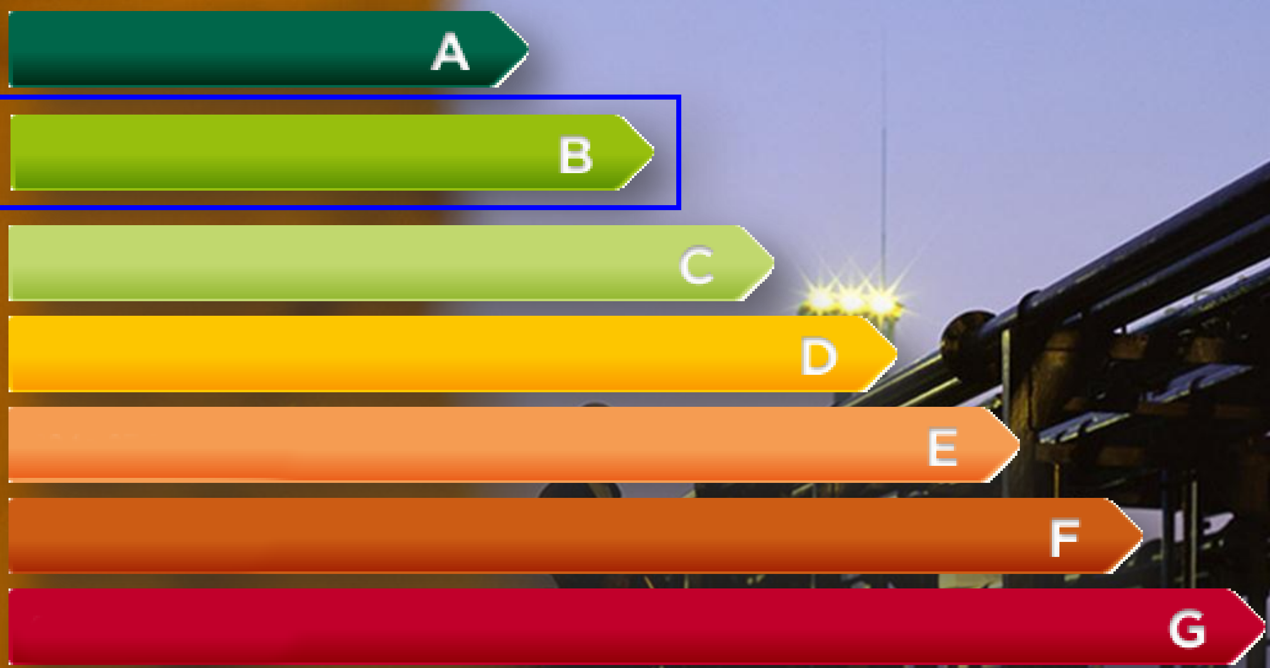
RIGHTSHIP

Calculating and Comparing CO_2 Emissions from the Global Maritime Fleet



December 2012

VISION

"To be the supplier of choice of marine vetting services to achieve with our customers a safer and cleaner maritime environment"

MISSION

To enable our customers to reduce their marine risk by providing comprehensive marine assessments on vessels and marine suppliers.

Background

While international shipping is the most carbon efficient mode of commercial transport, total emissions are comparable to those of a major national economy, necessitating emission reduction[1]. In 2009, shipping was estimated to have emitted 3.3% of global CO_2 emissions, of which international shipping contributed 2.7% or 870 million tonnes[2]. Moreover, according to the International Maritime Organization's (IMO) 2nd Greenhouse Gas (GHG) Study[2], if unabated, shipping's contribution to GHG emissions could reach 18% by 2050.

In July 2011, the IMO Marine Environment Protection Committee (MEPC) adopted mandatory measures to reduce GHG emissions from international shipping through amendments to MARPOL Annex VI Regulations. These amendments include the application of the Energy Efficiency Design Index (EEDI) for new ships which will require ships to meet a minimum level of energy efficiency. The EEDI applies to all new ships built from 1 January 2013.

From 1 January 2013, existing ships are required to document their energy usage through the introduction of a Ship Energy Efficiency Management Plan (SEEMP) that is linked to the ship's broader management plan.

Carbon dioxide emissions breakdown does not divide into all ships equally and considerations such as ship size, fuel type and engine performance as well as advances in maritime technology mean that some ships are more efficient than others. Recognising that such vessel specific sustainability information is dispersed and costly to obtain and coordinate in a systematic manner, RightShip created its GHG Emissions Rating. The GHG Emissions Rating is a simple to use tool enabling charterers to select the most energy efficient vessel; terminals, insurers and banks to provide preferred rates to owners of more efficient vessels; and reward ship owners for investing in technology to make their vessel more efficient.

[1] ICS, 2009, *Shipping, World Trade and the Reduction of CO_2 Emissions*. International Chamber of Shipping, London, UK.

[2] IMO, 2009, *Second IMO GHG Study 2009*, International Maritime Organization, London, UK.

Contents

Confidentiality

1. Summary

The IMO defined energy efficiency as grams of CO_2 per tonne nautical mile and the IMO MEPC formulated the EEDI as a measure of a ship's CO_2 emissions. EEDI is calculated using characteristics of the ship at build, incorporating parameters that include ship capacity, engine power and fuel consumption.

RightShip has developed an Existing Vessel Design Index (EVDI™) and a Greenhouse Gas (GHG) Emissions Rating. Similar to the IMO MEPC's EEDI, RightShip's EVDI™ measures a ship's CO_2 emissions, however, unlike the EEDI, the EVDI™ can be applied to existing ships. The GHG Emissions Rating is a practical measure derived from the EVDI™ that allows relative comparison of a ship's CO_2 emissions to vessels of a similar size and type. Ship types are largely consistent with those used by IMO MEPC.

This report details the calculations and methodology of the EVDI™ and GHG Emissions Rating and contains practical examples of their application to the shipping industry.

2. IMO MEPC EEDI

The EEDI was developed to measure the theoretical CO_2 emission performance of new ships over 400 gross tonnes and is calculated from ship design and engine performance data. The intended application of this index is to stimulate innovation and technical development of all elements influencing the energy efficiency of a ship from its design phase.

The EEDI is calculated using the following formula[3]:

$$\frac{\overbrace{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)}.C_{FME(i)}.SFC_{ME(i)}\right)}^{\text{Main engine(s)}} + \overbrace{\left(P_{AE}.C_{FAE}.SFC_{AE}*\right)}^{\text{Auxiliary engine(s)}} + \overbrace{\left(\left(\prod_{j=1}^{M} f_j.\sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)}.P_{AEeff(i)}\right) C_{FAE}.SFC_{AE}\right)}^{\text{Energy saving technologies (auxiliary power)}} - \overbrace{\left(\sum_{i=1}^{neff} f_{eff(i)}.P_{eff(i)}.C_{FME}.SFC_{ME}\right)}^{\text{Energy saving technologies (main power)}}}{\underbrace{f_i.Capacity.V_{ref}.f_w}_{\text{Transport work}}}$$

in which:

- ME and AE, represent Main Engine(s) and Auxiliary Engine(s);
- *P*, the power of the engines (kW);
- C_F, a conversion factor between fuel consumption and CO_2 based on fuel carbon content;
- *SFC,* the certified specific fuel consumption of the engines (g/kWh);
- *Capacity*, the deadweight or gross tonnage (tonnes);
- V_{ref}, the ship speed (nm/h); and
- f_j, a correction factor to account for ship specific design elements (eg. ice-class)

The calculated EEDI is a theoretical measure of the mass of CO_2 emitted per unit of transport work (grams CO_2 per tonne nautical mile) for a particular ship design.

$$\textbf{EEDI} = \frac{CO_2 \text{ emission}}{\text{transport work}}$$

The IMO should be commended for developing the EEDI, the first ever mandatory global greenhouse gas reduction regime for an international industry sector. However, as the EEDI applies to new ships built after 1 January 2013, it does not address the existing world fleet of 60,000 vessels that currently emit over one billion tonnes of carbon dioxide annually. Given the typical 25 year lifecycle of a vessel, it has been estimated that less than 15% of the fleet will be subject to EEDI certification by 2020[4].

