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Marine Energy Design Index and the Effects of Hydrodynamic Design

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Abstract: **The thesis wants to give a brief to the effect of the EEDI and application of other indexes than EEDI. But the most important part was to analyze the effect on ship design and hydrodynamics of ship. All the types of ship that is appear in the analysis has shown almost similar pattern of curves.**

How EEDI will give impact on the ship design parameters, For all the three sorts of vessels, it are often said that, if the vessel is to be designed for slow speed, it is better to have small length, breadth, draft and therefore the prismatic coefficient (Cp) for all speeds, as $EEDI_{reference}$ - $EEDI_{attined}$ value decreases with the increase of these parameters. On the opposite hand, it's better to extend L/B and B/T at slow speed but, decrease at high speed. This means, the present EEDI formula will influence the designer and ship owner to build small ships in low speed range.

Finally we find the result and we can say that, influence of speed and length has the highest impact on EEDI, then the beam. Draft and prismatic coefficient does not have very high effects. So, it is satisfied from this viewpoint, if a maker needs to change the value of EEDI for a particular ship, he should look in to the length and speed first, then width, draft and the prismatic coefficient.

Keywords: **Marine Energy, Marine Environment, Green House Gases GHG, IMO Regulation EEDI, Hydrodynamics Design.**

1. INTRODUCTION

In order to control this CO2 emission from shipping, the ship Energy Efficiency Design Index (EEDI) has been formulated by the IMO Marine Environment Protection Committee (MEPC) as a measure of the CO2 emission performance. The basic formulation of EEDI is predicated on the ratio of total CO2 emission per tonne.mile. The amount of CO2 emission depends upon fuel consumption and fuel consumption depends upon the entire power requirement which suggests the EEDI formulation eventually has certain impact on ship design parameters which are closely related to the economic performance of the ship.

2. IMO GHG STUDIES

In 2000, the First IMO GHG Study on GHG emissions from ships was published, which estimated that ships engaged in international trade 1996 contributed about 1.8 per cent of the planet total anthropogenic CO_2 emissions.

The Second IMO GHG Study, published in 2009, estimated international shipping emissions in 2007 to be 880 million tons, or about 2.7% of the worldwide total anthropogenic CO_2 emissions.

The Third IMO GHG Study, published in 2014, estimated international shipping emissions in 2012 to be 796 million tons, or about 2.2% of the worldwide total anthropogenic CO_2 emissions. The Study also updated the CO_2 estimates for 2007 to 885 million tons, or 2.8%.

MEPC 74 initiated a Fourth IMO GHG Study, for consideration of the ultimate report by MEPC 76 in autumn 2020. This extra study is predicted to supply an update of GHG emissions estimates from international shipping from 2012 to 2018 and future scenarios for shipping emissions from 2018 to 2050.

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3. FUTURE SCENARIOS (2012–2050)

1. Maritime CO_2 emissions are projected to extend significantly within the coming decades. Counting on future economic and energy developments, this study's BAU scenarios project an increase by 50% to 250% within the period to 2050. Further action on efficiency and emissions can mitigate the emissions growth, although all scenarios but one project emissions in 2050 to be above than in 2012.

2. Among the various cargo categories, demand for transport of unitized cargoes is projected to extend most rapidly altogether scenarios.

3. Emissions projections demonstrate that improvements in efficiency are important in mitigating emissions increase. However, even modeled improvements with the best energy savings couldn't yield a downward trend. Compared to regulatory or market-driven improvements in efficiency, changes within the fuel mix have a limited impact on GHG emissions, assuming that fossil fuels remain dominant.

4. Most other emissions increase in parallel with CO_2 and fuel, with some notable exceptions. Methane emissions are projected to extend rapidly (albeit from a low base) because the share of LNG within the fuel mix increases. Emissions of nitrogen oxides increase at a lower rate than CO_2 emissions as a result of Tier II and Tier III engines entering the fleet. Emissions of particulate show an absolute decrease until 2020, and sulphurous oxides still decline through 2050, mainly due to MARPOL Annex VI requirements on the Sulphur content of fuels.

4. PROJECTION OF USE OF EXAHUST GAS CLEANING SYSTEMS "EGCSs"

The projection of uptake of EGCSs and their use in 2020 is based on economic considerations, technical and operational constraints, availability of EGCSs and installation capacity, and regulatory uncertainty. We apply a five-stage filter model to each:

