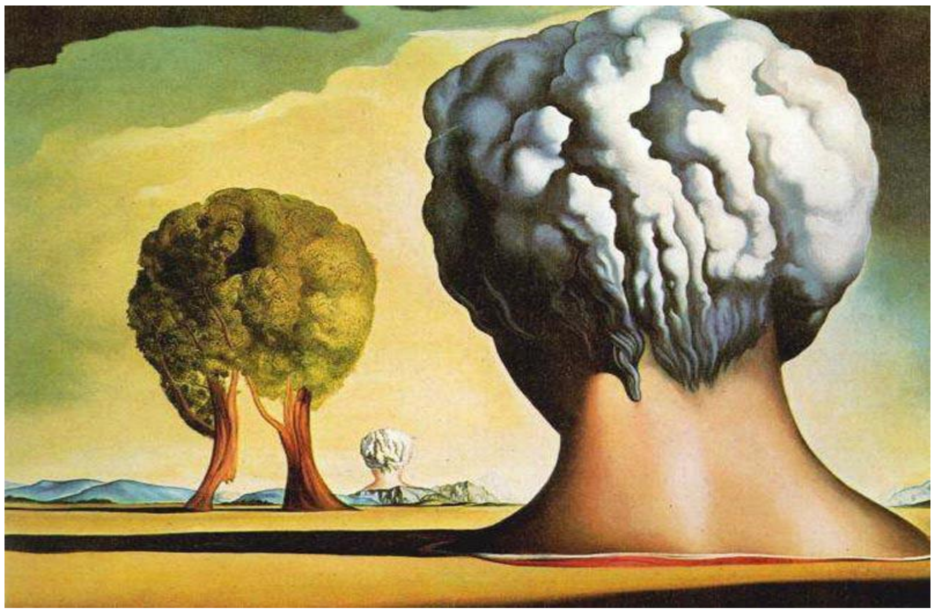
Master Thesis

Apportionment of Carbon Emissions:

Shipping Industry - Containership case



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Executive Summary

Sustainability is a reality that in the last decades has been a main concern in many companies, but the solution does not seem to be unique, since business areas are variegated and requiring different sustainable business models. Implement sustainable solution can be a competitive advantage for many companies, because it allows reducing environmental footprint, and thus being profitable and sustainable at the same time.

Globalization is ushering an increasing attention by the companies, towards awareness on the environmental impact, especially carbon emission. This attention is due to the relation between carbon emission and climate changes that has awakened a "forced" attention to many companies, to be aware on their carbon emission, and to have a waning environmental footprint. This company awareness goes for all levels of supply chain, including production, transport distribution, etc. Furthermore companies are not only held responsible for the own environmental performance, but also the performance of their suppliers, subcontractors and partners are considered.

I would consider IKEA, being one of the large importers of goods from Asia to Europe and to U.S. IKEA is highly concerned and committed to minimize the environmental impact of their products and their operations, which includes also their suppliers and subcontractors, IKEA Social & Environmental Responsibility Report (2006). The transport of goods accounts for 48% of the CO2 emissions caused by IKEA operations. Further, it is seen that transport by ocean freight sea accounts for 15% of the transportation, whereas road transport accounts for 70%, according to their environmental report (2006).

IKEA is interested to reduce the carbon emissions from their transport door to door, thus has established a partnership with Damco (one of the world's leading providers of freight forwarding and supply chain management services, damco.com), to identify their carbon emissions from transport, with the aim to reduce the emission and the environmental impact, according to Environmental Report IKEA. To look the IKEA mentioned case, we see a customized service provided by Damco that concerns the calculation of IKEA carbon emission.

For customized service it is intended, that Damco in this case has not just provided a logistic support to third companies, but it has also provided as "extra service", information regarding the environmental impact of the logistic solution supplied to the customer. The identification

of the own CO_2 emission, it permits to understand and to plan where and how can be possible to lower the own CO_2 emissions.

The thesis aims to analyse the CO_2 emission amenable to each container transported by sea freight. From this assumption it is intended to suggest the implementation in the container shipping supply chain of a system able to provide an actual CO_2 emission of each containers delivered by containership.

Contents

1. Introduction

1.1. Description of topics

"Trade between nations has been the cornerstone of increasing wealth for the world population"
(A. Smith, 1776)

Almost 90 % of the world trade is carried by ship, and over 70% of the value of world trade is today shipped in containers, according to UNCTAD (2007), and for the vast majority of this trade there is little or no alternative to transport by ship.
The accession of China to the World Trade Organization (WTO, is the international organization with the intend to supervise and liberalize international trade), and the resulting increase in overall world trade due to China, being the world's factory, it would be impossible without the ability to move products from one side of the world, and through the markets, to the other side, for a relatively low amount of money.

1.2. Problem Area & Identification

Shipping emits 1,000 million tons of carbon dioxide (from now, CO_2) in 2007 globally, and international shipping approximately 870 Million tons of CO_2 emissions, IMO[1] (2009). International shipping contributed to 2.7% of the global CO_2 emissions in 2007, the Greenhouse Gas (from now, GHG, further information in Appendix 1) component most leading for global warming. Kristensen (2007) has made a systematic and comprehensive study of the CO_2 indexing of different ships. The study concludes that the energy consumption and thereby the CO_2 emissions of ships is strongly dependent on ship size and ship service speed, i.e. the larger the vessel capacity the lower the CO_2 emissions per container. According to the report the CO_2 index of a 6,600 TEU[2] container ship is 8,4gCO_2/ton/km (grams of carbon dioxide per tonne carried per kilometre), which should be compared to the CO_2 index for road transportation by truck is 50,4gCO_2/ton/km, and by rail

