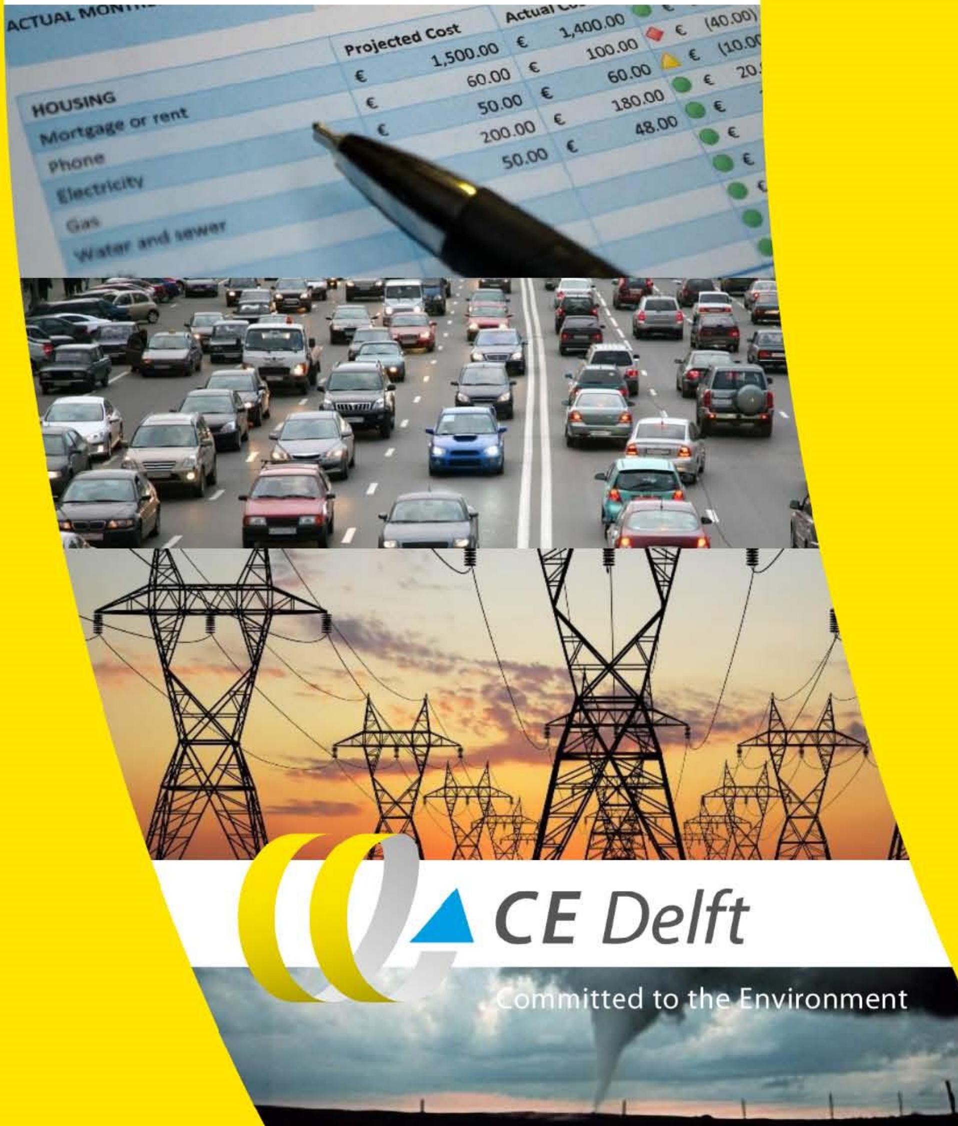
Readily Achievable EEDI Requirements for 2020



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Readily Achievable EEDI Requirements for 2020

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CE Delft
Committed to the Environment

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Content

Summary

The Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) is conducting a review of the 2020 requirements of the Energy Efficiency Design Index (EEDI). In the current regulation, a ship built after 1 January 2020 needs to have an EEDI that is 20% below the reference line value for that ship.

The aim of this project is to analyse which EEDI requirements are readily achievable for bulk carriers, tankers, general cargo ships and containerships.

A requirement is deemed to be readily achievable if it is achieved by the 10, 20 or 30% best performing ships that have entered the fleet in 2014 and 2015. To set more ambitious targets a view would also need to be taken of what is possible through innovative technologies and speed reductions.

