IMPROVEMENT OF THE ENERGY EFFICIENCY OF VESSELS AS A MEASURE FOR THE REDUCTION OF GREENHOUSES GASES EMISSION FROM SEA SHIPPING

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As all we know, pollution is a serious actual problem that affects our society. Maritime transport is responsible of part of that pollution and with this purpose; measure to be taken in the logistical and maritime transport field is to reduce ships emissions. Air pollution is not the only problem, but greenhouse gas emissions too, mainly in the case of maritime transport pollutants as NO_x and SO_x gasses. This article tries to do a quick view on the last measures took by the International Maritime Organization (IMO) in order to reduce greenhouse gas emissions of shipping. An energy efficiency index for ships was created by the Marine Environment Protection Committee (MEPC) to improve their energy efficiency and then reduce fuel consumption. This index was developed in voluntary interim guidelines established in last sessions of the MEPC among 2009 and 2010, and can be applied to both new designs and ships in operation. Nowadays is just a voluntary measure that whatever ship-owner could take and verify, but until its approval there is for the moment no sanction if the results are not the expected ones by the guidelines. A description of the above mentioned guidelines will be exposed.

Keywords*: energy efficiency of ships, greenhouse gas emission*

1. INTRODUCTION

In a highly environment conscious scenario, with an international regulation restricting the emission levels from ships at member part ports, but possibly existing a more restrictive local law. The concern of fleet adaptation to the new requirements is not only technical but also economical and logistics. From one side there are different technical alternatives, affording to comply with the regulations in force. Without major changes on board, the owner can decide to use low sulfur content fuels, and can carry out slight and inexpensive modifications in the main engine, to reduce the levels of nitrogen oxides.

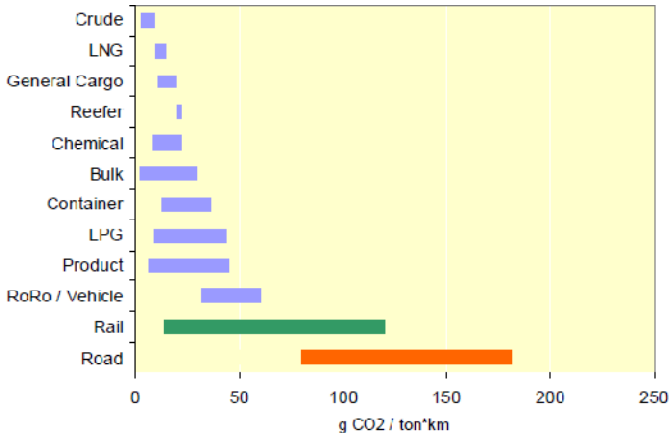
But what is posing this paper also, is the balance between the need to use oil derivates with an everyday better quality, due to environmental questions, and at the same time that the economic balance would be positive. In the long term the environment factor has an elevated cost for the producer (now the owner), and finally that cost will be charged in the following commercial chain step, the costumer. In the other hand and mainly in coastal navigation, maybe in the future it would be possible the establishment of new regulations controlling and penalizing high rates of CO2 emissions, question not dealt in MARPOL yet, but that is the base on which different protocols for climate change are based. In 2008, the expert group from the International Maritime Organization, modified their previous estimations on the world merchant fleet, fixing them in 1,120 millions of tons of CO_2 per year, produced by the worlds fleet, what means the 4.5% of the planet emissions. In the opinion of this working group, this figure is three times the contribution that was initially estimated, and of course those were not accounted in the objectives to fight against the climate change. The report “Maritime transport and the climate change challenge TD/B/C.I/MEM.1/2, from United

Nations, pointed out that other pollutants coming from the transport activity, and specifically navigation, are increasing quicker than the expected CO_2 growing (estimated in an additional 30% in 2020), like the soot and sulfur oxides, that would increase more than the 30% in the next decade. Both pollutants, contribute to the acid rain and to a wide variety of breath diseases, including the lung cancer. In fact the World Health Organization (2005) has established in 60,000 the number of deaths every year due to the pollution derived from the world's merchant fleet.