[1] **IMO:** International Maritime Organization is a specialized agency of the United Nations, with 169 Member States and three Associate Members. The IMO's primary purpose is to develop and maintain a comprehensive regulatory framework for shipping and its remit today includes safety, environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping. (imo.org)

[2] **TEU:** Twenty-foot Equivalent Unit, it is an inexact unit of cargo capacity often used to describe the capacity of container ship and container terminals. It is based on the volume of a 20 feet (6.1m) long, 8 feet (2.4m) wide, and 8.5 feet (2.6m) high, for a volume of 1,360 cubic feet (39 m^3). Intermodal container is a standard sized metal box which can be easily transferred between different modes of transportation, such as ships, trains and trucks. (businessdictionary.com)

is 35gCO2/ton/km, Kristensen (2001). Thus, in general it is seen that shipment of goods by containers has a low CO2 index compared to other transport modes.

There is now compelling evidence that global warming in excess of 2 degrees Celsius (3.6 degrees Fahrenheit) it would be dangerous, which it implies that heat-trapping gases, should be stabilized at a level no higher than 350 parts per million (ppm[3]) CO2-equivalent, in order to do not compromise irreversibly the climate, co2now.org , see below Figure 1:

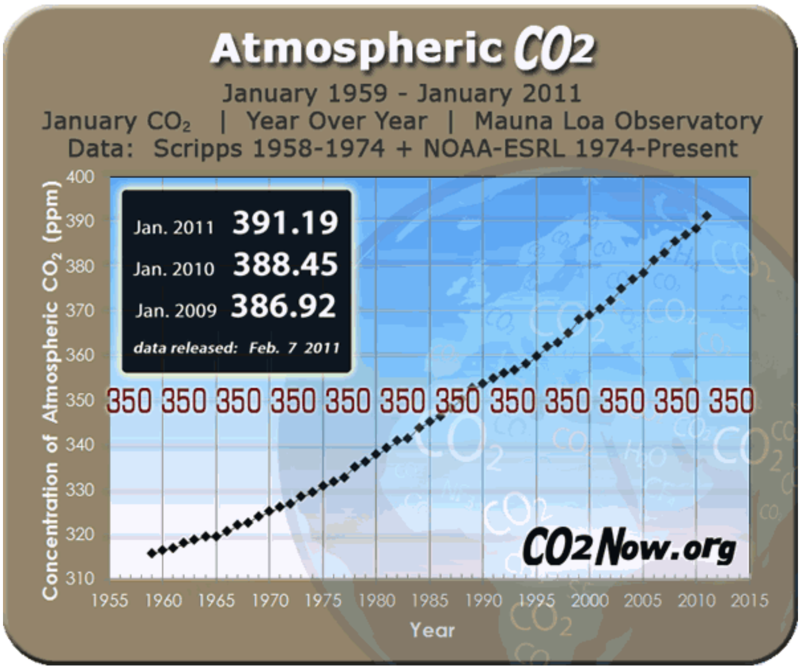


Figure 1: Atmospheric CO2 – co2now.org

If climate is to be stabilized at no more than 2ºC warming compared to the preindustrial[4] level by 2100 and emissions from shipping continue as projected, then they would constitute between 12% and 18% of the total CO2 emissions in 2050. Since this contribution is expected to increase in the future due to projected growth in world trade and the demand for seaborne transport, international shipping is, by far, the most energy efficient method of transporting goods; however, the resulting emissions will contribute to climate change due to the long lasting effects of CO2 in the atmosphere. At Marine Environment Protection Committee (from

[3] **ppm:** parts-per-million is used, especially in science and engineering, to denote relative proportions in measured quantities; particularly in low-value (high-ratio) proportions at the parts-per-million (**ppm**) 10^{-6}. Since parts-per notations are quantity-per-quantity measures, they are known as dimensionless quantities*;* that is, they are pure numbers with no associated units of measurement. In regular prose, parts-per-million generally take the literal "parts per" meaning of a comparative ratio. (wikipedia.org)

[4] **Preindustrial era:** the period before the Industrial Revolution, that was the period from the 18th to the 19th century where major changes in agriculture, manufacturing, mining, transportation, and technology had a profound effect on the socioeconomic and cultural conditions of the times. It began in the United Kingdom, and then subsequently spread throughout Europe, North America, and eventually the world. (wikipedia.org)

now, MEPC[5]) a work of the Expert Group, estimates that CO_2 emissions will increase to between an approximations of 2000 Million Tons to 3000 Million tons of CO_2 emissions in most mid-range assumption. The predicted consequence of the different growth scenarios for CO_2 emissions from international shipping are depicted in Figure 2:

