"Ship Fuel Efficiency in a Historical Perspective".

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This paper discusses ship efficiency over time, measured both in relative terms as well as in absolute figures. The author chaired the Shipping Subgroup under the IMO's "Informal Cross Government/Industry Scientific Group of Experts", established by IMO's Secretary General E. E. Mitropoulos in July 2007, which reported to IMO's Marine Environmental Protection Committee in April 2008 (MEPC 57). One of the Group's main tasks was to establish an estimate of the global consumption of fuel oil and the related emissions.

KEY WORDS:

Ship fuel efficiency, Greenhouse Gas - GHG, Carbon footprint, Energy Efficiency Design Index, IMO, Kyoto Protocol.

INTRODUCTION

Shipping is by far the most fuel efficient means of transport and 90% of all goods (measured in Ton·Miles) are transported by sea. Sea transport is a necessary vehicle in the globalisation process and is in many instances the only means of transporting the goods, e.g. iron ore from Brazil to China. In a time when all industries are expected to reduce their CO_2 emissions in order to mitigate the global warming, such an expectation is also put on the shipping industry. However, with the expected growth in world trade, and hence in sea transport, shipping is forecast to increase its emissions in spite of potential efficiency gains both for new and existing ships.

In the 1997 Kyoto Protocol, which entered into force in 2005, Shipping and Aviation were kept out, mainly because the very international nature of these industries rendered them unfit for the usual national or regional emission control schemes. They were, however, not forgotten and their respective internationally governing organisations, IMO and ICAO, were encouraged to produce regulations to minimize GHG, primarily CO_2, emissions from ships and air planes, respectively.

There are signatories to Annex I of the Kyoto Protocol who want to see shipping included in a new Protocol, expected to be agreed at COP 15 in Copenhagen in December 2009 and which will replace the Kyoto Protocol by 2012.

The expression "carbon footprint" has become a buzzword in recent years. Certain commodities sold in e.g. the British retail store TESCO hold the information on how much CO_2 has been produced during manufacturing and transport of the commodity in question.

A definition of "Carbon footprint" is offered by ISA-Research as follows:

"The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product."

In a world without fossil fuels there will exist a natural balance between the levels of Oxygen – O_2 - and Carbon dioxide – CO_2 in the atmosphere. The photosynthesis uses CO_2 to produce sugar which is a building block for plants and trees. During this process O_2 is released which is inhaled by living creatures which emit CO_2. When plants and trees decompose by oxidizing they also release CO_2 and the circle is completed.

Within a limited period of time (seen in the light of the time where life has existed on this planet) e.g. some centuries this balance will only be offset by volcanic activities and similar events.

However, since the Industrial Revolution starting in the late 18th Century, CO_2 from a 100 million years old account has been added to the present account and is now offsetting the balance.

Recent studies suggest that the CO_2 content in the atmosphere has increased from approx. 290 ppm in 1900 to 380 ppm in 2000. The curve is still on a steep increase.

IMO work

In 2000 a specially assigned IMO expert group submitted a study on Greenhouse Gas (GHG) to MEPC 45. This study was later to be known as the IMO 2000 GHG Study. The study amongst other work calculated the annual oil consumption by the world commercial fleet and the related CO_2 emissions.

In connection with the revision of MARPOL Annex VI on Air Pollution, which commenced in 2005, IMO established an “Informal Cross Government/Industry Scientific Group of Experts” where BIMCO chaired the Shipping Subgroup. One of the group’s tasks was to calculate the global shipping related fuel oil consumption in 2007 and the related emissions and project those figures to 2020. The projection, which was based on a very complex computer model containing models for predicted future trends in world trade for of a range of commodities as well as containers, showed that even if future ships will be more efficient than the present fleet, the sheer growth in world trade means that the projected fuel consumption in 2020 will be 24% higher than in 2007. This assumption also reflects the fact that in 2020 approximately half of the world fleet will be ships in existence today or in today’s order books, hence none of the new ship technologies in the pipeline today will be applied to those ships. The IMO Expert Group in their projection of the 2007 data had agreed to a 15% efficiency increase across the board for the 2020 world fleet (potential efficiency gains are discussed in details on page 8-9).

The results of the IMO Expert Group study:

Year	2007	2020
Fuel oil (mill t)	369	486
CO_2 (mill t)	1121	1478

The 2000 GHG Study recommended the use of an Operational CO_2 Index as later described in MEPC Circ.471. At the latest MEPC 58 in October 2008 BIMCO, Intertanko and OCIMF in a submission recommended that the Index was amended to a rolling Index as set out below:

$$\textit{Rolling Average Index} = \frac{(\sum FC_p x C_{Carbon})_{Fuel\ type1} + (\sum FC_p x C_{Carbon})_{Fuel\ type2} + (\sum FC_p x C_{Carbon})_{Fuel\ type3} + \cdots}{\sum (m_{cargo\,i}\ x\ Dist._i)}$$

FC_p is the fuel consumption of the fuel type in question
C_{carbon} is fuel to CO_2 factor for the fuel type in question
$M_{cargo\ i}$ is the amount of cargo transported
Dist is the Distance $_i$ the cargo $_i$ is transported

Importantly, it was also emphasized and agreed that the Index was not suited for mandatory application.

