ENERGY EFFICIENCY IN THE SHIPPING SECTOR – A CASE STUDY

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Abstract

The improvement of Ship Energy Efficiency has been a major issue for the Shipping industry, primarily for three reasons; Firstly because fuel expenses of merchant ships contribute substantially to the overall expenses, secondarily, as conventional diesel engines and gas turbines emit large amounts of Greenhouse Gases (GHGs), contributing to the Climate Change and thirdly due to recent legislation including IMO Resolutions and EU Directives. The above in addition to the recent economic recession, have made it imperative for the industry to lower costs and introduce novel technologies and technical innovations, through the application of the Energy Efficiency Design Index (EEDI) and Energy Efficiency Operation Index (EEOI).This paper aims to contribute to the identification of methods and management tools in order to improve energy efficiency, by developing Ship Energy Efficiency Management Plans (SEEMPs). The paper focuses especially on investments, modifications, management and operational changes that can be deployed, in order to improve energy efficiency of existing ships. Finally, the economic result of modifications made on an existing vessel is presented, using data from a study performed by the authors in collaboration with several shipping companies.

Key words: SEEMP, Energy efficiency, shipping, EEDI, EEOI

Classification JEL : M40, M41

1. Introduction

Shipping has been proven to be one of the most efficient means of transportation for bulk commodities worldwide. Within the global efforts to reduce greenhouse gases (GHG) shipping is under pressure to operate by developing and using higher energy efficient, as well as lower emission ships. IMO introduced mandatory standards on energy efficiency through the Energy Efficiency Design Index (EEDI) of the majority of new built vessels, a process already in development to include several ship types that, at first, were not included in the regulations. International Maritime Organization (IMO) made the Ship Energy Efficiency Management Plan (SEEMP) mandatory for all ships on July 2011 by adopting amendments to MARPOL Annex VI and they entered into force on 1 January 2013 [1]. The regulations make mandatory the Energy Efficiency Design Index (EEDI) for new ships, and the Ship Energy Efficiency Management Plan (SEEMP) is now a requirement for all ships.

The EEDI is defined as the ratio of the emissions to the performed work, i.e.

$$\frac{IMPACT\ TO\ THE\ ENVIRONMENT}{BENEFIT\ FOR\ THE\ SOCIETY}\ \frac{Ship\ CO2\ Emissions}{Peformed\ Work}$$

or

$$\frac{Ship\ CO2\ Emissions}{Peformed\ Work}$$

or

$$\frac{(CO2)ME+(CO2)AE}{Capacity\cdot Vref}$$

where ME and AE stand for main engines and auxiliary engines respectively and Vref is the speed at which the vessel travels to transport the cargo (capacity).

The Energy Efficiency Design Index and the Ship Energy Efficiency Management Plan (SEEMP) have been adopted in an attempt to highlight the important Energy Efficiency Operational Index (EEOI), thus leading to measurable values against which, improvents in efficiency can be compared.

The average EEOI is defined as follows :

$$\frac{\sum_{i}\sum_{j}(FCijxCFj)}{\sum_{i} mCARGOxDi}$$

where :
j represents the type of fuel used
i represents the number of an individual journey amongst many that the vessel has performeed
FC_{ij} is the amount (tns) of fuel (j) consumedon trip (i)
C_{FJ} is the coefficient for expressing mass of CO_2 produced, from the amount of fuel (j) consumed
m_{CARGO} is the cargo that was transported on trip (i) [DWT,TEUs, GT, passengers]
D_i is the distance travelled to transport m_{CARGO} during voyage (i)

This was the first legally binding climate change treaty to be adopted by IMO, since the Kyoto Protocol. SEEMP has been developed in order to create a mechanism for each individual company to improve the energy efficiency of ships This development has supported shipping companies to adopt management tools that provide a specific approach for monitoring ship and fleet efficiency, taking into account that any company is not the same as another, and that ships operate under a wide range of different conditions. To be successful energy efficiency and conservation must become a way of life involved and address the following topics :

1. Design
2. Application
3. Monitoring and measurement
4. Evaluation and improvement

From the literature and many studies [2] [3] [4], it is obvious that there is considerable potential for reducing emissions in shipping. Already many technologies and operations have been implemented, such as slow streaming, improved voyage planning, trim optimisation, hull coating, propeller cleaning, main engine tuning, new propellers and rudders etc. These are available for retrofitting on existing vessels; thus making it easy to implement with minimal capital costs. Other technologies are limited by the cost of implementation and the lack of knowledge pertinent to their effectiveness on specific ship types, sizes and operating routes. An IMO study estimates that the implementation of these systems by shipping companies can reduce emissions of carbon dioxide (CO_2) by 25-75% [5]. On the other hand, the European Commission recently stated that the shipping industry should reduce its CO_2 emissions by 40-50% during the period 2005-2050 [6]. Eide et al. (2011) [7], confirmed that an increase of over 33% in energy efficiency, by 2030, could be achieved by implementing measures at a marginal cost which is below zero. However, many companies find it difficult to identify the nature of the energy used and pricing it accordingly [8].

The feasibility of many of the steps already described depends on where the ship operates, the cost of fuel and the remaining service life of the ship. For example, the use of wind energy in ships operating in short sea transport, which requires high speeds in congested seaways, could not be applied and would be uneconomical. Another aspect is that each sea area has its own characteristics and specific conditions and so ships designed for specific routes, may not have the same benefits adopting similar technologies. It is obvious that any management decisions should take into account the characteristics of the vessel, the commercial and geographical area in which the ship is operating in order to draw the greatest advantages from measures chosen to implement.

