MARINE ENVIRONMENT PROTECTION COMMITTEE
69th session
Agenda item 6

MEPC 69/INF.28
12 February 2016
ENGLISH ONLY

FURTHER TECHNICAL AND OPERATIONAL MEASURES FOR ENHANCING THE ENERGY EFFICIENCY OF INTERNATIONAL SHIPPING

Economic, technical, commercial and practical issues related to definition and implementation of mandatory operational efficiency standards

Submitted by Brazil

SUMMARY

Executive summary:	This document offers additional information for the definition of an index for monitoring CO_2 emissions from international shipping and views on the technical, commercial and operational issues that are related with this subject
Strategic direction:	7.3
High-level action:	7.3.2
Output:	7.3.2.1
Action to be taken:	Paragraph 38
Related documents:	MEPC 69/6/6, MEPC 65/4/19, MEPC 65/4/30, MEPC 66/4/6, MEPC 67/5/4, MEPC 67/INF.3, MEPC 68/4/5, MEPC 68/INF.29 and MEPC 69/6

Background

1 The subject of monitoring, reporting and verification has been under discussion at IMO for some time and many parties have contributed to the debate. Below is a brief summary of previous proposals in line with the position of this information document.

2 At MEPC 65, the United States submitted a revised proposal (MEPC 65/4/19) addressing ship energy efficiency through a three-phase approach and suggesting one metric as monitoring index. Belgium et al. (MEPC 65/4/30) commented on the United States' submission and proposed three other metrics to improve energy efficiency and reduce fuel consumption of ships. One of the options suggested was the "Annual EEOI (Energy Efficiency Operational Index)". In that document, Belgium et al.:

IMO WORLD MARITIME DAY 2016
SHIPPING
INDISPENSABLE TO THE WORLD

.1 recognized the important fact that MARPOL Annex VI has used the same EEOI unit in the calculation of EEDI (Energy Operational Design Index) (gCO_2/t*nm) and that, by continuing to adopt this unit, the shipping industry may then facilitate energy efficiency improvements of both new and existing ships; and

.2 noted, however, that the EEOI value may fluctuate on a voyage basis and, to account for these fluctuations, suggested calculating the "annual EEOI value".

3 At MEPC 66, Japan and Germany jointly submitted a document (MEPC 66/4/6) to comment on and further develop the ideas expressed in document MEPC 65/4/30. Regarding the "Annual EEOI", Japan and Germany noted that:

.1 the need for a consistent policy in order to improve energy efficiency, which calls for the same metric of EEDI and EEOI to be used in the new index. Otherwise, as stated in the document, it could be argued that it is rather difficult to evaluate, in an accurate and fair manner, the extent and effect of the policy framework concerned;

.2 the EEOI Guidelines suggest (MEPC.1/Circ.684, Appendix, paragraph 5) that the use of a "rolling average" could minimize the effects of the index fluctuation;

.3 the difficulty in collecting cargo volume data which could be reliable enough for the monitoring purpose. Given this potential difficulty, the cargo volume could be accounted for in the same manner as for the EEDI calculation, i.e. using a DWT value (for instance: 100% DWT for tanker or 70% DWT for container ships, etc.); and

.4 the simplicity of the information to be collected and calculated, since the three necessary data fields, as described in Table 1, are already connected with other relevant mandatory requirements, as demonstrated below:

Fuel Consumption	Bunker Delivery Note (BDN) which shall be kept on board by regulation 18 of MARPOL Annex VI
Distance sailed	Log-book which shall be kept on board by regulation 28 of SOLAS charpter V and, GNSS which shall be fitted by regulation 19 of SOLAS charpter V
Cargo Volume	DWT which is contained in the suplement to the IEE Certificate of MARPOL Annex VI

Table 1. Three key data fields required for annual EEOI

4 At MEPC 67, Japan elaborated further (MEPC 67/5/4) on the arguments below:

.1 proposed to rename the metric option of the "Annual EEOI" as "Annual Efficiency Ratio (AER)", since the metric of "Annual EEOI" previously proposed by Japan does not necessarily correspond to the concept of the EEOI in the EEOI Guidelines (MEPC.1/Circ.684). This is because the metric proposed is an average value in one calendar year with deadweight (DWT) as a proxy for cargo volume and for that the name of "Annual EEOI" is not accurate. Accordingly, the expression for the AER is described as:

$$\text{Annual Efficiency Ratio (AER)} = \frac{\sum_j FC_j \times C_{Fj}}{DWT \times D}$$

where:

- *j* is the fuel type;
- *FCj* is the annual mass of consumed fuel *j*;
- *CFj* is the fuel mass to CO_2 mass conversion factor for fuel *j*;
- *DWT* is the design deadweight; and
- *D* is the annual distance sailed in nautical miles; and

.2 presented a brief analysis of the effectiveness of the AER, based on data voluntarily provided by the Japanese fleet, where the results obtained from the method of Least Squares show a strong correlation coefficient – nearly 1.0 for oil tankers and bulk carriers and 0.7 for container ships. This means that the regression curves and each calculated AER value have a strong interrelation with each other. Therefore, the concept of the AER could be an appropriate candidate as a metric for this initiative.

5 At MEPC 68, Germany presented the results of a commissioned study (MEPC 68/4/5) that analyzed and compared the different efficiency indices that have been under discussion, including the AER, which in the study was called "cDIST – the CO_2 emissions per unit of capacity in DWT and unit of distance in nm". Germany noted that:

.1 in principle, a regression curve could serve as a basis for ship specific targets. The effectiveness of such targets in improving efficiency highly depends on the number of ships that are not too far above or below the curve. Ships that are consistently more efficient than the target will not be encouraged to change their operations. On the other hand, ships that are consistently less efficient may not be able to reach the target since they cannot sufficiently change their operational patterns due to operational efficiency measures and the generated results being inherently limited; and

.2 the evaluation of the available data, consisting of 221 ships of German shipowners, and the establishment of regression curves showed that AER (cDIST) and "DIST – the CO_2 emissions per unit of distance" were the two metrics with more ships inside the zone between +20% and -20% of the regression curve.