At MEPC 57 in April 2008, a New Ship Design CO_2 Index was presented by Denmark for mandatory application. The thinking behind the Design Index is to ensure that future ships will be designed and built to the best standards with regards to speed/power performance, i.e. equivalent to the best present design within the ship type and size. The units of the Index are gram CO_2 per ton·mile.

MEPC 58 agreed to a slightly amended Index which was renamed Energy Efficiency Design Index – EEDI – as set out below:

Design Efficiency Index=

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} C_{FMEi}\, SFC_{MEi}\, P_{MEi}\right) + P_{AE} C_{FAE} SFC*_{AE} + \left(\sum_{i=1}^{nPTI} P_{PTIi} - \sum_{i=1}^{nWHR} P_{WHRi}\right) C_{FAE} SFC_{AE} - \left(\sum_{i=1}^{neff} f_{eff} P_{eff} C_{FMEi} SFC_{MEi}\right)}{fiCapacity\ \ V_{ref}\ \ f_W}$$

$\prod$ is a multiplier in case of several correction factors f_j
ME indicates main Engine throughout the formula
AE indicates Auxiliary Engines throughout the formula
C_F is a non-dimensional conversion factor between fuel and CO_2
SFC is the Specific Oil Consumption in g/kWh
P is the installed power in kW
f_i is a capacity factor – assumed to be 1
Capacity is DWT
V_{ref} is the referenced speed in knots
f_w is a non-dimensional weather factor – assumed to be 1

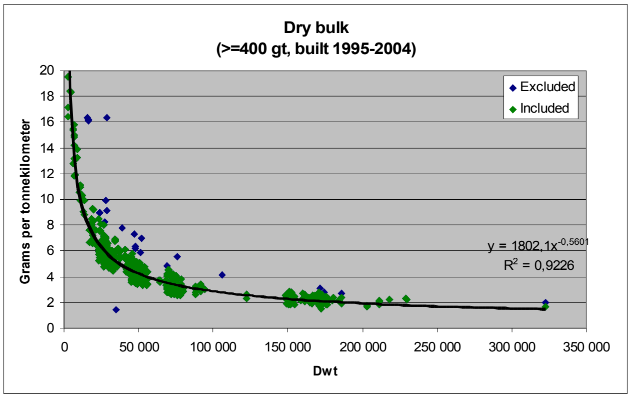
The first part of the formula is dealing with the Main Engine(s), second part with the Auxiliary Engine(s), third part is applicable to ships having a Waste Heat Recovery system installed. The last part is added to take account of new innovative efficiency technology.

The Auxiliary power is assumed to be:

5% of Main Engine, for M.E. < 10,000 kW,
250 + 2.5% of Main Engine, for M.E. > 10,000 kW

When a shipyard ship is designing a ship, it must during the design phase ensure that the baseline for that ship type and ship size is met (see diagram below applicable to Dry Bulk Carriers). At the actual sea-trials the shipyard must then verify that the baseline really is met. The idea is then to gradually lower the baseline year by year by a few percent and thus ensure that ships in general will become more and more efficient over time. This is similar to the mechanism applied in the Emission Trading Schemes agreed under the Kyoto Protocol.

Presently, the plan is to apply the Index concept to seven different ship types, but over time more may be included. What will happen to ships not being able to verify that they meet the baseline, is a problem not yet solved in IMO.



Baseline for dry bulk carriers (in gCO2/t·km)

Carbon footprint of various ships over time.

In the following section the "Energy Efficiency Design Index" will be calculated for a number of ships. The ships are in a historical sense rather spectacular as they include the world's first ocean going diesel powered ship, the world's fastest containership and the world's largest containership. Finally, a traditional coal fired steamship and a more conventional containership are exposed to the calculation. The exercise is meant to demonstrate efficiency gains over time as well as the "economy of scale" effect.

