Design Index (EEDI) baselines have been considered as one of the regulatory tools to improve energy efficiency of new ships by setting a benchmark or a minimum efficiency standard for EEDI for each ship type.

2 A concept of baselines was first introduced by Denmark at MEPC 57 (MEPC 57/INF.12), and through the consideration at the first session of Intersessional Meeting of the Greenhouse Gas Working Group as well as at MEPC 58, there is a general perception, although the detail is left for further consideration, as follows:

.1 a baseline is the average EEDI values of existing ships, expressed as a function of capacity by ship type;

.2 baselines take the form of exponential function $a \times b^{-c}$, where b is Capacity (usually, DWT) of ships; and

.3 the Attained EEDI to be calculated for each ship shall be less than the Required EEDI, which is the baseline for the corresponding ship type multiplied by the reduction rate (1-X/100), where X is the value to be determined by the year of construction.

3 At MEPC 58 it was pointed out by China, that new ships complying with newly introduced safety requirements, such as Common Structural Rules (CSR) ships and double-side skin bulk carriers, may likely cause an increase in average EEDI values and careful consideration should be given while developing baselines (MEPC 58/4/34).

4 Taking into account the above considerations to date, Japan has conducted various analytical work on the baselines regarding:

.1 the impact of the change of the EEDI calculation formula on the baselines;

.2 the change of baselines according to the time period of ships' delivery to identify the effects of recent safety and environment regulations; and

.3 the appropriate tonnage threshold to exempt EEDI requirements for smaller vessels.

Impact of the change of the EEDI formula on the baseline position

5 Baselines as proposed by Denmark at MEPC 58 (MEPC 58/4/8) were drawn as a mean regression line on estimated EEDI values of existing ships, applying the following formula to existing ships based on data in Lloyds Resister Fairplay (LRFP) Database:

$$Estimated\ EEDI\ of\ an\ existing\ ship = 3.114 \cdot 0.75 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 210 \cdot \sum_{i=1}^{NAE} P_{AEi}}{Capacity \cdot V_{ref}} \quad (1)$$

where:

V_{ref} is the service speed of the vessel at the maximum continuous rating of the engines (MCR), measured in knots at loaded draft;

Capacity is the maximum summer deadweight of the vessel in tonnes;

Power is the installed power of main and auxiliary engines measured in kW;

3.114 is an assumption of carbon emission factor, C_F; for all engines;

190 and 210 are assumptions of specific fuel consumption, SFC_{ME} and SFC_{AE}, in g/kWh for all main engines and auxiliary engines, respectively; and

0.75 is an assumption of the load on main and auxiliary engines, 75% of MCR.

6 At that time, the EEDI calculation formula was the following (annex 5 to MEPC 58/4), where P_{AE} was to be calculated by summing up installed power of auxiliary engines:

$$Attained\ EEDI = \frac{\left(\prod_{j=1}^{M} f_i\right)\left(\sum_{i=1}^{NME} C_{FMEi} SFC_{MEi} P_{MEi}\right) + \left(\prod_{k=1}^{L} f_k\right)\left(\sum_{i=1}^{NAE} C_{FAEi} SFC_{AEi} P_{AEi}\right)}{Capacity\, V_{ref}\ \ f_W}$$

7 As a matter of principle, the EEDI calculation formula for individual new ships and the calculation method of existing ships' EEDIs as a basis of drawing the baseline should be consistent as far as practicable. In reality, however, simplifications and assumptions in the calculation are inevitable for the latter. For example, while actual SFC would be used for an Attained EEDI for an individual new ship, there is no way to know the SFC value for each of those existing ships of which data are taken from LRFP; thus it is reasonable to assume a constant SFC value for the sake of existing ships' calculation. Given the EEDI calculation formula at that time, the formula for existing ships' calculation (1) was a reasonable one, based on practical assumptions.