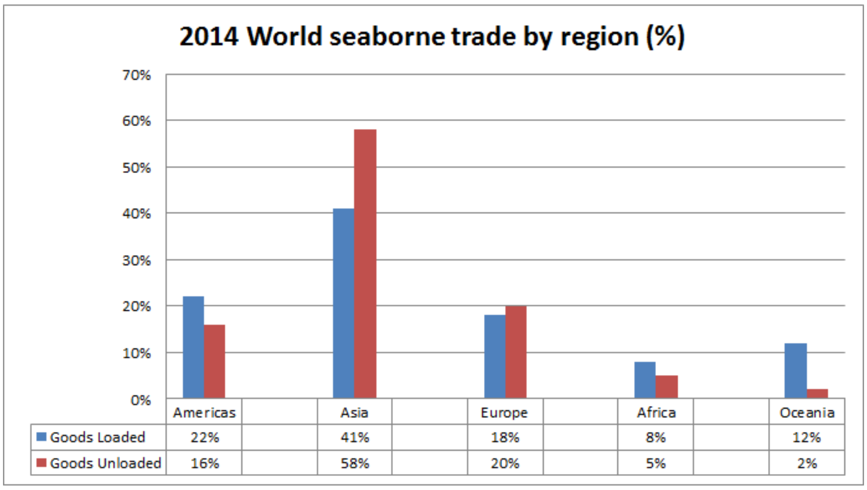
6 At the Intersessional Meeting of the Working Group on further technical and operational measures for enhancing energy efficiency (MEPC 69/6), several delegations, supported by a large majority of other delegations, proposed the use of "design DWT" as a proxy of cargo weight/volume as its use would resolve issues around confidentiality, reduce administrative burden both for ship and Administrations, remove complexity so improving robustness and would enable a clearly defined recommendation to be made to the Committee (MEPC 68/6, paragraph 48).

7 This brief background summary shows that there are many arguments and support for the selection of the "Annual Efficiency Ratio" as the metric to enhance the energy efficiency of international shipping and reduce fuel consumption. The objective of this information document is to provide additional arguments related to this subject.

The imbalance of the world seaborne trade

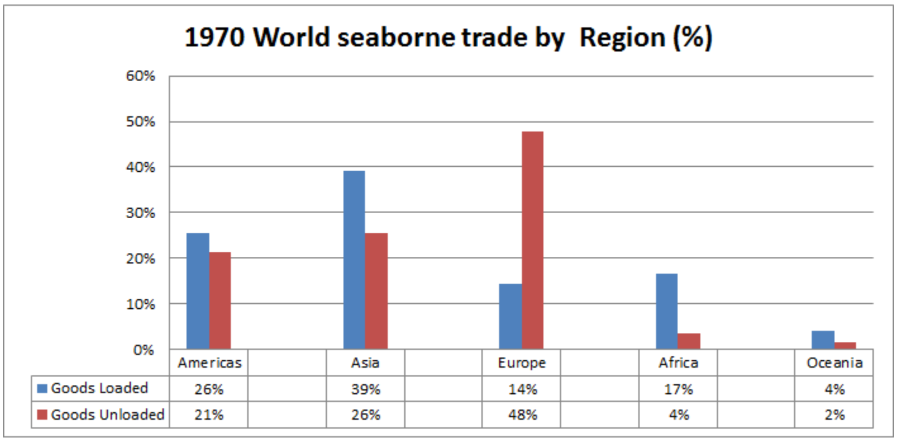
8 The unbalanced distribution of commodities around the world is a fact of the economy that has promoted maritime trade since early times. As the economy evolved, some trade routes have appeared and then disappeared, countries have undergone different development cycles and maritime trade has been in constant, albeit unbalanced, change.

9 The actual distribution of the seaborne trade can be seen in Graph 1, which shows the participation of each region in the goods loaded and unloaded in the year 2014. Today, the biggest difference between loaded and unloaded goods is in Asia with 17%, followed by Oceania with 10%, the Americas with 6%, Europe with 4% and Africa with 3%.

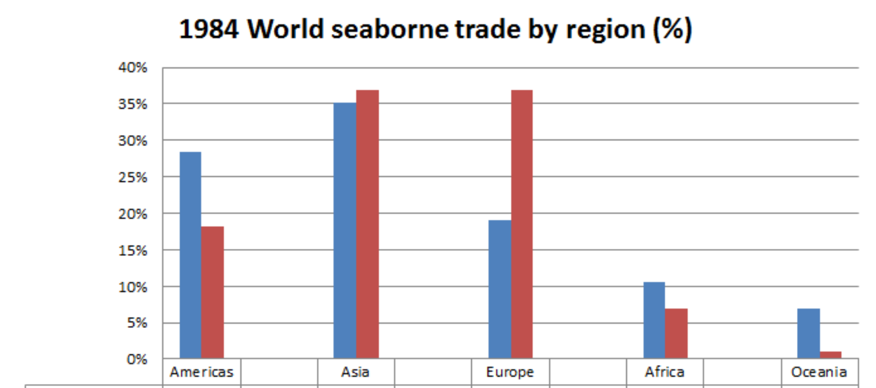


Graph 1 - Source: UNCTAD – Review of Maritime Transport 2015

10 If we compare the above with similar data from previous years, we will find a different configuration of the world's commerce, albeit still unbalanced. Graphs 2 and 3 show similar information for the years 1970 and 1984. In 1970, the biggest difference between loaded and unloaded goods among the regions was 34% in Europe, followed by Africa and Asia with 13%; while in 1984 it was 18% in Africa, Asia and Europe, followed by 14% in the Americas.



