INTERNATIONAL MARITIME ORGANIZATION

IMO

E

INTERSESSIONAL MEETING OF THE GREENHOUSE GAS WORKING GROUP
2nd session
Agenda item 3

GHG-WG 2/3/1
6 February 2009
ENGLISH ONLY

REVIEW OF THE ENERGY EFFICIENCY OPERATIONAL INDEX

Information on trials according to the Interim Guideline for Voluntary Ship CO_2 Emission Indexing

Submitted by Belgium

SUMMARY

Executive summary:	This document provides the findings of trials on 43 ships of five ship categories by applying the Interim Guidelines for Voluntary Ship CO_2 Emission Indexing. It breaks down the basic formula of the EEOI which leads to a better understanding and transparancy on the causes of variation of the EEOI.
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.3
Action to be taken:	Paragraph 11
Related documents:	MEPC/Circ.471; MEPC 53/INF.6; MEPC 55/4/3, MEPC 55/INF.6, MEPC 55/INF.9 and MEPC 58/INF.7

Introduction

1 Assembly resolution A.963(23) on IMO Policies and Practices related to the Reduction of Greenhouse Gas Emissions from Ships was adopted by the twenty-third session of the Assembly. As urged by the Assembly, MEPC 53 approved the Interim Guidelines for Voluntary Ship CO_2 Emission Indexing for Use in Trials, circulated as MEPC/Circ.471. By this circular, industries organizations and interested Administrations were invited to promote the use of the Interim Guidelines in trials and report experiences back to the Committee with a view to finalization at MEPC 58.

2 MEPC 58 was unable to finalize the review of the Interim Energy Efficiency Operational Index and the Working Group at MEPC 58 proposed a work plan for further work of progress in this area and approved the holding of an Intersessional Meeting of the GHG Working Group.

3 Belgium wishes to share information gained by trials performed by the Royal Belgian Shipowners Association (RBSA) and the Flemish Institute of Technological Research (Vlaams Instituut voor Technologisch Onderzoek, VITO) on 43 ships flying the Belgian Flag. The main purpose of this submission is to facilitate a better understanding of the Interim Guidelines and point out the necessity of claryfying some parameters, in order to use the data in a potential uniform environmental management system.

4 Data were collected of 43 ships covering five of the 18 ship categories as defined by Lloyds Register Fairplay. The results are in line with the findings of previous submissions to IMO on this topic such as MEPC 55/4/3 submitted by Germany and Norway and confirm that there is a high variation of the EEOI within some ship types, even between ships of comparable size. Through careful analysis of the influence of ballast voyages and port time on the total EEOI the study demonstrates that the average EEOI of a ship is strongly influenced by business availability. In other words, the EEOI is very much affected by the constantly changing business climate.

5 Operational variations in the index are mainly caused by the factors below as described in MEPC 55/4/3:

.1 relative utilization of cargo space;

.2 relative fuel consumption on ballast voyages (related to length of ballast voyages);

.3 efficiency of ship (engine condition, hull and propeller fouling, etc.);

.4 variations in speed;

.5 weather and currents; and

.6 errors in measurement and registration.

6 An additional analysis was made on the contribution of the fuel consumption during port time to the variation of the EEOI. Port time refers to manoeuvring, transiting, loading, unloading and time spent waiting for orders/cargo. The analysis shows that the fuel consumption during port time is yet another parameter causing a strong variation of the EEOI depending on ship type and it should be added to the list above.

7 Identifying the different causes for the variation in the index is difficult. A database was established in order to determine the contribution to the variation of the index due to ballast voyages and port time for each individual ship. A package of ship specific indexes more apt at monitoring the specific aspects of ship efficiency is derived by dividing the EEOI into three "sub-indexes":

– Cargo EEOI;

– Ballast EEOI; and

– Port EEOI.

8 Breaking down the basic formula of the EEOI leads to a better understanding and transparency on the causes of variation of the EEOI for the ship operator. This way it is much easier to identify where improvements are needed for each individual ship. The "sub-indexes" are represented in a graph, which is explained in the annex to this document. These sub-indexes could be included in an environmental management system and specific guidelines for the calculation of the sub-indexes would have to be considered by IMO.

Areas for further clarification in the MEPC/Circ.471

9 In the interim guidelines, the distance sailed is defined as the actual distance sailed in nautical miles (deck logbook data) according to the voyage or period in question. The interpretation of distance sailed by the operator thus depends on the definition that is given to a voyage but the definition of a voyage is not explicitly stated in the guidelines. There is an urgent need to clarify the definition of a voyage in MEPC/Circ.471.

10 About 40% of the fuel consumption of the LNG tankers in the study consisted of boil-off gas. Although a carbon factor for natural gas is provided in the guidelines, the guidelines should either specifically state that the carbon factor for natural gas can be applied to LNG boil-off or alternatively derive another factor for LNG boil off because the carbon content can be expected to be slightly lower than in natural gas.

Action requested of the Intersessional Meeting

11 The Intersessional Meeting is invited to consider the information provided in the annex to this document and take action as appropriate.

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ANNEX

TRIAL USING THE DRAFT GUIDELINE FOR THE ENERGY EFFICIENCY OPERATIONAL INDEX

Introduction

1 Belgium wishes to share information gained by a trial performed by the Royal Belgian Shipowners' Association (RBSA) and the Flemish Institute of Technological Research (Vlaams Instituut voor Technologisch Onderzoek, VITO) on 43 ships flying the Belgian Flag. During this trial the Energy Efficiency Operational Index (EEOI) of these ships has been determined on the basis of the Interim Guideline for Voluntary Ship CO_2 Emission Indexing for Use in Trials, circulated as MEPC/Circ.471. The aim of the work is to identify remaining gaps in knowledge and to propose further improvement and potential use of the guidelines.