8 The formula for the EEDI calculation was, however, significantly modified at MEPC 58, and the following is the formula contained in the draft Guidelines for the Calculation of Energy Efficiency Design Index for New Ships ("Interim Guidelines", hereafter):

Attained EEDI =

$$\frac{\left(\prod_{j=1}^{M} f_i\right)\left(\sum_{i=1}^{nME} C_{FMEi} SFC_{MEi} P_{MEi}\right) + P_{AE} C_{FAE} SFC^{*}{}_{AE} + \left(\sum_{i=1}^{nPTI} P_{PTIi} - \sum_{i=1}^{nWHR} P_{WHRi}\right) C_{FAE} SFC_{AE} - \left(\sum_{i=1}^{neff} f_{eff} P_{eff} C_{FMEi} SFC_{MEi}\right)}{f_i\ Capacity\, V_{ref}\ \ F_W}$$

9 A significant change from the previous version was to define P_{AE} as the required auxiliary engine power to supply "normal maximum sea load", not the installed power. Although various options were discussed to estimate "normal maximum sea load", it was agreed to use a simple approximation formula where P_{AE} is derived as a fixed percentage of the power of the main engine installed (MCR_{ME}). The Interim Guidelines explain the calculation method of P_{AE} as follows:

> *5.5 P_{AE} is the required auxiliary engine power to supply normal maximum sea load including necessary power for machinery, systems, equipment and living on board in the condition where the ship engaged in voyage at the speed (V_{ref}) under the design loading condition of Capacity.*
>
> *.1 For ships with a main engine power of 10,000 kW or above, P_{AE} is defined as:*
>
> $$P_{AE(MCRME\ >\ 10000KW)} = \left(0.025 \times \sum_{i=1}^{nME} MCR_{MEi}\right) + 250$$
>
> *.2 For ships with a main engine power below 10,000 kW, P_{AE} is defined as:*
>
> $$P_{AE(MCRME\ <\ 10000KW)} = 0.05 \times \sum_{i=1}^{nME} MCR_{MEi}$$

10 With this difference, the formula for existing ships' EEDI for the sake of drawing the baseline should be modified to be consistent with the revised EEDI formula in the Interim Guidelines. Using the same assumptions as Eq.1, the modified formula for existing ships' EEDI should be as follows:

$$Estimated\ EEDI\ of\ an\ existing\ ship = 3.114 \cdot \frac{190 \cdot 0.75 \sum_{i=1}^{nME} P_{MEi} + 210\ P_{AE}}{Capacity\ V_{ref}} \qquad (2)$$

where:

P_{AE} is calculated in accordance with paragraph 5.5 of the Interim Guidelines.
Other factors are to be set in the same way as explained in paragraph 5.

11 The first step of the baseline analysis is to see how the baselines would shift when the old formula (1) and new formula (2) were applied to existing ships' data. The baselines drawn by (1) and (2) were compared for three major ship types of dry bulk carriers, tankers and containerships, with data of ships delivered from 1 January 1995 to 31 December 2004, based on the methodology described in document MEPC 58/4/8. The number of samples for each baseline are shown in Table 1.

Table 1 – Number of samples[1]

	For old formula (1)	For new formula (2)
Dry bulk carriers	1,255	2,224
Tankers	1,814	2,422
Containerships	1,561	1,890

12 Figures 1 to 3 show the calculated baselines based on formulas (1) and (2) for dry bulk carriers, tankers and containerships, respectively.