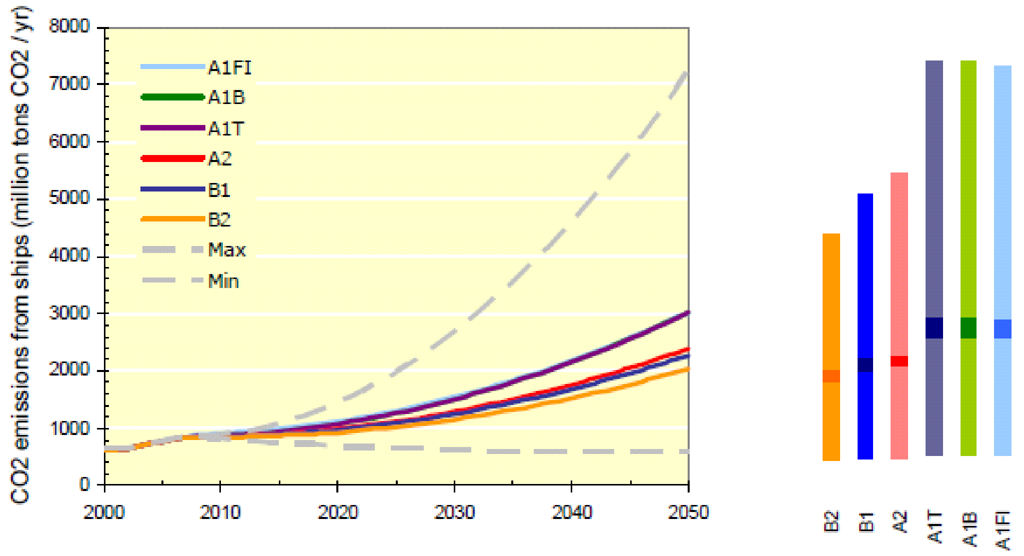


Figure 2: CO2 emissions scenarios for international shipping (IMO GHG Study 2009)

These scenarios planning, according to MEPC INF.2 (2010), are commonly used to evaluate an uncertain future, and they can be used to provide possible fleet and emission growth projections into the future. Scenarios are modeled from 2007 to 2050

Min and Max curves shown in figure 3 are considered the CO_2 range of possible scenarios, where annual increases of CO_2 emissions, in the range of 1.9 – 2.7%, are found in base scenarios, instead with extreme scenarios, are indicated annual increases of 5.2% and − 0.8%, respectively. The increase in emissions is driven by the expected growth in seaborne transport. The scenarios with the lowest emissions shows reductions in CO_2 emissions in 2050 compared to emissions during 2007.

The main scenarios are named A1FI, A1B, A1T, A2, B1 and B2, according to terminology from the IPCC Special Report on Emission Scenarios (SRES). These scenarios are characterized by global differences in population, economy, land-use and agriculture which are evaluated against two major tendencies: first, globalization versus regionalization and,

[5] **MEPC:** is the IMO's senior technical body on marine pollution related matters. It is aided in its work by a number of IMO's Sub-Committees. (imo.org)

second, environmental values versus economic values. For instance the scenarios corresponding to the A1B and B2 scenarios examined. The A1B assumes a more globalized world with rapid and successful economic development, economic and cultural convergence globally, pursuit of personal wealth and use of a balanced mix of energy sources. In contrast B2 assumes a world in which the emphasis is on local solutions to economic, social and environmental sustainability with continuously increasing population and intermediate economic development.

1.3. Problem specification

Be sustainable does not mean necessarily implement innovative technologies, but also a reconsideration of own business management or supply chain management capacity. In container shipping companies, it has always been considered that be the faster in market, it was one of the most relevant aspects of this business, nowadays the tendency is "slow steaming[6]". Concerning containership speed, further details in the list below, according to people.hofstra.edu:

- **Normal** (20-25 knots[7]; 37.0 - 46.3 km/h). Represents the optimal cruising speed, a containership and its engine have been designed to travel at. It also reflects the hydrodynamic limits of the hull to perform within acceptable fuel consumption levels.

- **Slow steaming** (18-20 knots; 33.3 - 37.0 km/h). Running ship engines below capacity to save fuel consumption, but at the expense an additional travel time, particularly over long distances.

- **Super slow steaming** (15-18 knots; 27.8 - 33.3 km/h). Also known as economical speed. A substantial decline in speed for the purpose of achieving a minimal level of fuel consumption while still maintaining a commercial service.

- **Minimal cost** (12-15 knots; 22.2 - 27.8 km/h). The lowest speed technically possible, since lower speeds do not lead to any significant additional fuel economy. The level of

6 **Slow steaming:** means running ship engines below capacity to save fuel consumption, but at the expense an additional travel time, particularly over long distances. (people.hofstra.edu)

7 **Knot:** the knot is a unit of speed equal to one nautical mile, which is defined as 1.852 km per hour. (wikipedia.org)

service is however commercially unacceptable, so it is unlikely that maritime shipping companies would adopt such speeds.

In 1850s the average knots could achieve 14-17 knots.

The current large oversupply of maritime transport capacities, partly caused by the last economic recession and partly by the fact that ship orders were at record highs just before the recession struck, Platou (2010). Shipping companies have to some degree reacted by slow steaming, Notteboom (2008), thereby using the oversupply to lower their fuel costs and CO2 emissions. This creates a unique opportunity to reduce speed in order to match the supply with the demand, this would also result in lower emissions.

"With the economic upturn, the future of slow steaming has been widely discussed – in both Maersk Line and the shipping industry." Maersk Post (2009)

Even if the economic situation of the last decade and the instability of oil prices has accelerated the implementation of sustainable solutions, in this contest, according to people.hofstra.edu, slow steaming emerged during the financial crisis of 2008-2009 as international trade and the demand for containerized shipping plummeted at the same time.
Slow steaming links containership companies implicitly with the triple bottom line approach, considering the slow steaming benefits from an economic, ecological and human perspective.

"Slow steaming has been the single most important factor in reducing fuel consumption and CO2 emissions in recent years. Maersk Line cut CO2 emissions per container by 12.5 % from 2007 to 2009; the goal is to reduce CO_2 *emissions by 25% in 2020 and slow steaming is critical in reaching this target."* Maersk Post (2009)

Speed reduction involves a tangible CO2 emissions reduction, according to IMO (2009), reducing ship speeds with 10% the energy consumption and thereby CO2 emissions are reduced approximately 27%. This means that a 10% reduction in speed corresponds to a drop in emissions of approximately 27% reduction per unit of time (e.g. considering a medium large container ship, from 600 Tons of CO2 per day, to 438 Tons of CO2 per day), or 19% per unit of distance. However, a ship sailing 10% slower will use approximately 11% more time to cover a certain distance (e.g. for a same distance; at an average speed of 20 knot the distance it is covered in 35 days, on the other hand, at an average speed of 18 knot to cover the same distance it takes approximately 39 days). A 10% decrease in speed will result in 19% reduction in engine power, MEPC 61/INF.22 (2010).