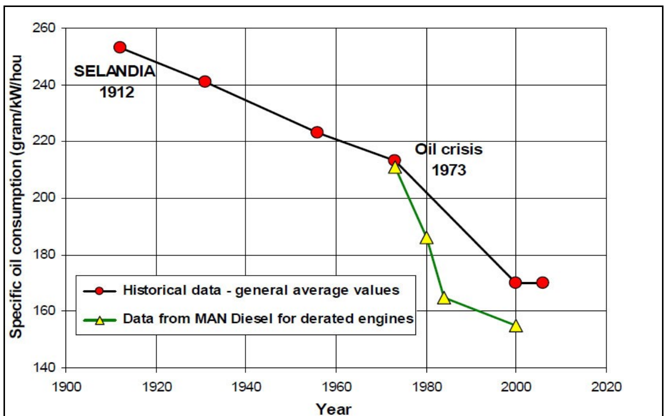


Fig. 1 General development of specific fuel oil consumption for 2-stroke diesel engines

The graph above shows the development in Specific Fuel Oil Consumption since the commissioning of the first ocean going diesel ship "Selandia". The figures from later years are based on engines running on Marine Gas Oil on the test bed. Actual figures experienced onboard are somewhat higher and for the purpose of this exercise 190 g/kWh is used.

Assumptions in the calculations:

For the purpose of the calculations of the Energy Efficiency Design Index for the ships below, the following assumption have been made:

<u>Specific Fuel Consumption:</u>

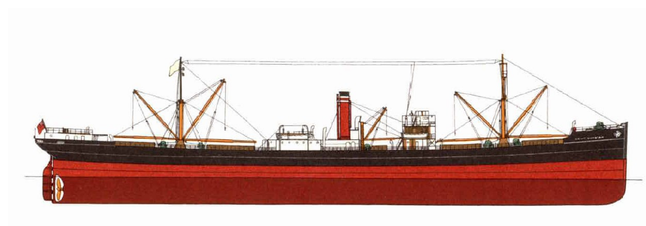
Coal fired steam engine:	320 g/HPh ~ 435 g/kWh
Oil fired steam turbine:	217 g/HPh ~ 295 g/kWh
Old diesel engine:	185 g/HPh ~ 252 g/kWh
Modern 2-stroke diesel engine:	140 g/HPh ~ 190 g/kWh
Modern 4-stroke diesel engine:	155 g/HPh ~ 210 g/kWh

Where the actual fuel consumption at a specific speed has been provided, this figure has also been used.

The non-dimensional fuel to CO_2 ratio:

Coal –> CO_2:	2.86
MDO –> CO_2:	3.21
HFO –> CO_2:	3.11

Trial assessment of five different ships.

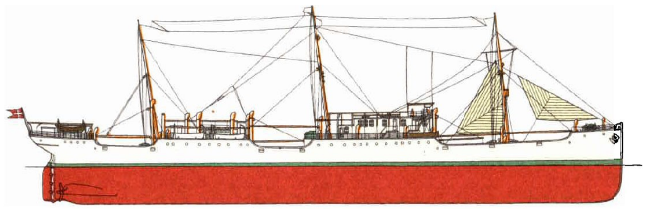


S/S "Saint Dunstan"

The S/S "Saint Dunstan" was a typical steam ship delivered in 1919 from Northumbria Shipbuilding Company in Howdon-on-Tyne. It was equipped with a coal-fired, triple expansion steam engine and its main features, for this exercise, were:

DWT	5661 t
Power	3450 IHP = 2540 kW
Fuel	Coal
Speed	11.5 knots

Index = 38.8 gCO_2/t·mile

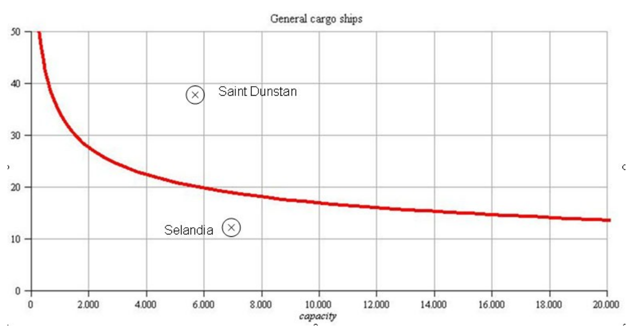


M/S "Selandia"

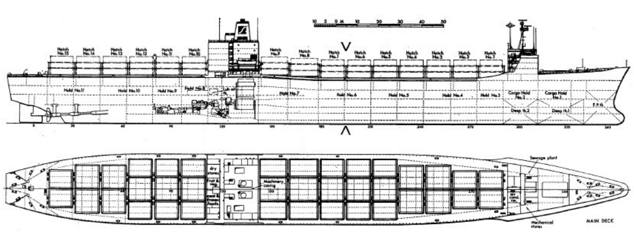
The world's first ocean going diesel ship was the M/S "Selandia" delivered in 1912 to the East Asiatic Company in Copenhagen. The ship was built at Burmeister & Wain Shipyard in Copenhagen and had two diesel engines directly coupled to two propellers.