Graph 2 - Source : UNCTAD - Review of Maritime Transport 1985



	Americas	Asia	Europe	Africa	Oceania
Goods Loaded	28%	35%	19%	11%	7%
Goods Unloaded	18%	37%	37%	7%	1%

Graph 3 - Source: UNCTAD – Review of Maritime Transport 1985

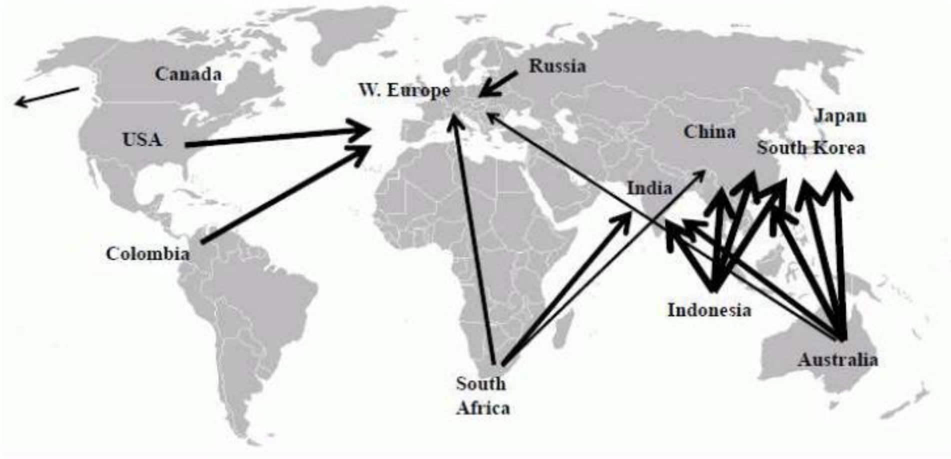
11 In fact, said imbalance can be much bigger if we consider the individual figures for each country and not the totality of goods loaded and unloaded, but instead divide the cargo by type: dry cargo, crude, oil products and gas. In terms of shipping, this analysis is more relevant because a ship for one type of product (i.e. dry cargo) cannot carry another product, (i.e. crude). Unfortunately, the data available in the UNCTAD Review of Maritime Trade does not allow to make the same analysis per type of products.

12 Although the totality of goods loaded should be equal to the totality of goods unloaded, any imbalance in any region is converted into ballast voyages as there is more cargo being loaded than unloaded, or vice-versa. The sum of imbalances across the globe is not zero because a positive imbalance in Asia cannot be compensated by a negative imbalance in Europe: in both cases there are ballast voyages.

13 In view of the above, currently it is possible to conclude that in many trade routes cargo is flowing mostly in one direction, with no return cargo, making ballast voyages an operational reality. A pictorial representation of this fact can be seen in the trade maps below (Pictures 1 to 6).

14 A robust index should not change over time whenever the world's economic configuration changes. A ship cannot be considered efficient one year and deemed to have become more or less efficient a few years later just because the trade flows have changed.

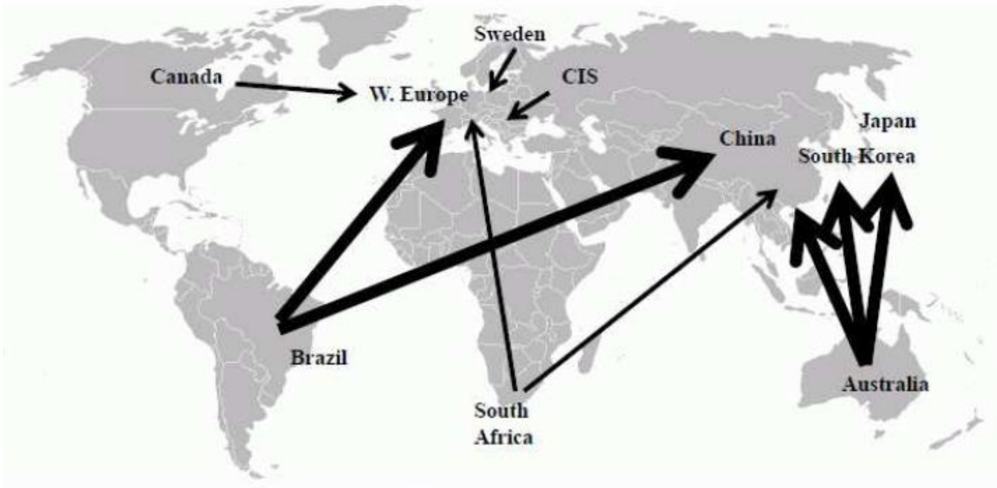
Coal Trade



Major Coal Exporters in 2014 (thermal + coking):		Major Coal Importers in 2014 (thermal + coking):	
Indonesia	418 +3 mln tonnes	China	230+64 mln tonnes
Australia	205+155 mln tonnes	India	165+42 mln tonnes
Russia	101+18 mln tonnes	Japan	142+54 mln tonnes
USA	33+52 mln tonnes	South Korea	97+31 mln tonnes
Colombia	78+1 mln tonnes	Taiwan	60+7 mln tonnes
South Africa	75+0 mln tonnes	Germany	41+10 mln tonnes