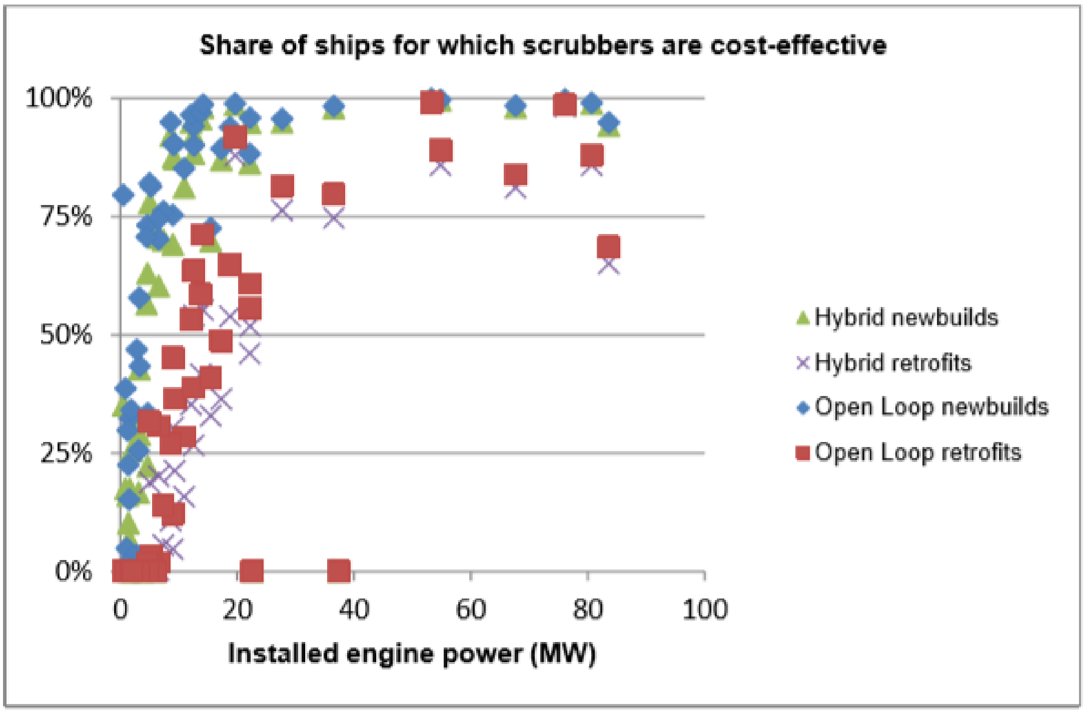
1. Economic analysis

2. Regulatory constraints to operating EGCSs

3. Technical and operational feasibility

4. Availability of EGCSs

5. Other constraints



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TECHNICAL AND OPERATIONAL CONSTRAINTS ON "EGCS" USE

Technical and operational constraints on installing EGCSs may comprise:

1. The space required for EGCSs and the impact on cargo space.

2. Impacts on vessel stability.

3. Impacts on power requirements.

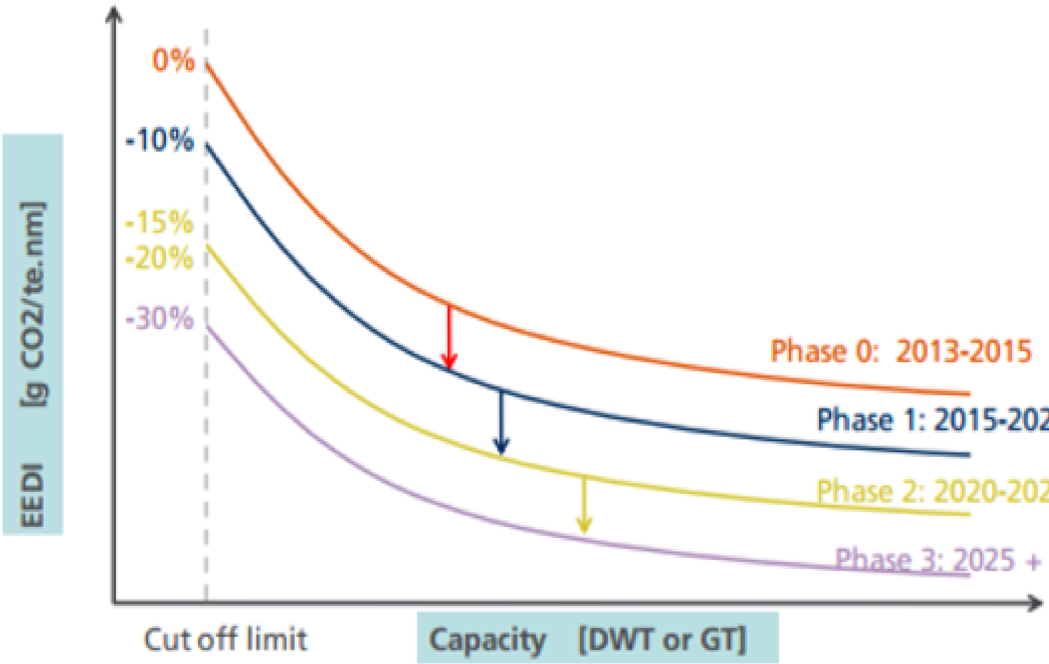
4. Compatibility of EGCSs with Tier III requirements.

ATTAINED EEDI

Attained EEDI is the actual EEDI of a ship as calculated using EEDI formula According to the regulation

REQUIRED EEDI

The Required EEDI is the regulatory limit for EEDI and its calculation involves use of "reference lines" and "reduction factors".



Concept of Required EEDI, reduction factor, cut off limits and EEDI phases

REQUIRED EEDI CALCULATION FORMULA

Reference EEDI = $a*b^{-c}$ **(1)**

Where: b: Ship capacity

a and c: Constants agreed for each ship type and included in the regulation.