Such a definition would lead to more stringent requirements in 2020, as shown in Table 1. For bulk carriers and tankers, the requirement could be increased to -25 to -33%, for containerships and general cargo ships to -37 to -48%. These requirements do not, however, reflect the design efficiency of small containerships and the smallest and largest bulk carriers. For these ship categories, a further analysis of which requirements are achievable could be warranted.

Table 1 Readily achievable uniform EEDI requirements for 2020

Ship type	Bulk Carrier	Containership	Tanker	General cargo ship
Minimal distance to the reference line of the 30% best ships	-25%	-39%	-26%	-37%
Minimal distance to the reference line of the 20% best ships	-28%	-42%	-31%	-40%
Minimal distance to the reference line of the 10% best ships	-32%	-48%	-33%	-44%

Source: This report.

1 Introduction

The Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) is conducting a review of the 2020 requirements of the design efficiency of new ships. Each new ship built in 2013 or later has an Energy Efficiency Design Index (EEDI). The value of the EEDI needs to be better than the reference value for that ship. The difference between the attained EEDI and the reference value is set to increase over time. By 2020, the difference needs to be 20%. However, analyses by CE Delft (CE Delft, 2016) and others has shown that many ships built in 2015 and 2016 already exceed the 2020 requirement.

The aim of this project is to identify possible new EEDI requirements that can be readily achieved for bulk carriers, tankers, general cargo ships and containerships.

1.1 Method for analysing requirements

There are several ways to set an efficiency target. One is to analyse through case studies or otherwise what the most efficient ship would be. Another method is to set the target on the basis of the efficiency of the most efficient ships in the current fleet.

Both methods have advantages and disadvantages when applied to the EEDI requirements.

The advantage of case studies is that they can show the efficiency improvements of new designs, engines and equipment, even when they have not been widely adopted in the market due to different kinds of market and non-market barriers (CE Delft; Marena Ltd.; D.S. Lee, 2012).
The disadvantage, however, is that the case studies may not have been tested in practice, or that the case study ships may be designed for specific trades, or that they do not take into account all the constraints on dimensions, crew, costs, yard capabilities, et cetera that ship designs in reality have to deal with.

The advantage of an analysis of the current fleet is that it is evident that all the ships can be built and put to use. The disadvantage is that the target does not reflect the potential of innovative designs and equipment which may be large, especially when the adoption of new technologies is slow.

Some efficiency targets, like the Japanese Top Runner Program, combine these two methods by setting targets on the basis of both the efficiency of the best-in-class in the current market and an analysis of the impact of innovations (METI, 2015)

This report considers a target to be readily achievable if a certain percentage of ships that have recently entered the fleet have met or exceeded it already. An analysis of the potential for additional improvements beyond this in the period up to the application of the target is beyond the scope of this study, but a view on this would need to be taken before setting any new EEDI requirement.

Because the EEDI database that the IMO Secretariat maintains contains less than half of the ships that have an EEDI (CE Delft, 2016), the basis for our analysis is not the EEDI but the *estimated* EEDI of all ships that have entered the fleet in 2014 and 2015. The EEDI was estimated on the basis of the Estimated Index Value (EIV), which MEPC has used to calculate the EEDI reference lines, and the empirical relation between the EEDI and the EIV of ships for which both values are known.

1.2 Outline of the report

Chapter 2 shows that for the ship types analysed in this report, the EIV and EEDI are strongly correlated and that an EEDI can be estimated on the basis of the EIV. Therefore, the benefit of being able to take all ships that have recently entered the fleet into account outweighs the disadvantage of the slight inaccuracy introduced by using a different metric.

Chapter 3 continues to analyse the requirements that are achieved by different shares of recently built ships. It analyses various options for requirements: a uniform requirement for all ships, regardless of their type and size that is achieved by the best-in-class of ships that have entered the fleet in 2014 and 2015; different requirements for different ship types; and different, size-dependent requirements for different ship types.

Chapter 4 draws conclusions.