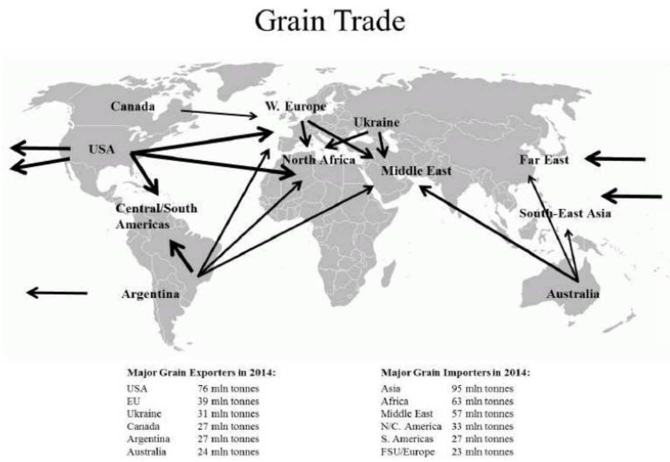
Picture 1: Coal trade map – source: Banchero Costa Research, September 2015

Iron Ore Trade

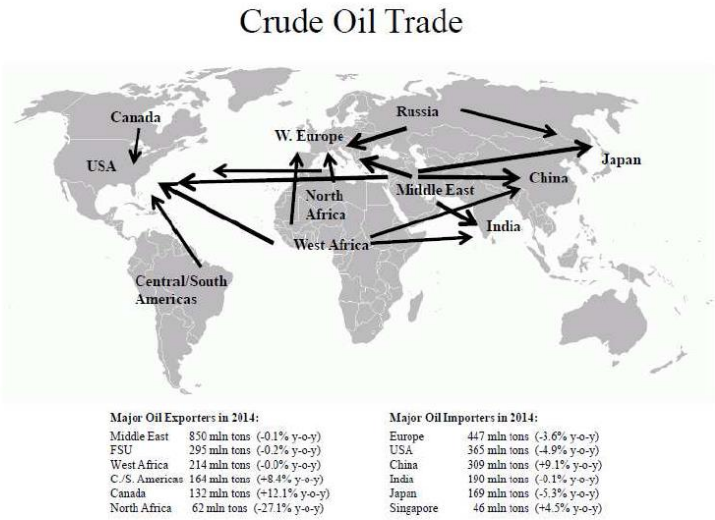


Major Iron Ore Exporters in 2014:		Major Iron Ore Importers in 2014:	
Australia	726 mln tonnes	China	931 mln tonnes
Brazil	340 mln tonnes	Japan	137 mln tonnes
South Africa	67 mln tonnes	EU	115 mln tonnes
Canada	38 mln tonnes	South Korea	74 mln tonnes
Sweden	22 mln tonnes	Middle East	25 mln tonnes
Chile	14 mln tonnes	Taiwan	23 mln tonnes

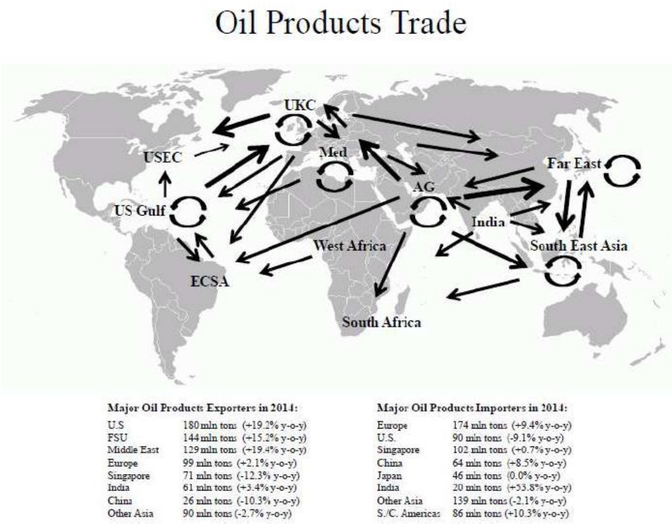
Picture 2: Iron trade map – source: Banchero Costa Research, September 2015



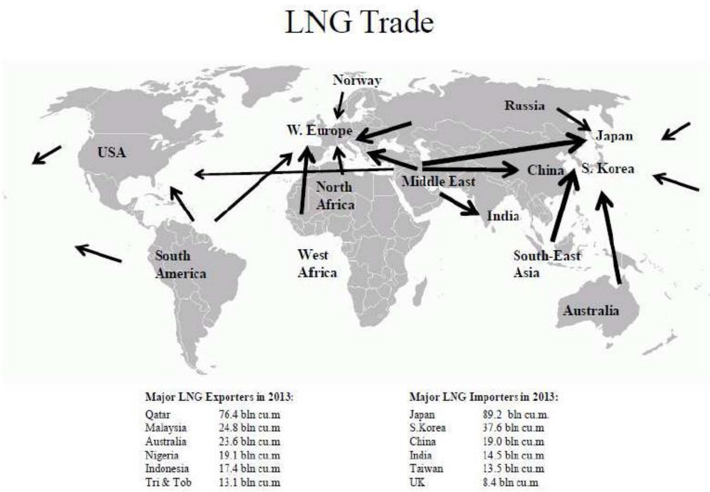
Picture 3: Grain trade map – source: Banchero Costa Research, September 2015



