Potential Fuel Savings from Operational Measures in Sea Transport

A Study on general environmental improvements and specifically on fuel management

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Summary

The fossil fuels used to propel the ships of today across vast oceans are a finite resource. In addition to them eventually being depleted, the combustion of carbon based energy forms emits greenhouse gases that are destructive to the ecological environment.

Shipping as a mean of transport has always been considered a relatively "clean" way of transporting goods but in reality the shipping industry emits substantial amount of greenhouse gases in absolute terms. The sea trade is crucial to an ever growing global economy and will grow at the same rate. Measures to make the shipping industry´s ecological footprint as small as possible should be a priority for everyone involved. It is not just a question about the environment; it is a question of economic survival.

There are numerous saving regarding fuel consumption to be made by operational measures alone. The fuel wasted in today´s shipping industry represents money that could be better spent elsewhere; it should therefore be in every ship owner´s interest to use that money more efficiently. The road to better fuel economy aboard is long and winding, so the sooner improvements are begun, the better.

Language: English Key words: energy, efficiency, operational, methods

EXAMENSARBETE

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Sammanfattning

De fossila bränslen som används för framdrivningen av moderna fraktfartyg är en förgänglig resurs. I tillägg till problemet att de en vacker dag kommer att vara slut skapar förbränningen av bränslet växthusgaser som är destruktiva för miljön

Traditionellt har sjöfarten ansetts vara en relativt "ren" transportform men sanningen är att sjöfartsindustrin släpper ut avsevärda mängder växthusgaser, mätt i absoluta siffror. Åtgärder för att göra sjöfartsindustrins ekologiska fotspår så litet som möjligt borde vara en prioritet för alla verksamma inom industrin. Det är inte bara en fråga om miljön, det är också en fråga om ekonomisk överlevnad.

Enbart på den operativa sidan av verksamheten finns det finns ett otal inbesparingsåtgärder som kan vidtas för att minska bränsleförbrukningen. Det bränsle som idag förslösas inom sjöfarten representerar rena pengar som kunde användas till annat. Det borde därför ligga i varje fartygsägares intresse att använda kapitalet mer effektivt. Vägen mot en bättre bränsleekonomi är lång så ju förr förbättringar inleds, dess bättre.

Språk: Engelska Key words: Energi, effektivitet, operativa, metoder

1 Introduction

As demands for more energy efficient transports are required by both legislators and ship operators, the focus on how to reduce fuel consumption, by any possible mean, is widening. New technologies and innovations presents vast possibilities in fuel consumption reductions in ship newbuildings but a significant percentage of the world fleet will continue to consist of vessels with equipment designed with low cost rather than good fuel economy in mind. The life cycle cost seems to be of little interest to shipping companies and investors.

However, there are methods that can enable significant energy savings without the large costs of new-buildings or retro-fit/upgrades projects. By changing the way vessels are operated energy savings can be accomplished both in relative and absolute terms. The incentive for the shipping companies to make these changes should be high since low costs versus savings in fuel expenses make for a relatively short time until the investment breaks even. In other words an investment in operational procedures will break even in a short time since the investment costs are low. After the breakeven point has been reached every cent saved will be pure bottom line result effect to the company.

1.1 Objective

The objective of this study is to analyze four international shipping companies and study what operational methods they have implemented with regards to energy efficiency. The results of the implemented methods are also analyzed and general recommendations are made when possible. An assessment of the inter-corporate culture regarding energy efficiency is also made in order to examine what it takes in order to make a shipping company energy conscious. The hypothesis of the study is that significant savings in fuel consumptions can be made relatively easily but it takes determination and focus of the company and its employees, both ashore and aboard the vessels.

1.2 Research questions

In this thesis I will focus on answering two main research questions. Firstly I will try to answer the question whether operational measures alone are enough to reduce fuel consumption significantly in sea transports. The definition of the term “significant” will in this thesis mean savings that are measurable, i.e. savings starting from about one percent and up. Already a one percent saving is considered significant because of the large amount of fuel used by the shipping sector, measured in absolute terms, combined with current high fuel prices.

The second question I will try to answer is how big a role inter-corporate culture plays in the process of deciding if and what operational, energy saving, measures are to be implemented. I will through interviews examine the culture of the chosen shipping companies and try to find patterns and/or differences in their views on the importance of energy conservation.

1.3 Delimitations

I have chosen to focus solely on the absolute savings that can be made using the different methods described in this thesis. I have not taken into account surrounding factor that might make the decision of whether to implement a new procedure or not, more difficult. Factors not included in this study are for example: late arrival in a port, with subsequent penalty fees, as a result of steaming slower or the revenues lost due to a slower cruising speed that could lead to a fewer trips being possible in a fiscal year.

The complexity of the shipping industry makes the energy efficiency part of the industry an interesting object for further studies. The barriers to implement new methods and procedures in a shipping company could be an interesting aspect to investigate further, in my opinion.

1.4 Method

I have used two methods in this study. Firstly, I have conducted interviews with leading personnel in the field of operations and the field environment in the shipping companies picked for the study. The companies in the study were selected because of their size in the sector of shipping that they operate in and because of my pre existing notion that they are considered, by active sea-farers, to be pro active in their work to improve energy efficiency. Secondly I conducted literature studies to research what had already been done in the field and I then tried to compare my interview results to the research already made.