2 The relation between the EIV and the EEDI

2.1 Introduction

The EEDI is the measure for the design efficiency of a ship that MEPC has adopted in 2011 Resolution MEPC. 203(62) (MEPC, 2011).The EEDI is based on the premise that the design efficiency is the quotient of the CO_2 emissions of a ship under standard conditions and the transport work. In a simplified formula, it is defined as (IMO, 2012)

$$EEDI = \frac{CO_2 emissions}{transport\ work}$$

The formula actually used to calculate the EEDI is more complicated and requires information about the speed-fuel consumption curve, auxiliary engine power and other parameters that are not publicly available for each ship.

Because the EEDI can in practice only be calculated when all the ship details are known (and needs to be verified in a sea trial), the reference line that determines the required EEDI was calculated using a simplified form of the EEDI, namely the Estimated Index Value (EIV). The EIV is defined as Resolution MEPC.233(65) (MEPC, 2013)):

$$EIV = 3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 215 \cdot P_{AE}}{Capacity \cdot V_{ref}}$$

Where:
- P_{MEi} is 75% of the power of main engine i (MCRME(i));
- NME is the number of main engines;
- P_{AE} is the auxiliary power[1];
- *Capacity* is the deadweight tonnage of a ship, or 70% of the deadweight tonnage of a containership;
- V_{ref} is the ships' service speed.

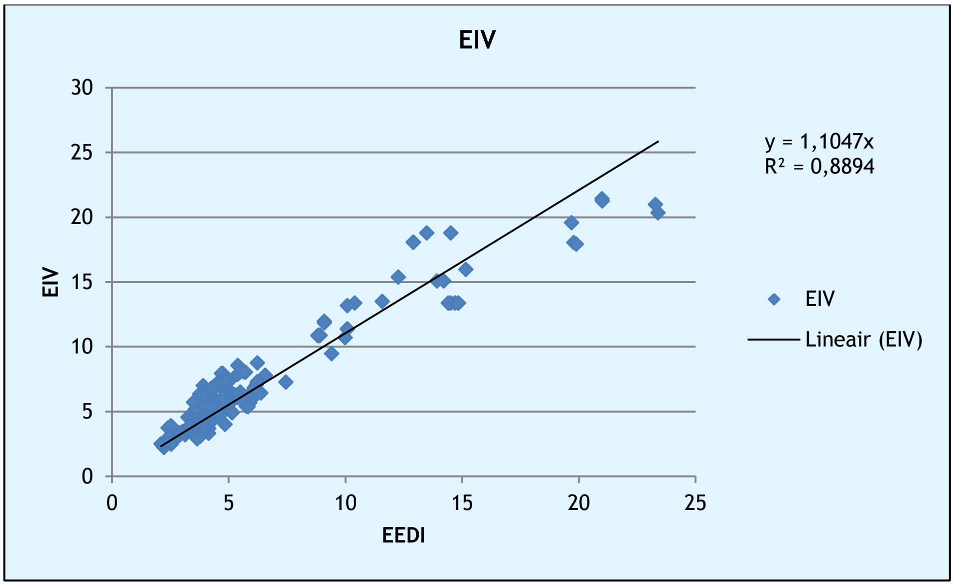
2.2 Empirical analysis of the relation between the EIV and the EEDI

In order to analyse the relation between the EIV and the EEDI, we have collected EEDI values for different ships and calculated the EIV for each of these ships. In total, we were able to match 280 ships (187 bulk carriers, 21 tankers, 24 containerships, and 18 general cargo ships). Although this is a small sample of the total number of ships with an EEDI (which (CE Delft, 2016) estimates to be 1,230 for ships that entered the fleet before 1 January 2016), we consider the sample to be sufficiently large to draw conclusions about the relation between the EIV and the EEDI.

[1] As information on PAE is often lacking, PAE is calculated according to paragraphs 2.5.6.1 and 2.5.6.2 of the annex to (MEPC, 2012).

Figure 1 shows that for this sample of ships, the EIV overestimates the EEDI by approximately 10%. This is in line with the expectations because the IMO definition of the EIV assumes a specific fuel consumption (SFC) of the main engine of 190 g/kWh, while the average SFC of new ships is around 174 g/kWh, or 8.5% lower.[2]
In addition to the lower main engine SFC, the SFC of auxiliaries is also likely to be lower and there may be other, smaller factors that contribute to a lower EEDI.

Figure 1 Relationship between the EEDI and the EIV



Source: CE Delft.