Despite this situation, most of the world administrations have sub estimated up to now, the marine traffic contribution to the greenhouse effect. European Union, has minimized this fact confirming that this one, contributes to less than 2% of the total CO_2, emissions, a reason because those never have been contemplated in the national estimations. In this sense we should keep in mind, that recently there are exploring initiatives to correct the previous situation, being one example the recommendations contained in the proposal of report "On the strategic objectives and recommendations for the maritime transport policy in the EU towards 2018" (EU Parliament 2010), complaining that the Copenhagen Summit on Climate Change could not agree conclusions to reduce emissions of maritime navigation, but introducing valid criteria to reach that objective. So we can conclude that the contribution of Maritime transport on the greenhouse gases emission, has been recognized by the worlds' administrations, and this is going to put a superior pressure on the owners to begin to use cleaner fuels and more efficient engines. In the other hand it is possible that EU could include the shipping industry within the CO_2 emissions market.

CONTRIBUTION OF MARITIME TRANSPORT TO GREENHOUSE EFFECT GASES

CO_2 emissions from ships are directly proportional to the bunker consumption, for all uses, id est propulsion, auxiliary services, heating or others. The consumption estimates and then the emissions of greenhouse effect gases, varies in the time, because the better definition of scenarios and the improvement on the modeling techniques. In the following graphic, it is showed that the estimations on the greenhouse effect gases coming from maritime sector represent from the 1.6% to 4.1% of the world CO2 emissions coming from bunker burning. IMO estimations for the international maritime transport from 2007 to 2050, are pointing an increase from 2.4% to 3%.



Graphic 1: Range of typical CO_2 efficiencies for various cargo carriers in g CO_2 per Ton and kilometer. Source based on IMO study on greenhouse gases emissions from maritime traffic 2008 (OMI 2008).

Maritime transport represented in 2005, the 10% of the greenhouse gases emissions of the transport sector, which were headed by the road transport with the 73% of total contribution (IEA 2005).

In absolute figures the greenhouse gases emissions coming from maritime transport are very important, in relative terms show that ships are much more efficient than other transport modes, implying a specific consumption per ton of freight carried much lower than the other modes. CO_2 is created in all the combustion processes and thus is produced in big quantities in the maritime transport, being those directly proportional to the fuel consumption. Maybe the best way to reduce CO_2 emissions would be to improve the energetic performance of ships.

In order to reduce greenhouse gas (GHG) emission from international shipping, the Marine Environment Protection Committee (MEPC) from IMO proposed take some measures involving the design phase of the new ships, helping to improve their fuel efficiency too. The measures had been reviewed in a number of sessions from the MEPC and almost approved in the last one, the 61st session of the MEPC, celebrated on September 2010 in London.

In the 59st session (July 2009) of the IMO's Marine Environment Protecion Committee (MEPC) a package of interim and voluntary technical and operational measures was agreed as one of the first steps of the implementation of the Energy Efficiency Design Index (EEDI) for the objective of greenhouse gas emissions reduction.

These measures were used as trial purpose until they were refined in the new session of the MEPC (60st session on March 2010).

The measures include:

- Interim guidelines on the method of calculation, and voluntary verification, of the Energy Efficiency Design Index for new ships: To stimulate innovation and technical development of the elements those have influence in the energy efficiency of a ship in its design phase.

- Guidance on the development of a Ship Energy Efficiency Management Plan, for new and existing ships and a guidelines for voluntary use of the Ship Energy Efficiency Operational Indicator for new and existing ships, which enables operators to measure the fuel efficiency of a ship.

The 61st session of the MEPC (September 2010) was due to finalize technical aspect of the EEDI and agree the detail of its mandatory application, along with the Ship Energy Efficiency Management Plan (SEEMP), but proponents do not obtained the consensus approval.

So, the mandatory energy efficiency rules could be adopted for new ships, this year but measures come into force in 2013. If made mandatory, ship-owners could be penalized if they do not meet minimum fuel efficiency standards for their vessel type.

It's a process needed for adoption to be possible at the next MEPC meeting next July (2011).

2. DESCRIPTION OF THE PACKAGE OF TECHNICAL AND OPERATIONAL REDUCTION MEASURES FOR SHIPS AGREED BY MEPC 59

If the entire fleet of the world trade applies the measures proposed to increase the efficiencies that involve reducing fuel consumption, save money and decrease environmental impacts for individual ships, the results will be very importants for the reduction of global carbon emissions.

2.1 GUIDANCE FOR THE DEVELOMPMENT OF A SHIP ENERGY EFFICIENCY MANANGEMENT PLAN (SEEMP)

The purpose of the SEEMP is to establish a mechanism for a company or a ship to improve the energy efficiency of a ship's operation. SEEMP should be adjusted to the main characteristics and need of individual companies and ships in order to develop the performance of ongoing environmental of its vessel in the way that any onboard administrative burden will be minimum.