Picture 4: Crude trade map – source: Banchero Costa Research, September 2015



Picture 5: Oil trade map – source: Banchero Costa Research, September



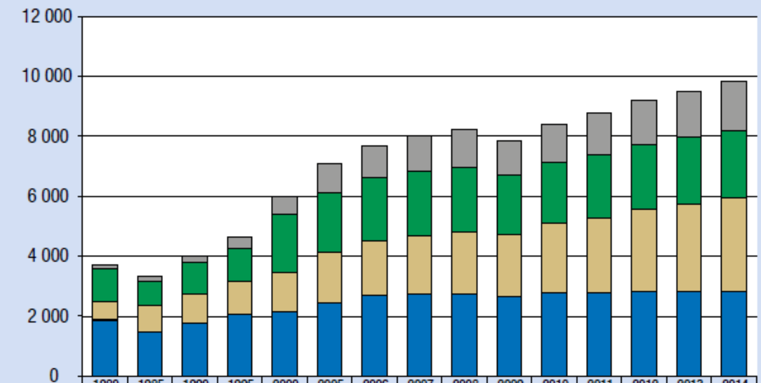
Picture 6: LNG trade map – source: Banchero Costa Research, September 2015

Efficiency of international shipping

15 The discussions at IMO about a data collection system already indicated the importance that any metric reflecting CO_2 emissions by international shipping consider energy efficiency via transport work. In fact, recent studies by IMO and UNCTAD reveal that international shipping has reduced its CO_2 emissions even though the total volume of cargo shipped has increased. This historic effort by maritime operators to improve the energy efficiency of their ships can be seen in Tables 2 and 3 below:

Marine sector	Fuel type	2007	2008	2009	2010	2011	2012
International shipping	HFO	773.8	802.7	736.6	650.6	716.9	667.9
	MDO	97.2	102.9	104.2	102.2	109.8	105.2
	NG	13.9	15.4	14.2	18.6	22.8	22.6
Bottom-up international total	All	884.9	920.9	855.1	771.4	849.5	795.7
Domestic navigation	HFO	53.8	57.4	32.5	45.1	61.7	39.9
	MDO	142.7	138.8	80.1	88.2	98.1	91.6
	NG	0	0	0	0	0	0
Bottom-up domestic total	All	196.5	196.2	112.6	133.3	159.7	131.4
Fishing	HFO	1.6	1.5	0.9	0.8	1.4	1.1
	MDO	17.0	16.4	9.3	9.2	10.9	9.9
	NG	0	0	0	0	0	0
Bottom-up fishing total	All	18.6	18.0	10.2	10.0	12.3	11.0
All fuels bottom-up		1,100.1	1,135.1	977.9	914.7	1,021.6	938.1

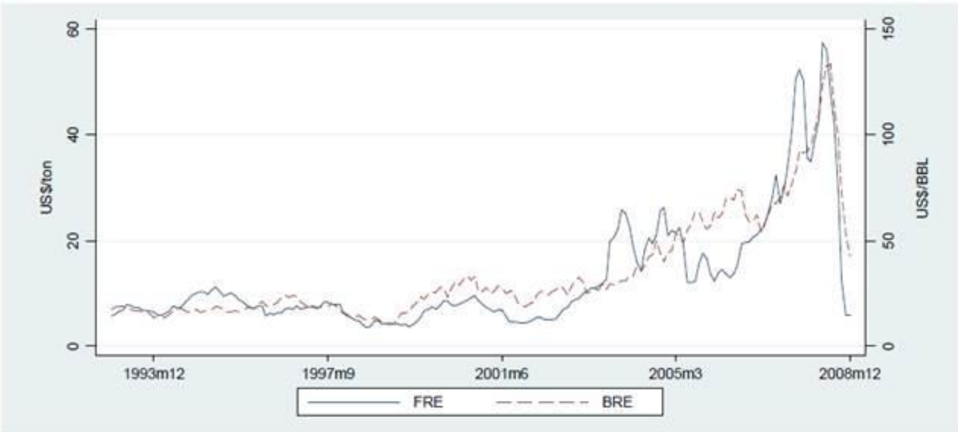
Table 2: International, domestic and fishing CO_2 fuel consumption 2007-2012, in millions of tonnes, using the bottom-up method. Source: Third IMO Greenhouse Gas Study, 2014.



	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Container	102	152	234	371	598	969	1 076	1 193	1 249	1 127	1 280	1 393	1 464	1 544	1631
Other dry cargo	1 123	819	1 031	1 125	1 928	2 009	2 112	2 141	2 173	2 004	2 022	2 112	2 150	2 218	2272
Five major bulks	608	900	988	1 105	1 295	1 709	1 814	1 953	2 065	2 085	2 335	2 486	2 742	2 923	3112
Oil and gas	1 871	1 459	1 755	2 050	2 163	2 422	2 698	2 747	2 742	2 642	2 772	2 794	2 841	2 829	2 826

Table 3: International seaborne trade, selected years (millions of tonnes loaded). Source: UNCTAD – Review of Maritime Transport 2015, based on Clarksons Research.

16 This improvement in energy efficiency has a direct impact on cost reduction. Freight costs depend mainly on fuel costs (Graph 4). Maritime transport usually has a small profit margin. Therefore any increase in efficiency will immediately manifest itself in lower costs as well as lower emissions.



Graph 4: Source: UNCTAD - Oil Prices and Maritime Freight Rates: An Empirical Investigation

17 Another aspect to be considered is that maritime transport is part of a value chain and any mechanism adopted by this segment may affect downstream and upstream industries. Specifically regarding climate change, it is important to take into account the entire value chain to avoid emissions leakage, that is, when a mobile source becomes expensive, cargoes may be shifted to other sources that may be cheaper but also less efficient and more polluting.