The study was conducted as qualitative research since obtaining large amounts of data about the energy efficiency work of shipping companies is difficult as this is often regarded as confidential information. Interviewing key personnel was therefore considered a sufficient way of discovering the possibilities of what energy efficient operational measures may achieve.

The interviews with the representatives from the shipping companies were carried out in December 2011 as well as in January and March 2012 in person by me. Follow up questions and/or clarifications were made through telephone conferences or via e-mail in January 2012.

In chapter 7, Operational Methods, the interviews were carried out to illuminate methods used and tried by the different shipping companies. All the statements and opinions concerning the mentioned shipping companies represent those of the interviewees. All statements concerning Maersk Line are the opinions of Mr. Karl Jivén, Sustainability Manager of Maersk Line, located in Gothenburg. All statements concerning Stena Line are the opinions of Mr. Lars-Erik Hellring, Superintendent and Project Manager for the Energy Savings Programme at Stena Line situated in Gothenburg. Concerning Wallenius Marine, all statements are the opinions of Mr. Per Tunell, Head of Environmental Management at Wallenius Marine located in Stockholm. Regarding Neste Oil, all statements concerning the company are the opinions of Mr. Sami Niemelä, Technical Manager at Neste Oil, situated in Espoo. The data stated in chapter 7.3.3 regarding Tallink Silja Line, was received from Captain Ola Bengtsson, senior captain on M/S Silja Symphony, a Tallink Silja Line owned and operated vessel. In addition to the interviews with representatives of the shipping companies, Mr. Hannes Johnson, doctoral student at Chalmers Maritime Environment, provided insightful information about the challenges concerning energy efficiency in sea transports.

In chapter 7 the results of the interviews are compared to the estimates made by Wartsila in their Energy Efficiency Catalogue 2011. It is important to point out that the numbers in the catalogue are only estimates made by Wartsila. Since Wartsila has been a well known actor in the world wide maritime cluster for a considerable amount of time their estimates are considered expert opinions. The numbers do therefore provide a baseline for comparison of the findings of the interviews.

2 General fuel efficiency

Saving fuel is not just a matter of protecting the environment; it is also a question of financial benefits. With every tonne fuel less consumed in propelling a ship forward, there is the monetary value of that tonne saved. In a case where fuel can be saved with little or no cost to the ship operator, the benefits are both environmental and economical. There are often no, or at least relatively small, costs involved when operational measures are implemented. Therefore, it is often easiest bunker-saving measures on the operational side of the business.

Oil and fuel prices are currently at a high level and there are is little reason to believe that prices will drop in the future. The higher the price on fuel, the more incentive to reduce bunker consumption there is. Every shipping company should realize that a tonne of saved fuel today will be worth even more in the future.

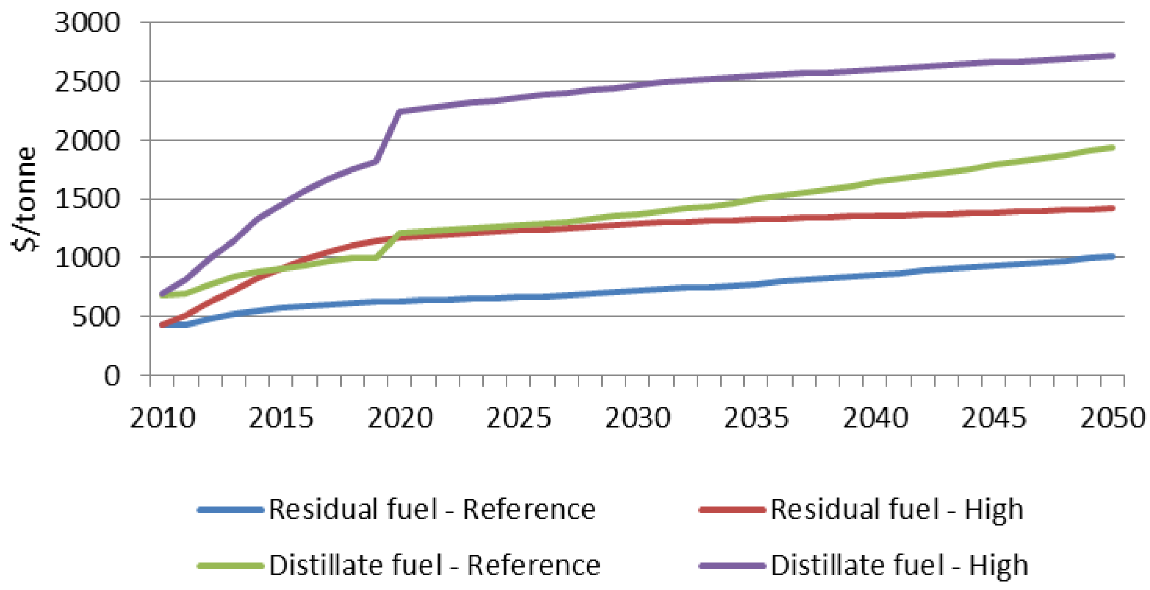

Figure 1. Predicted fuel prices 2010 – 2050 (Bazari & Longva, 2011)

Figure 1 shows IMO´s projection of where the fuel prices might be going from 2009 until 2050. The reference price starts at 371/594 $/tonne for residual/distillate and peaks at 1008/1935 $/tonne in 2050. The high estimate starts at 371/594 $/tonne and peaks at 1416/2719 $/tonne in 2050. In the reference scenario the price almost triples for residual fuels and a little more than triples for distillates. The high estimate shows price increases that are almost four times as high for residual fuels and about four and a half times for distillates. (Bazari & Longva, 2011)

Commercial ships are usually run on Heavy Fuel Oil (HFO) that is a residual fuel and/or Marine Diesel Oil (MDO) that is a residual diluted with distillate fuel. The bunker cost for an average vessel will therefore be the combined HFO and MDO bunker consumption times a weighted average that lies somewhere between the prices of the residual- and distillate fuels. This goes to show that a tonne saved today will increase its own saving over time and end up saving anywhere between about three and four times its present market value until 2050.