2 This interim guideline is the first step towards the development of an official index and it was adopted by IMO's Marine Environment Protection Committee, MEPC 53 in July 2005. The basic expression for the Energy Efficiency Operational index (EEOI) is defined as:

$$\mathrm{EEOI} = \frac{\sum_j \left(\sum_i FC_{i,j} \times C_{carbon,j} \right)}{\sum_i m_{cargo,i} \times D_i}$$

- j : fuel type
- i : voyage or travel period
- C_{carbon} : the carbon factor
- FC : the fuel consumption
- m_{cargo} : the cargo mass
- D_i : the distance sailed

3 For ballast voyages it is still necessary to include the fuel used during this voyage in the denominator. The fuel consumption includes all fuel consumed by main and auxiliary engines, boilers and incinerators at sea and during port time. Port time includes fuel consumption during manoeuvring, transiting, loading and unloading and time waiting for orders/cargo.

Collection of data

4 Data were collected of 43 ships covering five of 18 ship types as defined by Lloyds Fairplay. Table 1 shows the amount of ships covering the different ship types. All parameters such as fuel type, fuel consumption (during ballast voyages, laden voyages and port time), cargo load and distance sailed were filled seperately for each voyage/leg in an Access database developed by the Flemish Insitute of Technological Research (VITO) in order to have a better understanding of the influence of fuel consumption during ballast voyages and port time on the overall EEOI. This database was developed according to the formula in MEPC/Circ.471.

Table 1: number of ships in the trial

Ship type	Number of ships
Bulk dry	15
Crude oil tanker	8
General cargo	6
LNG tanker	4
LPG tanker	10

Critical parameters

5 There are three important parameters which should be interpreted in the same manner when determining the EEOI of a ship:

.1 the distance sailed according to the voyage in question;

.2 the fuel consumption; and

.3 reporting period.

Distance sailed

6 In the interim guidelines the distance sailed is defined as the actual distance sailed in nautical miles (deck logbook data) according to the voyage or period in question. The interpretation of "distance sailed" by the operator thus depends on the definition that is given to a voyage but the definition of a voyage is not explicitly stated in the guidelines.

7 Consider the following example: A ship travels in ballast from port A to port B where it picks up cargo and then proceeds to a closely situated port C to pick up more cargo. The ship then proceeds with an intercontinental voyage followed by unloading all of its cargo in port D. This could be considered as a single voyage. A single voyage number will be assigned to the entire operation by the ship operator, however accurate calculation of the EEOI requires that each distance between the ports (voyage leg) should be considered as a single voyage.

8 In this study, the distance travelled between two ports, laden or in ballast, was considered as an individual voyage leg (further referred to as cargo leg and ballast leg) as was also done in MEPC 54/4/3. The fuel consumption during port time was attributed either to the ballast leg or the cargo leg.

Fuel Consumption

9 The fuel consumption includes all fuel consumed by main and auxiliary engines, boilers and incinerators at sea and in port as defined in MEPC/Circ.471. The fuel consumption and fuel type was recorded for each leg. Dry bulk and crude oil tankers mainly use heavy fuel oil (HFO) during their legs, the fraction of marine diesel oil (MDO) was less than 1%. The fraction of marine gas oil (MGO) was recorded but not included in the database because the amount is negligible.

10 About 40% of the fuel consumption of the LNG tankers in the study consisted of boil-off gas. Although a carbon factor for natural gas is provided in the guidelines, the guidelines should either specifically state that the carbon factor for natural gas can be applied to LNG boil-off or alternatively derive another factor for LNG boil off because the carbon content can be expected to be slightly lower than in natural gas.

Reporting period

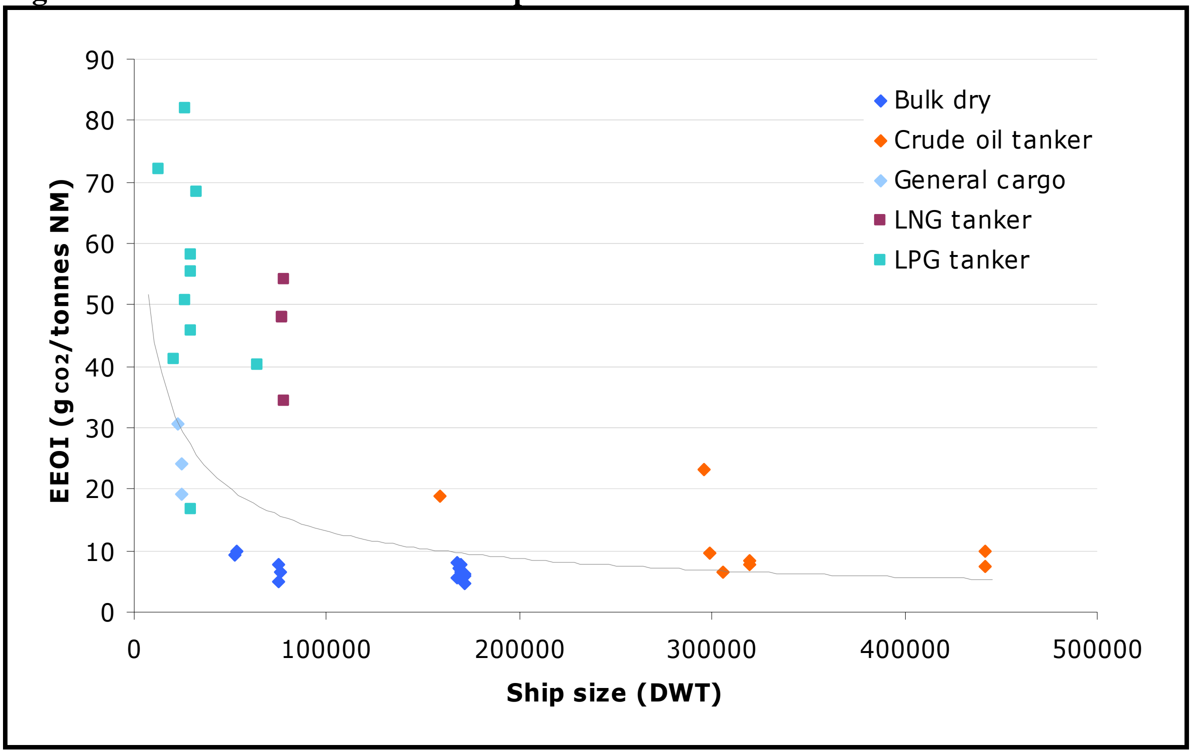
11 As defined in MEPC/Circ.471 the EEOI should represent a value of the energy efficiency of a ship operation over a period of one year. In most cases a whole year was covered and 2007 was chosen as the base year for the collection of data. The number of days covered is shown in the last column of Table 3. It is important to stress that the EEOI is an average value of the legs during one year. When calculating the EEOI based on the total distance travelled during one year multiplied by the total mass transported during that year the EEOI will be much lower.