18 Maritime transport is still the most efficient in terms of energy consumption and, therefore, CO_2 emissions. The management of these emissions, by means of an indicator or other mechanisms, should not only seek to penalize energy inefficiency but also encourage the relatively more efficient sources. Table 4 below presents the AER for different mobile sources:

Mobile source	**$gCO_2/t*nm$**
Heavy trucks	4963
Aviation	2926
Train	56
Bulk carrier 14.000dwt	13

Table 4: Emission factor by mobile sources
Source: http://www.ghgprotocol.org/files/ghgp/tools/co2-mobile.pdf

19 The third aspect of international shipping efficiency can be observed by the constant increase in the size of ships. Said increase is a consequence of the growth in maritime trade and the search for efficiency, as bigger ships may consume more fuel in absolute numbers but have less consumption per ton of cargo carried and distance sailed. Table 5 shows the average size of the world's fleet grouped by age and type of ship. It can be seen that:

.1 all types of ships have increased their average size in the past 5 years;

.2 with the exception of tankers, which reached their peak average size about 10 years ago, all other types of ships are at their peak average size; and

.3 the average size of the world's fleet has been progressively increasing, in fact almost doubling its average size in 15 years.

Country grouping Types of vessel		*0–4 years*	*5–9 years*	*10–14 years*	*15–19 years*	*20 + years*	*Average age 2014*	*Average age 2015*	*Change 2015/2014*
World: Bulk carriers	Ships	47.50	18.68	11.12	11.55	11.15	9.07	9.15	-0.09
	Dwt	51.88	18.73	10.46	9.94	8.99	8.08	7.98	0.10
	Average vessel size (dwt)	80 338	73 728	69 145	63 323	59 290			
World: Container ships	Ships	20.94	34.31	17.61	17.55	9.60	10.88	10.70	0.18
	Dwt	34.88	34.22	16.58	10.18	4.14	8.23	8.19	0.04
	Average vessel size (dwt)	74 310	44 487	42 001	25 869	19 235			
World: General cargo	Ships	10.68	14.89	7.70	8.96	57.76	24.86	24.18	0.68
	Dwt	22.09	18.86	10.05	10.17	38.83	17.97	17.76	0.21
	Average vessel size (dwt)	8 297	5 388	6 086	4 885	2 758			
World: Oil tankers	Ships	18.74	21.72	12.69	8.32	38.54	18.37	17.92	0.45
	Dwt	29.90	32.59	22.83	10.04	4.64	8.98	8.51	0.47
	Average vessel size (dwt)	83 196	78 871	95 231	65 702	6 521			
World: Others	Ships	16.55	16.87	9.22	8.88	48.48	22.22	21.86	0.36
	Dwt	20.41	26.49	12.31	9.16	31.62	15.65	15.30	0.35
	Average vessel size (dwt)	6 619	8 547	7 574	5 834	3 962			
World: All ships	Ships	14.94	15.64	8.35	7.96	53.12	20.25	19.89	0.35
	Dwt	38.71	25.50	14.90	9.92	10.97	9.63	9.41	0.22
	Average vessel size (dwt)	42 873	30 899	34 042	23 160	6 095			
Developing economies: All ships	Ships	20.28	17.71	8.64	9.24	44.12	19.76	19.43	0.33
	Dwt	41.55	20.45	10.97	10.98	16.05	10.37	10.20	0.17
	Average vessel size (dwt)	36 453	21 879	25 241	22 128	6 788			
Developed economies: All ships	Ships	20.20	21.02	12.79	11.24	34.76	18.52	18.17	0.35
	Dwt	37.46	29.00	17.56	9.10	6.88	8.90	8.65	0.25
	Average vessel size (dwt)	52 026	39 690	40 847	24 649	7 142			
Countries with economies in transition: All Ships	Ships	7.29	7.71	3.68	4.03	77.30	28.82	28.12	0.70
	Dwt	20.21	22.70	15.56	12.57	28.97	15.56	15.03	0.53
	Average vessel size (dwt)	17 659	20 706	27 366	20 029	2 398			

Table 5: Average deadweight increase of the world fleet (propelled vessels 100GT and above)
Source: UNCTAD – Review of Maritime Transport 2015, based on data supplied by Clarksons Research

20 When viewed under the perspective of the AER, the difference in efficiency in terms of emissions per ton*mile between small and big ships is also very significant, with reductions over 80%. This is an index that recognizes the importance of economy of scale in the search for efficiency and the investment of shipowners in building bigger ships.

21 In summary, in order to choose an index to monitor shipping efficiency, the shipping community should always bear in mind these three dimensions: the great effort that has already been made to reduce emissions in shipping, the enormous advantage of shipping in relation to other means of transport and, lastly, the differences in efficiency within the shipping business itself.

Case study for Capesize ships on Brazil – Asia route

22 The three graphs below (5, 6 and 7) show the case study of a Capesize ship mainly on the Brazil – Asia route. The four year operational data (2011 to 2015) is presented in the form of a one year rolling average, i.e. each point in the graph represents the average of the previous 365 days. The data was also parameterized considering the initial point as 100 to evaluate the percentage variation. The graph unit is g CO_2/t*nm.