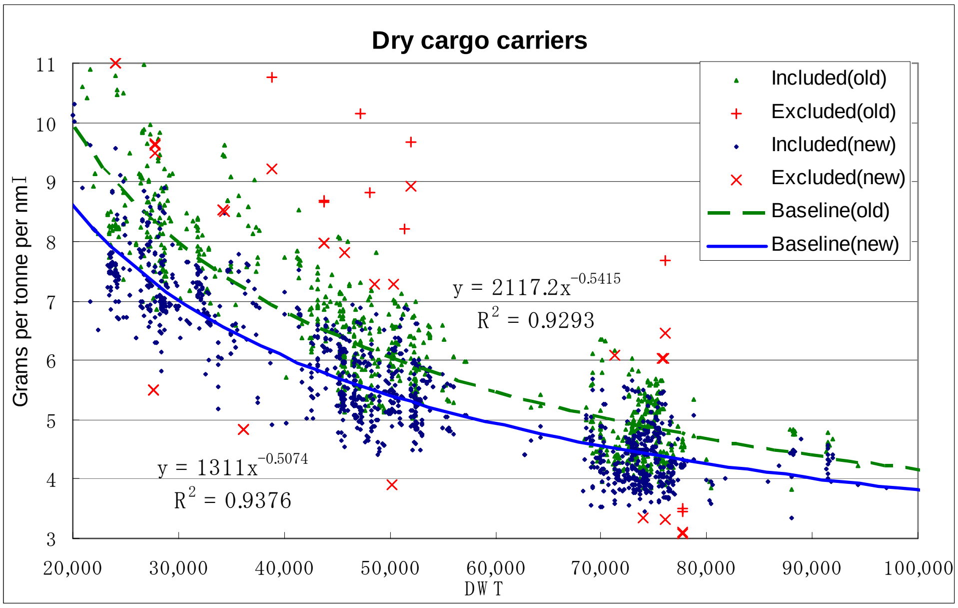


Figure 1 – Difference of baselines for dry bulk carriers

1 The reason for the difference of sample numbers between the old formula (1) and the new formula (2) is that the old formula requires the installed power of auxiliary engines for PAE, but such data is not always given in the LRFP database, while the new formula does not require such data as PAE is simply defined as a fixed percentage of the power of main engine installed (MCR_{ME}).