"Slow steaming is defined as a vessel operating at lower than average speed at different legs during the given route. When speed is reduced by 20%, the fuel consumption is reduced by 40% per nautical mile. To compensate for the lower average speed, one to two extra vessels are added to the route to ensure the same service frequency (e.g. one port call per week)"

Maersk Post (2009)

On the other hand, also IMO for instance has suggested through the "Guidelines for voluntary use of the ship Energy Efficiency Operational Indicator" (from now, EEOI) to define the ratio of mass of CO_2 (Mass, i.e. Tons) emitted per unit of transport work, MEPC.1/Circ684 (2010). EEOI can be used to measure CO_2 emission for dry cargo carriers, liquid tankers, gas tankers, Ro-Ro[8] cargo ships, general cargo ships (Tons); for containerships carrying solely containers (TEU or Tons); for ships carrying a combination of containers and other cargoes (TEU); for passenger ships, including Ro-Ro passenger ships, or ships that combines transportation of passenger and container, etc.

In this Guideline IMO invites the Member Governments to bring the Guidelines to the attention of all parties concerned and recommend them to use the Guideline on a voluntary basis.

Multiple seafarer contexts allow to monitor, and to optimize the measurements of CO_2 emissions. The more accurate are the measurements, more may become possible to create opportunity of CO_2 trade. CO_2 trading could become a relevant aspect, considering that international shipping industry is not subject of any restriction about CO_2 emissions, and it is not included in the Kyoto protocol. Shipping industry will be included in the "post-Kyoto protocol" agreement, and Kyoto protocol expires in 2012.

[8] **RORO-Ships:** Roll-on/Roll-off ships are vessels designed to carry wheeled cargo such as automobiles, trucks, semi-trailer trucks, trailers or railroad cars that are driven on and off the ship on their own wheels. (ship-efficiency.org)

1.4. Limitations

The model will mainly be suited for shipping companies engaged in the implementation of technical and/or operational sustainable solution. This follows from the project being, based on a one sample model to derive efficiency in containership shipping.

The simplification of reality further requires us to consider that the assumptions which the model is based are limited.

The limitations of the model are related to the approximations of the data utilised for the quantitative analysis that it is supposed to preclude a margin of reliability comparable to the reality. For instance the amount of fuel burned is related to days and not to distances, and the lack of diversification, concerning the weight of the containers it has been used a simplification of the reality, since the analysis is limited on two hypothetical groups of container's weight, 25 Tons and 15 Tons. In reality the variety of containers boarded on the containership have a wide range of weights, i.e. TEU weigh usually from 10 Tons to 27 Tons. Forty-Foot Equivalent Unit (40' Feet, FEU) and any other types of container are not been included in the analysis. The data used are been estimated and approximated researching in different specialized sources.

If these assumptions are violated, the model will under or over estimate the actual valuation and the CO2 emission allocated to the containers may be unreliable. Lack of CO2 emission allocation associated with the respective container, as factor model, may not be quoted as a market instrument.

2. Literature review

2.1. Approaches to emission efficiency Modelling

Much of the literature involving modelling of GHG emission within shipping markets are made for the measurement of CO2 index and efficiency amenable to containership speed and size. For instance, researches have been conducted on the valuation of the carbon emission, through the containership power engine efficiency, or calculating the direct relationship between the ship fuel consumption and the weight of the containers carried, estimating the CO2 emission related of each container. This calculation has been developed in order to be applicable to a large variety of ship, showing its limitations when applied to specific cases, as for containership which required more accurate quantitative data.

CO2 emission calculator are already been developed, as for instance the one provided by coscon.com (COSCO Container Lines, the sixth largest container shipping company in the world, see figure 9) and elaborated by DNV[9]. This calculator provides the CO2 emission amenable to the container, inserting the container's weight and trade lane interested.

The thesis often uses A.P. Maersk - Moller Group as company sample, particularly Maersk Line, and the information has been extrapolated from Maersk Sustainability Report 2009, Maersk Post, and information available at maersk.com, and related websites of other Maersk Business Units, i.e. maerskline.com.

All fields treated in the thesis has been supported with related argumentations, in order to cover the relevant information regarding the maritime industry, in particular containership industry; corporate social responsibility approaches; and they are presented different perspective concerning the entrance in the CO2 trade market.

The literature review is an overview of the research field on international shipping market, focused on the in-progress approaches to CO2 emission trade, at the climate exchange market. It has been developed a systematic research on the major library's databases up until February 2011, inserting "containership", or "maritime industry", or "CO2 trade", or "CO2 emissions" and combinations of these topics as search criteria in the title, keywords or abstracts. Then, I searched in the CBS library (Copenhagen Business School) and Google.com identifying the books and .pdf files useful for the research. Working papers are been included in the searching criteria, as for instance, from the economic department of others Universities (e.g. Aarhus School of Business) concerning knowledge regarding the CO2 trade theoretical implication. They are been investigated meeting documents of Maritime Environment Protection Committee (MEPC), the IMO's competent department concerning environmental and sustainability policies. I subscribed to imo.org website to consult public documents, to able an in depth analysis of the articles present in the database.