[3] IMO, 2009, *Interim Guidelines on the Method of Calculation of the Energy Efficiency Design Index for New Ships.* Circular MEPC.1/Circ.681. International Maritime Organization, London, UK.

[4] IMO, 2011. *Circular MEPC 63 5 13 GHG Emissions from Existing Vessels*, WWF & CSC.

3. RightShip's GHG Emissions Rating

In response to customer demand, RightShip developed a systematic and transparent means of comparing the relative theoretical efficiency and sustainability of the existing fleet.

The GHG Emissions Rating is an innovative measure that allows comparison of a ship's theoretical CO_2 emissions relative to peer vessels of a similar size and type using a simple A - G scale. Ship types are largely consistent with those used by IMO MEPC. While the A - G benchmarking scale is simplistic and easy to understand, the methodology using an algorithm to calculate the GHG Rating is complex.

This A - G rating enables shippers to identify the most energy efficient vessel, ship owners to compare their vessels to peer vessels and reward them for investing in sustainability, banks to reduce their risk by investing in efficient vessels and ports to reward efficient vessels with reduced port fees.

3.1 EVDI™

RightShip's Existing Vessel Design Index (EVDI™) is the core measure used to calculate the RightShip GHG Emissions Rating and is comparable across all vessels in RightShip's Ship Vetting Information System (SVIS™) database.

> Similar to the IMO MEPC's EEDI, RightShip's EVDI™ measures a ship's theoretical CO_2 emissions per nautical mile travelled. However, unlike the EEDI that is applied only to new ships the EVDI™ is designed for application to existing vessels.

The 2007 DNV paper that initially proposed the EEDI to the IMO at MEPC 57 suggested that from a technical perspective, it is possible to retrospectively apply the EEDI to existing ships. The IMO has now documented EEDI benchmarks and reference lines based on the existing fleet and historical data.

3.1.1 Data Validity

EVDI™ values are calculated from vessel design information and associated data.

The primary sources of this data are:

- RightShip's Ship Vetting Information System (SVIS™);
- Ship-sourced data;
- Classification Societies; and
- IHS Fairplay (IHS) database.

RightShip recognises that the reliability of its calculations directly correlates to the accuracy of source data used. Prior to the launch of the EVDI™ in 2010, RightShip invited all owner/manager customers to validate the vessel design particulars of their fleet provided by IHS Fairplay and other sources. In September 2012, RightShip also contacted over 4,300 ship owners and managers inviting them to view and update their fleet's design particulars through the free site shippingefficiency.org. RightShip continues to work closely with ship owners, yards and Classification Societies to validate the data used for the calculations.

Since RightShip launched the EVDI™ and GHG Emissions Rating, our system and data has been accessed and validated over 96,000 times and this gives us confidence about the reliability of our information.

RightShip welcome feedback pertaining to any missing or additional information including retrofits or upgrades through RightShip's SVIS™ portal, shippingefficiency.org or by emailing environment@rightship.com

3.1.2 Assumptions

Where ship specific data is not available such as specific fuel consumption, the values used in the EVDI™ calculation are based on the same assumptions used in the IMO GHG Study[2] and/or detailed in IMO Circulars on calculation of the energy efficiency measure. RightShip's approach utilises the same data set recognised by IMO MEPC in their establishment of an EEDI reference line for new ships. Assumptions are shown below:

- Specific Fuel Consumption (Main Engine), SFC_{ME}:

Engine Age	MCR_{ME} (kW)	SFC_{ME} (g/kWh)
Pre-1983	> 15,000	205
	5,000 to 15,000	215
	< 5,000	225
1984-2000	> 15,000	185
	5,000 to 15,000	195
	< 5,000	205
2001-2007	> 15,000	175
	5,000 to 15,000	185
	< 5,000	195

- Specific Fuel Consumption (Auxiliary Engine), SFC_{AE}:

Engine Age	MCR_{AE} > 800 kW	MCR_{AE} < 800 kW
Any	220 g/kWh	230 g/kWh

- Power (Main Engine), P_{ME}: = 0.75 MCR_{ME}
- Power (Auxiliary Engine), P_{AE}:

MCR_{ME}	> 10,000 kW	< 10,000 kW
P_{AE}	$=(0.025*MCR_{ME})+250$	$0.05*MCR_{ME}$

- Ship Speed, V_{ref}:= Design Speed
  Capacity:
  - 100% deadweight, for bulk carriers, tankers, gas tankers, ro-ro cargo and general cargo ships
  - 70% deadweight, for containerships
  - 100% gross tonnage for passenger and ro-ro passenger ships
- CO_2 Conversion Factors, C_F:

Fuel Type	Carbon Content	C_F (t-CO_2/t-Fuel)
Diesel/Gas Oil (DGO)	0.875	3.206
Light Fuel Oil (LFO)	0.86	3.15104
Heavy Fuel Oil (HFO)	0.85	3.1144
Liquified Petroleum Gas (LPG)		
Propane	0.819	3.000
Butane	0.827	3.030
Liquified Natural Gas (LNG)	0.75	2.750

3.1.3 Ship Types

The categories of ship used for the derivation of comparative GHG Emissions Ratings predominantly follow those in the IMO document MEPC 61/WP.10[5]:

01	Bulker
02	Chemical Tanker
03	Container
04	Crude & Products Tanker (inc OBO)
05	Cruise
06	General Cargo
07	LNG Tanker
08	LPG Tanker
09	Refrigerated Cargo Ship
10	Vehicle
11	Ferry Pax Only
12	Ro Ro Cargo Ship : weight carrier

Non-Standard Propulsion: The EEDI, as presently constructed, is not designed or intended for application to vessels with a non-conventional propulsion system. It is anticipated that the IMO will develop refined parameters, formulas, and reference baselines for these ships in the near future. These vessels (including LNG and passenger vessels which have diesel-electric, turbine, and other non-conventional means of propulsion) do not have calculated EVDI's and GHG Emissions Rating's and display a banner in the system. Accordingly, any attempted evaluation of this type of ship using the EVDI™ needs to be understood as being outside the effective purpose of the index.

Ice Class Vessels: Ice-class vessels have design and structural features that increase their estimated EVDI™ relative to similarly-sized conventional vessels. Power and capacity correction factors (where available) have been applied to the EVDI™ calculation and this is reflected in the system –

Ice Class	1A
Length Between Perpendiculars	174.00
Ice Power Factor	1.000
Ice Power Calc	fj0 = 1.037701, fj.min = 0.8322742 used fj0 (reduced to 1.000)
Ice Capacity Factor	1.131
Ice Capacity Calc	fi0 = 1.356007, fi.max = 1.131418 used fi.max
Non-Ice EVDI	8.303
Environmental Rating Methodology (pdf)	Environmental Rating Methodology

Figure 1: Ice Class Vessel Correction Factors within SVIS™

[5] IMO, 2010, *Report of the Working Group on Energy Efficiency Measures for Ships*. Annex 2. Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index. Paper MEPC 61/WP.10 Annex 2. International Maritime Organization, London, UK.