Today many shipping companies face decisions involving ways to reduce energy consumption as well as abiding with current regulations and directives. In Europe this is especially true, due to the European Union's commitment to reducing Green House Gass (GHGs) emissions by 40% by 2030, compared to 1990 levels [9].

2. Real case scenario

The paper presents a real case scenario for a maritime firm (name of firm and vessels changed), which faces the following management decision: In order to build a "green fleet" does it need to "buy new" or upgrade the existing fleet. Suppose the shipping company VITA TANKERS, owns a fleet of 30 tankers. The company is known in shipping circles to have an excellent record providing services. The fleet management is considered successful, since six (6) of its ships are chartered with long-term charters and the rest traded on the spot market, involving the chartering department of the company. The company is acknowledging positive signs from the chartering of ships in the spot market and has decided not to renew the charter of the six ships of the fleet, since they do not generate the necessary revenue compared to other ships. These ships are sister ship 5-6 years old and have been properly maintained, however further modifications and improvements are needed to keep pace with the new requirements and keeping-up the good vetting record approved by the majors. The 6 ships have the following characteristics (Table 1).

Table 1. Ship characteristics

Type	Suezmax
Built	2009
Deadweight	156,929
Gross Tonnage	83,545
Net Tonnage	49,022
Breadth	48.00
Depth	23.70
Main Engine	DOOSAN B&W
Aux Engine	3xYanmar

Costs involved by introducing new technologies, are described in Table 2

Three (KM VSL, TN VSL and TO VSL) of the six ships are upgraded as described above with a Schneekluth duct and silicone antifouling, and compared to their sister ships (AT VSL, VD VSL and KR VSL) which have undergone no conversion.

Table 2. Novel technologies introduced and related costs

TECHNOLOGY	COST (USD)
Propulsion System (Duct)	200,000
Silicon Coating Propeller & Hull	500,000
Installation of Ballast Water System	2,500,000
Main Engine upgrade	200,000
Smart Power Management System	100,000
TOTAL	**3,500,000**

Table 3. Comparison of sister vessel performance.

	Vessel	Speed (kts)	Slip	RPM	FO Cons (MT/Day)	Dev. fm AVG (MT/Day)	Dev. fm as built (%)
Silicon Coating/Duct	KM VSL	12.5	4.44	67.0	37.8	-5.7	-13.2
	TN VSL	12.4	8.17	69.2	40.0	-3.5	-8.1
	TO VSL	12.4	8.16	69.5	41.2	-2.3	-5.4
	Average	**12.4**	**6.92**	**68.6**	**39.6**	**-3.9**	**-8.9**
Conventional	AT VSL	12.3	10.68	70.6	44.0	0.5	1.2
	VD VSL	12.5	9.29	70.8	48.2	4.7	10.9
	KR VSL	12.3	11.95	71.7	48.2	4.7	10.9
	Average	**12.4**	**10.64**	**71.0**	**46.8**	**3.3**	**7.7**
Average as built		**12.3**		**69.0**	**43.5**		

FO Cons. = fuel consumption, Dev. fm AVG = Deviation from average, Dev. from as built (%) = Deviation from newly constructed ship (%)

The results of the comparison between the three vessels sets, are presented in Table 3, pertinent to the average consumption for ships that have incorporated energy-saving technologies compared to conventional, which have not undergone any conversion for energy savings, that are ships as built.

3. Conclusion

The improvement of ship energy efficiency has been a major issue for the shipping industry, mainly for three reasons; primarily because the fuel expenses of merchant ships contribute dramatically to the overall vessel's expenses, following the continuous increase of the bunker prices. Secondarily, the conventional diesel engines and gas turbines emit great amounts of greenhouse gases (GHGs), contributing to the climate change. Thirdly, the last six years the shipping industry was characterized by a recession, followed with a decrease in revenues and a low interest for new-buildings. Consequently, the low income made crucial the need for lowering of costs and thus new technologies through EEDI. This gave the opportunity and the time frame to the shipyards, to follow the new industry requirements, modify the standard designs and proceed with technical innovations.

On average, ship calorific efficiency technologies (duct & silicon coating) decrease fuel consumption to about 4MT/day or 8.9%, compared with the consumption as measured when newly built. From the above analysis it is concluded that when a ship is subject to modifications/upgrades, the consumption can be reduced by up to 4MT/day, compared to the consumption of a newly built ship. Ships that have not undergone an upgrade have an increased consumption of 7% compared to when it was newly built and 16.6% more than the ships that have been upgraded with energy-saving technologies. Finally, it must be added that a newly built vessel with all the recent advances in energy saving technologies has a lower consumption of about 2,08MT/day compared to an upgraded vessel. Considering other cost issues, especially fuel costs, that account to nearly 60% of all costs, it can be shown that if there is an increase in fuel costs from 360$/t to 600 $/t, the cost to the owner with upgraded vessels amounts to 11.1% less that the costs incurred to the non-upgraded vessel owner. These conclusions indicate that for the above described situation, upgrading existing vessels of the type described herewith, is a viable alternative to the purchase of newly constructed vessels.

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