With the MEPC.1/Circ.684 (2010) IMO invites the member states, to use an efficiency model to calculate the CO2 emission per unit of transport work (e.g. container, passenger, cargo, etc.).

The whole maritime sector is considering different options in matter of lowering CO2

9 **DNV:** (Det Norske Veritas) is an independent foundation with the purpose of safeguarding life, property, and the environment. It is a leading international provider of services for managing risk. DNV provides services concerning management system certification and corporate responsibility that can be applied successfully in any industry. Its main focus industries are: Martime; Oil, gas and energy; Food and beverage; Heath care. (dnv.com)

emissions. The building of new generations of ships, aimed to be more energy efficient and less polluting; and the development of CO2 index in order to provide accurate information. The thesis treats solely containership sector.

Concepts concerning sustainability are been covered reporting perspectives from different authors. These different perceptions about the implication between company shareholders responsibilities and corporate social responsibility, has involved the interpretations of what it should mean for a companies, to become sustainable.

Triple Bottom Line approach introduced by Elkington (1998) permits us to have an overview regarding the interrelation of the three aspects taken in consideration (economy, environment, people). According to Elkington these aspects pursue the development for company sustainability approach. The deepening of these concepts could become a potential strategic instrument to share in the managerial decision-making process.

3. Emission Trading

CO2 emissions reduction can become a profitable opportunity for companies aware about sustainability, becoming an eventual benefit for both, transporters and clients. In addition to the positive effect on the group's environmental footprint, and to save energy, it also leads to significant fuel cost savings. It is important to report that fuel costs represent between 67% and 87% of voyage costs for a tanker owner at current fuel prices of around $600 per tonne, MEPC INF.2 (2010). In containership, fuel consumptions account 26% of the total costs, however, considering only the direct shipping costs, bunker consumptions accounts for approximately 56% of the transport costs, and therefore ship owners have a direct incentive to reduce these costs, MEPC INF.2. To keep a competitive and efficient service saving fuel and fuel cost, it can open windows to new areas of investment, as R&D of innovative solution, and also developing opportunity of CO2 trading.

In line with the GHG work plan, according to MEPC 61 (2010) on Technical, Operational and Market-Based Measures, a market-based mechanism[10] would serve two main purposes:

[10] **Market-based mechanism:** are regulations that encourage behaviour through market signals rather than through explicit directives regarding pollution control levels or methods. These policy instruments, such as tradable permits or pollution charges, are often described as "harnessing market forces" because if they are well designed and implemented, they encourage firms (and/or individuals) to undertake pollution control efforts that both are in those firms' (or individuals') interests and that collectively meet policy goals. (www.rff.org)

1. off-setting in other sectors of growing ship emissions and providing an economic incentive for the maritime industry to invest in more fuel-efficient ships and technologies; and
2. to operate ships in a more energy-efficient manner.

Emission reduction and CO2 trading in the shipping industry is the next challenge of the entire sector. The Maritime Environment Protection Committee (MEPC) in the last years has discussed different solutions in order to develop a Global Emission Trading System (from now, ETS[11]) for international shipping, as for instance the Norwegian proposal, MEPC 61/INF.2. The above proposal would set a sector-wide cap on net emissions from international shipping and establish a trading mechanism to facilitate the necessary emission reductions, be they in-sector or out-of-sector. The use of out-of-sector credits allows for further growth of the shipping sector beyond the cap. In addition the auction revenue would be used to provide for adaptation and mitigation (additional emission reductions) through United Nations Framework Convention on Climate Change (from now, UNFCCC[12]) processes and R&D of clean technologies within the maritime sector. A number of allowances (Ship Emission Units) corresponding to the cap would be released into the market each year. It is proposed that the units would be released via a global auctioning process. Ships would be required to surrender one Ship Emission Unit, or one recognized out-of-sector allowance or one recognized out-of-sector project credit, for each tonne of CO2 they emit.
The Norwegian ETS would apply to all CO2 emissions from the use of fossil fuels by ships engaged in international trade above a certain size threshold.

United Kingdom proposal (MEPC 60/4/26) is very similar in most respects to the global ETS proposal by Norway. Two aspects of the UK proposal that differ from the Norwegian ETS suggested, are the methods of allocating emissions allowances and the approach for setting the emissions cap. The UK proposal suggests that allowances could be allocated to national governments for auctioning. It also suggests that the net emission cap, would be set with a

[11] **ETS:** The EU Emissions Trading System (EU ETS) is a cornerstone of the European Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively. Being the first and biggest international scheme for the trading of greenhouse gas emission allowances, the EU ETS covers some 11,000 power stations and industrial plants in 30 countries. (ec.europa.eu)

[12] **UNFCCC:** it is an international treaty joined by most of the countries. To begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. (unfccc.int)

long term declining trajectory with discrete phases (for example, five to eight years) with an initial introductory or transitional phase of one to two years.

The thesis suggests an operational implementation in the shipping supply chain that provides the actual CO2 emission amenable to each container landed by a containership. In other words, to allocate the CO2 emission which each container is responsible, because of its transport from the port of departure to the port of arrival.

The assumption of this operational proposal should be considered as an option to implement in the regular container shipping supply chain, because as previously mentioned, international shipping is facing the entrance in the Global Emission Trading System. ETS is the international carbon emission system responsible of the "cap and trade" principle. This means that is given a "cap", or limit, on the total amount of certain greenhouse gases, particularly relevant is carbon dioxide (CO2) that can be emitted by the factories, power plants and other installations in the system. Within this cap, companies receive emission allowances which they can sell to or buy from one another as needed. The limit on the total number of allowances available ensures their value, ec.europa.eu.