Results

12 The index level of the EEOI determined according to the interim guideline is shown in Figure 2 and in the second column of Table 3. The index levels shown in Figure 2 are not representative for the respective ship types in general because the EEOI is strongly affected by external factors such as the business and seasonal variation.

13 It is clear from Figure 2 that there is a strong relationship between the EEOI and the ships size as was already mentioned in previous studies.

Figure 2: EEOI in function of the ships DWT



14 The level of the index for the different ship types has been compared with the results of MEPC 55/INF.9 from Japan and MEPC 55/4/3 from Germany and Norway. When comparing between different studies one has to look carefully at all assumptions on the parameters described above for each of these studies to be able to compare them properly.

Dry Bulk

15 MEPC 55/INF.9 calculated the index for individual legs of three dry bulk ships. The minimum value was 4.7 gCO_2/ton nm, the maximum value 27.4 gCO_2/ton nm. The size of the studied ships is not mentioned. The average EEOI calculated in MEPC 55/4/3 for four dry bulk ships with an average GT of 81519 is 7.6 gCO_2/ton nm.

16 In this study, the average EEOI of the 15 dry bulk ships with an average GT of 69624 is 6.7 gCO_2/ton nm.

Crude Oil Tankers

17 In MEPC 55/INF.9 the index for oil tankers ranges from 3.7 gCO_2/ton nm to 6.6 gCO_2/ton nm but no GT was mentioned. In MEPC 55/4/3 the average EEOI of the 46 oil tankers with an average GT of 57703 is 8 gCO_2/ton nm.

18 In this study, the average EEOI of the eight oil tankers with an average GT of 169078 is 11.4 gCO_2/ton nm.

19 There are two outliners with an EEOI of approximately 20 gCO_2/ton nm. These outliners are due to the influence of ballast legs on the EEOI and a more elaborate description of this influence can be found further in this document. The average EEOI of the six other ships, not taking into account the outliners is 8.2 gCO_2/ton nm.

General Cargo

20 This study considered at first six general cargo ships. Details on ballast legs and fuel consumption during port time of three cargo ships could not be obtained. The average EEOI of the three remaining cargo ships of comparable size with an average GT of 17000 is 10.2 gCO_2/ton nm.

LNG

21 In MEPC 55/4/3, the average EEOI was 66.5 g CO_2/ton nm for ships with an average GT of 79652. Four LNG tankers of comparable size with an average GT of 94000 are included in this study: the average EEOI is 46.1 g CO_2/ton nm.

LPG

22 For the LPG tankers with an average GT of 22800 the average EEOI is 53 gCO_2/ton nm. No other studies determining the EEOI of these types of ships were found and consequently no comparisons could be made.

Table 3: EEOI for the different ships

SHIP TYPE	EEOI MEPC/Circ.471 gCO_2/ton nm	EEOI without ballast leg gCO_2/ton nm	EEOI without port time gCO_2/ton nm	Period days
Bulk dry	6.2	3.4	5.8	361
Bulk dry	7	3.5	6.5	383
Bulk dry	5.9	3.4	5.4	367
Bulk dry	5.9	3.2	5	381
Bulk dry	5.5	3.2	5.1	383
Bulk dry	6.6	3.6	4.9	84
Bulk dry	5.6	3.6	5.4	353
Bulk dry	4.5	3.4	4.4	128
Bulk dry	7.9	3.6	7.	201
Bulk dry	7.9	5.1	7.3	251
Bulk dry	4.9	2.5	4.5	96
Bulk dry	9.9	7.2	8.7	197
Bulk dry	9.2	7	8.1	371
Bulk dry	6.4	4.5	5.9	368
Bulk dry	7.7	3.4	7.5	350
AVERAGE	**6.7**	**4**	**6.1**	-
Crude oil tanker	23.1	10.1	22	186
Crude oil tanker	18.9	5	17.3	131
Crude oil tanker	6,5	4,6	6	229
Crude oil tanker	10	7.5	9.1	285
Crude oil tanker	9.6	5.2	8.4	639
Crude oil tanker	7.3	5.3	6.8	208
Crude oil tanker	7,6	5,9	7	256
Crude oil tanker	8,3	6,6	7,5	256
AVERAGE	**11.4**	**6.3**	**10.5**	-
General cargo	24	17.2	20.1	562
General cargo	19.3	16.8	16.8	370
General cargo	30.8	22.4	27.7	220
General cargo	/	/	/	/
General cargo	/	/	/	/
General cargo	/	/	/	/
AVERAGE	**10.2**	**6.3**	**10.8**	-
LNG tanker	54	19.4	42.3	354
LNG tanker	34.2	15.2	31.9	373
LNG tanker	48	15.9	30.4	357

SHIP TYPE	EEOI MEPC/Circ.471 gCO_2/ton nm	EEOI without ballast leg gCO_2/ton nm	EEOI without port time gCO_2/ton nm	Period days
LNG tanker	48	19.1	41.4	364
AVERAGE	**46.1**	**17.4**	**36.5**	-
LPG tanker	50.7	15	30.4	347
LPG tanker	41.1	18.4	36.1	368
LPG tanker	45.8	19.2	39.3	368
LPG tanker	55.5	22.1	50	7
LPG tanker	68.3	24.1	56.1	350
LPG tanker	16.6	7.6	12.7	361
LPG tanker	82.1	33.6	64.6	365
LPG tanker	71.9	23.6	44.8	373
LPG tanker	58	29	49,5	376
LPG tanker	40.2	19.9	35.7	1436
AVERAGE	**53**	**21.3**	**41.9**	**-**

23 MEPC 55/4/3 revealed a clear distinction in trendlines of the EEOI of ships with volume intensive cargo and ships with dry and liquid bulk cargo as shown in Figure 3. Higher indices were observed for ships with volume intensive cargo including LNG tankers. The same trend regarding LNG and LPG tankers was observed in this study as shown in Figure 4.