The separation of gas and chemical tankers: The EEDI currently combines the performance of Gas Tankers into a single reference line. Based on the bimodal distribution of the underlying data, RightShip believes a better statistical comparison can be achieved by analysing LNG and LPG Tankers separately. Chemical tankers are similarly considered separately from other tankers (Crude & Products) to acknowledge different design characteristics.

3.2 GHG Emissions Rating A - G Scale

A vessel's GHG Emissions Rating is presented using the standard European A - G energy efficiency scale and relative performance is rated from A through to G, the most efficient being A, the least efficient being G.

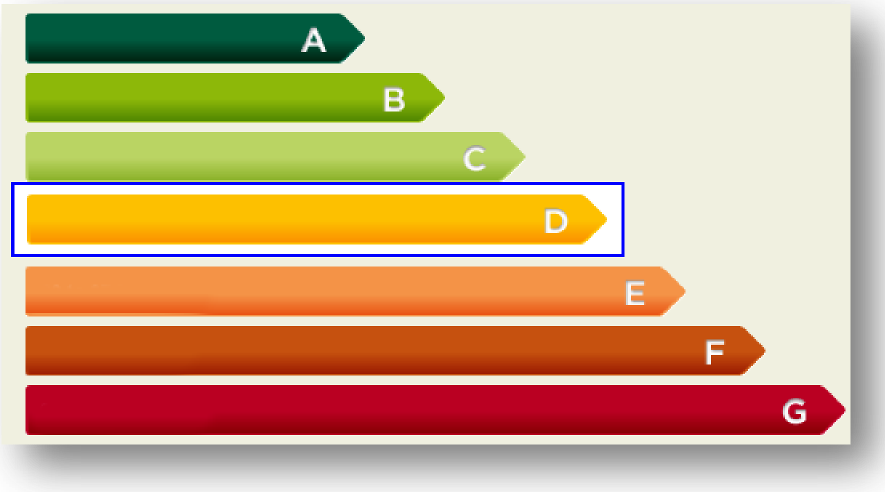


Figure 2: GHG Emissions Rating A - G Scale

The GHG Emissions Rating Size Group: A - G, are based on the EVDI™ Size Score, which indicates the number of standard deviations a vessel varies from the average for similar sized vessels of the same ship type.

The vessel's position on the scale is determined by the EVDI™ Size Score and GHG Emissions Rating Key as follows:

GHG Emissions Rating	A	B	C	D	E	F	G
Size Score	> 2.0	> 1.0	> 0.5	> -0.5	> -1.0	> -2.0	<= -2.0

Figure 3: GHG Emissions Rating Key

If the distribution of the EVDI™ Size Scores exactly fitted a normal distribution, the score ranges would match the following fixed percentiles of the data set -

GHG Emissions Rating	A	B	C	D	E	F	G
Size Score	> 2.0	> 1.0	> 0.5	> -0.5	> -1.0	> -2.0	<= -2.0
Area Under Curve	2.5%	13.5%	16%	36%	16%	13.5%	2.5%

The bell curve below in Figure 4 shows the percentage distribution with the corresponding letter displayed in the appropriately coloured area under the curve. The x- axis is expressed as a count of standard deviations which matches the Size Score in the key.

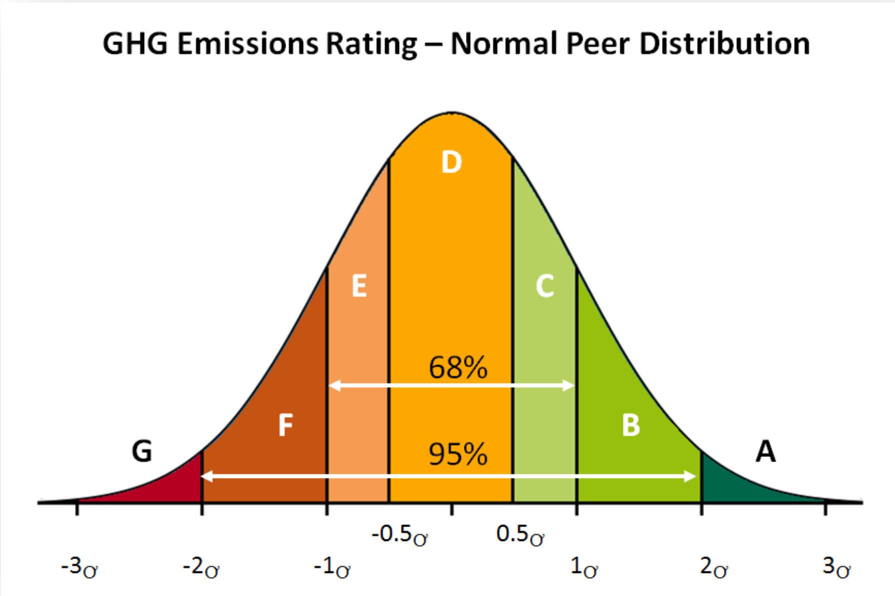


Figure 4: GHG Emissions Rating Key – Normal Peer Distribution

It is important to note that as each vessel size group is a subset of the entire ship type group the percentages within each subset's size group will have some variability from these percentages. The size groups are discussed in detail in 3.2.5.

3.2.1 GHG Emissions Rating Calculation

To produce an A - G Rating, EVDI™ values are converted using a logarithmic calculation - due to a strongly skewed distribution of raw data - to permit correct and normalised statistical comparison. The transformed value allows calculation of a Z Score which is the metric that determines the GHG Emissions Rating.

The reasoning is best described by example: The frequency of occurrence of EVDI™ values for bulk carriers is presented in Figure 5. The distribution of values for all ships does not fit a normal bell-shaped curve, with the average of all values not central to the distribution. Therefore, direct comparison of individual ship values to the average value would have a bias against above average ships for the overall ship type and the ship size group within the ship type.