2.1 Possible saving due to operational measures

There are a number of operational measures that can be implemented onboard a ship with little or no investment cost. The actual savings in bunker consumption naturally depends on the actual measure taken but some studies have also been conducted on the possible monetary gaining in lowering carbon dioxide emissions at sea. A study by CE Delft in 2011 (Faber;Behrends;& Nelissen, 2011) calculated the marginal cost of reducing carbon dioxide (CO2) exhaustion from the world shipping fleet. The CO2 produced by burning a gallon of HFO is approximately 11.79 kilograms. (Energy Information Administration, Office of Integrated Analysis and Forecasting, U.S. Department of Energy, 2005). Since there are 264,2 gallons to a meter cubed, a meter cubed of HFO will emit approximately 3,1 tonnes of CO2. The density of HFO is 930 kilograms per meter cubed, one tonne of HFO will therefore emit approximately 2,9 tonnes of CO2.

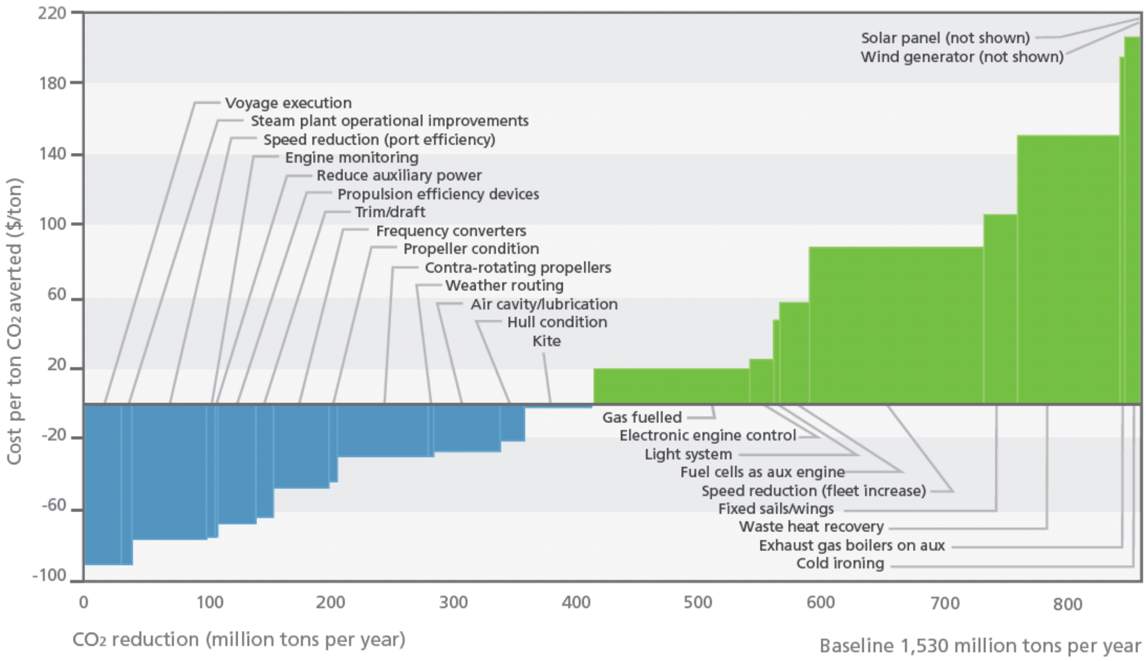

Figure 2. The marginal cost of carbon dioxide reduction by different measures. (Faber, et al., 2011)

In Figure 2 the marginal cost of different CO2 reduction alternatives in the world fleet are shown. All the measures that show a negative marginal cost (blue bars in the figure) are measures that will save money from the moment of implementation. The opposite is also true; the green bars tell us that implementing that particular measure will generate a cost for each additional tonne of CO2 not emitted. Since I have concluded that one tonne of HFO emits approximately 2,9 tonnes of CO2, the marginal cost of reducing one tonne of CO2 can be divided by 2,9 to get the monetary value of reducing the bunker consumption by one tonne. The blue bars will show the profit made and the green bars the loss accumulated. If we also assume the price development of residual- and distillate fuels that IMO predicts, that monetary value can be multiplied by the price hike to estimate future savings or losses.

It is easy to see from Figure 2 that many of the measures with a negative marginal cost are operational. On the other hand all of the measures with a positive marginal cost are technical and/or possible only in new built ships. Because of this correlation it seems as though the easiest and most profitable way to start reducing the bunker consumption in any company would be to go at it from an operational point of view.