DWT	7000 t
Power	2100 BHP ~2210 IHP = 1630 kW
Fuel	Marine Diesel Oil (MDO)
Speed	11.0 knots

Index = 12.6 gCO_2/t·mile



It is quite remarkable how much more efficient the diesel ship is compared to the coal fired steam engine ship. Still, it would take several decades before diesel engine installations became the norm in merchant ships.



Outline of the Sea-Land SL-7

Sea-Land SL-7 after conversion to US Military Sealift Command service.

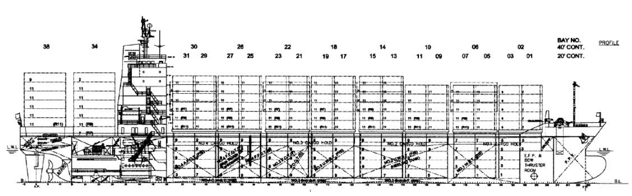
The USA based container company Sea-Land commissioned eight sister-ships in 1972-73 from three shipyards in Germany and the Netherlands. The ships were extremely spectacular and albeit not being the world's largest containerships at that point in time they were by far the fastest, and indeed the fastest ever built. They were equipped with two General Electric steam turbines, each providing 60,000 SHP on each propeller.

Their service speed was 31 knots but they were capable of doing 34-35 knots. Their daily fuel consumption at 31 knots is stated to be 490 tons of HFO.

DWT	27,634 LT = 28,049 MT
Nos. of TEU:	1968
Power	120,000 SHP = 128,076 IHP = 94,866 kW
Fuel	Heavy Fuel Oil (HFO)
Service Speed:	31 knots
Max Speed:	35 knots
Consumption (at 31 knots):	490 t/d

Index = 75.6 gCO_2/t·mile (based on 490 t/day)
Index= 79.8 gCO_2/t·mile (based on formula)

Index = 1041 gCO_2/TEU·mile (based on 490 t/d)
Index = 1100 gCO_2/TEU·mile (based on formula)



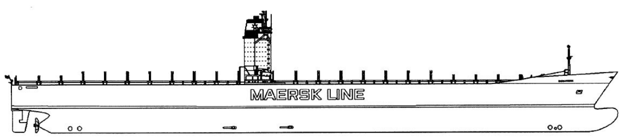
"YM Intelligent" in profile

The "YM Intelligent" is included to compare "like with like", i.e. to show how a modern containership with almost the same capacity as the SL-7 series performs today. The “YM Intelligent” was built in 2006 for Yang Ming Marine Transport Corp. (Taiwan) by China Shipbuilding Corp. Taiwan. In 1972 this would have been reckoned as a large containership, however, today it is merely a container feeder-ship.

DWT	22,027 t
Nos. of TEU:	1805
Power	15,820 kW
Fuel	HFO
Service Speed:	20.2 knots (at 90% MCR)

Index = **16.7 gCO_2/t·mile**

Index = **204 gCO_2/TEU·mile**



“Emma Maersk” in profile

“Emma Maersk” upon delivery

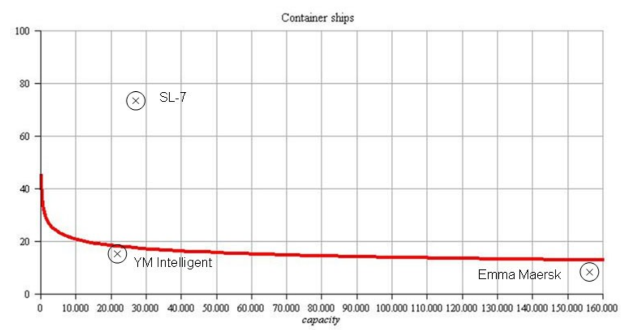
“Emma Maersk” was delivered in 2006 from Odense/Lindø Shipyard in Denmark as the first in a series of seven sister-ships. The official nos. of TEUs given by Maersk Line is 11,000, whereas the magazine “Significant Ships of 2006” (RINA) suggests 11,500. The theoretical number is most likely 15,000+ but for consistency the number 11,500 is used in this calculation.

The “Emma Maersk” has, like a number of previous Maersk containerships, been equipped with a “Waste Heat Recovery” (WHR) system. The WHR utilizes the heat in the exhaust gas to feed a boiler which via a turbine produces electricity. Under optimum conditions as much as 10% of the installed Main Engine power may be retrieved this way and can be applied to the shaft motor.

DWT	157,000 t
Nos. of TEU:	11,500
Power	80,080 kW
Shaft motor:	8,000 kW
Fuel	HFO
Max Speed:	25.0 knots (without WHR)
Max Speed:	25.8 knots (with WHR)

Index = **9.4 gCO_2/t·mile** (without WHR)
Index = **9.2 gCO_2/t·mile** (with WHR)

Index = **128 gCO_2/TEU·mile** (without WHR)
Index = **125 gCO_2/TEU·mile** (with WHR)



It is worth noting that the two containerships from 2006 both qualify for the Design Index.