24 The trendline of the EEOI of the dry bulk and crude oil tankers lies well in the range of the dry and crude oil tankers of MEPC 55/4/3.

Figure 3: Calculated EEOI from MEPC 55/4/3 in function of gross tonnage

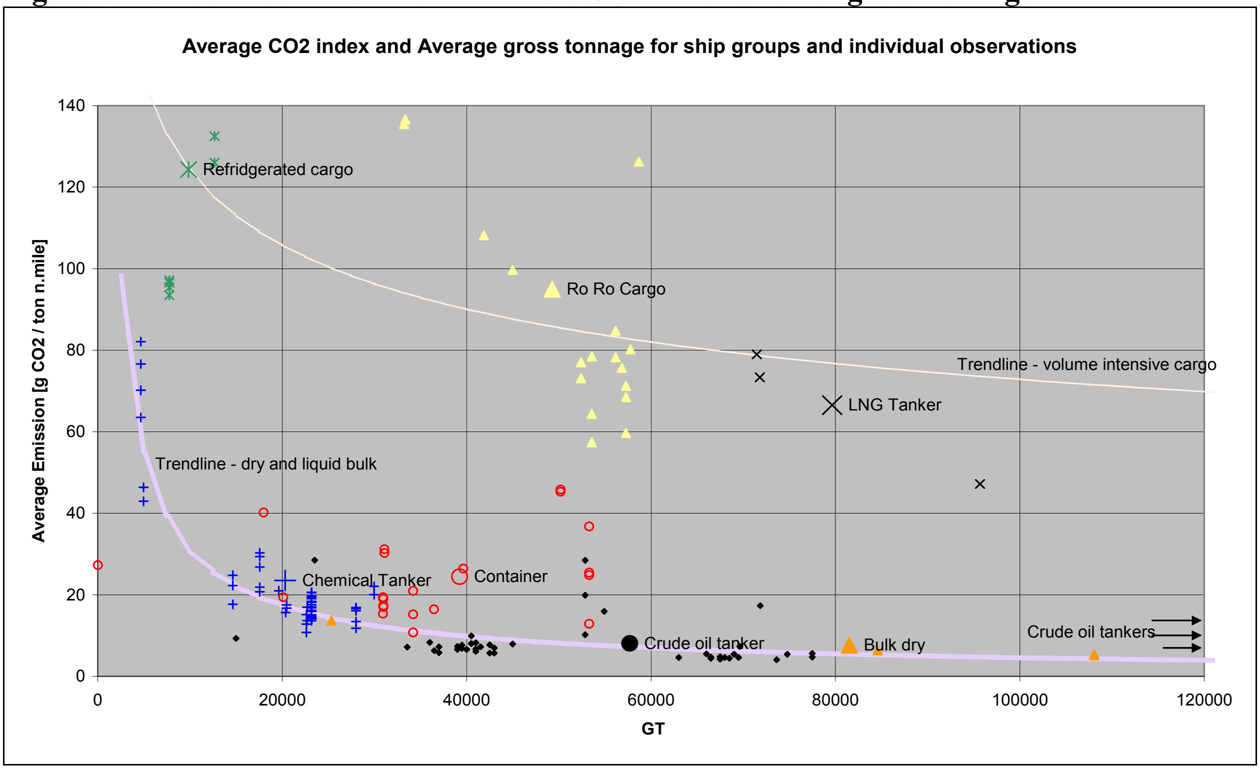
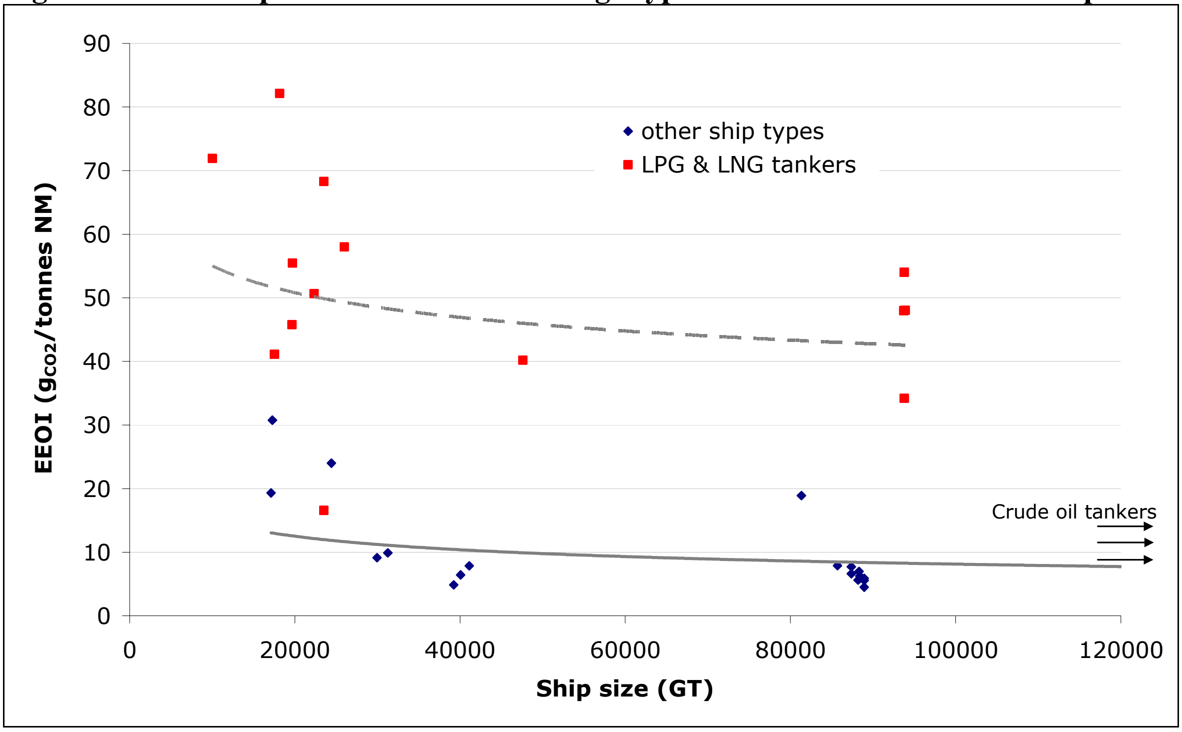