The exponentially decreasing Environmental Performance Curve shows us the same fact in a different context: when implementing measures that are aimed at preserving the environment, the investment cost buys a lot of result early on. The more work done, the harder it gets to continue showing positive results and the marginal cost for continued improvement increases exponentially. (Conlogic AB, 2010)

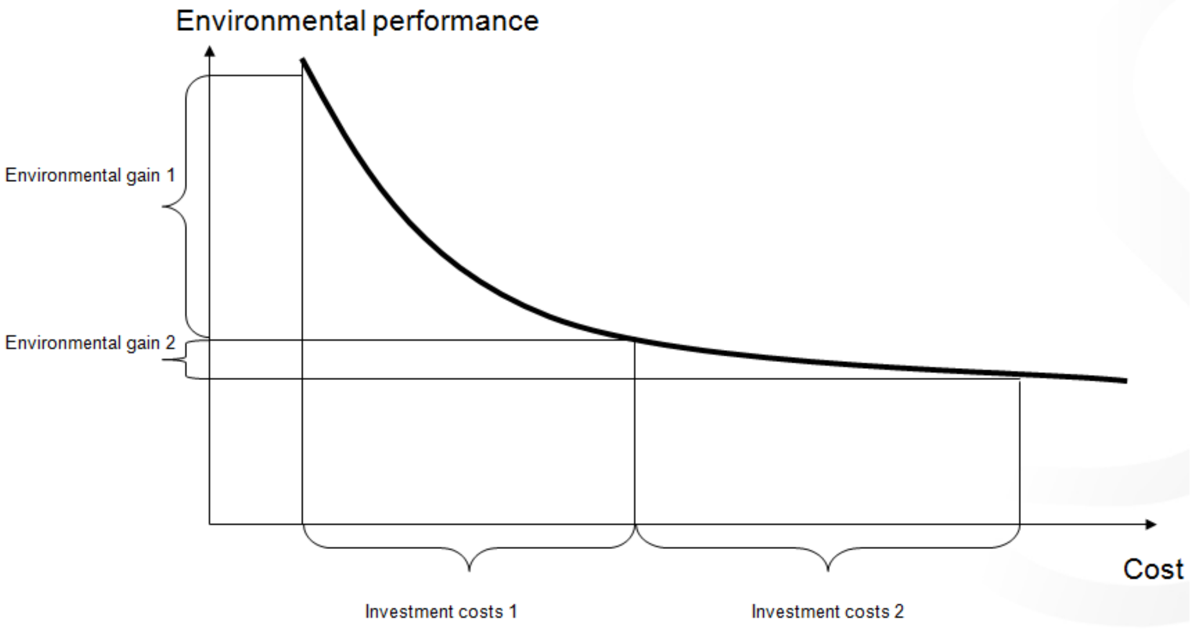

Figure 3. The exponentially increasing cost of environmental gain. (Conlogic AB, 2010)

In figure 3 the exponentially increasing marginal cost of environmental gain is evident. The first investment buys a significant amount of environmental gain. The second investment is larger than the first, but still only buys a fragment of the gain. The environmental performance curve fits perfectly into the theory that operational measures will buy a lot of bunker consumption reduction for a relatively small cost.

2.2 Why saving money on bunker consumption should be important to a company.

The basic concept of company operations tells us that a company needs to make a profit to survive long term. By saving money on operations the profit will increase which in turn will increase the shareholders return on investment. From a strictly financial point of view the environmental factors are just an added bonus even though the environmental savings probably are usable in the company´s PR department, since ecological care currently is a hot and media sexy topic. There is however also a long term survivability issue that the company will benefit from.

A company´s profitability is the difference between the amount of capital used on running the business and the revenues received from the customer. The customer pays a price for the company´s product that is defined by the law of supply and demand and it is reached in the equilibrium between the two.

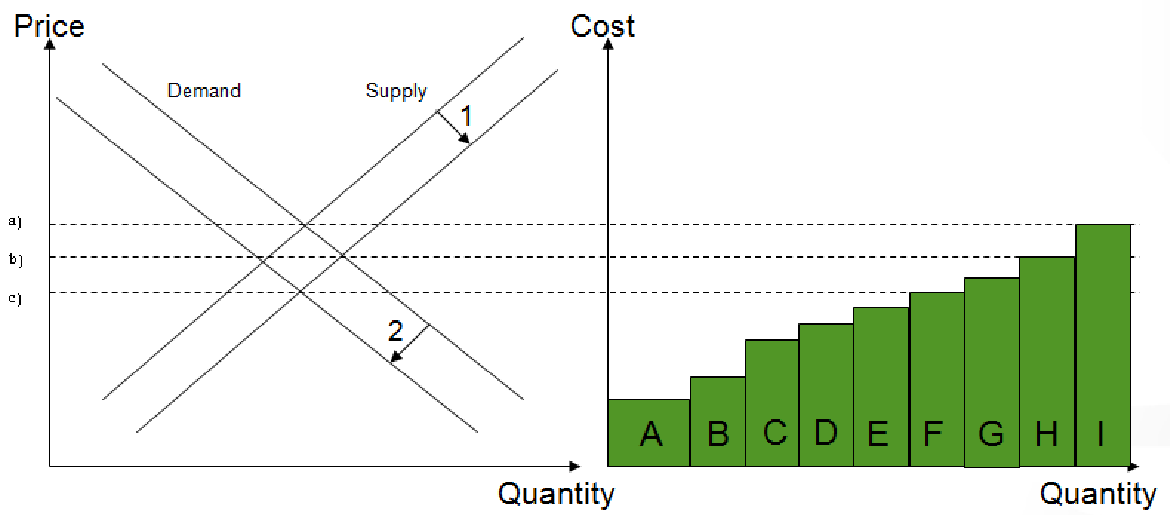

Figure 4. The effects of different supply and demand curves on company profitability. (Conlogic AB, 2010)