APPLICATION

The SEEMP try to improve a ship's energy efficiency through four steps plus an extra voluntary one:

1) PLANNING:
   Is the most important stage of the SEEMP that includes the current status of the ship energy usage and the future improvement of ship energy efficiency.
   a. The ship – Specific measures:The method to improve ship efficiency depends of the ship type, cargoes, routes and other factors, because not all measures can be applied to all ships or under different operating conditions. In the first place, the specific measures for the ship should be identified as a list to be implemented.
   b. The company – Specific measures: It is recommended that a company also establish an energy management plan for its fleet to reach the most improvement expected. And a good coordination between stakeholders (operators, ports and traffic management service) should exist.
   c. The human resource development: To provide the necessary training to the personnel both on shore and on board is another important thing.
   d. The goal setting: It's a voluntary part, It serves as signal of reference to be conscious and to improve the measures for the energy efficiency.

2) IMPLEMENTATION
   a. Establishment of an implementation system: It is necessary to have a system where tasks and assignation of them to qualified personnel are defined.
   b. Implementation and record-keeping: The planned measures should follow the implementation system. Record-keeping for the implementation of each measure is beneficial for self-evaluation at a later stage.

3) MONITORING

The energy efficiency of a ship should be monitored by an international standart method as the Energy Efficiency Operational Indicator (EEOI) that was developed by the Organization for operational ships for collecting data. A Rolling Average Index of the EEOI values may be calculated to monitor energy efficiency of the ship over time.

4) SELF-EVALUATION AND IMPROVEMENT

This is the final phase of this plan and should produce meaningful feedback for the coming first stage (of the improvement cycle). In this part the effectiveness of the planned measures and implementation is evaluated to find out which procedures of ship energy management should be developed.

Another step, but just for voluntary application, is the reporting or review of the results of this manangement plan:

5) VOLUNTARY REPORTING / REVIEW

Some shipowners/operators may wish to make public the results of the actions they have taken in their SEEMP and how have impacted in their ship efficiency. Some national Administrations, may wish to recognize their efforts.

GUIDANCE ON BEST PRACTICES FOR FUEL-EFFICIENT OPERATION OF SHIPS

In the search of efficiency there are many parties envolved and should consider all apropiate measures in their operations, both individually and collectively, to get it.

- Some Fuel-Efficient Operations:
    a) Improved voyage planning: Differents software tools are available for planning the optimum route to improve the efficiency and executing voyages too
    b) Weather routing: This parameter has a high potential for efficiency saving on specific route. It may also increase fuel consumption for a given voyage.

- Speed optimization: This can produce significant savings. It means the speed at which the fuel used per ton-mile is at a minimum level for that voyage. Possible adverse consequences of slow speed operation should be taken into account (increased vibration and soot). May need to be taken into account that it is necessary to coordinate arrival times in port with the availability of loading/discharge tools, berths, etc.
- Optimized shaft power: Operations at constant shaft rpm can be more efficient than continuously adjusting speed through engine power. The selection of the propeller may be decisive for the design of the ship and the use of rudder and heading control systems (autopilot) are more effective for the bridge team and can achieve significant fuel savings. A hull maintenance and a cleaner and more polish propeller may not be forgotten in order to increase fuel efficiency.
- Optimized ship handling: There are many factors that influence the optimization of the ship. Trim and ballast may be varied for achieve different load levels for which the vessel operates at different speeds.

- Waste heat recovery: A system to use thermal heat losses from the exhaust gas for either electricity generation or additional propulsion is used too.
- Fuel type: Use of emerging alternative fuels may be considered as a CO_2 reduction method but availability will often determine the applicability.
- Other measures: The development of computer softwares for the calculation of fuel consumption, the establishment of emissions to optimize operations, and the establishment of goal for improvement and tracking of progress may be considered.

It should be recognized that the international fleet of merchant vessels comprises a wide range of ship types and sizes that differ significantly in their design and that ships operate under a broad variety of different conditions. In conclusion, the most efficient combination of measures will be unique to each vessel within each shipping company.

2.2 INTERIM GUIDELINES ON THE METHOD OF CALCULATION OF THE ENERGY EFFICIENCY DESIGN INDEX FOR NEW SHIPS

An Energy Efficiency Design Index for new ships is needed to be developed in order to stimulate innovation and technical development of all elements influencing the energy efficiency of a ship from its design phase. In order to improve the method of calculation of the EEDI for all categories of ships the EEDI formula need to be further refined. Member Governments and observer organizations are invited to use the Interim guidelines on a voluntary basis and to provide the outcome and experiences in applying this to future sessions of the Committee, in order to improve the method of calculation of the EEDI for new ships.