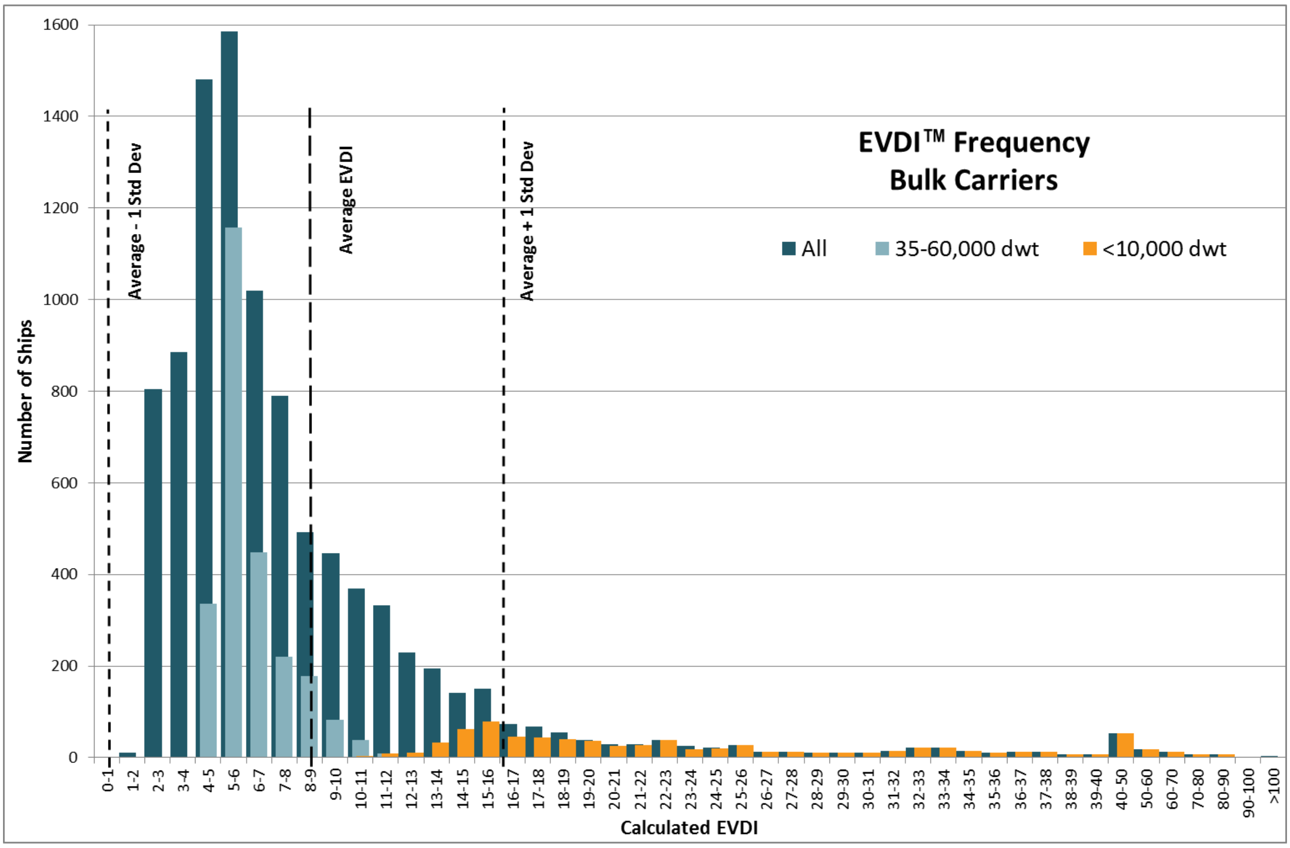


Figure 5: Frequency distribution of EVDI™ values for all bulk carriers in the SVIS™ database and two dwt banding examples.

Applying a logarithmic transformation to the calculated EVDI™ values normalises the frequency distribution for the overall ship type and ship size groups within the ship type (Figure 6). Individual ship values can then be accurately compared to the average for the size group within the ship type.

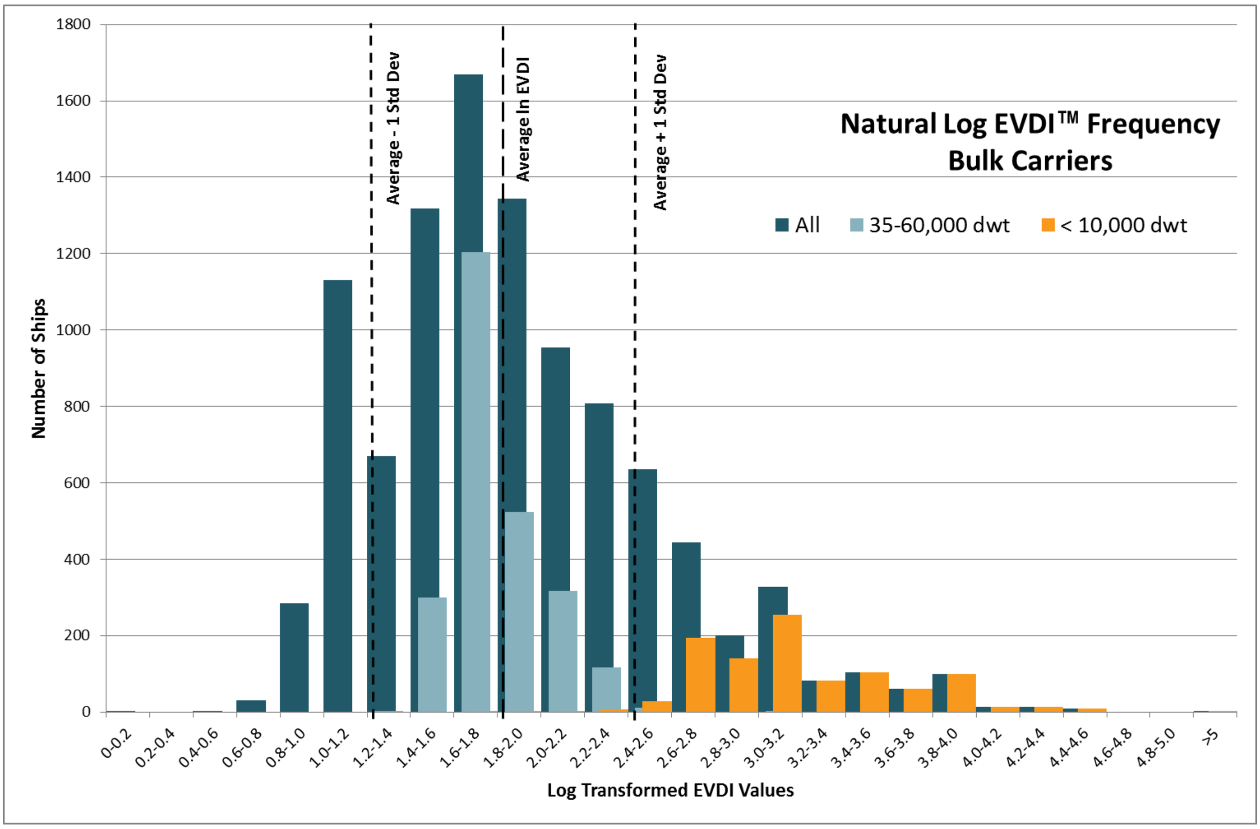


Figure 6: Frequency distribution of logarithmic (natural log) transformed EVDI™ values for all bulk carriers in the SVIS™ database and two dwt banding examples.

The method for comparing an individual ship's EVDI™ value to the ship type or size group within the ship type, and to derive the EVDI™ Size Score reported in the RightShip GHG Emissions Rating, is based on calculating a statistical Z Score.

A Z Score is a standard measure of the variation of an individual value from a normally distributed average with a mean of zero and a standard deviation of one. It is calculated by dividing the difference between the ship value and the overall average for the type or size within the type by the standard deviation for the type or size within the type.

$$\text{Z Score} = \frac{y_i - \hat{y}}{\sigma}$$

Where:

- y_i is the ship natural log EVDI™ value;
- $\hat{y}$ is the average of natural log EVDI™ values for the type or size group within the type; and
- σ is the standard deviation of the natural log EVDI™ value distribution for the type or size group within the type.

For the purpose of the RightShip GHG Emissions Rating, the negative Z Score is used; ie. the sign, positive or negative, of the calculated Z Score is reversed. The negative Z Score is used because the calculation will give positive numbers for values above the average (high EVDI™) and negative numbers for values below the average (low EVDI™). Low EVDI™ values represent better energy efficiency, therefore it is more intuitive to assign a positive value to the score as it represents good performance.

3.2.2 Natural Adjustment

The GHG Emissions Rating is dynamic and will almost always use a different dataset for each vessel's relative calculation. As older vessels are scrapped and new vessels are commissioned or existing retrofits/upgrades are verified at sea trials, relative performance adjusts and vessels continue to rate better and worse than the average.