In figure 4 three different supply and demand curves are shown in the left hand diagram and the effects of these on companies A-I on the right hand side. The green bars in the right hand diagram are the operational costs of the companies and it is obvious that company A has the lowest and company I the highest operational costs. The empty space between the top of each green bar and the equilibrium, represented by horizontal lines a), b) and c), represents the difference between revenue and cost, i.e. the profit. In scenario a) companies A-H are profitable and company I just barely breaks even. In scenario b) the supply grows (e.g. new companies that offers the same services as A-I are formed) and therefore the equilibrium moves down and to the right (represented by arrow 1 on the left hand side). In this new scenario companies A-G are profitable, company H breaks even and company I loses money. In the third scenario c) the demand decreases (e.g. as during a financial crises) and the equilibrium continues down but to the left (represented by arrow 2). Now only companies A-E are profitable, company F breaks even and companies G-I are all losing money. (Conlogic AB, 2010)

The above mentioned scenarios are perhaps simplified but still present the correlation between operational costs and profitability during market wide changes that are out of control of the individual company. The company that has put the most effort into reducing costs will make the most profit and have the highest chances of long-term survival. In above mentioned scenarios this company is company A. In the shipping business a company that purposefully works towards reducing its fuel consumption, and therefore its costs, could have significant advantages over its competitors if the market changes for the worse.

2.3 Why more is not done already

Since many, if not all, of the operational measures described in this thesis have been known for a significant period of time, the question of why they have not been more widely adapted rises. Adding that many of these measures are possible to implement at a small, or no cost to the ship operator, the answer is even more allusive.

A significant reason for not improving energy effectiveness in the shipping industry might be that a large share of the fuel expenses is passed on to the customer. As much as 70% - 90% of the bunker costs might not actually be paid by the shipping company but by the end customer, e.g. bunker surcharges that passenger cruise companies sometimes levy. (Faber, et al., 2008).

Another major reason for the non actions taken can probably be found in the parts of the shipping industry that involve a lot of bare-boat and time charter contracts. Since the shipowner is the one responsible for improvments on the ship, but the charterer is the one paying for the fuel there is no incentive for the owner to invest in improvments (e.g. measuring equipment) onboard the vessel. (Stopford, 2009).

A third issue is that second hand prices of vessels do not correlate with the investments made to increase their fuel efficiency. The shipowner who has invested money in bunker saving equipment will not see an increase in the price he gets once he sells the vessel. (Faber, et al., 2011)

Shipyards are also not prone to change their ship designs at a resonable cost or they simply do not have the capacity to do so (Faber, et al., 2011). Therefore especially a smaller shipping company has little or no possibilities to affect the design of a “standard” ship.

Finally, the initial cost in developing a new energy saving method might discourage a ship owner from making the investment (Faber, et al., 2011). Even though the investment is sure to pay itself off in the long run, the owner might not be in the position, real or imagined, to make the investment.

3 Operational measures

During January, February and March 2012 I conducted a series of interviews with experts on energy efficiency. The experts were all employed by shipping companies that by seafarers are considered leaders in the field of energy saving. The aim of the interviews was to study the general process in the shipping company when working with energy conservation measures and to examine which of the more common operational measures were implemented and how.

I noticed that a common denominator among the experts was that they all seemed very proud of the amount of work their companies were putting into solving and developing energy related questions. I was also surprised by the experts´ willingness and openness in sharing information about their companies and the work they are doing.

As the individual interviews progressed it became apparent to me, in each interview individually, that a whole-hearted commitment to energy efficiency and ecological thinking is of utmost importance if you truly want to make a change in the way the shipping industry is run. Mr Jivén of Maersk Line noted that to be a leader in the field of energy efficiency, the path starts with top management saying so openly and officially. The questions that arise when trying to implement new measures are complicated and affect a lot of people; therefore effective communication within the company is crucial for success, said Mr Tunell of Wallenius Marine.

3.1 The measuring problem

Another common denominator in the interviews was that the respondents immediately turned to the problem of measuring. The effect of an implemented energy efficiency technique can only be assessed if you can accurately measure the effect of said technique. As it turns out, the most problematic aspect of the measuring difficulties is the measuring of the vessel´s speed through water (STW), all of the shippings company interviewees thought. Speed over ground (SOG) is fairly accurately measured today with the help of satellite navigation, but to find out whether or not you are saving bunker STW is crucial. If the vessel encounters strong currents the SOG might differ greatly depending on the direction of the current contra the heading of the vessel. The engine however is turning the propeller at constant speed with constant fuel consumption, regardless of the difference in SOG.

Since the ocean is never completely still the measurement must be made in STW. Because many of the techniques are only expected to save a fraction of a percent of bunker, the measuring of the ships STW should be made with an accuracy that is not attainable today. Wallenius Marine even did simultaneous practice runs with two identical ships on a course to try to measure the difference in their fuel consumption performance but the results were still conflicting.

To get as accurate data as possible Maersk Line retrofitted 8000 measuring points on its PS-class vessels. All the information gathered is followed in real time and the ships are benchmarked against each other. The information gathered is also of utmost importance when designing the next generation, Triple E, container vessels.