The overall goal of an emissions trading plan is to minimize the cost of meeting a set emissions target. The cap is an enforceable limit on emissions that is usually lowered over time, aiming towards a national emissions reduction target. In other systems a portion of all traded credits must be retired, causing a net reduction in emissions each time a trade occurs. In many cap-and-trade systems, organizations which do not pollute may also participate, thus environmental groups can purchase and retire allowances or credits and hence drive up the price of the remainder according to the law of demand. Corporations can also prematurely retire allowances by donating them to a no-profit entity and then be eligible for a tax deduction.

Tinggaard (1998) explains the concept of emissions trading, as follow in Figure 3:

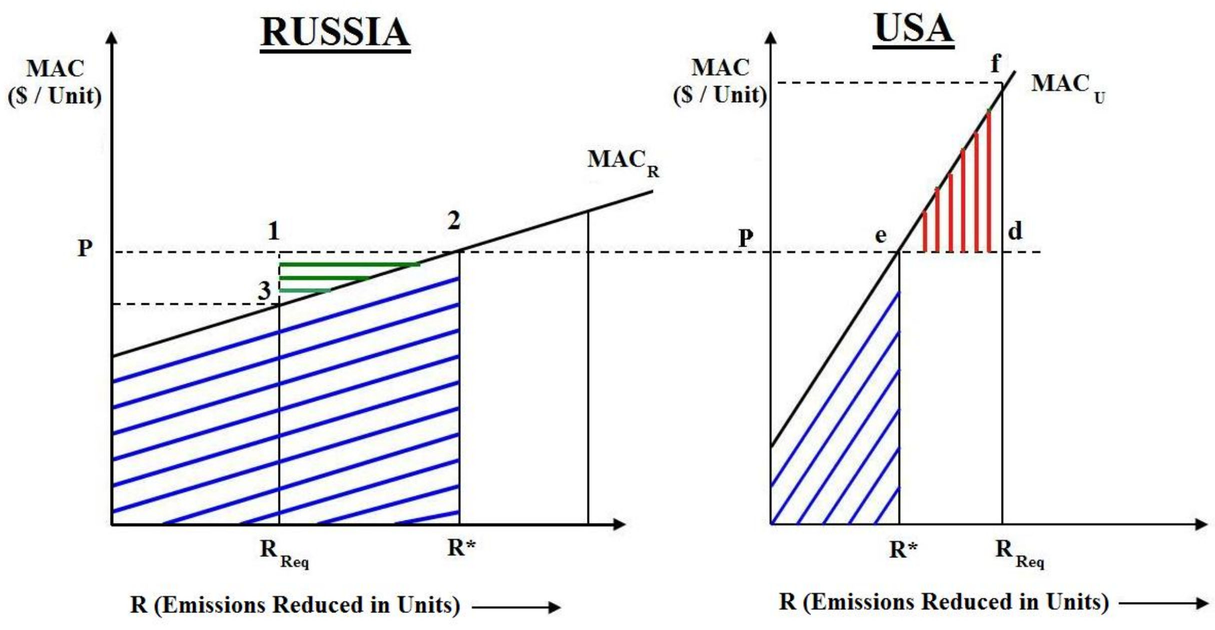


Figure 3: "The idea of global CO2 trade" - WP 1998-13

Legend:

MAC: Marginal Abatement Costs (expressed in USD per carbon credit unit, tonne of CO2)

MAC_R: Marginal Abatement Costs of Russia

MAC_U: Marginal Abatement Costs of USA

R*: amount of emissions units at the market allowance price P

R_{Req}: amount of emissions units that need to be reduced by a country

P: market allowance Price of CO2 emissions

Considering two countries as Russia and USA, each can either reduce all the required amount of CO2 emissions by itself, assumed at the Kyoto Protocol cap, or it can choose to buy it or sell it in the market of carbon emission.

Figure 3 shows the MAC curves for the two countries, it is assumed that Russia can abate its CO2 emissions at a much cheaper cost than USA, e.g. $MAC_U > MAC_R$. In the graph this is demonstrated by the MAC_U curve of USA that has higher slope than that MAC_R curve of Russia. On the left side of the graph there is the MAC_R curve of Russia, where R_{Req} is the amount of required reductions for Russia, but at R_{Req} the MAC_R curve has not intersected the market allowance price, P. Thus, given the market price of CO_2 allowances, Russia has potential for profit if it abates more emissions than required.

On the right side is the MAC_U curve for USA, R_{Req} is the amount of required reductions for USA, but the MAC_U curve already intersects the market price of CO_2 allowances before R_{Req} has been reached. Thus, given the market allowance price of CO_2, USA has potential to make a cost saving if it abates fewer emissions than required internally, and instead abates them elsewhere. In this example, USA would abate emissions until its MAC_U intersects with P at " R* ", but this would only reduce a fraction of USA's total required abatement. After that, it could buy emissions credits from Russia for the price P (per unit). The internal cost of abatement for USA, combined with the credits bought in the market from Russia, adds up to the total required reductions R_{Req} for USA. Thus, USA can economize from buying credits in the market, the triangle area " d-e-f " in the graph. This represents the "Gains from Trade", the amount of additional expense that USA would otherwise have to spend, if it wanted to abate all its emissions by itself without trading.

Russia makes a profit on its additional emissions abatement, above what was required: it meets the regulations by abating all of the emissions that was required of it, R_{Req}. Additionally, Russia sells its surplus to USA as credits, and was paid " P " for every unit it abated, while spending less than " P ". Russia total revenue is the quadrangle area " R_{Req}-1-2-R* " in the graph, its total abatement cost is the quadrangle area " R_{Req}-3-2-R* " in the graph, and so its net benefit from selling emission credits is the triangle area " 1-2-3 " in the graph.