23 The following curves are presented separately in the graphs:

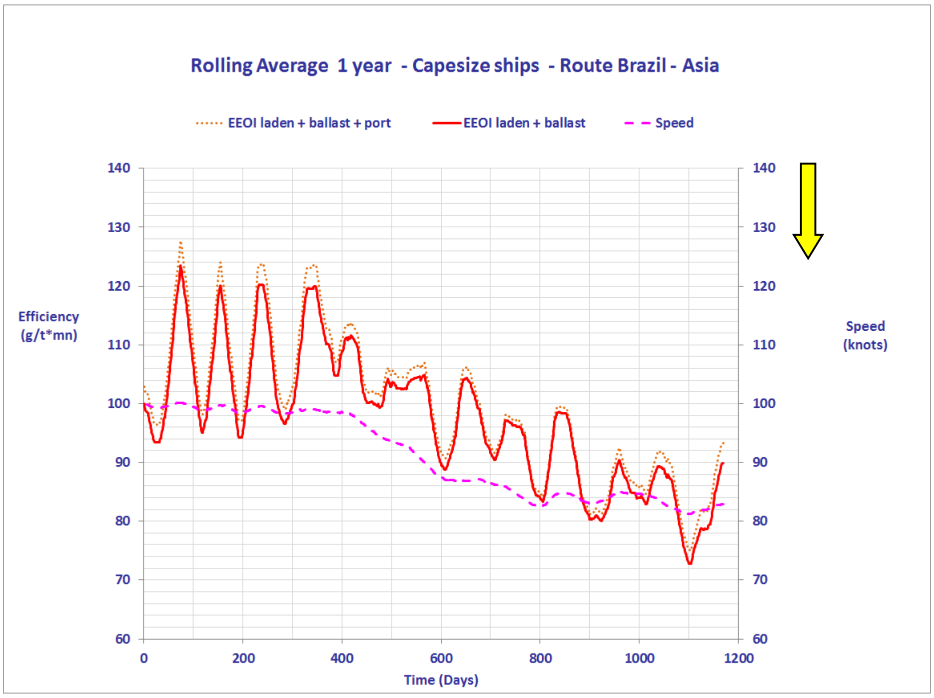
.1 Annual EEOI for laden and ballast – red continuous line, Graph 5;

.2 Annual EEOI for laden, ballast and port – orange dotted line, Graph 5;

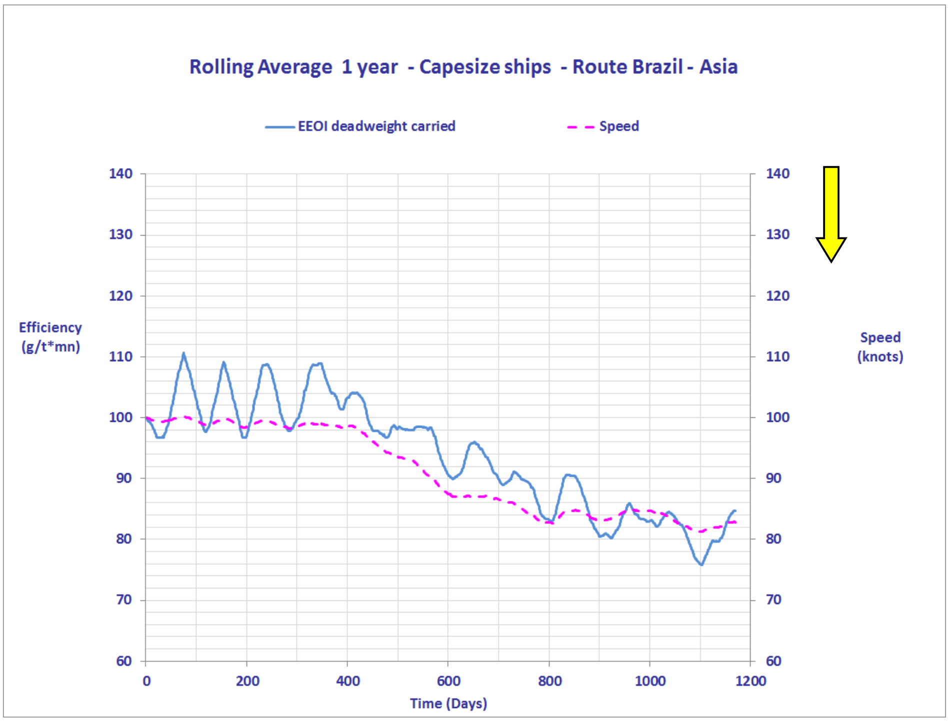
.3 Annual EEOI for laden and ballast as cargo (deadweight carried) – blue continuous line, Graph 6;

.4 AER – green continuous line, Graph 7; and

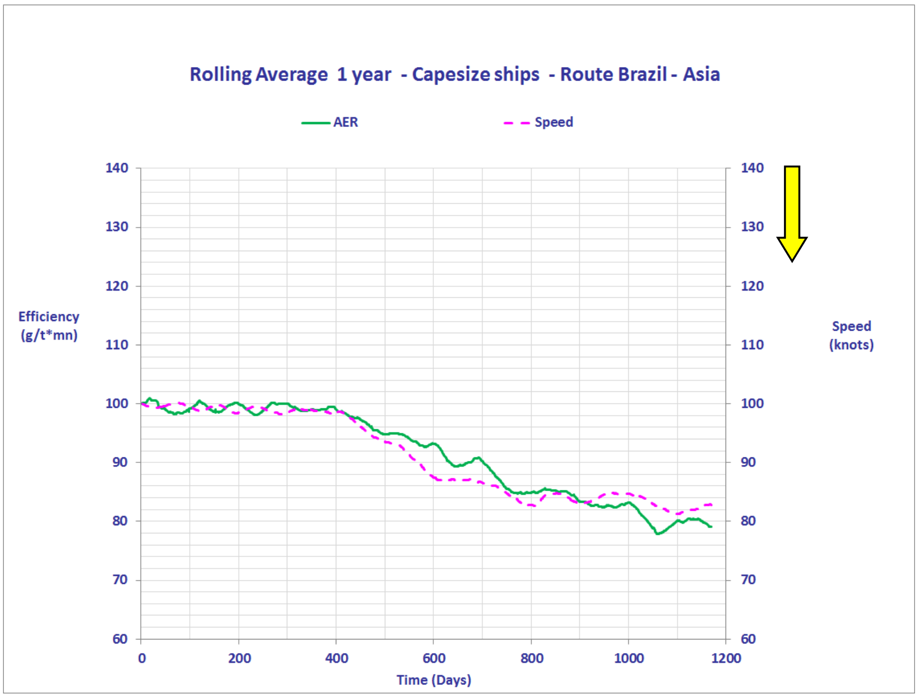
.5 speed (in knots) – pink dashed line, Graphs 5, 6 and 7.