Stena Line has invested a lot of time and money in upgrading their measurement equipment with, amongst others, portable measuring equipment that easily can be moved to measure the quantity of current interest. The measuring results also made the switch to frequency-controlled pumps an easy choice since it was noted that almost all pumps were operating with unnecessary high effect and the pay-off time of new controll systems for the pumps would be short.

With eleven vessels with one hertz measuring techniques Per Tunell of Wallenius Marine still noted that frustration sometimes arises in the company when measuring data is not consistent. Performance can vary over time without apparent reasons by as much as tens of percentages. The difficulty of measuring STW is, however, the most likely cause.

4 Operational methods

Methods that are possible to implement onboard a vessel with little or no investment costs are deemed operational in this chapter. In sub chapter 7.1 the term “Eco driving“ also includes a measure of human attitudes towards environmental issues that strictly cannot be called operational but that are included anyway. The attitude towards change is of utmost importance when trying to establish whether a new measure has a chance of being successful or not.

4.1 Eco driving

The term “Eco driving” can mean a number of things. Usually in the maritime industry the term is used to describe the operational use of the main propulsion during a sea voyage. I have chosen to include the mindset of the individual in which he regards changes in operational routines and how he is motivated to perform more fuel efficiently.

The way in which any given ship is to be operated for maximum energy efficiency is always individual, due to the unique layout concerning main- and auxiliary engines, hull form, route, autopilot settings and multiple other variables of each ship. Some general guidelines can however hopefully be drawn up for use onboard various types of vessels.

4.1.1 Expected gains

According to Wartsila Marines Energy Efficiency Catalogue (Wartsila, 2011) a culture and mind set among the crew onboard of saving fuel could alone generate as much as a 10% reduction in fuel consumption. Adding a slower cruise speed, autopilot adjustments and other operational factors the fuel consumption savings can be even greater.

4.1.2 Measures carried out

Maersk Line

According to Maersk Line, shipping crew knowledge about fuel consumption reduction is crucial for any gains to be made. Their crews are continuously educated, mainly through the masters and chief engineers of the vessels, to improve performance. All sister ships fuel efficiency performance is continuously bench-marked against each other for ease of comparison between ships. The masters and chief engineers receive an annual appraisal in which fuel consumption plays a major part. Other parts of the appraisal include safety onboard and crew well being.

Stena Line

Stena Line educates their officers once a year ashore and once a year with a visit from technical shore personnel onboard all the vessels. A concern within Stena Line is the reluctance of some officers to change the way they operate their ship and to implement new routines. This problem can to some extent be conquered by training and education but accuracy in recruiting and incentives for current crews are also important in continuously improving performance.

Stena Line has implemented a program called Stena Innovations that awards monetary bonuses to every employee that comes up with an energy- and/or cost saving idea that is implemented. A price for “best vessel” is also presented every year as a way of promoting the energy saving way of thinking.

Crew members that show interest in developing the company´s energy saving plans are selected to help with or run new projects outside the boundaries of their usual jobs. This provides an incentive for the individual as well as promotes energy efficiency thinking.

Stena Line has completed approximately 100 fuel efficiency projects since 2005 and estimates the total saved fuel since then at a quantity of 16.000 tonnes. Mr. Hellring also noted that Stena Line without delay implements all bunker saving ideas that can be shown to have a pay off time of 2 years or less.

Wallenius Marine

Wallenius Marine focuses on training their vessel crews with officers’ conferences twice a year as well as computer-based environmental training aboard the ships. There is high focus on training existing crews to be more energy efficient but the interest in environmental questions is already screened during the recruitment of officers.

Wallenius Marine has a written instruction describing what criteria are to be met in an energy efficiency initiative for it to be implemented. Anyone is free to come up with initiatives and a competition between the fleet vessels was held in 2011 to come up with new ideas. A total of 65 vessels participated and 107 different initiatives were submitted.

Neste Oil

Neste Oil has produced an operational manual for their energy efficiency techniques. The manual is soon to be updated as the work towards ever more efficient energy use continues. An incentive program that, amongst other factors, measures the vessels energy efficiency is also in use and it rewards captains and chief engineers. Improvements and new operational measures are usually implemented when freight rates are low so as not to lose business opportunities.

4.2 Weather routing

Weather routing or route optimizing are terms used for route planning that includes other factors than the traditional route plan, i.e. the shortest, safe route between two given points. In optimal conditions the least amount of fuel consumed by a ship would be by travelling the shortest possible distance between two points. In theory this always means using a great circle but a rhumb line is often used on many shorter distances since the difference is negligible. It is considered good seamanship to take weather forecasts into account for reasons of safety, but to do it for the sake of bunker economy is not as widespread.

Since weather and currents greatly can affect the speed over ground (SOG), or the speed at which the vessel is actually approaching its goal, there can be an advantage in choosing a route that uses the weather conditions to improve the SOG or at least minimizes the loss in SOG in unfavourable conditions. A route optimizing service will expectedly be more effective the longer the route is. Crossing an ocean can be done in a multitude of ways whilst crossing a bay or navigating in archipelago conditions might only have a few viable route options.

Many different types of weather routing services are available, ranging from the deck officers making their own judgement based on weather maps to complex systems where expert meteorologists give recommendations based on sophisticated data from a number of weather services. A company´s vessels´ automated communication between each other, sharing information about current and wind, speed and direction is a modern weather routing service.