Summary

	DWT	kW	kW/DWT	Index
Saint Dunstan	5661	2540	0.449	38.8
Selandia	7000	1630	0.233	12.6
SL-7	28076	94866	3.379	73.0
YM Intelligent	22027	15820	0.782	16.7
Emma Maersk	157000	80080	0.510	9.1

It is evident that the formula rewards ships with limited installed power and high DWT, by providing such ships with a low index. Speed is also rewarded (being in the denominator of the index formula), but as the relationship between power and speed is an exponential curve, with the exponent often > 3, the power required for speed over a certain level will increase the numerator more than the speed itself will increase the denominator and thus result in an increase of the index.

There are many other apparent examples which could be illustrated here, for example steam turbine VLCCs built before the oil crises typically using around 180 t/day compared with new diesel powered VLCCs using around 120 t/day. However, when comparing tankers it must be borne in mind that the double hull requirements, introduced and imposed after the "Exxon Valdez" oil spill in 1989, have resulted in tankers generally being more voluminous and thus difficult to compare directly. Even so, a modern VLCC is far more fuel efficient than an old one.

RECENT TRENDS

As shown above the Shipping Industry has demonstrated a remarkable increase in efficiency when measured in terms of "Economy of Scale". In order to assess the efficiency increase when comparing "like with like" eight shipping associations incl. BIMCO decided to have a study to that effect carried out. The project description was formulated in June 2008 and Lloyd's Register Maritime Services was engaged to carry out the work based on data contained in the Lloyd's Fairplay database. The study assesses ships of equal sizes built in 1985, 1990, 1995, 2000, 2005 and 2008 and evaluates the efficiency of each "vintage" measured in gram CO_2/ton·mile, similar to the Energy Efficiency Index.

It was decided to investigate the following ship types and ship sizes:

Ship type	Subtype	Size range	Fuel consumption and CO2 indices' units
Tanker	VLCC	220,000 < DWT <320,000	grams/tonne mile
	Aframax	85,000 < DWT <120,000	grams/tonne mile
Bulk	Handysize	30,000 < DWT <40,000	grams/tonne mile
	Panamax	65,000 < DWT <80,000	grams/tonne mile
	Capesize	170,000 < DWT <180,000	grams/tonne mile
Container	4500 TEU	4000 < TEU < 5000	grams/TEU mile & grams/tonne mile
	1800 TEU	1600 < TEU < 2000	grams/TEU mile & grams/tonne mile
Cruise	Panamax	60,000 < GRT < 110,000	grams/Pax mile & grams/tonne mile & grams/GRT.mile

Before going to the results of the study, the following statement is put on the table:

When freight rates are low:

- Meagre order books for shipyards
- Competition between shipyards is tough
- The innovative designs will win the day

When freight rates are high:

- Owners queue up to order ships
- Shipyards are reluctant to change Standard Designs
- Shipyards have no incentive for innovation

This paper will divide the total period of the referenced study into three periods:

1) In broad terms, and only looking at tankers, bulk carriers and containerships, the period from early 1980's to early 1990's were relatively stable. A few ups and downs in the freight rates but no major disruptions. Freight rates were not impressive, but neither disastrous during that period. Room for some innovation, but no major incentives.

2) From early 1990's to approx 2002, including the Asian Crises starting in 1997, the freight rates were rather poor and the same period saw many shipyards, in particular within the EU, going bankrupt. This was truly a time for innovation.

3) From 2002 and up till now (October 2008) the freight rates have been booming, in particular in the dry bulk business where the daily freight rates have reached pikes never previously seen or anticipated. Capesize bulk carrier rates, which were often below USD 10,000 per day in the previous period, sky rocketed to USD 100,000. In 2007 the USD 200,000 bar was exceeded, primarily due to China's unsaturated craving for iron ore. During this latter period many shipyards and ship designers have put more emphasis on cargo intake than on fuel efficiency. As an example, Panamax bulk carriers have increased their DWT from around 75.000 to close to 80,000 within the same design constraints (L, B, D, T). This is only possible by increasing the Block Coefficient (C_b).

Other factors influencing the efficiency of ships in later years are the introduction of MARPOL Annex VI and the NO_X Technical Code. The various NOx abatement techniques have proved to have a negative influence on the overall efficiency of the engines, which is also illustrated in the curve on page 3 of this paper. Moreover, the booming freight rates have also resulted in larger engines in many newer ships, in particular tankers and bulk carriers. A larger engine will by the nature of the Index formula produce a larger index.