The two R* in both graphs represent the efficient allocations that arise from trading.

- Russia sold " R* - R_{Req} " emission credits to USA at a unit price P.
- USA bought emission credits from Russia at a unit price P.

The example above it is applied not just at the national level, and it is applied as well between two companies in different countries, or between two subsidiaries within the same company.

The thesis tries to provide a logic and realistic operational improvement that could be considered and eventually be implemented in the container shipping supply chain. The hope is to develop evaluation criteria related to container's weight that can provide strategic client information in term of CO_2 emissions.

This assumption it is based on the fact that 90% of worldwide goods it is transported by ship, and according to UNCATD (2007) over 70% of the value of world trade is today shipped in containers, and there are not many other alternative of transportation, at the same competitive price.

From this assumption the amount of information related to the company´ CO_2 emission for sea freight transportation, can be massive. This status could offer the opportunity to create contracts "CO_2 oriented" between clients and shippers, since CO_2 trade is considered to be in/for the containership industry.

During the development of the thesis it will be proposed the modality assumed to make possible the realization of an efficient way of monitoring the CO_2 emissions attributable to each container. The modality suggested has been assumed to not interfere with the ordinary logistic supply chain in container shipping industry.

4. Problem statement

How sustainable solutions can keep companies competitive, innovative and profitable? How they can contribute to corporate responsibility and business development, in containership industry?

The thesis will analyse the opportunity to develop an operational system able to monitor through the containership fuel consumption, the related CO_2 emission, thereafter the CO_2 emissions of the single container delivered. The utilization of official document as Bunker delivery note, indicating specifications regarding the fuel supplied. Bunker is the name of the type of fuel burned by the containership engines, and the document reports information as, the fuel density, the percentage of sulphur content, the quantity released, and other relevant information.

To elaborate an efficient way to monitor the weight of each container boarded on the containership, it is one of the main issues of the thesis. Trough the elaboration of weight and fuel consumption will result the amount of CO_2 emissions of the container, expressed in Tons.

The weight of the container it is used to allocate the CO_2 emission which the container it can be “considered” responsible for. This should provide a real time reliable official data, about the fuel consumption required for the single container. Container's weight can become additional information related to containership fuel supply, thus fuel consumption. Fuel consumption related to CO_2 emissions is the bargaining for a future CO_2 trading.

According to MEPC 61/5/3 Annex 2 (2010), IMO is considering through a working group on energy efficiency measures for ships of new generation, called Energy Efficiency Design Index (from now, EEDI). MEPC is discussing the consideration to adapt an international indicator, expressible in a mathematics equation form, which it is supposed to be a measure of new ships CO_2 emission efficiency. The EEDI shall be a specific of each ship, and it is a measure indicating CO_2 efficiency in terms of energy efficiency. The method of calculation of the EEDI for “New Ships”, meaning ships constructed after the entry in force of MEPC 60/WP.9 Annex 5 (2010), it is made to assist ship owners, shipbuilders and manufacturers, being related to the energy efficiency of the ships, and other interested parties in understanding the procedures of the voluntary EEDI verification.

As explained above, EEDI is focused on applying a mathematics formula that estimates the energy efficiency of a ship, and implicitly CO_2 emissions. The thesis instead, it proposes a real time calculation of efficiency and CO_2 emissions.

The thesis assumption is that a real time calculation of CO_2 emissions of the containers shipped by containership, it can be information more relevant at ETS level, instead of the solely use of estimation of CO_2 efficiency in terms of energy efficiency. The carbon calculation methods available are basically mathematical estimation, and some of them are based on statistical data. An actual calculation of CO_2 emissions differs from an estimate, because it is based on actual container's weight carried by the containership. The difference it consists on the quality of the calculation, thus the accuracy of the result. It becomes a comparison between estimation of the CO_2 emission against actual CO_2 emission.

But even if this assumption will not be considered as an option, actual CO_2 emissions of the containers could become information that might be useful to deal with clients, suggesting customized “CO_2-oriented” contracts with.

The calculations of carbon emission are transformed in carbon credit in the climate exchange market.

4.1. Carbon credit

A permit allows the holder to emit one ton of carbon dioxide. Credits are awarded to countries or groups that have reduced their green house gases below their emission quota. Carbon credits can be traded in the international market at their current market price, investopedia.com.

The reason of using CO2 emission, based on a real time calculation could be considered an interesting solution. Carbon credits are traded in the climate exchange market, as European Climate Exchange (ECX), and Chicago Climate Exchange (CCX). These Carbon Financial Instruments are traded as any other financial instrument traded in the stock market. This statement involves from my perspective, the possibility to deal with elevated accuracy, real carbon credit, based on real data, and not on estimation of CO2 emissions. These stocks will be inserted in the Climate Exchange market, and they will affect the market itself somehow.