A closer examination of Figure 1 shows that ships with an EEDI of 20 or higher have an EEDI that is very close or identical to the EIV. This is to be expected because these ships are smaller ships, which typically have smaller engines with a higher SFC.[3]

For large ships with an EEDI of 10 or less, the EIV is typically about 20% higher than the EEDI.

In the remainder of this report, we will use the empirical relation that the EEDI is 90% of the EIV and define the *estimated EEDI* or *eEEDI* as 90% of the EIV value.

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2 This average is based on 5,001 ships in the Clarksons World Fleet register that entered the fleet in 2010 or later, had a deadweight of at least 5,000 tonnes and for which the main engine SFC was listed.

3 While the average SFC of ships that have entered the fleet since 2010 is 174 g/kWh, the SFC of ships with a main engine of 5 MW or less is 181 g/kWh.

3 Achievable requirements

3.1 Introduction

This chapter analyses which EEDI requirements for Phase 2 (2020–2024) would be readily achievable. A requirement is considered to be readily achievable if it is met by the best-in-class of the ships that have entered the fleet in 2014 and 2015. We apply three criteria for the best-in-class: the 10% best ships, the 20% best ships and the 30% best ships.

The approach taken here is inspired by the Japanese Top Runner Program, which sets targets for appliances and transport equipment (albeit not for ships) based on the energy efficiency of the best-in-class in a certain year (METI, 2015). The main difference between the Top Runner Program and the readily achievable requirements in this study is that the Top Runner Program also takes into account the potential technical improvement over the current state of the art, something which is outside the scope of this study.

Since the possible requirements calculated in this report are based on an analysis of what the best ships that entered the fleet in 2014 and 2015 have been able to achieve, but not on an in-depth analysis of which further improvements are possible, the requirements described here could be considered to be the minimum achievable requirements.

This report assumes that the requirements will be based on the existing reference lines.

This report considers three types of requirements:
1. Uniform requirements for all ships: all tankers, bulk carriers and containerships have to meet or exceed the same reduction from the reference line, regardless of their size. This is the way in which requirements were set in 2011.
2. Ship type-specific requirements: different requirements may be set for different ship types, but all ships of a certain type will be required to meet or exceed the ship type-specific requirement, regardless of their size. This takes into account that different ship types have different improvement potentials or that the market for different ship types has developed in different ways, e.g. with regards to the required design speed.
3. Requirements that depend on both the ship type and the ship size. This takes into account that for large or small ships, it may be harder or easier to achieve a certain requirement than for ships of other sizes.

3.2 Uniform requirements for all ships

If the requirement would be set so that all ship types considered here could readily achieve it, it would be between 25 and 32% below the reference line, as this is the value which 30 and 10% of the bulk carriers can achieve (see Table 2). All other ship types considered here have a larger share of new ships below the proposed requirement values.

Table 2 **Readily achievable uniform EEDI requirements for 2020**

Ship type		Bulk carrier	Containership	Tanker	General cargo ship
Size class		(All)			
Year of entry in the fleet		2014-2015			
Number of ships	Total number	936	289	287	127
Distance of the eEEDI to the reference line	Mean	-16%	-30%	-18%	-22%
	Median	-20%	-31%	-20%	-27%
	Standard deviation	19%	17%	16%	27%
Reference line value	Mean	5.1	18.9	8.4	14.6
eEEDI	Mean	4.3	13.5	6.8	11.5
Minimal distance of the eEEDI to the reference line of the 30% best ships		-25%	-39%	-26%	-37%
Minimal distance of the eEEDI to the reference line of the 20% best ships		-28%	-42%	-31%	-40%
Minimal distance of the eEEDI to the reference line of the 10% best ships		-32%	-48%	-33%	-44%

Source: This report.

Note: The distance to the reference line has been calculated according to the method presented in Annex B. The eEEDI is the estimated EEDI which is 90% of the value of the EIV (see Chapter 2).

3.3 Requirements differentiated to ship type

The efficiency improvements since the period over which the reference line was calculated have varied per ship type. While all ship types have witnessed improvements of the EIV (and consequently of the EEDI), the improvements have been smaller for bulkers than for containerships (CE Delft, 2016).

This section analyses which achievable requirements could be set for different ship types.