3.2.3 Retrofits and Upgrades

Vessels that acquire eco-efficiency technologies and/or measures such as waste heat recovery systems or propeller ducts are eligible for recognition from RightShip. The efficiency retrofits and/or upgrades are documented as part of the SVIS™ Environmental Rating page, as shown:

Section 8: Retrofits / Upgrades				
Measure	Efficiency	Date	Class Soc Approved	Approved By Admin
Propulsion - Propeller efficiency measurement	< 4%	13/Aug/12	Yes	Yes

Figure 7: Display of a vessel's efficiency retrofits and or upgrades

The efficiency percentage used by RightShip is based on the Fathom publication Ship Efficiency: the Guide[6] and is an approximate estimate of the efficiency gain associated with a retrofit or upgrade. The example in Figure 7 (shown above) indicates that the vessel is operating around 4% more efficiently than design due to the inclusion of a propulsion – propeller efficiency measurement where multiple retrofits/upgrades are shown, it is important to note the efficiency percentages need to be looked at individually and are not a cumulative total.

[6] 2011, Lokley, P., & Jarabo-Martin, A., (Ed), *Ship Efficiency: The Guide* , Fathom, Berkshire, UK.

Approved enhancement measures will have a plus + sign adjoined to their GHG Emissions Rating which is shown for the E rated vessel below:

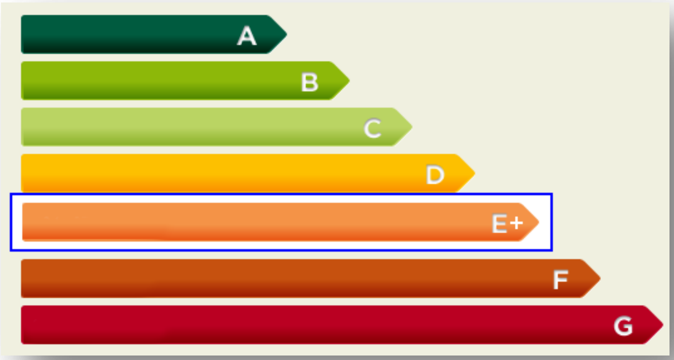


Figure 8: A plus + sign is adjoined to a vessel's GHG Emissions Rating for recognised retrofits and or upgrades

RightShip believe it is important to acknowledge and reward owners who have invested capital and systems to operate their vessels above compliance and the plus + notation helps to increase their visibility.

3.2.4 Sister Ships

Some sister ships will have different GHG Emissions Ratings. A vessel's EVDI™ value is based on many parameters and if one of these parameters (normally deadweight tonnage) differs between sister ships they could have a different EVDI™, moving them into a different rating bracket. The base data used in the rating calculation of an individual vessel is displayed in SVIS™, so the source of differences between sister ships can be checked.

3.2.5 Comparing Existing Ship's CO_2 Emissions

RightShip's GHG Emissions Rating methodology differentiates between vessel type and size. The major ship types that the rating applies to are shown below:

Ship Type	Basis of Size Range	Size Rating Range (Vessels)	Approximate Number of Ships
Bulker	DWT	200	11,300
Chemical Tanker	DWT	50	700
Container	TEU	200	5,300
Crude & Products Tanker (inc OBO)	DWT	200	10,300
Cruise	GT	50	600
General Cargo	DWT	100	11,700
LNG Tanker	CBM	50	400
LPG Tanker	CBM	50	1,200
Refrigerated Cargo Ship	DWT	50	1000
Vehicle	DWT	50	800

The Size Rating Range (Vessels) column shows the number of vessels by Ship Type included in the EVDI™ Size Score calculation. The number of ships chosen for comparison is based on the quantity of ships of that type in the SVIS™ database and their size distribution.

For the typical GHG Emissions Rating calculation, the size comparison is to the 50, 100 or 200 ships within the type that are closest in capacity (dwt, gt, teu or cbm) to the individual ship, for example: For vessel types in the 100 Size Rating Range, the 50 ships with capacity closest to, but less than the ship, and the 50 ships with capacity closest to but greater than the ship is the basis of the size group range used for comparison.

Where there is an insufficient quantity of vessels to allow for an even split of vessels (near to the upper and lower ends of the group) the Size Rating Range is adjusted to best approximate a like-for-like comparison, for example: The second largest bulk carrier would be compared to the 199 bulk carriers immediately smaller and the 1 larger bulk carrier to determine its GHG Emissions Rating.

Scattergrams of the calculated EVDI™ Size Scores for each of these ship types against capacity (dwt, gt, cbm or teu) show the EVDI™ Size Score/capacity relationship to be best represented by a power regression line, as recognised by IMO MEPC in their establishment of an EEDI “reference line” for new ships.

Detailed analysis of the EVDI™ Size Scores across RightShip’s SVIS™ database has shown the method used to develop a comparative rating of EVDI™ Size Scores as a component of the RightShip GHG Emissions Rating, is applicable across the different ship types. The method therefore provides a statistically valid means of comparing the energy efficiency of existing ships.

Notwithstanding a vessel’s individual size, speed and year of build it is possible to demonstrate that certain vessels are simply designed more efficiently and it is important that this is factored into the decision making process.

3.2.6 Why Newer is Not Always Better or More Efficient

By using appropriate mathematical techniques, a meaningful comparison between vessels can be achieved and as shown by the Figures below, newer vessels do not always perform as well as their existing peers.

Figure 9 (overleaf) shows bulk carriers delivered over the last 22 years between 75,000 and 80,000 dwt using the A - G GHG Emissions Rating scale. The x-axis shows dwt and the y-axis displays EVDI™. The IMO MEPC reference line has been overlaid as a comparison and right across this dwt range there are a large number of vessels above and below the line. This makes sense as the reference line is reflective of 92.89% of bulk carriers delivered during the IMO MEPC reference period as noted in MEPC 62/6/4.

Figure 10 (counterfoil) shows this same dwt spread and deliveries since 2007 onwards. If newer vessels are always more efficient, we would expect all of the bulk carriers built in the last five years between 2007 and 2012 to be below the reference line in Figure 9, which is clearly not the case. More efficient and less efficient vessels are always evident if we apply a consistent framework to gauge efficiency.