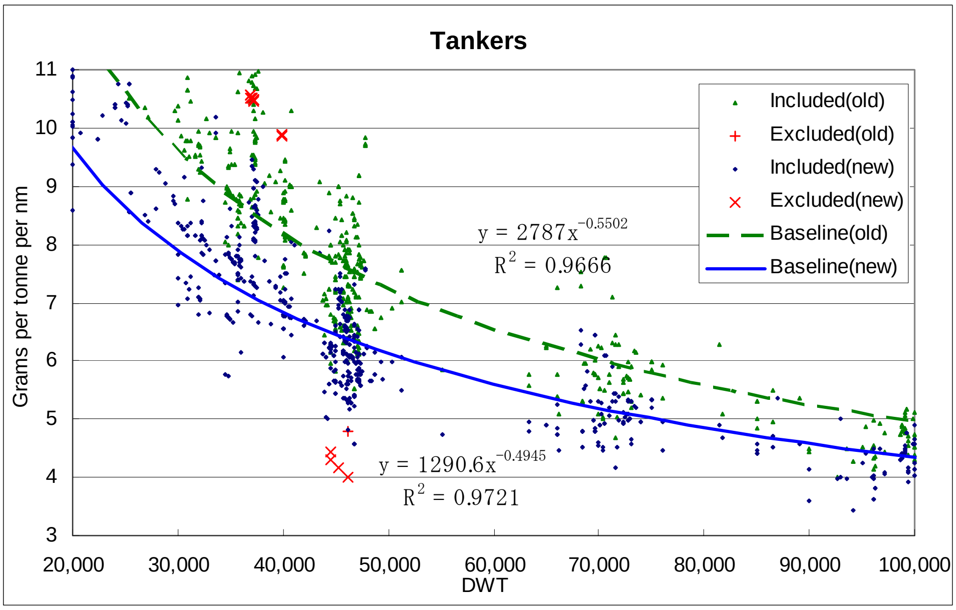


Figure 2 – Difference of baselines for tankers

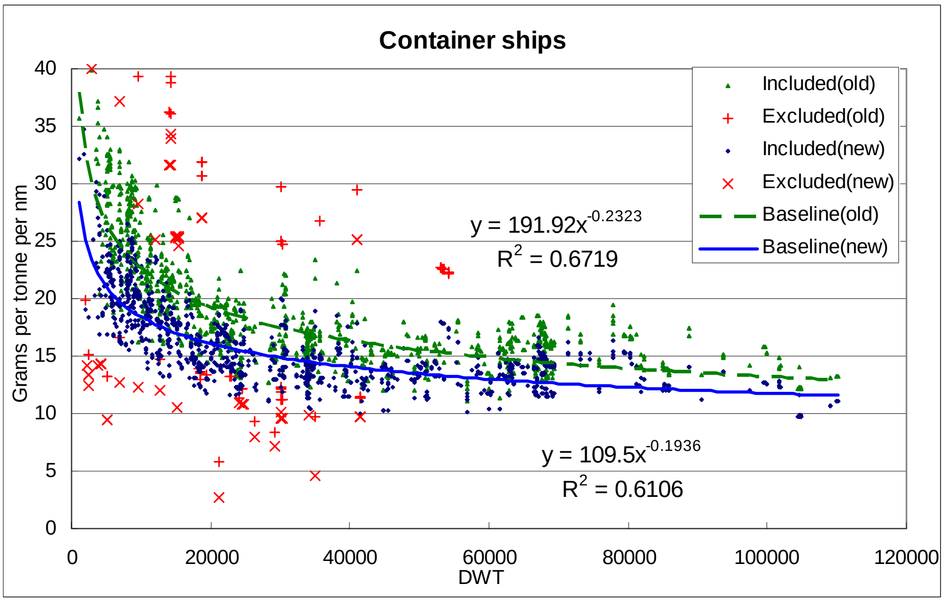


Figure 3 – Difference of baselines for containerships

13 As can be seen in Figures 1 to 3, baselines drawn by the new formula (2) are lower than those by the old equation (1). This is obvious because the formula (1) used the total installed power of auxiliary engines multiplied by 0.75, while the formula (2) used the required power for normal maximum sea load, which is normally much smaller than 75% of the installed power. The smaller the vessels are, the more two baselines deviate, as shown in Table 2. This is because the proportion of auxiliary engines to all engines installed in small vessels is bigger than that in larger vessels, thus the impact of difference in P_{AE} calculation methods is larger.

Table 2 – Degree of difference of two baselines by ship type and size

	Size of vessel (DWT)	Difference of two baselines
Dry cargo carriers	28,000 (handy size)	12.2%
	48,000 (handy max)	10.6%
	74,000 (Panamax)	9.2%
	170,000 (Cape size)	6.6%
Tankers	46,000 (handy max)	16.7%
	70,000 (Panamax)	12.6%
	107,000 (Aframax)	10.2%
	150,000 (Suez max)	10.0%
	300,000 (VLCC)	7.6%
Containerships	20,000	13.8%
	35,000	12.0%
	68,000	16.0%

14 In any case, the new formula (2) lowers the baselines by about ten percent and this means that Required EEDI becomes a tougher target for new ships' Attained EEDI to achieve. It should be noted that this tendency would also be observed in other type of ships, including gas tankers, ro-ro cargo and passenger ships as well as general cargo ships.

Baselines according to the time period of ships delivered

15 One important question for drawing the baselines is the range of years of construction to be selected for determining existing ships' data. The previous proposal (MEPC 58/4/8) used the years from 1995 to 2004. As argued by China at MEPC 58, ship design and structure have been changed from year to year not only by owner's request but also by various safety and environment regulations and recommendations, such as double hull requirements for oil tankers, CSR for oil tankers and bulk carriers, and oil fuel tank protection for all ships, and it is presumed that those regulations affect the Attained EEDIs of new ships. Therefore, it is very important to consider the impacts of such regulations on baselines in order to set baselines at an appropriate level. To this end, baselines for dry bulk carriers, tankers and containerships were drawn by certain periods of ship delivery shown in Table 3 and Figure 4.

Table 3 – Number of samples by the period of ship delivery[2]

Ship delivered	January 1992-June 1996	July 1996-December 1999	January 2000-December 2003	January 2004-December 2007
Dry bulk carriers	747	754	853	1,091
Tankers	1,050	758	983	1,585
Containerships	616	826	710	1,172

2 Data are chosen from 1 January 1992 to 31 December 2007 (16 years) and divided by 4 years in 4 periods. In order to examine the effect of the regulation on double-hull requirements for tankers, July 1996 was chosen for the starting month of the second period instead of January 1996.