Figure 4: EEOI separated for different cargo types in function of the GT of ships



Variations in the index

25 Although there is a strong correlation between the ship size and the EEOI, Figure 2 shows that there is a high variability of the EEOI especially for the LNG and LPG ships. It is important to have a better understanding of the variations observed in order to monitor the CO_2 emissions of ships and to evaluate the performance of ships within the framework of, e.g., an environmental management system.

26 In general, operational variations in the index are mainly caused by the factors below as described in MEPC 55/4/3:

.1 relative utilization of cargo space;

.2 relative fuel consumption on ballast legs (related to length of ballast legs);

.3 efficiency of ship (engine condition, hull and propeller fouling, etc.);

.4 variations in speed;

.5 weather and currents; and

.6 errors in measurement and registration.

27 In this study, the fuel consumption during port time for each individual ship was entered in the database and an analysis was made on the contribution of this consumption to the variation of the EEOI. The analysis shows that the relative fuel consumption during port time, which is

related to the length of port time, is another parameter causing for the variation of the EEOI and it should be added to the list above.

28 Identifying the different causes for the variation in the EEOI proves to be difficult. Breaking down the basic formula of the EEOI leads to a better understanding and transparency on the causes of variation of the EEOI for the ship operator. The initial EEOI could be divided into three "sub-indexes" more apt at monitoring the specific aspects of ship efficiency:

– Cargo EEIO;

– Ballast EEOI; and

– Port EEOI.

29 This way it is much easier to identify where improvements are needed for each individual ship. The "sub-indexes" could be included into an environmental management system such as, e.g., the Ship Efficiency Management Plan proposed in MEPC 58/INF.7. Hence, specific guidelines for the calculation of the sub-indexes should be considered by IMO.

30 The sections below analyse in detail to what extent the ballast legs and port time contribute to the variability of the total EEOI of crude oil tankers, LPG tankers and LNG tankers.

Effect of ballast legs

31 The EEOI of LNG and LPG tankers decreases with 60% on average when ballast legs are not included in the index calculation. The EEOI of the crude oil tankers decreases with 33% when ballast legs are not included. The EEOI of bulk dry ships decreases with 43% when ballast legs are not included. The highest contribution of ballast legs was found for an oil tanker and was 73.5%.

32 The two outliners of the two oil tankers previously mentioned were due to the higher number of ballast legs as shown in Figure 5.

33 For the (base) year 2007, the number of ballast legs was the dominant factor influencing the level of the EEOI of the LNG and LPG tankers. Figure 6 and especially Figure 7 show that the variability due to fuel consumption from ballast legs is high for all LNG and LPG ships. As already discussed in previous studies this shows again that the level of the EEOI is a function of the business availability (i.e. voyage orders and in particular cargo availability) and that it is subject to the limitations imposed by the trade these ships perform.

Figure 5: EEOI in function of ship size for crude oil tankers with and without the inclusion of ballast legs