4.2.1 Expected gains

The gains expected by using weather routing are higher the longer the journey is. This is because the ship is exposed to the weather for a longer time and the possibilities for different route choices are greater. The expected gain can be up to a 10% reduction in fuel consumption given a scenario with a long journey, for example an ocean crossing in foul weather (Wartsila, 2011). It is, however, noteworthy that also on short routes there are consumption savings to be made, especially if the conditions are such that strong currents and/or heavy winds are often encountered.

4.2.2 Measures carried out

Maersk Line

Weather routing has long been a tool for Maersk Line in reducing bunker consumption. The newest system in use uses a wide variety of factors when determining the most effective route between two points. The vessels in the fleet automatically communicate the weather and current information they currently are experiencing to all the other vessels and therefore a database of weather information from around the globe is created and continuously updated. The system is also implemented on all vessels that are chartered by Maersk. The effects on bunker consumption are considered substantial.

Neste Oil

For 6-8 years Neste Oil used weather routing services sporadically. Weather routing services were bought on a trip-by-trip basis only when the vessel had an ocean crossing or other longer trip ahead. The positive effects on bunker consumption did, however, inspire the implementation of a fleet-wide weather routing system. Since the autumn 2011 a weather routing service is permanently available to all the vessels in the fleet. Factors taken into account in the system are currents, wind and wave height prognosis. The information is then analyzed by a team of experts at a meteorological institute and a route recommendation is constructed. Neste Oil estimates the bunker savings to be in the range of Wartsila´s Energy Efficiency catalogue.

Stena Line

Since Stena Line operates on shorter routes than the other companies interviewed in this thesis the expected gains from weather routing are naturally smaller. However, I found it very interesting that Stena Line uses weather routing on the route between Oslo and Frederikshavn (a distance of just under 160 nautical miles). The bunker saved with the implemented weather routing is estimated at 1 – 1,5 %.

4.3 Slow steaming

Slow steaming is a term used to describe the operational measure of reducing the vessel speed to save fuel. In general it can be said that a reduction in speed reduces bunker consumption per nautical mile. There are, however, nuances, mainly because of different engine room layouts, that need to be accounted for. Slow steaming will generally always improve fuel efficiency but in exactly what way it should be done depends on the technical characteristics of the actual vessel.

4.3.1 Expected gains

The bunker saving can be significant if the speed is reduced drastically, but already a modest decrease in speed of 1 knot can reduce bunker consumption by 11%. (Wartsila, 2011)

The layout of a given vessel´s engine room greatly affect the actual bunker reduction for a number of reasons:

- A vessel with only one main engine will probably gain the most from a speed reduction if the engines load program is also modified for the new speed, even if just a speed reduction in itself also will reduce bunker consumption. (Wartsila, 2011)
- A vessel with more than one main engine can probably use a lesser number of main engines if travelling at a smaller speed than if travelling at full speed. A smaller number of engines in use also means less bunker consumed.
- If the operating speed of a ship is reduced, other fuel savings might also be possible, for example changing the propeller to better suit the new speed range might give additional savings.

4.3.2 Measures carried out

Tallink Silja

In 2012 Tallink Silja decided to increase the travel time for its ferries traveling between Stockholm and Helsinki via Mariehamn on their eastbound leg during the months when ice conditions were expected. The arrival time in Helsinki was moved 35 minutes forward but the departure time from Stockholm and the arrival- and departure times in Mariehamn were unchanged. This effectively increased the travel time on the leg from Mariehamn to Helsinki by 35 minutes whilst the distance obviously was unchanged. The first numbers gathered by M/S Silja Serenade showed that a saving of approximately 6 tons of fuel oil was made every trip from Mariehamn to Helsinki. The savings for one vessel during one month amounted to about 80 tons. The direct reason for the savings in fuel consumption was that one main engine less was used for a period of about 5 hours on each trip.

The CO2 not emitted by this change in schedule can, according to section 5.2 in this thesis, be estimated to approximately 232 tonnes per vessel per month. The money saved on bunker can equally be estimated to approximately 56.000 euros, given a current bunker price of about 700 euros per tonne. For the two ships operating on the Helsinki – Mariehamn – Stockholm line the total savings where, therefore, just under 500 tonnes of CO2 not emitted at the "cost" of saving the company over 100.000 euros every month.

Stena Line

One ship was moved to a new route with a new timetable that only required a cruising speed of 18 knots instead of the 26 knots that is the ship´s maximum speed. A change of propeller to a design more suitable for the new speed, resulted in a fuel saving of approximately 16%. The old propeller is kept in store, awaiting possible future use and the cost of the new propeller was quickly repaid by the bunker savings.

Maersk Line

Maersk Line has been trying different ways of slow steaming and the results have been a distinguishable reduction in bunker consumption. In the beginning, engine manufacturers objected to the idea due to imagined risks of the engines taking damage, but a test program was still carried out on 120 vessels. That test showed no negative effects. The Maersk Line vessels will slow steam as low as 5 knots but the normal cruising speed within the new speed scheme is usually around 15-17 knots. The total bunker consumption reduction because of slow steaming in the Maersk fleet is approximately 7%. A concept of so-called super slow steaming is also being planned, a concept that will lower the cruising speed to 12-14 knots, saving even more.

Slow steaming had some operational problems that had to be addressed by the company. A decision was made that the Maersk Line ships will continue to slow steam even if a shortage of capacity is noticed. A concentration of ports in which cargo was loaded and unloaded was also implemented to shorten the total time needed for a voyage with increased travelling time at sea with the slower speed.