ENERGY EFFICIENCY DESIGN INDEX (EEDI)

EEDI is a measure of ships CO_2 efficiency and calculated by the following simplified formula:

$$EED\ Index = \frac{M_{CO2}}{Transport\ Work}$$

M_{CO2}: Total emissions of CO_2 from the ship.

Capacity for the calculation of the Transport Work:

TYPE OF SHIP	PARAMETER
Dry cargo carriers, Tankers, Gas tankers, Ro-Ro cargo and General cargo ships	Deadweight
Passenger ships and RO-RO passenger ships	Gross Tonnage
Containerships	65% of the Deadweight

The next figure shows that a combination of improvements from different parts of the vessel could reduce considerably CO_2 emissions.

DESIGN (New ships)	Saving of CO_2/tonne-mile	Combined	Combined
Concept, speed and capability	2% to 50%+	10% to 50%+	25% to 75%+
Hull and superstructure	2% to 20%		
Power and propulsion systems	5% to 15%		
Low-carbon fuels	5% to 15%*		
Renewable energy	1% to 10%		
Exhaust gas CO2 reduction	0%		
OPERATION (All ships)			
Fleet management, logistics and incentives	5% to 50%+	10% to 50%+	25% to 75%+
Voyage optimization	1% to 10%		
Energy management	1% to 10%		

Potential reductions of CO2 emissions by using existing technology and practices
+ Reductions at this level would require reductions of operational speed.
* CO2 equivalent, based on the use of LNG. ***Source: Second IMO GHG Study 2009***

2.3 GUIDELINES FOR VOLUNTARY USE OF THE SHIP ENERGY EFFICIENCY OPERATIONAL INDICATOR (EEOI)

The Committee indentified and developed the mechanisms needed to achieve the limitation or reduction of GHG emissions from international shipping and they also developed a methodology to describe the GHG efficiency of a ship in terms of GHG emission indicator for that ship.
These guidelines explain the concept of an indicator for the energy efficiency of a ship in operation, expressed as the CO_2 emitted per unit of transport work and are used to assist shipowners, ship operators and parties concerned in the evaluation of the performance of their fleet with regard to CO_2 emissions. CO_2 emitted from ships is directly related to the consumption of bunker fuel oil, the EEOI can also provide useful information on a ship's performance with regard to fuel efficiency.
The objectives of the Guidelines for the use of EEOI are:

- How a ship's CO2 performance should be measured
- How the index could be used to promote low-emission shipping in order to help limit the impact of shipping on global climate change.

FORMULA

The Energy Efficiency Operational Indicator is defined as the ratio of mass of CO_2 (M) emitted per unit of transport work.

$$EEO\ Indicator = \frac{Actual\ CO_2\ \mathrm{E}mission}{Performed\ Transport\ Work}$$

DEFINITIONS

Fuel Consumption: FC all fuel consumed at sea and in port or for a voyage period in question.

Distance sailed: The actual distance sailed in nautical miles for the voyage or period in question.

Voyage: The period between the point of departure from a port to the point of departure from the next port.

Ship and Cargo types: The guidelines are applicable for all ships performing transport work.

- **Ships:** Dry cargo carriers, Tankers, Gas tankers, Containerships, Ro-Ro cargo ships, General cargo ships, Passenger ships including Ro-Ro passenger ships.
- **Cargo:** All gas, liquid and solid bulk cargo, general cargo, containerized cargo (including the return of empty units), break bulk, heavy lifts, frozen and chilled goods, timber and forest products, cargo carried on freight vehicles, cars and freight vehicles on ro-ro ferries and passengers.

ESTABLISHING ENERGY EFFICIENCY OPERATIONAL INDICATOR (EEOI)

EEOI should represent the energy efficiency of the ship operation in a period which represents the overall trading pattern of the vessel.

Steps to follow:

1) Define the period for which the EEOI is calculated
2) Define data sources for data collection
3) Collect data
4) Convert data to appropriate format
5) Calculate EEOI

GENERAL DATA RECORDING AND DOCUMENTATION PROCEDURES

The collection of data from ships should include the distance travelled, the quantity and type of fuel used, and all fuel information that may affect the amount of carbon dioxide emitted.