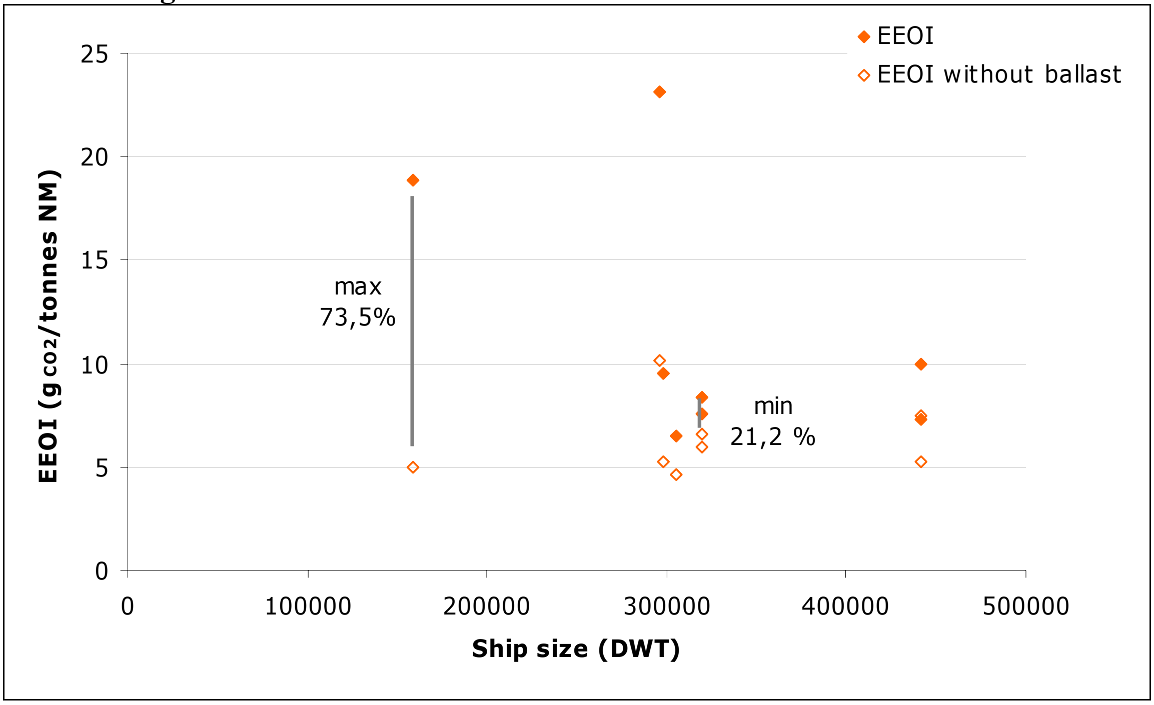


Figure 6: EEOI in function of ship size for LNG tankers with and without the inclusion of ballast legs

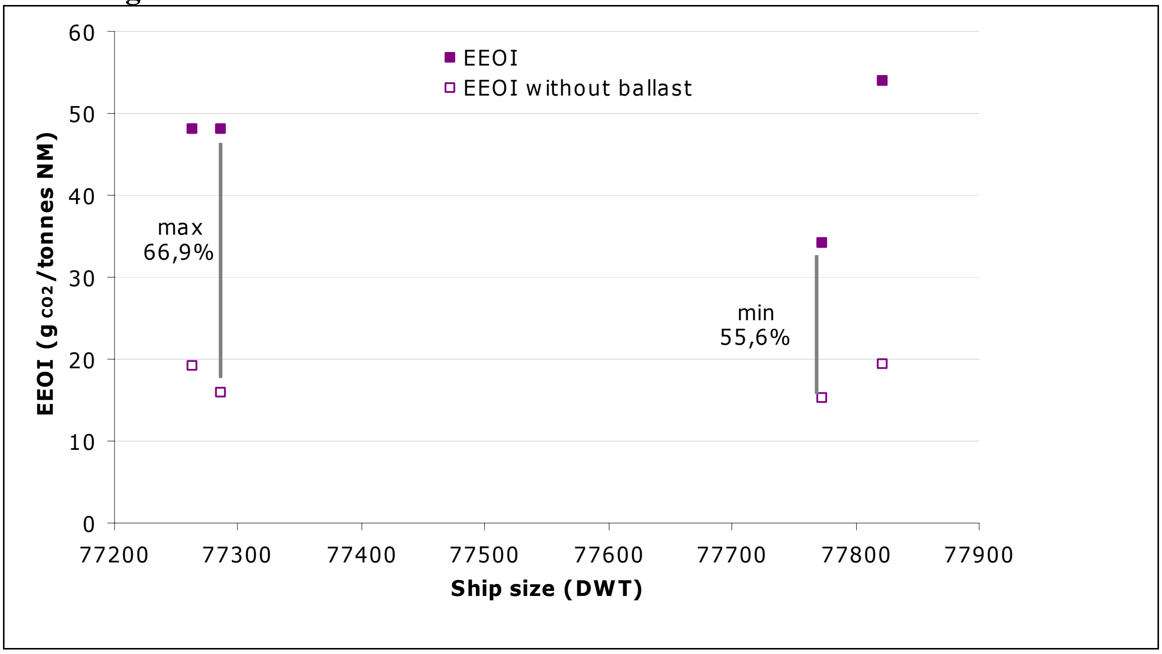
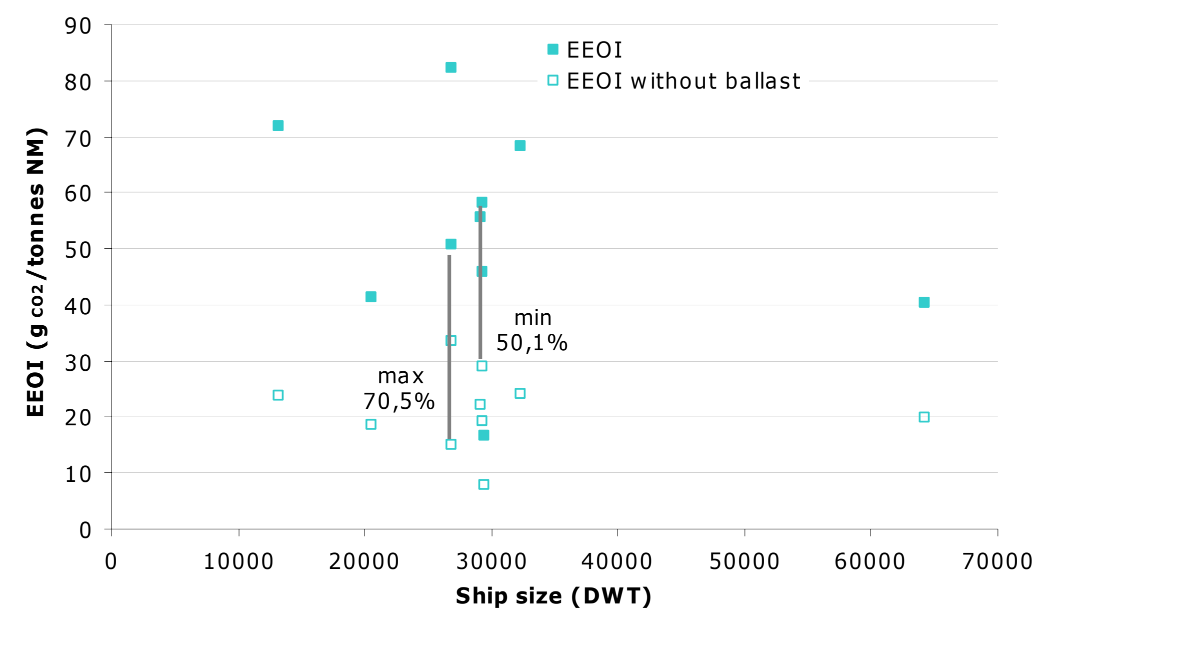


Figure 7: EEOI in function of ship size for LPG tankers with and without the inclusion of ballast legs



Effect of port time

34 The influence of the fuel consumption during port time on the EEOI for all the ships in this study is 13% on average. The influence of the fuel consumption for the ballast legs on the EEOI for all the ships in this study is much higher and is 45% on average.