3.3.1 Bulk carriers

Table 2 shows that of the 936 bulk carriers that entered the fleet in 2014 and 2015 and for which an EIV could be calculated, 30% had an estimated EEDI at least 25% below the reference line, 20% an estimated EEDI at least 28% below the reference line and 10% an estimated EEDI 32% or more below the reference line.

This analysis implies that a readily achievable requirement for bulk carriers in 2020 would be between -25 and -32% below the reference line, depending on whether the requirement would be based on the 10%, 20% or 30% most efficient recently built ships.

3.3.2 Tankers

Table 2 shows that of the 287 tankers that entered the fleet in 2014 and 2015 and for which an EIV could be calculated, 30% had an estimated EEDI at least 26% below the reference line, 20% an estimated EEDI at least 31% below the reference line, and 10% an estimated EEDI 33% or more below the reference line.

This analysis implies that a readily achievable requirement for tankers in 2020 would be between -26 and -33% below the reference line, depending on whether the requirement would be based on the 10%, 20% or 30% most efficient recently built ships.

3.3.3 Containerships

Table 2 shows that of the 289 containerships that entered the fleet in 2014 and 2015 and for which an EIV could be calculated, 30% had an estimated EEDI at least 39% below the reference line, 20% an estimated EEDI at least 42% below the reference line, and 10% an estimated EEDI 48% or more below the reference line.

This analysis implies that a readily achievable requirement for containerships in 2020 would be between -39 and -48% below the reference line, depending on whether the requirement would be based on the 10%, 20% or 30% most efficient recently built ships.

3.3.4 General cargo ships

Table 2 shows that of the 127 general cargo ships that entered the fleet in 2014 and 2015 and for which an EIV could be calculated, 30% had an estimated EEDI at least 37% below the reference line, 20% an estimated EEDI at least 40% below the reference line, and 10% an estimated EEDI 44% or more below the reference line.

This analysis implies that a readily achievable requirement for general cargo ships in 2020 would be between -37 and -44% below the reference line, depending on whether the requirement would be based on the 10%, 20% or 30% most efficient recently built ships.

3.4 Requirements differentiated to ship type and size

The efficiency improvements since the period over which the reference line was calculated have varied not only per ship type, but also per size category. Requirements that are differentiated to ship type and size could take differences in the rate of technical progress into account.

When considering the rate of technical progress, one should consider that classes in which relatively few ships are built may not be subject to the same competitive pressure to improve their efficiency as classes in which many ships are built.

3.4.1 Bulk carriers

The median bulk carrier that entered the fleet in 2014 and 2015 has an EIV of 11% below the reference line (see Table 2). This is also true for most size categories, except for the largest bulk carriers in our sample, those with deadweight between 250,000 and 300,000 tonnes. These ships, of which the sample is small, are relatively less efficient than the smaller ships (see Table 3).

Table 3 shows that if requirements were different for different size categories, the smallest and largest bulkers would have less stringent requirements than the bulkers with a deadweight between 20,000 and 250,000 dwt. An achievable requirement for bulk carriers between 10,000 and 25,000 dwt would be between -23 and -24%; a requirement for ships over 250,000 dwt -17%. Note, however, that relatively few of these ships entered the fleet in 2014 and 2015. For the other bulk carriers, an achievable requirement would be between -24 and -32%.

Table 3 **Readily achievable EEDI requirements for bulk carriers for 2020**

Ship type		Bulk Carrier					
Size class (1,000 dwt)		10-25	25-55	55-75	75-120	120-250	250-330
Year of entry in the fleet		2014-2015					
Number of ships	Total number	20	293	309	206	92	12
Distance of the eEEDI to the reference line	Mean	-2%	-18%	-14%	-16%	-16%	-12%
	Median	-20%	-21%	-19%	-20%	-19%	-15%
	Standard deviation	35%	17%	20%	18%	15%	7%
Reference line value	Mean	9.3	6.3	5.0	4.3	2.9	2.5
eEEDI	Mean	9.0	5.2	4.3	3.6	2.5	2.2
Minimal distance of the eEEDI to the reference line of the 30% best ships		-23%	-24%	-26%	-27%	-25%	-17%
Minimal distance of the eEEDI to the reference line of the 20% best ships		-24%	-28%	-28%	-28%	-27%	-17%
Minimal distance of the eEEDI to the reference line of the 10% best ships		-24%	-34%	-31%	-34%	-28%	-17%

Source: This report.