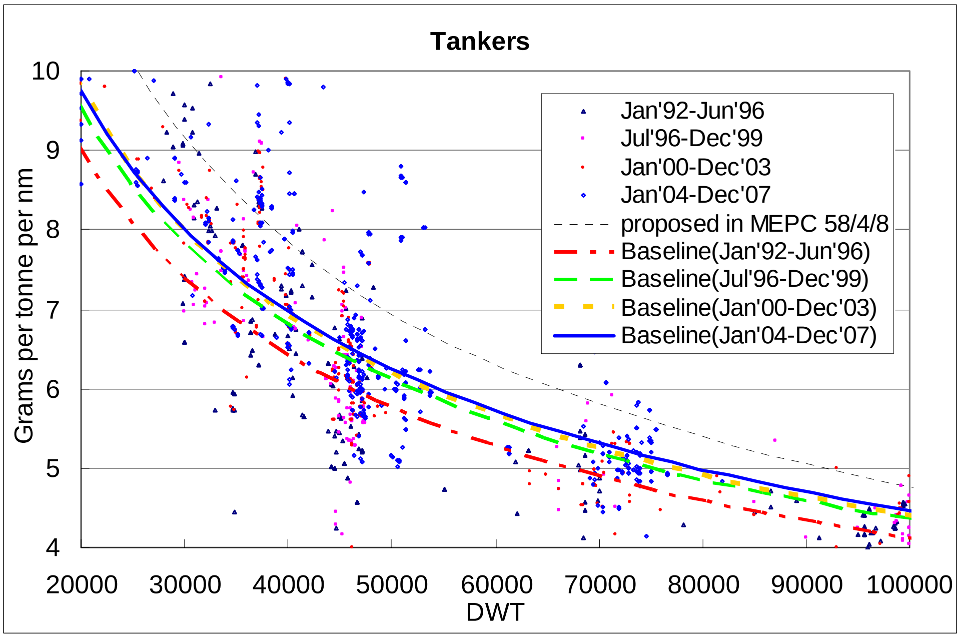
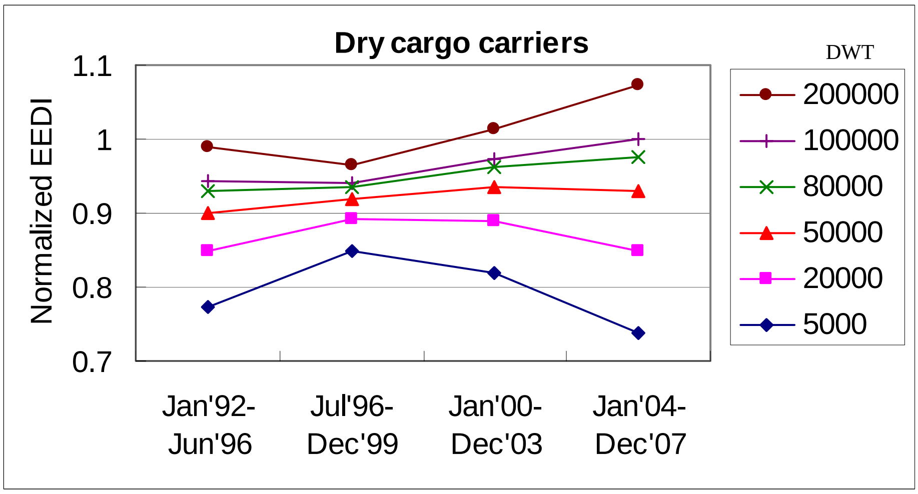


Figure 4 – Change in the baseline of tankers by delivery date of ships

16 It is clearly shown in Figure 4 that double hull requirements, which apply to oil tankers delivered on or after 6 July 1996, affect the EEDI significantly and the baseline drawn by the latest vessels, which were delivered from 1 January 2004 to 31 November 2007, is the highest among all periods (the worst efficiency).

17 To compare the baselines of different period of ships' delivery according to ship type, size and period, normalized EEDI values for each baseline (normalized in terms of the "old-formula" baseline proposed in MEPC 58/4/8) are shown in Figure 5. It appears that not only for tankers but also for dry cargo carriers as well as containerships, vessels built in recent years tend to have larger EEDI except for small dry cargo carriers.