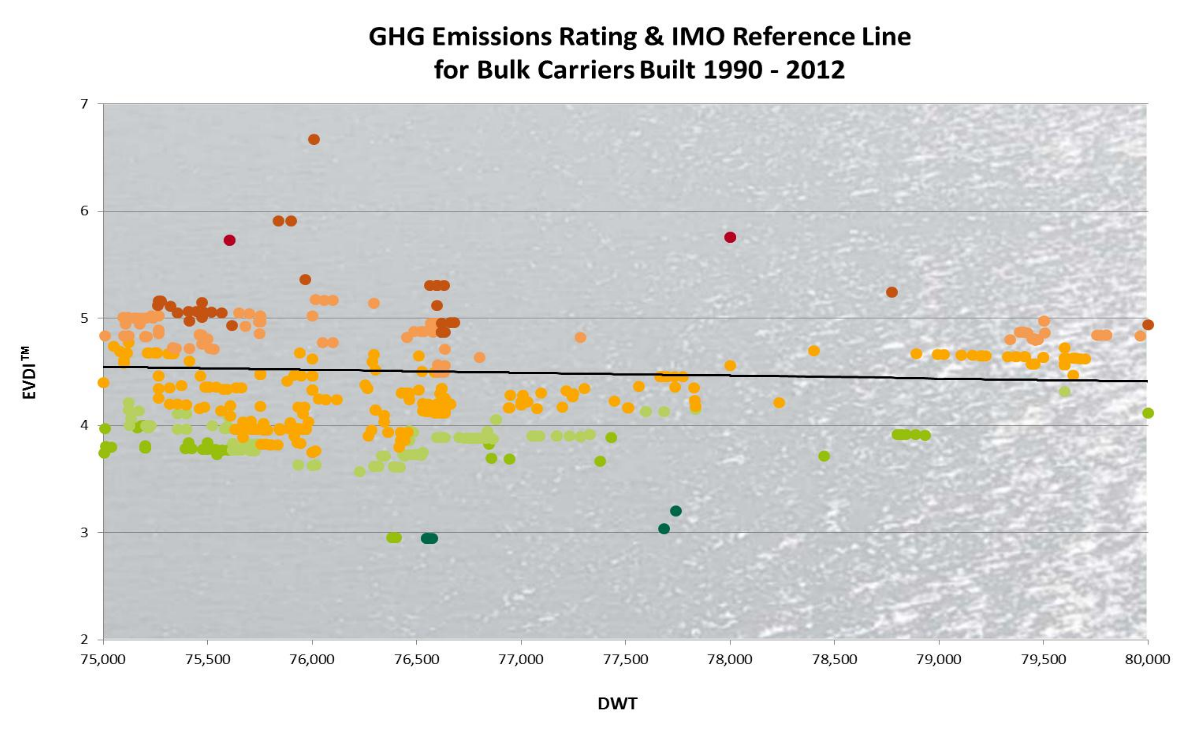


Figure 9: GHG Emissions Rating & IMO Reference Line for Bulk Carriers Built 1990 – 2012

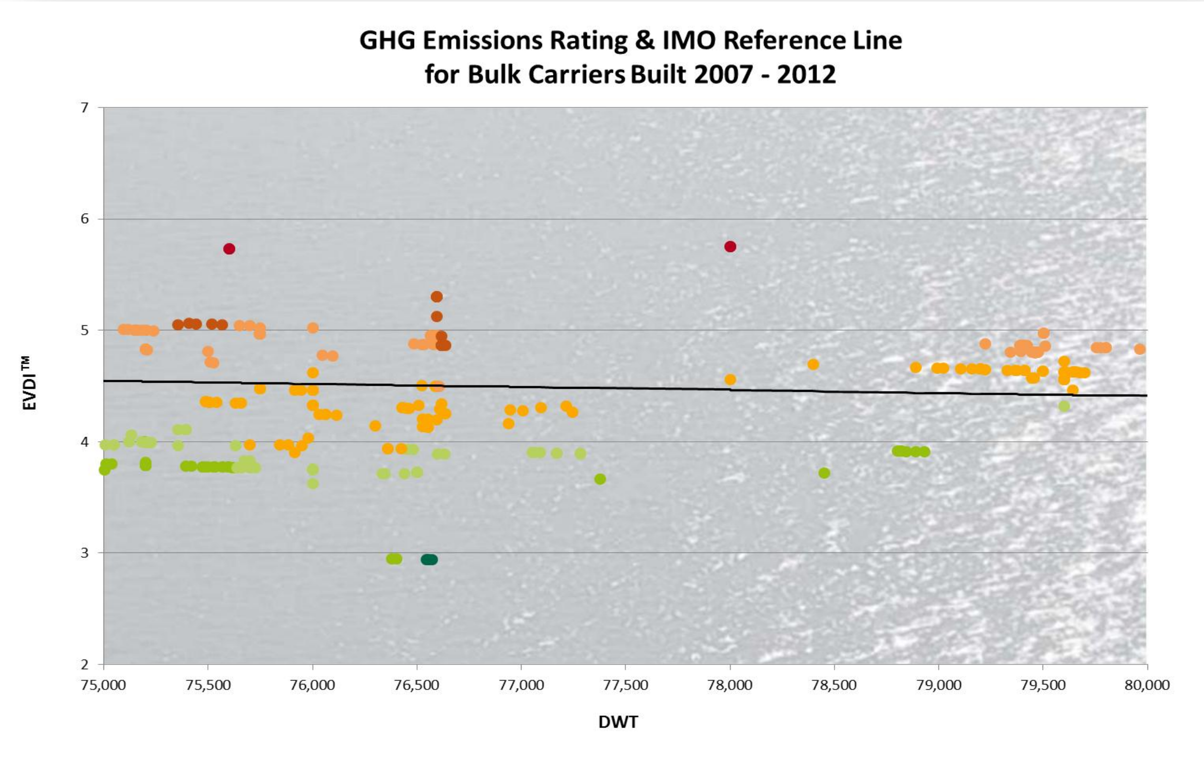


Figure 10: GHG Emissions Rating & IMO Reference Line for Bulk Carriers Built 2007 – 2012

The same approach to tankers between 105,000 – 115,000 dwt (Figure 11) delivered in the last five years yields three interesting insights.

- Although the reference line for tankers is reflective of 94.46% of tankers delivered during the IMO MEPC reference period (MEPC 62/6/4) in this subset of data almost all tankers are already below the reference line.
- Despite being more efficient than the minimum required from 2013, there is still separation across the fleet (some are better and some are worse).
- An owner building at minimum efficiency (reference line) would not be competitive and needs to understand his relative peer efficiency rather than rely on legislation to guide decision making. Particularly given the oversaturation of tonnage and emerging two tiered market for more efficient vessels.

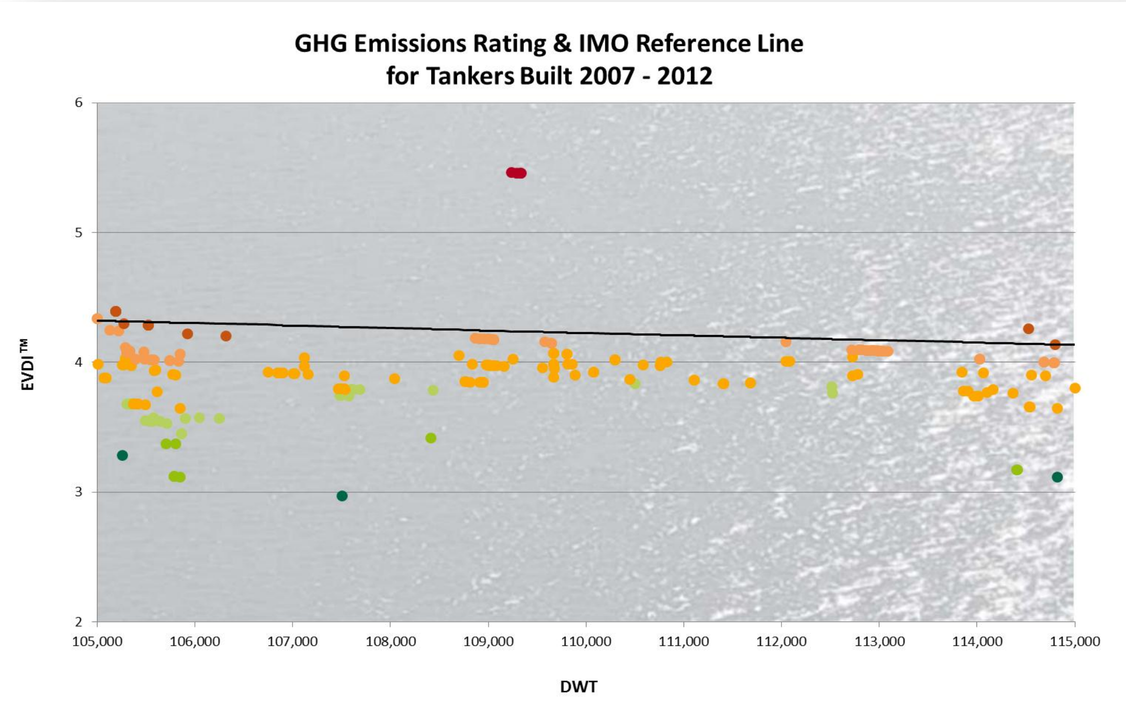


Figure 11: GHG Emissions Rating & IMO Reference Line for Tankers Built 2007 – 2012