The following graphs from the referenced study are meant to verify the statement made above on freight rates' influence on innovation in shipbuilding. Note that the units used are "Fuel Consumption Index. A blue ellipse emphasizes an increase in ship efficiency whereas a dark red ellipse shows a decrease in ship efficiency:

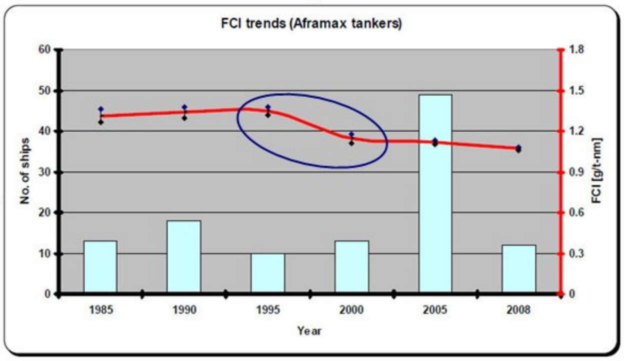


Figure 2 – Fuel consumption index (FCI) for aframax tankers

A 15% increase in efficiency in Period 2.

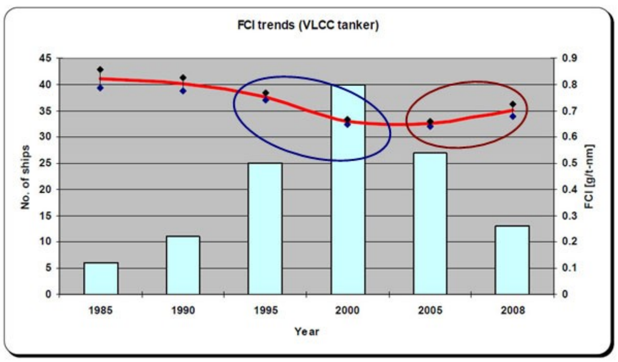


Figure 3 – Fuel consumption index (FCI) for VLCC tankers

Increase in efficiency in Period 2, a decrease during Period 3

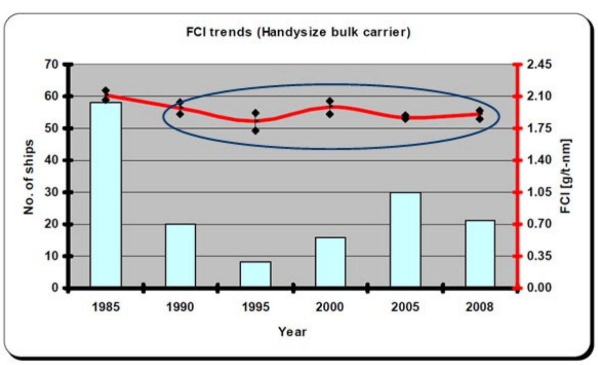


Figure 4 – Fuel consumption index (FCI) for handysize bulk carriers

No real significant trend – however, no improvement from 1990 to 2008.

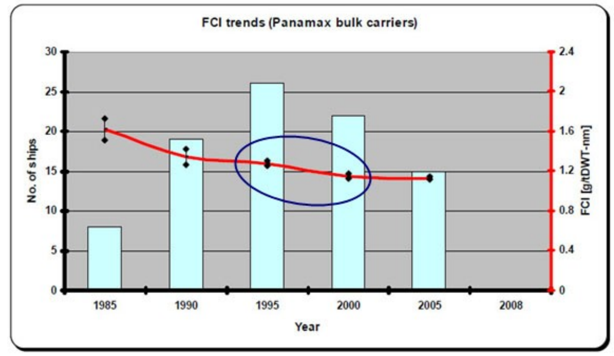


Figure 5 – Fuel consumption index (FCI) for Panamax bulk carriers

A general increase in efficiency during Period 1 and 2, thereafter a flat curve.