Note: The distance to the reference line has been calculated according to the method presented in Annex B. The eEEDI is the estimated EEDI which is 90% of the value of the EIV (see Chapter 2).

Overall, the uniform requirement for bulk carriers suggested in Section 3.3.1 of -25 to -32% looks achievable for most size categories, with the possible exemption of the largest and smallest size categories.

3.4.2 Tankers

The median tanker that entered the fleet in 2014 and 2015 has an EIV of 11% below the reference line (see Table 2). A closer inspection of the different size categories reveals that the median tanker with a deadweight between 10,000 and 55,000 dwt has a better relative efficiency than smaller or larger tankers (see Table 4). Note, however, that relatively few tankers of over 55,000 dwt have entered the fleet.

Table 4 does not reveal a clear size-dependency of the relative efficiency of new tankers. Although a cursory look at the table suggests that a more stringent requirement could be set for tankers with a deadweight between 75,000 and 120,000 dwt, and a less stringent requirement for tankers over 120,000 dwt, a detailed inspection shows that the number of ships in each size category is small so the results may have been influenced by a single ship owner or one specific design.

Table 4 Readily achievable EEDI requirements for tankers for 2020

Ship type		Tanker					
Size class (1,000 dwt)		4-10	10-25	25-55	75-120	120-170	250-330
Year of entry in the fleet		2014-2015					
Number of ships	Total number	48	36	156	14	12	18
Distance of the eEEDI to the reference line	Mean	-19%	-23%	-18%	-25%	-14%	-13%
	Median	-15%	-25%	-24%	-17%	-13%	-17%
	Standard deviation	17%	13%	17%	15%	8%	11%
Reference line value	Mean	17.4	10.5	6.5	4.3	3.6	2.5
eEEDI	Mean	14.2	8.1	5.4	3.3	3.1	2.2
Minimal distance of the eEEDI to the reference line of the 30% best ships		-22%	-31%	-27%	-30%	-13%	-21%
Minimal distance of the eEEDI to the reference line of the 20% best ships		-27%	-33%	-31%	-42%	-23%	-23%
Minimal distance of the eEEDI to the reference line of the 10% best ships		-55%	-34%	-31%	-50%	-26%	-24%

Source: This report.

Note: The distance to the reference line has been calculated according to the method presented in Annex B. The eEEDI is the estimated EEDI which is 90% of the value of the EIV (see Chapter 2).

Overall, the uniform requirement for tankers suggested in Section 3.3.2 of -26 to -33% looks achievable for most size categories, with the possible exemption of the largest tankers.

3.4.3 Containerships

The median containership that entered the fleet in 2014 and 2015 has an EIV of 24% below the reference line (see Table 2). Larger containerships have a markedly better relative efficiency than smaller ones. Table 5 shows that the median EIV for containerships with a deadweight between 15,000 and 30,000 tonnes was 4% below the reference lines, whereas it was 31% below the reference line for ships with a deadweight of 70,000 tonnes or more.

Table 5 shows that a uniform ship type requirement of -39 to -48% would reflect the state of the art for large containerships, but that smaller containerships are far removed from such a requirement.

Table 5 Readily achievable EEDI requirements for containerships for 2020

Ship type		Containership			
Size class (1,000 dwt)		10-15	15-30	30-70	70-200
Year of entry in the fleet		2014-2015			
Number of ships	Total number	16	41	82	150
Distance of the eEEDI to the reference line	Mean	-23%	-9%	-29%	-37%
	Median	-24%	-14%	-32%	-37%
	Standard deviation	10%	17%	14%	13%
Reference line value	Mean	26.1	23.2	19.8	16.4
eEEDI	Mean	20.0	21.1	14.1	10.3
Minimal distance of the eEEDI to the reference line of the 30% best ships		-30%	-20%	-38%	-44%
Minimal distance of the eEEDI to the reference line of the 20% best ships		-31%	-21%	-39%	-48%
Minimal distance of the eEEDI to the reference line of the 10% best ships		-33%	-27%	-39%	-53%

Source: This report.