Graph 5 – Source: Brazilian fleet data



Graph 6 – Source: Brazilian fleet data



Graph 7 – Source: Brazilian fleet data

24 From the graphs we can see:

.1 the negative impact of including ballast voyages only as penalty to the ship; and

.2 the negative impact of including port emissions as a penalty to the ship.

The negative impact of including ballast voyages only as penalty to the ship

25 According to the methodology to calculate the EEOI, when a vessel is sailing in ballast the emissions should be computed and the cargo moved is equal to zero.

26 The reasoning behind adding such ballast emissions would be to measure the commercial efficiency of a ship, theoretically obtained through a higher occupation of the vessel when moving cargo.

27 However, this methodology raises serious concerns: firstly, the problem of great dispersion in the index when ballast voyages are considered as a penalty and, secondly, the predominance of the ballast factor in detriment of other aspects more relevant to efficiency.

28 The first impact is the great index dispersion that can be observed by comparing the annual EEOI for laden and ballast voyages (red continuous line, Graph 5) with the AER (green continuous line, Graph 7). When a vessel undertakes very long voyages (in this case study the voyages last between 30 and 45 days), although the number of ballast voyages is half the total number of voyages, the percentage of time in ballast could be well above 50%. In such cases, depending on the starting date for calculation of the index, the sailing time in ballast could vary significantly. Therefore, if a vessel starts and finishes a given year sailing in ballast, the calculated EEOI Index will be negatively impacted. On the other hand, if the same vessel starts and finishes that year in laden voyages, the resulting index will be comparatively much better. The good, or rather, better result, in this case, is merely a consequence of the vessel's position at the beginning of the year in question.

29 It has already been pointed out by Belgium, Japan and others that the EEOI value may fluctuate on a voyage basis, and to account for these fluctuations, it has been suggested to calculate the "annual EEOI value". As we can see in Graph 5, the annual EEOI for laden and ballast voyages is also subject to high fluctuations, in this case in the magnitude of 30%, and hence not adequate as a monitoring index. Such fluctuations are a serious technical deficiency of such metric which will prevent any ship sailing in a similar operation profile to predict its result or establish actions to accomplish a target.

30 The second impact of ballast voyages as penalty comes from the comparison between the annual EEOI for laden and ballast voyages (red continuous line, Graph 5), the AER (green continuous line, Graph 7) and speed (pink dashed lines, Graph 5, 6 and 7). It can be stated that the improvement in the efficiency observed in this case study was mainly due to speed reduction; in fact, a high correlation can be observed between the AER and speed curves, which means that the impact of speed on the result is important. It should be noted that this vessel has suffered interventions to improve its performance, such as hull and propeller cleaning, which can be seen in Graph 7 when the AER is decoupling from the speed curve; firstly, efficiency is reduced and after that intervention it is improved. However, we note that the impact of speed reduction is much more important than the impact of technological and operational improvements, with the latter also represented in the graph. On the other hand, on checking the EEOI curve in Graph 5 it can be seen that the effect of the ballast voyage on this type of index is even greater than the effect of speed; that is, the commercial aspect which cannot always be controlled is offsetting all other initiatives to improve efficiency, including technological and operational improvements, which cannot be seen in the graph.

31 The arguments above evidence that an index that penalizes ballast voyages is technically deficient because it presents:

.1 high dispersion around the average; and

.2 an impossibility to detect other significant factors like improved operational and technological innovations.

The negative impact of including port emissions as penalty to the ship

32 In the original methodology used to calculate the EEOI, when a ship is waiting to berth or is at berth loading or discharging, emissions should be computed by considering the distance navigated as zero, thus penalizing the efficiency of the ship.

33 By including emissions at port in the index it is assumed that port efficiency is impacting the ship's efficiency, regardless of whether the extended time at port is a consequence of long queues or low loading/unloading rates.

34 Again in this case, similarly to what happens with ballast voyages, it is assumed that a factor beyond the control of a ship's operator influences the ship's efficiency. In Graph 5 the orange line shows the results of our case study when emissions at port are included. Although the impact in this case is lower than the impact of penalizing ballast voyages, at around 5% it is still significant.

Conclusion

35 In this document some of the proposals submitted to earlier MEPC sessions were reviewed to highlight some of the aspects that have been considered important throughout this debate, such as comparability, confidentiality and simplicity.

36 Public official data from UNCTAD – Review of Maritime Transport was compiled to show that maritime trade is always unbalanced and thus ballast voyages are an operational reality in shipping and will always need to be dealt with. This strengthens the view that the shipping industry must discuss its emissions in terms of energy efficiency, i.e. transport work, and should consider the efforts made so far to reduce emissions as well as its performance in comparison with other mobile sources so as to avoid excessive burden on shipping and subsequent emission leakage. Another key point highlighted in this document is that the search for efficiency is directly related to the increase in size of vessels.

37 Finally, a case study was presented to show the importance of having a metric that is robust but does not present dispersion and which will allow for future reduction targets to be precisely defined by IMO and then met by ships.

Action requested of the Committee

38 The Committee is invited to consider the views expressed in this document.

____