Lessons learned from the implementation of slow steaming also affected the design of the new Triple E container ship series. A reduction in the maximum speed of the Triple E series to 23 knots from the previous standard of 25 knots in the PS-series, the Triple E hull is now being built in a more box like shape than its predecessors. A more boxed hull equals more boxed like cargo compartments and therefore a higher number of containers that can be loaded, which in turn means lower relative fuel consumption per cargo unit.

Because of the reduction in top speed, the Triple E series is also fitted with 19% smaller main engines than the PS series whilst loading 30% more containers. The combined advantages of the design features will give the ships of the Triple E series a 20% better fuel consumption than the one generation older PS.

Neste Oil

During the low freight rates of the summer and autumn 2008, Neste Oil decided that all the vessels of the fleet where to cruise at 80% of the engine capacity. The bunker savings were in line with what Wartsila´s Energy Efficiency Catalogue 2011 predicts.

4.4 Trim

The trim of a ship is the difference between the draft at the forward- and aft perpendiculars (PP). If the drafts at both perpendiculars are equal, the ship is considered to be on even keel. If the draft at the forward PP is greater than at the aft the ship has a negative trim and if the forward draft is lesser than the draft at the aft PP the ship has positive trim.

At what trim a vessel is most energy efficient is individual to the vessel type and sometimes even sister ships might have different optimums. The common conception amongst seafarers is that a ship should always be floating on even keel or with a slight negative trim to be most efficient. The most efficient trim should, however, always be measured on the ship to avoid speculation and possible negative fuel consumption consequences.

Factors like the shape of the hull, mean draft and cruising speed all affect the optimum trim and therefore it is impossible to give a general answer as to what the optimum trim for a vessel is (Wartsila, 2011). Wartsila´s Energy Efficiency Guide, however, speculates that the difference between the least effective and most effective trim with a given hull shape with a given draft and speed might be as high as 20%.

4.4.1 Expected gains

Because of the reasons mentioned in the trim explanation an estimate of fuel savings is difficult to give. The gain could however be as big as 5% (Wartsila, 2011) but it is more likely that, at least on a ship with an experienced crew that already trim their vessel according to acquired experience, the gain would be smaller.

4.4.2 Measures carried out

Maersk Line

Measurements onboard the PS class vessels have concluded that optimal trim saves Maersk approximately 1% in bunker consumption. The difficulty in trimming the ship to the optimal, without using ballast water with its added weight, used to be that the cargo weight of the containers loaded was not exactly known. The vessel had to rely on the weight information provided by the freight consignor. That piece of data was outside the control of the company and many times turned out to be wrong. The aggregated errors could therefore be substantial on a vessel with a 15.000 TEU capacity. Maersk Line now demands that all containers are weighed before loading and that data is then processed in a load computer program to achieve optimal loading for an optimal trim.

Wallenius Marine

The results of measuring fuel consumption in different ballast conditions concluded that an optimally ballasted vessel would use approximately 3% less fuel than on a bench-mark voyage. An add-on to the loading computer now calculates the right amount and placement of ballast water in the ballast tanks to achieve higher energy efficiency. Not only the final optimal trim is calculated but the program also minimizes the amount of ballast water needed to minimize the weight of the vessel and therefore further reduces the fuel consumption.

5 Conclusions

As the theory suggested and as the interviews confirmed, there are a number of relatively easy ways to reduce bunker consumption in sea transports. A lot of the research has already been done and is only awaiting implementation. The possibilities seem so vast that it seems amazing that more is not done in the field internationally.

The reasons why more is not done seem partly to be the result of market failures and partly reasons such as the unwillingness of humans to change established patterns of operations. If market failures exist it is part of the failure´s definition that the market itself cannot change them. In this case legislators should step in and provide the frame work for modern energy efficient operations, essentially by forcing the shipping companies to operate with higher efficiency. Emission standards and taxes on fuels are examples of judicial tools available.

Other problems really seem to be the measuring and the consequent uncertainty in what the real results are, on one hand, and the human weakness of accepting change on the other. Regarding the measuring problem it is evident that some investments are needed if the actual results are to be accurately measured. There is, however, the possibility to simply take advantage of research and measurements already made by others and trust that their energy conserving effects will bring monetary advantages in the long run. The instant effect of a certain implemented method is only relevant if the aim is to continuously improve operations. If the ambition level is lower, smaller investments are needed. Substantial savings in fuel consumption can still be made even though the measuring is not state of the art.

During the interviews for this thesis it really became apparent to me that what is needed above all is the will to change the way we consider fuel efficiency. That will needs, to begin with, to form and develop in the minds of the managers of the company. From there it should be communicated down through the ranks so that it finally is intrinsic within the whole company. Incentive programmes for crews also seems like a working concept for coming up with new, energy saving, ideas. It is obvious that the people who operate a vessel have a great knowledge of how to maximize the output of the resources available. Their knowledge, experience and ingenuity are immaterial commodities that the company can take advantage of at no extra cost. The company just has to elicit the new ideas by proper motivation.

The interviews carried out as a part of the research for this thesis were done with experts in the field of energy efficiency. A greater number of interviews would probably have lead to even more ideas on how to preserve energy and to more solid data regarding the methods described in this thesis. Even so, the expert opinion of the interviewees paints an adequate picture of what is at least possible, given time and resources, in terms of making energy use more efficient.

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Interviewees: Appendix I

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