Note: The distance to the reference line has been calculated according to the method presented in Annex B. The eEEDI is the estimated EEDI which is 90% of the value of the EIV (see Chapter 2).

3.4.4 General cargo ships

The median general cargo ship that entered the fleet in 2014 and 2015 has an EIV of 19% below the reference line (see Table 2). Larger general cargo ships have a markedly better relative efficiency than smaller ones. Table 6 shows that the median EIV for general cargo ships with a deadweight between 3,000 and 10,000 tonnes was 13% below the reference lines, whereas it was 29% below the reference line for ships with a deadweight of 70,000 tonnes or more.

Table 6 shows that despite the fact that larger ships are relatively more efficient, a uniform ship type requirement of -37 to -44% would reflect the state of the art of both size categories of general cargo ships.

Table 6 Readily achievable EEDI requirements for general cargo ships for 2020

Ship type		General cargo ship	
Size class (1,000 dwt)		3-10	10-55
Year of entry in the fleet		2014-2015	
Number of ships	Total number	60	67
Distance of the eEEDI to the reference line	Mean	-15%	-29%
	Median	-21%	-36%
	Standard deviation	31%	19%
Reference line value	Mean	16.4	13.0
eEEDI	Mean	14.0	9.2
Minimal distance of the eEEDI to the reference line of the 30% best ships		-31%	-39%
Minimal distance of the eEEDI to the reference line of the 20% best ships		-33%	-41%
Minimal distance of the eEEDI to the reference line of the 10% best ships		-49%	-44%

Source: This report.

Note: The distance to the reference line has been calculated according to the method presented in Annex B. The eEEDI is the estimated EEDI which is 90% of the value of the EIV (see Chapter 2).

4 Conclusions

The EEDI requirement for 2020, a reduction of 20% relative to the reference line, is a step back from what is readily achievable for bulk carriers, tankers, containerships and general cargo ships that have entered the market in 2014 and 2015.

30% of the recently built bulkers have an estimated EEDI of 25% or more below the reference line, and 20% of the new containerships and general cargo ships have an estimated EEDI of 40% or more below the reference line.

The 2020 requirement could be based on what is readily achievable for new ships, although such a method would not take into account the potential of new designs and innovative equipment.

If a uniform requirement would be set for all ship types, based on the 30, 20 or 10% best performing ships that entered the fleet in 2014 and 2015, a requirement of 25, 28 or 32% respectively below the reference line could be set.

A uniform requirement would reflect what is readily achievable for new bulk carriers and tankers, but not of containerships and general cargo ships, which have become more efficient relative to the reference lines. For these ship types, a requirement of -37, -40 or -44% would reflect what is readily achievable for the best 30, 20 or 10% of the new ships respectively.

For bulk carriers and containerships, the analysis of the current fleet suggests that it could be hard to achieve either the uniform or the ship type specific requirements for some size categories. Recently built small and large bulkers were relatively less efficient than other bulkers, whereas smaller containerships were also relatively less efficient than large ones.

Hence, when setting requirements for bulk carriers and containerships, a more detailed analysis of the efficiency improvement potential for small and large bulkers, as well as for small containerships would be warranted.

Annex A Data Sources and Descriptive Statistics

There were 13,224 ships built in 2009-2015 with a minimum dwt above the reference value in accordance with MEPC.215(63). (MEPC, 2012).

Ship type	Minimum dwt
Bulk Carrier	10,000
Combination carrier	4,000
Containership	10,000
Gas carrier	2,000
General cargo ship	3,000
Tanker	4,000

The number of vessels of the six IHSF ship types included in the calculation of reference lines built in the period 2009-2015 is 10,617. For 2,607 ships that fulfilled the minimum deadweight criterion for their ship type insufficient data was available to calculate the EIV.

Ships that were included in the analysis were Bulk carriers (49%), Containerships (13%), Gas Carriers (3%), General Cargo Ships (14%) and Tankers (21%). 18% of the ships were built in 2009, 20% in 2010, 19% in 2011, 16% in 2012, 11% in 2013, 8% in 2014 and 8% in 2015.

Compared to the EIV study of 2015 (CE Delft, 2015) the number of ships included in the calculations for 2014 is higher in this study. This is because only the first half of 2014 was available in the last study. Other differences occur, mainly because the data in the Clarksons database has been updated.