Reference EEDI: Reference value for EEDI.

Required EEDI = (1-X/100)* (Reference EEDI) **(2)**

Where: X: Reduction rate, agreed and included in Regulation.

Required EEDI: The regulatory limit of the ship's EEDI, which the actual EEDI must not exceed.

Attained EEDI < Required EEDI **(3)**

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(Table) Parameters for determination of reference values for the different ship types:

Ship type defined in regulation	a	b	c
Bulk carrier	961.79	DWT of the ship	0.477
Gas tanker	1120.00	DWT of the ship	0.456
Tanker	1218.80	DWT of the ship	0.488
Container ship	174.22	DWT of the ship	0.201
General cargo ship	107.48	DWT of the ship	0.216
Refrigerated cargo carrier	227.01	DWT of the ship	0.244
Combination carrier	1219.00	DWT of the ship	0.488

* If the design of a ship allows it to fall into more than one of the above ship type definitions, the required EEDI for the ship shall be the most stringent (the lowest) required EEDI

EEDI CALCULATION

$$\text{EEDI} = \frac{\text{Impact to the environment}}{\text{Benefit for the society}} = \frac{\text{Ship CO2 emissions}}{\text{Transprt Work}}$$

Equation :

$$\frac{f_j(P_{ME}\ X\ SFC_{ME}\ X\ C_{FME}) + (P_{AE}\ X\ SFC_{AE}\ X\ C_{FAE}) + \left((f_j.P_{PTI} -\ P_{AEeff})\ X\ SFC_{AE}\ X\ C_{FAE}\right) - (P_{eff}\ X\ SFC_{ME}\ X\ C_{FME})}{f_i\ X\ f_c\ X\ Capacity\ X\ V_{ref}\ X\ f_w}$$

HOLTROP AND MENNEN METHOD AND THE LIMITATION

This is a really well-known approximate resistance and power prediction method for displacement and semi displacement vessels. However, not all types of ships are covered by this method. The approximate formulations are supported hydrodynamic theory with coefficients obtained from the multivariate analysis of the results of 334 ship model tests. This method works well for tankers, general cargo vessels, bulk carrier, container ship; fishing vessels tug boats and frigates with a particular boundary of prismatic coefficient, L/B and B/T. The limitations are shown in table. In order to possess the foremost accurate results for the facility prediction by this method; these limitations were maintained within the analysis process.

(Table) Limitation for Holtrop and Mennen's method.

Ship type	Max Froude no.	Cp		L/B		B/T	
		Min	Max	Min	Max	Min	max
Tankers, bulk carriers	0.24	0.73	0.85	5.1	7.1	2.4	3.2
Trawlers, tugs	0.38	0.55	0.65	3.9	6.3	2.1	3.0
Container ships, destroyers	0.45	0.55	0.67	6.0	9.5	3.0	4.0
Cargo liner	0.3	0.56	0.75	5.3	8.0	2.4	4.0
RoRo Ships, Car ferries	0.35	0.55	0.67	5.3	8.0	3.2	4.0

BEST DESIGN PARAMETERS FOR RORO, YACHTS AND SERVICE TUG VESSEL

In these three tables, two different sized bulk carrier, container vessel and oil tanker have been analyzed, to see maximum possible speed, where the combined impact of all the parameters are:

Vessel Type	Speed (knot)	Length (m)	Fn	L/B	Beam (m)	B/T	Draft (m)	EEDI ATT	EEDI REF
RoRo	14	329	0.15	7.1	46.4	2.4	19	3.38	3.276
RoPax	20	150	0.22	6.2	24.3	2.4	10.12	10.47	10.367

Vessel Type	Speed (knot)	Length (m)	Fn	L/B	Beam (m)	B/T	Draft (m)	EEDI ATT	EEDI REF
Large Yachts	24	229	0.27	6	38.17	3	12.72	21.08	21.61
Small Yachts	16	42	0.27	6	6.3	3	2.43	30.73	30.42

Vessel Type	Speed (Knot)	Length (m)	Fn	Beam (m)	Draft (m)	Capacity (Tone)	MCRME (kW)	Allowed MCRME (kW)
Small Service vessel	16.17	120	0.24	21.05	7.51	10093	4973	4983
Multi used vessel	16.77	160	0.21	28.07	10.02	23924	8027	8039
Medium Tug	17	190	0.20	33.33	11.90	40062	10553	10611
Large Tug	17.21	230	0.18	40.35	14.41	71066	14401	14407

5. CONCLUSIONS

1. Perfection in EEDI of a vessel also means the perfection of ship hull resistance.
2. In way to compare a small and large vessel in terms of EEDI we find that the small vessels are allowed to have higher, it can be said easily that present EEDI is acceptable small vessels to have higher EEDI. Its free foe feel that the small vessel can be higher speed a large one. In the previous 3 Tables describes it well, where it has been shown that larger vessel can make higher speed than smaller vessel.
3. Thinking EEDI is not an accurate emission behavior at present it is good in all terms to have an emission control appliance at the design stage. In future, the equation may be editing by insert new coefficients or present coefficient values to make the EEDI more accurate and efficient.

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