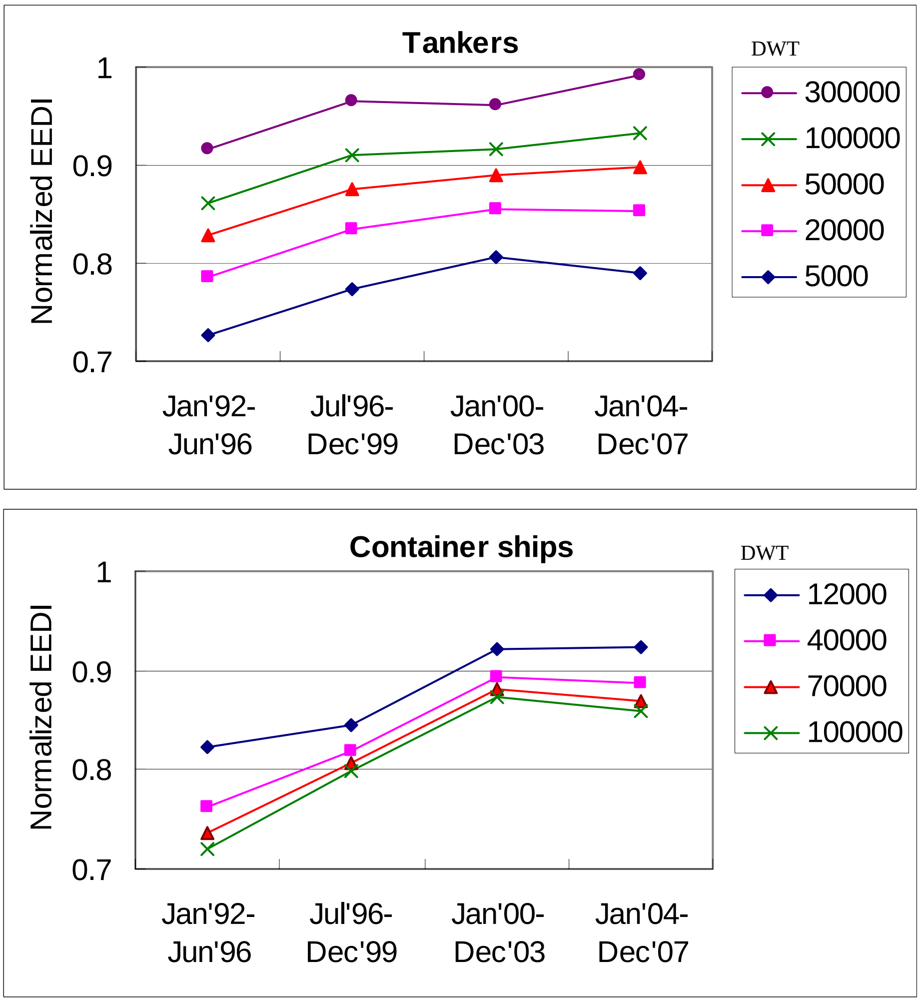


Figure 5 – EEDI values of each baseline normalized against the baseline (based on old formula) proposed in MEPC 58/4/8

18 The above analysis could not identify the impacts of the CSR on the EEDI because of the lack of data of CSR-applied ships (contracted on or after 1 April 2006); however, it is expected that the application of CSR would increase the weight of hull steal and thus lead to an increase in the EEDI. In addition, new regulations, such as double side-skin requirement for bulk carriers (constructed on or after 1 July 2006), damage stability requirements (constructed on or after 1 January 2009), oil fuel tank protection (delivered on or after 1 August 2010), and instalment of ballast water treatment system under the Ballast Water Management Convention, would lead to increase in the hull weight because of constraint of tank arrangement and rearrangement of subdivisions, an increase of machinery room space, and/or an increase of required electric power; could lead to a decrease of DWT against the same displacement and/or an increase of required auxiliary engine power and thus result in a deterioration of energy efficiency. NO_x regulations Tier II (constructed on or after 1 January 2011) and Tier III (constructed on or after 1 January 2016) would also have a negative impact on energy efficiency.

Consideration of baselines for smaller vessels

19 Figure 6 shows a sample baseline for dry cargo carriers drawn by data of ships delivered over the period from 1 January 1998 to 31 December 2007.