MONITORING AND VERIFICATION

Elements for establishing procedures for monitoring could include:

- Identification of operations/activities with impact on the performance
- Identification of data sources and measurements that are necessary, and specification of the format
- Identification of frequency and personnel performing measurements
- Maintenance of quality control procedures for verification procedures

The results could be used as indicators of the System's success and reliability and to correct actions or for the operation's improvement.It is recommended that monitoring of an EEOI be carried out by shore staff, utilizing data from existing required records.

ROLLING AVERAGE INDICATOR

The rolling average indicator is a tool for the ship energy efficiency management and should be calculated using the minimum period of time or a number of voyages that is statistically relevant.

DATA

For voyage or period data on fuel consumption/cargo carried and distance sailed in a continuous sailing pattern should be collected.

2.4 INTERIM GUIDELINES FOR VOLUNTARY VERIFICATION OF THE ENERGY EFFICIENCY DESIGN INDEX

In order to promote uniform use of the Interim Guidelines on the method of calculation of the energy efficiency design index for new ships a method for voluntary verification of the energy efficiency design index for new ships was developed.

PROCEDURES FOR VERIFICATION

Voluntary EEDI verification should be conducted on two stages:

1) Preliminary verification at the design stage

An application for the verification and an EEDI Technical File with the necessary information (the relevant characteristics of the ships engine, the propulsion system and the calculated value of the Attained EEDI) for the verification and other relevant documents should be submited to a verifier by a shipowner.

2) Final verification of the attained EEDI at sea trial

Prior to the sea trial, a shipowner should submit the application for the verification of EEDI together with the final displacement table and the measured lightweight.

The verifier should attend and confirm:

- Propulsion and power supply system
- Draft and trim
- Sea conditions
- Ship speed
- Shaft power of the main engine

The shipbuilder should develop power curves obtained as a result of the sea trail and the estimated power curves at the design stage. In case differences are observed, the Attained EEDI should be recalculated.

ISSUANCE OF THE EEDI VERIFICATION REPORT

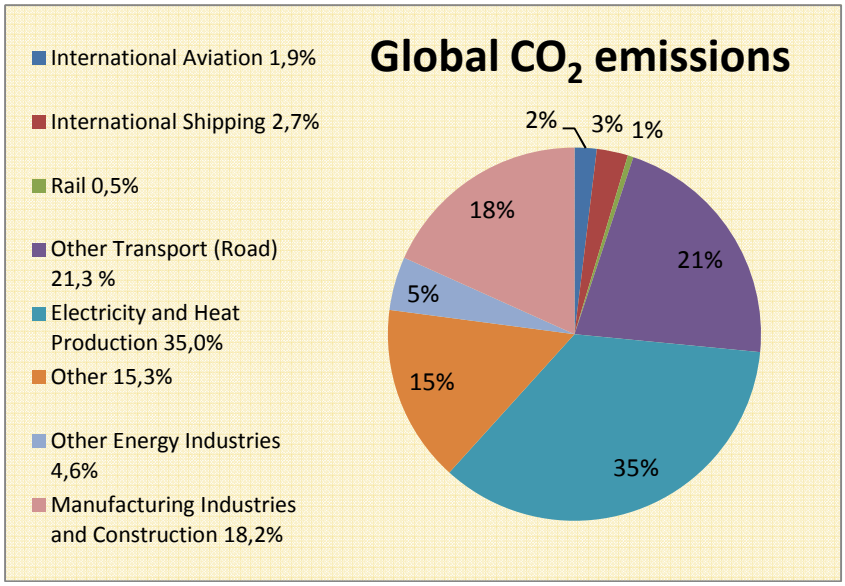
The verifier should issue the Report on the Preliminary Verification of EEDI after it verified the attained EEDI at design stage and after the sea trial.

3. CONCLUSIONS

The interim guidelines that were exposed in this article are just for voluntary users because there are not already in force and therefore who applies these guidelines could not be sanctioned if he doesn't reach the established results. These rules are expected to be in force in the next session of the MEPC.

A singular ship will have a little significant improvement of his efficiency energy and less contribution to the environment pollution but if all the international fleet takes the same measures then, a valuable contribution to reducing global carbon emissions will become aware. Even so, international shipping is not the only responsible of the environment pollution and GHG emission, but else it has just 2,7 % of the CO_2 global emission (global CO_2 emission graphic) so, it is necessary that the other activities or sectors that have an important impact on the global environment take measures in order to do something about the global warming and greenhouse gases emission.

In the next figure, it can be seen the CO_2 emissions of the different sectors and activities of the global level:



Emissions of CO_2 from shipping compared with global total emissions for 2007 (Source: Second IMO GHG Study 2009)

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