3.2.6 Improving a Vessel's GHG Emissions Rating

The data used to calculate a vessel's EVDI™ can be verified by accessing RightShip's SVIS™ (for customers) or through shippingefficiency.org. Any changes can be updated in the SVIS™ portal, through these websites (Figure 12 below) or by emailing environment@rightship.com

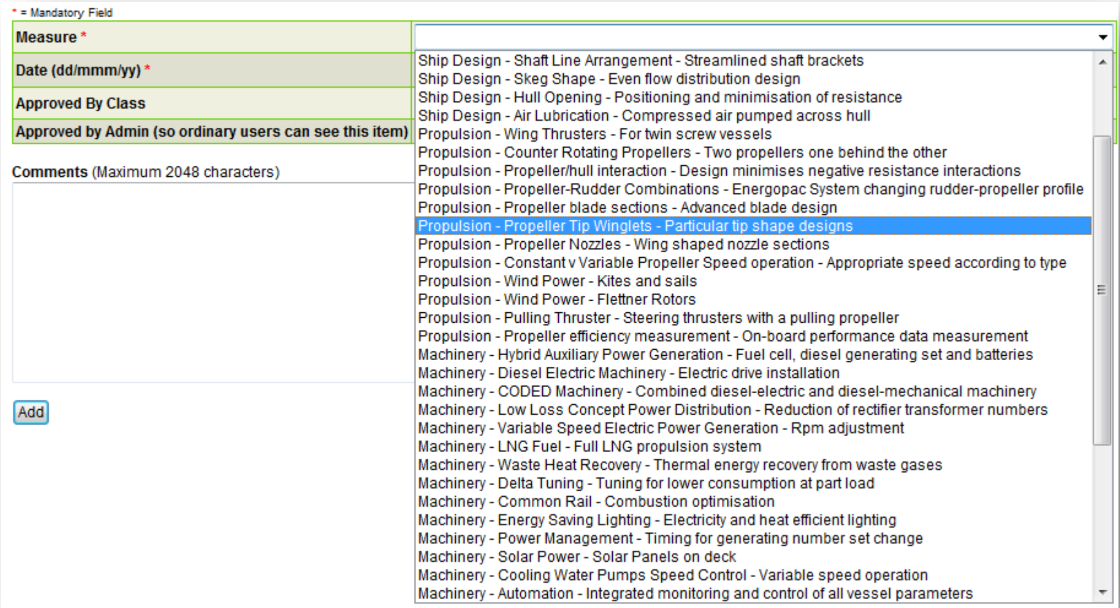


Figure 12: Retrofit and Upgrade drop-down menu in www.shippingefficiency.org

A raft of retrofits and upgrades such as changes to ship design, propulsion and machinery may help to improve a vessels GHG Emissions Rating. Any upgrade or retrofit which has been verified by a Classification Society can be submitted to RightShip to enable the GHG Emissions Rating to be recalculated.

A vessel's EVDI™ does not take into account operational measures such as slow steaming or eco speeds. By focusing on design and then supplementing results with operational metrics, a more meaningful outcome is achievable - enabling a like-for-like comparison.

4. Presentation of Information in SVIS™

Figure 13 (below) shows a system display of the EVDI™ and GHG Emissions Rating graphic, including the data used in calculating the EVDI™ Size Score and accompanying GHG Emissions Rating. The hyperlinks (in blue) indicate the top five rated peer vessels based on EVDI™ Size Score. The top rated peers enables the user to identify the relative performance differential between any given vessel and the most efficient in its peer group.

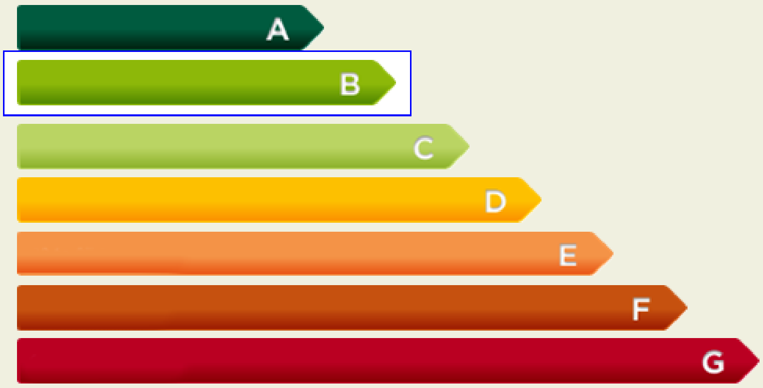
Section 2: Existing Vessel Design Index (EVDI)	Hide Details
EVDI (grams CO_2 per tonne nautical mile)	4.675
Ship Type, Comparison Factor	Bulker, DWT
GHG Emissions Rating	
Size Score (Z Score)	1.572
GHG Emissions Rating Key	GHG Emissions Rating: A, B, C, D, E, F, G Size Score: > 2.0, > 1.0, > 0.5, > -0.5, > -1.0, > -2.0, <= -2.0
Top Rated Peers	SPAR VEGA (B) OCEAN SYMPHONY (B) BULK AMERICAS (B) BULK HONDURAS (B) BULK URUGUAY (B)
Year Of Build	2007
DWT	57,982
MEPC Reference Line Comparison	Bulker vessel 5.140. Vessel EVDI is more efficient than MEPC Reference Line.
ln(EVDI)	1.542
Speed (V)	14.500
Gross Tonnage	32,379
Gas Capacity	0
TEU	0
MCR (Main Eng - kW)	8,400
Engine Count	1
Power (Aux Eng - kW, 0.05 * MCR me)	420
Specific Fuel Cons (Main Eng, g/kWh)	185.000
Specific Fuel Cons (Aux Eng, g/kWh)	230.000
Power (Main Eng- kW, 0.75 * MCR me)	6,300
Fuel Conv Factor (Aux Eng) (HFO)	3.1144
Fuel Conv Factor (Main Eng) (HFO)	3.1144
ME Element (Power * SFC * Fuel Conv Factor)	3,629,833
AE Element (Power * SFC * Fuel Conv Factor)	300,851
Ice Class	Override
Length Between Perpendiculars	185.60 Override
Environmental Rating Methodology (pdf)	Environmental Rating Methodology

Figure 13: Example of the GHG Emissions Rating data table for an individual ship in SVIS™

5. EVDI™ – Practical Applications

Figure 14: Possible voyage plan of a vessel travelling from Vitoria, Brazil to Qingdao, China

EVDI™ is an estimated measure of the CO_2 emitted per tonne nautical mile travelled.