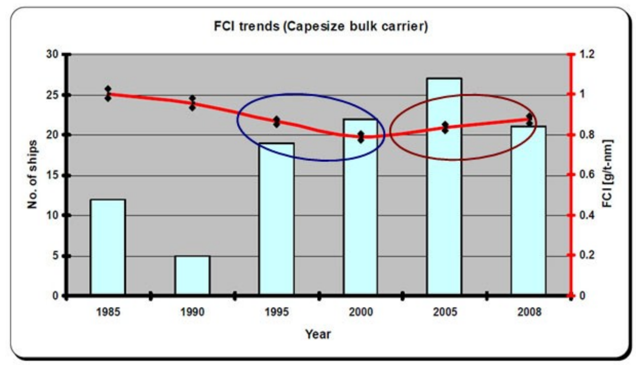
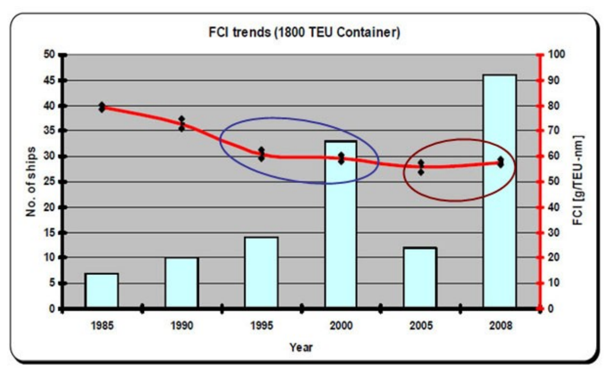
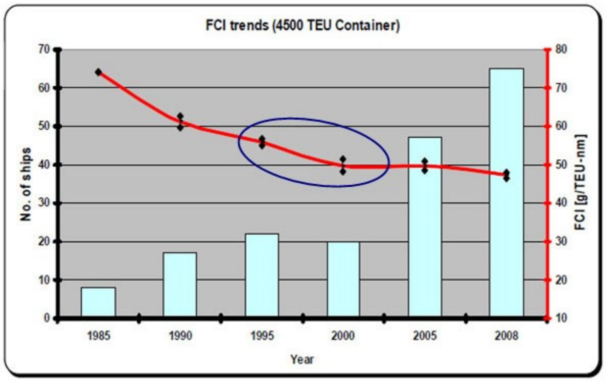


Figure 6 – Fuel consumption index (FCI) for capesize bulk carriers

Remarkable increase in efficiency during period 1 and 2, thereafter a roughly 10% decrease in efficiency.



Increase in efficiency during Period 1 and 2, thereafter quite flat curve.



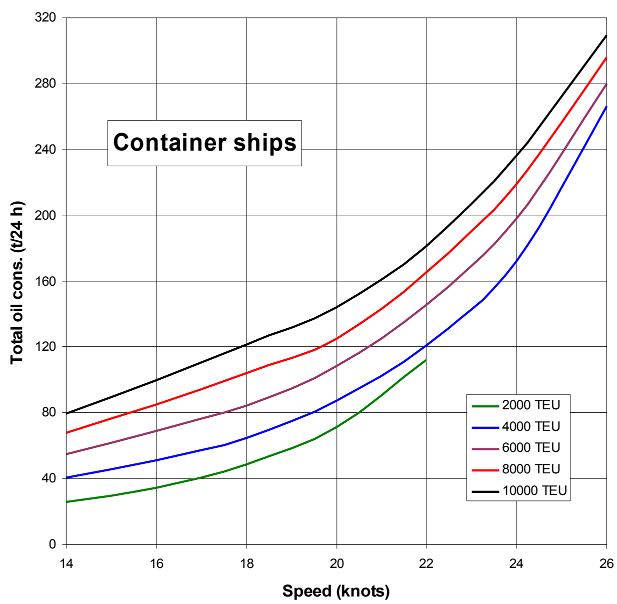
A quite remarkable increase during Period 1 and 2. Thereafter no development.

MEASURES TO ENHANCE FUEL EFFICIENCY

The Shipping Subgroup of the IMO "Informal Cross Government/Industry Scientific Group of Experts" was also tasked with identifying measures to reduce air emissions by reductions in fuel consumption.

For shipowners it will always be an advantage to operate ships with lower oil consumption than the ships of competitors. Even when his ships are on time charter, where the charterer pays the fuel costs, it will be beneficial when negotiating the charter rate.

There are a number of operational measures to reduce fuel consumption which shipowners can implement, the most obvious being to reduce speed, also called "Slow steaming".



Based on the speed-power curves above it can be demonstrated that if a 8000 TEU containership (second curve from top) reduces its speed by 20% (from 25 knots to 20 knots) the fuel consumption is reduced by 51%. Lately some container operators have adopted that measure in order to save fuel and, allegedly, to stabilize the freight rates.

However, slow steaming in the tramp market may pose a contractual problem as it in most cases will be in breach of the basic principle of Charter Parties, which is usually expressed as: *"..the ship must proceed with utmost despatch…"*. BIMCO is presently working on a "Slow Steaming Clause" to cater for this problem.

In connection with slow steaming, another very efficient means of reducing fuel consumption would be to improve the logistics system efficiency. All too often ships steam at full speed to meet the charter requirement only to find that they have to anchor and wait two days or two weeks for a vacant berth. If the speed could be reduced early in the voyage a considerable fuel saving could be achieved. This measure is largely outside the control of the shipping industry. Only a few major liner operators who operate their own terminals have some control of this.

Technical efficiency gains can be best captured with newbuildings where measures are incorporated into the design from the outset. There are, however, a number of relatively simple measures that many shipowners have adopted for existing ships. Below is a table listing some of the measures which can be utilized by new and/or existing ships.