35 The EEOIs of the LNG (Figure 8) and LPG tankers (Figure 9) were the most affected compared to the other ship types again due to business and operational constraints. The fuel consumption during port time represents 20% on average of the EEOI for LNG and LPG tankers, whereas for the other ship types, this percentage lies around 10%. The contribution to the variation of the EEOI, which can be attributed to the fuel consumption during port time for the LNG tankers in this study, is 6.7% and the maximum 36.6%. The contribution for the LPG tankers in this study is 9.9%, the maximum 40%.

36 Analysing the influence of port time could lead to a better understanding of the ship-port interface. As referred to in MEPC 53/INF.6, time spent loading and/or unloading is a function of both ship and port capacities.

Figure 8: EEOI in function of ship size for LNG tankers with and without the inclusion of port legs

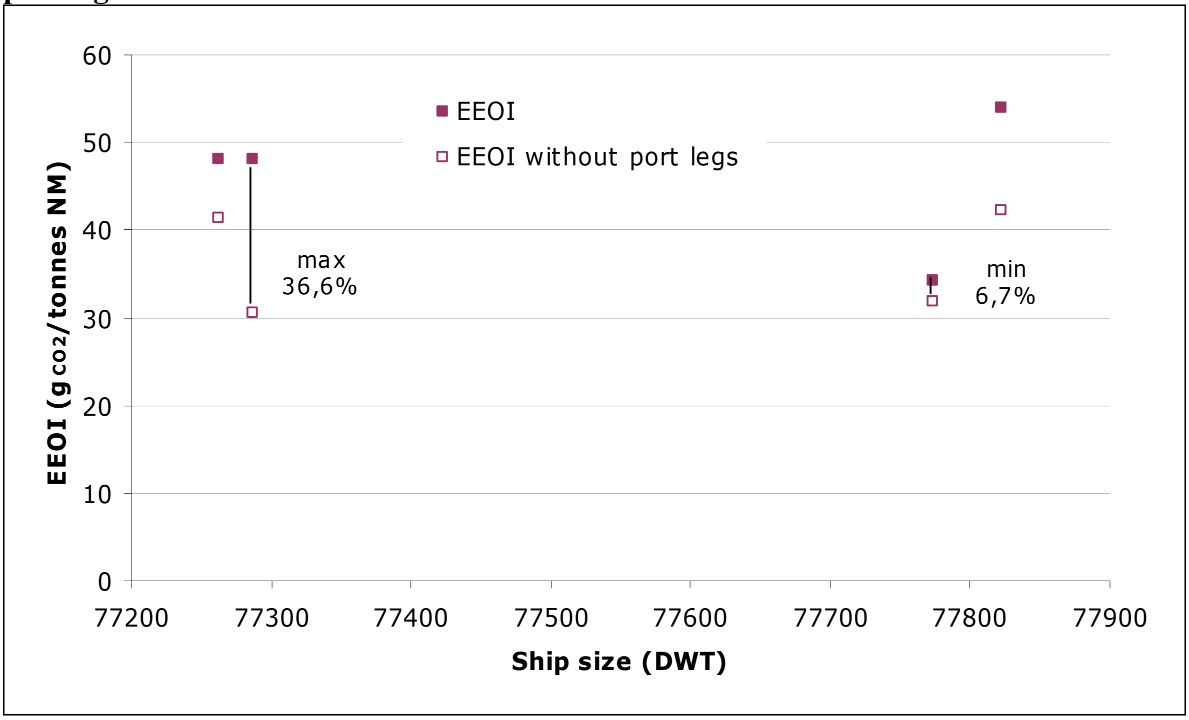
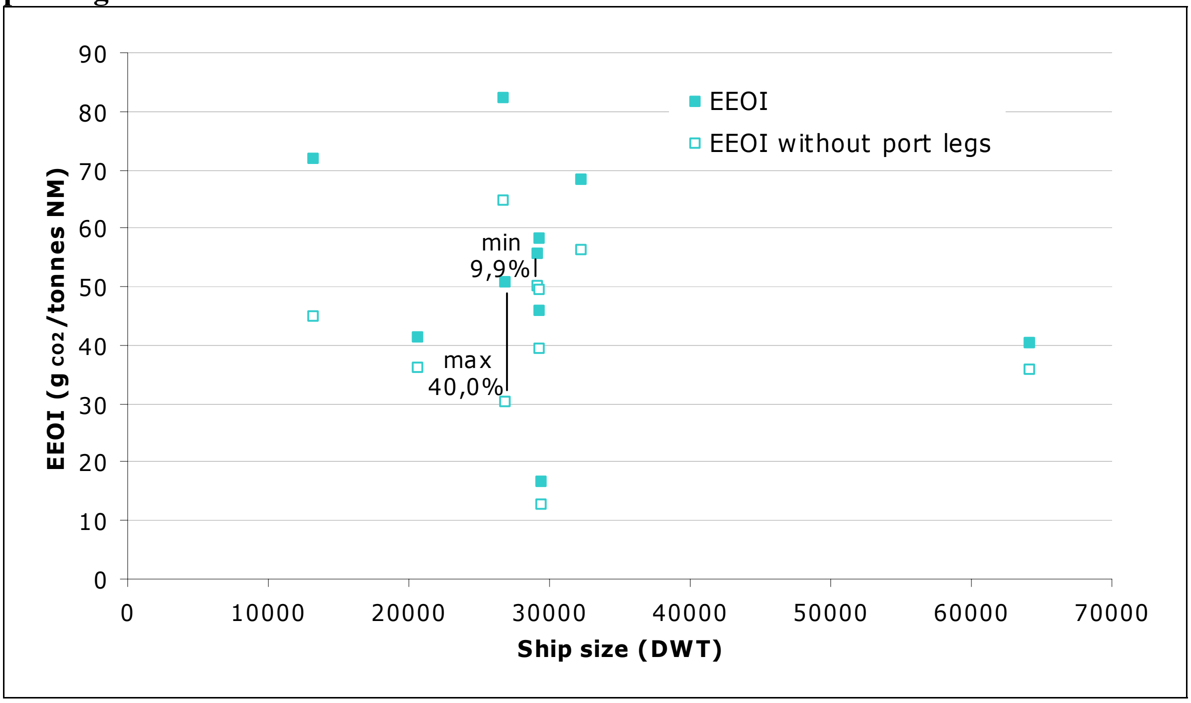