Therefore a vessel's theoretical footprint is the EVDI™ multiplied by both the distance travelled and tonnes carried: CO_2 footprint = EVDI™ x nautical miles travelled x tonnes carried.

The following page shows two tables, common among each are the vessels selected and their 170,000 to 173,000 dwt range and the 11,023 nautical mile voyage as illustrated above in Figure 14.

Although complications regarding ballast leg measurement and confusion around who should be responsible for vessel emissions exist, these simple examples highlight the potential efficiency benefits and economic savings accessible through informed selection.

Actual emissions for a voyage will vary from this theoretical calculation due to the fuel consumption and consequent emissions varying with operational voyage characteristics such as speed, cargo load and weather conditions.

By focusing on vessels less than 2 standard deviations from the mean – B through to F – the potential variation in CO_2 emitted for the same journey and the same amount of cargo being delivered is significant.

CO_2 emitted for the 11,023 nautical mile journey:

GHG Emissions Rating	DWT	EVDI™	CO_2 Tonne	Variation from Mean	Variation from Mean %
B	172,964	2.63	5,013	-734	-13%
C	172,964	2.75	5,243	-504	-9%
D	171,516	2.94	5,567	-181	-3%
E	171,681	3.15	5,966	218	4%
F	170,000	3.42	6,410	662	12%

The theoretical difference between a B rated vessel and an F rated vessel is 1,400 tonnes with a 25% variance from the mean.

Using USD650 for the price of fuel / tonne:

GHG Emissions Rating	DWT	Power (Kw)	USD Price of fuel for voyage	USD Variation from Mean	% USD Variation from Mean
B	172,964	16,044	$1,387,498	-$89,410	-6%
C	172,964	15,404	$1,332,150	-$144,757	-10%
D	171,516	16,861	$1,412,400	-$64,508	-4%
E	171,681	18,736	$1,517,494	$40,587	3%
F	170,000	18,661	$1,630,174	$153,267	10%

The spread between the best and worst performing vessel represents around a USD245,000 differential for the same amount of cargo being delivered over the same distance.

5.1 The Benefits of RightShip's EVDI™ and GHG Emissions Rating

From 2020, developed economies have pledged to generate US$100 billion annually to help finance climate mitigation and adaptation in developing economies through the Green Climate Fund[7]. In June 2012, Christine Lagarde, Managing Director of the International Monetary Fund gave a speech to the G20 countries at the United Nations Conference on Sustainable Development suggesting that US$25 billion of the fund should come from international shipping.

[7] de Mooij, R., Parry, Ian W.H., & Keen, M., (Ed), 2012. *Fiscal policy to mitigate climate change: A guide for policymakers,* International Monetary Fund, ebook.

An accompanying policy paper flagged the introduction of a carbon charge of $25 per tonne of carbon dioxide on maritime fuel as a means of raising the funds[8]. Applying a flat tax across the shipping industry's 80,000 vessels translates to $312,000 per vessel. This would be a huge cost to ship owners at a time when the global shipping market is severely depressed. While a fuel tax will raise money, it won't do anything to meaningfully reduce carbon dioxide emissions.

By using informed selection through the EVDI™ to only charter the more efficient vessels in the market, we have estimated that US$70 billion can be saved annually – this is almost three times the proposed amount to be raised by the IMF. By incentivizing sustainability through market based solutions and informed decisions rather than penalizing emissions through a tax, a much bigger win for industry and the environment is achievable.

5.5.1 Charterers

As at November 2012, seven RightShip chartering customers, who between them transport 475 million tonnes of cargo per annum, factor energy efficiency into the vessel selection process. This represents around 10,000 vessel movements a year and nearly 10% of global non-containerized trade. Feedback from the early adopters suggests this framework has not only helped to reduce shipping costs, but has also gone a long way to publically demonstrate their commitment towards corporate social responsibility.

These companies have taken an environmental leadership position and are enjoying the economic and sustainability benefits flowing through to the business.

5.1.2 Vessel Owners

Depending on the chartering arrangement, a vessel owner with a more energy efficient vessel can reduce their bunkers and will be a preferred vessel for shippers that factor efficiency into their chartering selection process.

While retrofits and upgrades can be costly, the payback period can be as little as six months. In a joint initiative between NGO, The Carbon War Room, vessel owners, technology providers and financial institutions, two pilot programs are underway to measure the payback period for vessels investing in a range of energy efficiency measures. The upgrades are being funded by the financial institutions and technology providers with no outlay by the ship owner.

Other benefits to vessel owners include port/terminal discounts, lower insurance premiums and an enhanced reputation.

5.1.3 Terminals

Terminals seeking to position themselves as an environmental leader can provide discounts and incentives to more efficient vessels.

Under the Port of Vancouver's Eco Action Program vessel's that have an EVDI™ rating of A, B or C are

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[8] de Mooij, R., Parry, Ian W.H., & Keen, M., (Ed), 2012. *Fiscal policy to mitigate climate change: A guide for policymakers,* International Monetary Fund, ebook.

given discounted harbour due rates of $0.061 per gross registered tonne compared to the base rate of $0.094 per gross registered tonne.

RightShip is also an incentive provider to the Environmental Ship Index (ESI) which identifies ships that reduce air emissions above the current emission standards of the IMO. The index is used by ports to reward vessels when they participate in the ESI. Participating incentive providers include:

- Port of Amsterdam;
- Port of Rotterdam;
- Port of Oslo;
- Hamburg Port Authority;
- Ports of Bremen, Bremerhaven;
- Port of Antwerp;
- Seehafen Kiel GmbH & Co. KG Kiel;
- Autorità Portuale di Civitavecchia;
- Port of Zeebrugge;
- Port of Le Havre;
- Brunsbüttel Ports GmbH;
- Port of Ashdod;
- Tata Steel IJmuiden Terminals;
- Port of Los Angeles; and
- The Port Authority of New York & New Jersey.

Last year ESI recognised ships received discounts amounting to around €40,000. In 2012, this figure has already risen to more than €600,000.[9]

Terminals seeking to set targets for their environmental performance can calculate their historical benchmark and compare their performance over time for reporting purposes such as the Annual Report.

5.1.4 Financial Institutions

Financial institutions increasingly factor in sustainability into their financing criteria as the trend towards responsible investment grows. An energy efficient vessel has lower fuel costs and better chartering potential which may lead to a higher initial asset value and a longer period of economic depreciation. Given the current over supply of vessels in the market, it makes economic sense for banks to reduce their risk by financing energy efficient assets, particularly given the typical 25 year investment horizon.

The EVDI™ and GHG Emissions Rating provide a standardised framework for measuring the efficiency of an investment portfolio and tracking changes over time. Financial institutions can also use the environmental rating to map the correlation between investment risk and vessel employment as an increasing number of charterers seek out more efficient vessels. As more nations

[9] Port of Rotterdam Authority, 2012. Media Release, *Green Award Foundation and Environmental Ship Index Join Forces*, www.portofrotterdam.com, 30/10,2012.

place a price on carbon, the payoff for investing in energy efficient vessels will materialise and financial institutions who are first movers will have significant market advantage.

6. RightShip – In a Nutshell

RightShip is committed to achieving with our customers a safer and cleaner maritime environment.

RightShip's major services are:

- Online vetting through our proprietary web-based Ship Vetting Information System (SVIS™),
- Physical inspections of ships worldwide,
- Vessel environmental performance assessments,
- Hosting and supporting clients' own in-house vetting system, and
- Advice on vetting policy and processes.

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