Measure no.	Description	Existing ships gain %	Newbuildings gain %
1	Main Engine efficiency rating	2	
2	Main Engine optimization		2
3	Waste Heat Recovery		5-10
4	Optimize hull shape, incl. reduced Cb		3-10
5	Optimized propeller	2	3-6
6	Maintenance of wetted hull surface	2-5	2-5

7	Improved anti fouling paints	2-8	1-2
8	Twin skeg + twin propeller		5-8
9a	Trim optimization – large Cb ships	1-2	1-2
9b	Trim optimization – small Cb ships	Max 10	Max 10
10	Misc. Fuel saving devices	2-6	2-6

Measure No. 1 and 2 are in-engine improvements for new and existing ships based on today's technology.

No. 3, the Waste Heat Recovery system is mostly applicable to ships with large power plants and cannot be expected to be introduced on ships in general. Not likely to be retrofitted on existing ships.

No. 4 can be broken down into optimized bulb, optimized stern and reduced block coefficient (Cb).

No. 6 and no. 7 may introduce some degree of double counting if just added as two independent measures. The effect will be most significant on existing ships.

No. 8 is basically used to improve manoeuvrability or for reasons of redundancy, rather than being optimized as a fuel saving measure

No. 9 "Trim optimization" gives little effect for slow steaming ships with high Block Coefficients (Cb) like tankers and bulk carriers, which also are ships typically operating at very differing draughts. For fast ships with low Cb, like containerships, reefers, and RoRos, there may be up to 10% fuel savings if the ships can be operated at optimum trims.

No. 10 is a combination of various devices such as ducts, fins etc. to improve the water flow to the propeller.

It is difficult to estimate a total gain from the above listed measures, as not all may work together, however 10% for existing ships and up to 30-40% or more for newbuildings should be achievable.

For most ships a speed reduction of 10% will mean a 15-25% reduction in fuel consumption, however, with everything else being equal, 10% speed reduction will also call for 10% more ships. Weather routing is also suggested as a means to reduce fuel consumption, but is believed to gain less than 1% in average.

A relatively new potential reduction measure is "Air Cavity System" where an air cushion is introduced under the ship to reduce the hull/water friction, achieving a 7-15% fuel saving. Full scale tests with a 2,560 DWT ship has been carried out and the company behind the concept (DK Group) is negotiating application of the system on a Capesize bulk carrier.

Sails have for a long time been a feature in the leisure industry where a number of relatively large passenger sailing ships are popular. The sails are, however, more of a gimmick than an actual means of propulsion, whereas sails have also been tested on cargo ships with limited success. A recent invention is branded as "Sky Sails" where a large kite, attached to the fore mast, adds to the propulsion. The fuel savings are difficult to quantify as they will be depending on the actual routes the ships in question are trading.

Finally, the ultimate solution to curb emissions from ships is to use nuclear power. This has been tried in the past with little economical success, e.g. on the US merchant ship "Savannah" and the German "Otto Hahn". However, in the Russian Arctic waters a number of nuclear powered icebreakers as well as a nuclear powered cargo ship are in year-round operation. For more generic use of nuclear powered ships, a number of concerns such as availability of specialized crew as well as maritime security need to be addressed.

SUMMARY AND CONCLUSION

Although this mini-study by no means is comprehensive, it should be evident that ships generally have improved their fuel efficiency over time. This is particularly the case when taking "Economy of Scale" into account. A number of other examples could have been used to demonstrate this statement, in particular pre-oil crises ships compared to post-oil crises ships.

The trend in recent years, which seems to indicate that ships within the three categories addressed in this study are decreasing their fuel efficiency, is interpreted by the author as a result of more emphasis on cargo intake and speed than on fuel efficiency. This is specifically the case for tankers and bulk carriers.

Although fuel prices have tripled over the last six years the booming freight rates have in general been able to absorb this. Fuel cost has, however, very different impact on the shipowner depending on whether the ships are operated on time-charter, voyage charter or if it is liner business. The two former can partly or fully pass on the fuel bill to the charterer, whereas the liner operator must bear all the fuel costs himself.

Given the enormous focus on CO_2 and global warming in later years, the author of this paper will encourage ship designers and shipyards to pay more attention to fuel efficiency rather than optimizing for cargo intake.

DISCLAIMER

Any political positions which may be interpreted from this paper are to be construed as the author's and not as official BIMCO positions.

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It should be acknowledged that before the world wide introduction of the Internet, studies required long hours exercising fact finding in dusty libraries. In today's world there is an abundance of information available on the Internet. However, with this easy access to information a more critical approach must be exercised. As an example for this paper, when Googling "Emma Maersk" some 57,000 hits are found and not all pages are equally factual. The media Wikipedia offers an abundance of information on almost every issue, but it is an uncensored media which must be used with the utmost scepticism. For the purpose of this paper information has been collected from the following Internet addresses:

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