Figure 9: EEOI in function of ship size for LPG tankers with and without the inclusion of port legs

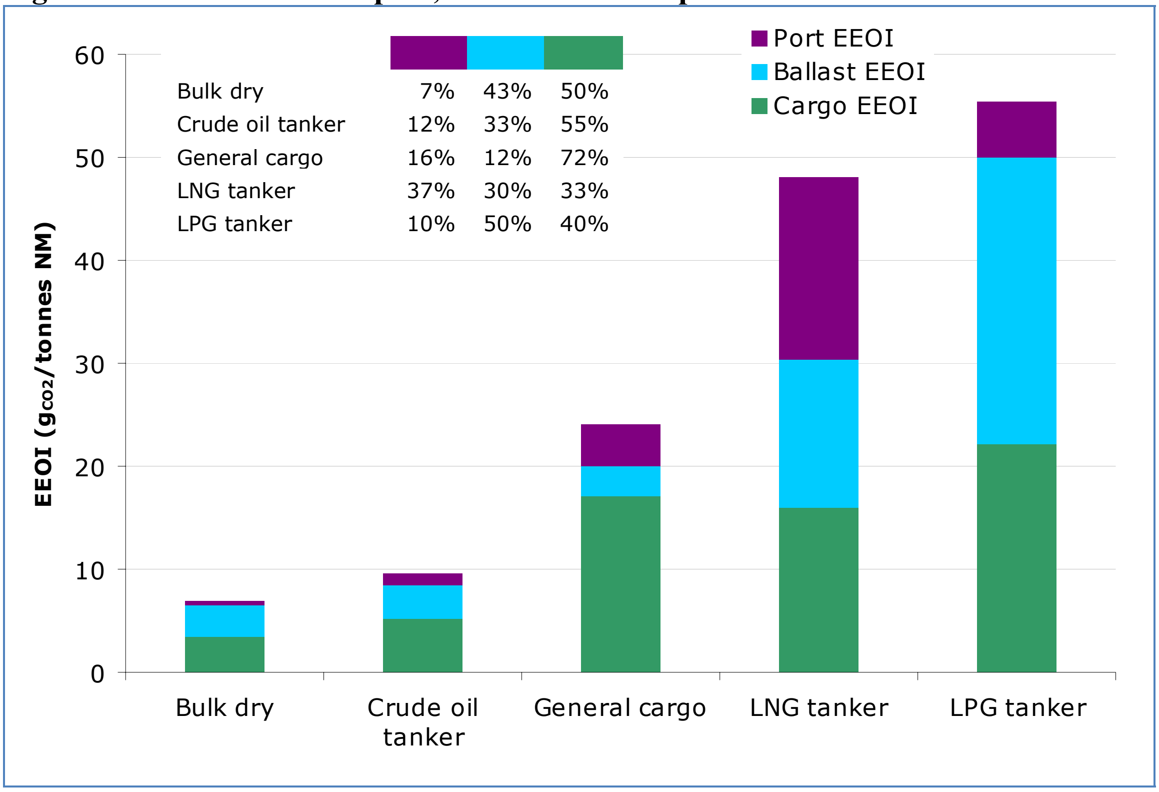


Interpretation of EEOI results

37 Figure 10 shows the percentage of the fuel consumption during port time, ballast legs and cargo legs using the three "sub-indexes". This visual interpretation of the EEOI should make it easier for the ship operator to interpret the energy efficiency of each of its ship in order to evaluate the performances and take action were appropriate.

38 It should be stressed that it is not the intention to replace the original index. By dividing the original EEOI in sub-indexes it will be easier to understand the variations of the index and take action as appropriate.

Figure 10: contribution of port, ballast and transport work to the total EEOI



Summary

39 Based on the study conducted and presented in this document, the following observations have been made:

.1 data were collected of 43 ships covering five of 18 ship categories as defined by Lloyds Fairplay to determine the EEOI as defined in MEPC/Circ.471;

.2 the distance sailed is one of the critical parameters when determining the EEOI. It depends on the definition of a voyage which can be interpreted in different ways. There is an urgent need to clarify the definition of a voyage/leg in MEPC/Circ.471;

.3 the level of the EEOI of this study is comparable with previous studies on the EEOI such as MEPC 55/4/3 from Germany and Norway and MEPC 55/INF.9 from Japan;

.4 among the five categories of each ships studied the highest variability of the EEOI is found for LNG and LPG tankers;

.5 by investing in detail to what extent the ballast legs and port time influence the total EEOI the study demonstrates that the total EEOI of a ship is strongly influenced by business availability (i.e. voyage orders and in particular cargo availability); and

.6 the EEOI could be used as a tool for the ship operator to monitor the energy efficiency of each individual ship within the framework of, e.g., the Ship Efficiency Management Plan by calculating and evaluating the three sub-indexes in order to improve the performances and take action were appropriate.

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