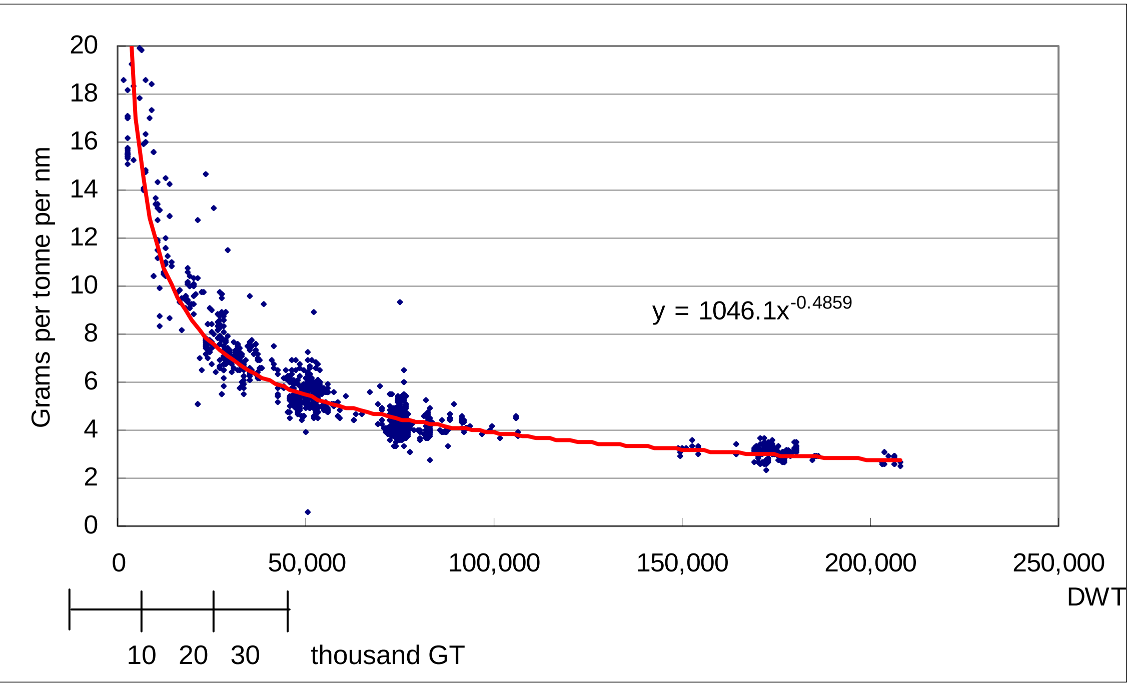


Figure 6 – A sample baseline for dry cargo carriers

20 As shown in Figure 6, a sample baseline of the Required EEDIs takes the form of a long-tailed curve rising steeply for ships below 20,000 DWT. The deviation in EEDI values for existing vessels, which is used to develop the baselines, is very large for smaller vessels as shown in Table 5. Such considerable deviation in EEDI values for existing ships would reduce the reliability of the baseline; for some ships it would be very easy to meet the Required EEDI based on the baseline, while for other ships it would be very difficult to meet the requirement.

Table 5 – Deviation of EEDIs of existing ships against the baseline

DWT Ranges	0 ~ 20,000	0 ~ 50,000	All
Correlation factor (R^2)	0.663	0.842	0.898
Number of ships	133	730	2,308

21 In addition, the contribution of CO_2 emissions from smaller vessels is quite small. According to Phase 1, Report of the IMO updated Study on Greenhouse Gas Emissions from Ships, CO_2 emissions from bulk carriers of less than 10,000 DWT is 2.4 per cent of the total CO_2 emissions from bulk carriers of all sizes; and bulk carriers between 10,000 DWT and 19,999 DWT account for 3.6 per cent of the total as shown in Table 6. Therefore, bulk carriers of less than 20,000 DWT are responsible for approximately 6 per cent of the total CO_2 emissions from all the bulk carriers.

Table 6 – Fuel consumption of bulkers, categorized by ship sizes[3]

DWT	~9,999	10,000~ 19,999	20,000~ 34,999	35,000~ 59,999	60,000~ 99,999	100,000~ 199,999	200,000~
Fuel consumption (kT)	1338.0	1973.2	10,856.0	14,519.8	14,551.4	9,694.9	1,951.8
Percentage (%)	2.4	3.6	19.8	26.5	26.5	17.7	3.6

22 Considering that the number of small vessels is quite large, that work associated with application of the Required EEDI and related enforcement are considerable, that the reliability of the baselines for small vessels are low, and that CO_2 emissions from small vessels are marginal; it is reasonable to consider an alleviation of the requirements for small vessels, e.g., less than 20,000 DWT (approximately 10,000 GT in case of bulk carriers). Namely, it would be appropriate to exempt the requirement that the Attained EEDI shall be less than the Required EEDI, although the requirement of calculating an Attained EEDI for each ship can be applied except for very small ships and boats, e.g., less than 400 GT. Proposed application of the requirements is described in another submission by Japan (GHG-WG 2/2/16).

23 It should also be noted that there is a possibility that baselines for certain ship types cannot be developed because of some reasons such as the lack of enough data for establishing baselines and the excessive deviation of existing ships' data from the baselines. Ship of these types should also be exempted from mandatory requirements on Attained EEDI being below the Required EEDI.

Action requested of the Intersessional Meeting

24 The Intersessional Meeting is invited to consider the above information and associated proposals and take action as appropriate.

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[3] This table is extracted from the Phase 1 Report of the IMO updated Study on Greenhouse Gas Emissions from Ships (MEPC 58/INF.6). The report shows the contribution of bulkers between 10,000 DWT and 34,999 DWT accounts for 23.4 percent, 3.6 percent out of which turned out to be attributed to ships less than 20,000 DWT as a result of the further analysis of the IMO study with the LRFP database.