Figure 2 Data from Clarksons World Fleet register used in this study 2009-2015

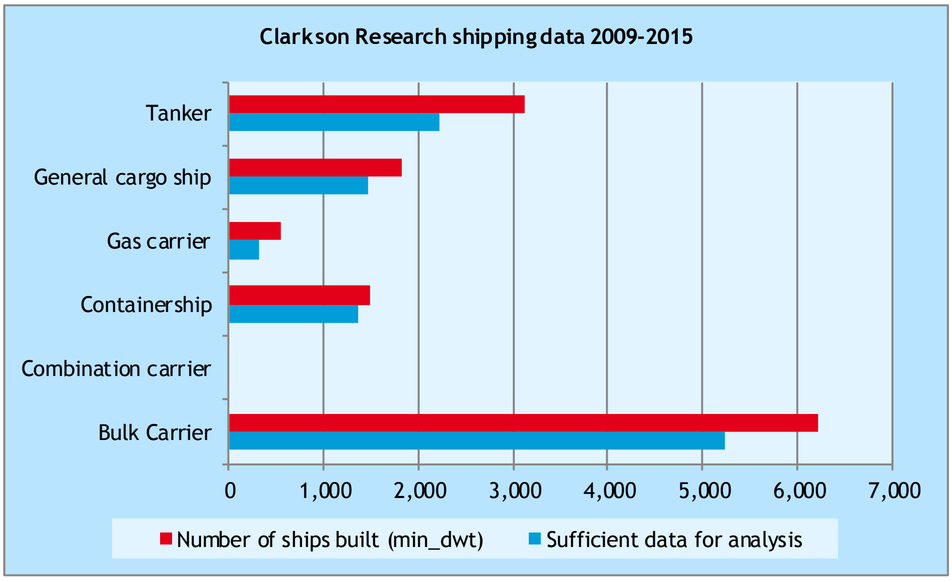

Figure 2 shows the ships that were built in 2009-2015 with a minimum deadweight corresponding with the ship types.

Table **7** provides more detail on the EIV of ships built in 2014-2015.

Table 7 Descriptive statistics for ships built in 2014-2015

Ship type		Bulk Carrier	Containership	Tanker
Built year		2014-2015	2014-2015	2014-2015
Number of ships	Total number	936	289	287
Distance of the EIV to the reference line	Mean	-6%	-23%	-9%
	Median	-11%	-24%	-11%
	Standard deviation	19%	17%	16%
Reference line value	Mean	5,1	18,9	8,4
EIV	Mean	4,8	15,0	7,6

Annex B Calculation methods

For each ship in our database which had sufficient data, the EIV was calculated according to MEPC.233(65) (MEPC, 2013)):

$$EIV = 3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 215 \cdot P_{AE}}{Capacity \cdot V_{ref}}$$

Where:
- P_{MEi} is 75% of the power of main engine i (MCRME(i));
- NME is the number of main engines;
- P_{AE} is the auxiliary power[4];
- *Capacity* is the deadweight tonnage of a ship, or 70% of the deadweight tonnage of a containership;
- V_{ref} is the ships' service speed.

Taking into account that the value of the attained EEDI is on average 90% of the value of the EIV (see Section 2.2), the estimated EEDI (eEEDI) is defined as 90% of the EIV.

Subsequently, the difference between the eEEDI and the required EEDI for each ship was calculated. The required EEDI is determined by the reference line for the ship type and the capacity of the ship using a formula from Table 8.

Table 8 Reference line formula for different ship types

Ship type	Reference line value
Bulker	$961.79*(dwt)^{-0.477}$
Tanker	$1218.8*(dwt)^{-0.488}$
Containership	$174.22*(0.7*dwt)^{-0.201}$
General Cargo ship	$107.48*(dwt)\text{-}^{0.216}$

Source: Resolution MEPC.203(62).

Finally, the ships in a specific category (ship type, ship type and size category) are ordered from the highest relative distance above the reference line to the highest relative distance below the reference line. The values for the 70th percentile, the 80th percentile and the 90th percentile are shown in the tables in Chapter 3.

4 As information on PAE is often lacking, PAE is calculated according to paragraphs 2.5.6.1 and 2.5.6.2 of the annex to (MEPC, 2012).

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