In the late years, carbon market has received different critiques and protest against. Most of these protests consider as a "false solution" to the problem of climate change:

"...cap-and-trade scheme successfully created a working carbon market, "but its effects on emissions, the European economy, and technology investment are less certain."...use of carbon offsets[13] *can "undermine the system's integrity" because there is no way to ensure that the projects invested in would not have been built anyway, or that they will last long enough to reduce the amount of emissions that they are expected to reduce. Carbon offsets..." involves fundamental tradeoffs and may not be a reliable long-term approach to climate change mitigation."*

csmonitor.com (2008)

And also the allocation of emission rights has been questioned:

"The allocation of emission rights amounts to an unprecedented distribution of property rights in the carbon cycle and its regulation, and thus on life itself. This is socially and geographically unfair".

climateandcapitalism.com (2008)

[13] **Carbon offset:** is a reduction in emissions of carbon or greenhouse gas made in order to compensate for or to offset an emission made elsewhere. Carbon offsets are measured in metric tons of carbon dioxide-equivalent (CO2) and may represent six primary categories of greenhouse gases. One carbon offset represents the reduction of one metric ton of carbon dioxide or its equivalent in other greenhouse gases. (wikipedia.org)

The carbon credit system was ratified in conjunction with the Kyoto Protocol. Its goal is to stop the increase of carbon dioxide emissions. The example below can clarify the concept, investopedia.com:

"If an environmentalist group plants enough trees to reduce emissions by one ton, the group will be awarded a credit. If a steel producer has an emissions quota of 10 tons, but is expecting to produce 11 tons, it could purchase this carbon credit from the environmental group. The carbon credit system looks to reduce emissions by having countries honour their emission quotas and offer incentives for being below them".

4.2. Accuracy of the EEDI

The Report on EEDI prepared by Deltamarin[14] for the European Maritime Safety Agency published the applicability of the EEDI, and it is concluded, that the current approach could be feasible with certain reservations for large ocean-going cargo ships which have uniform design criteria, i.e. large tankers, bulk carriers, containerships, and these ship types account for the majority of CO2 emissions from shipping. However, the current EEDI approach is not feasible for small vessels, passenger, Ro-Ro ships and short sea shipping in general or ships designed for a certain route or with a specific transportation task in mind. For these ship types the basic calculation methodology still requires further refinement, in order to demonstrate the momentary inaccuracy of the EEDI index, according to Krüger from Hamburg University of Technology (ship-efficiency.org). Several Ro-Ro ships which were known to be very fuel efficient were analyzed according to the proposed EEDI concept. It was found that this EEDI actually results in a severe speed limit for those ships. It was further found that this type of ship can fulfil the EEDI only at physically impossible negative wave resistances for their desired design speed. This is due to the fact that the present EEDI violates commonly accepted physical principles of the powering of ships. It is strongly recommended to review the EEDI concept or to introduce a better speed dependency into the future baseline definition.

[14] **Deltamarin:** is a company that operates globally providing Contract management, engineering and consulting services for the entire life cycle from feasibility studies up to complete engineering packages, construction management and technical operation support. (deltamarin.com)

The development of the thesis describes the supply chain in the containership industry, in daily operations at a port Terminal. All the information related to, are been provided from an expert in the sector, an ex Maersk Terminal manager that had covered different position in port Terminal worldwide. The purpose of the thesis is to explain where it could be possible to implement the operational solution able to improve the information efficiency in containership supply chain, in order to develop the containers emission monitoring system.

5. Research questions

How container's weight can be used as an indicator for carbon emission efficiency, in containership sector?

How container's weight in containership sector should be considered? As an information to add, to substitute or to complement the indexes that IMO is considering most actual, as Energy Efficiency Design Index (EEDI) and Energy Efficiency Operative Index (EEOI)?

Which could be the ways to lower environmental footprint in order to make it as an opportunity for profit?

How could shipping companies become involved to use carbon credits in order to enter in the CO2 trade market?

Which can be the relevance of a CO2 emission monitoring system, able to calculate actual CO2 emission of the container?

Why weigh the containers, whereas the container's weight is already provided in the booking list?

6. Methodology

The thesis is developed through the intersection of qualitative and quantitative contents derived by the application of concept and theories to economical and sustainable aspects of shipping sector. Analytical model are introduced to justify the assumption taken, in order to provide a practical example of the thesis main subject, the relevance of an actual CO2 emission calculation. Qualitative approaches are defined as how people construct meanings, and how these meanings may become operational solution, and potential competitive advantage. Quantitative approaches in contrast are aimed to generate numerical data amenable to statistical analysis, emphasising validity and reliability.

The thesis try to elaborate relevant information related to international container shipping and CO2 emission, assuming slow steaming as the first significant step in containership sector, concerning awareness on CO2 emissions. The core of the thesis to create an efficient system able to allocate proportionally the CO2 emissions produced by the containership to the cargo boarded. The allocation and reduction of the CO2 emissions produced, it could create opportunity of CO2 trade.

A descriptive part concerning technical and operational aspects of container shipping industry and its supply chain is introduced and described in the thesis. In order to provide an exhaustive overview regarding technical components and operations, considered to be relevant for the comprehension of the context wherein the thesis is involved to.

The importance of this descriptive part becomes significant in the understanding of the criteria that are then taken to develop the quantitative analysis of the thesis.

The thesis is structured as a path between qualitative and quantitative research. Qualitative research concerns theoretical aspects regarding corporate social responsibility and sustainability, caring about companies lower footprint; CO2 emission in present and future international maritime regulations; innovative aspects related to develop an efficient real time CO2 emissions monitoring system, without affecting the regular supply chain in container shipping industry.

The qualitative analysis is the most suitable examination for the thesis because of its flexibility, and its subjectivity creates the perfect context to build a speculative case study grounded on the field.

The quantitative analysis of the thesis is aimed to generate numerical data amenable to statistical analysis, with an emphasis on generalizability, validity and reliability. It has been managed through the elaboration of public documents data, from different maritime corporations, as the International Maritime Organization (IMO), and they are been investigated the most recent MEPC documents/reports related to greenhouse gas emission (GHG) in ship industry.

Interviews to professional of container ship sector it has helped me to obtain relevant information from a technical and logistic perspective. The people interviewed are, Deputy Director of Danske Maritime[15], Sales & Marketing Manager of Maersk Maritime Technology in Denmark, and an ex Marine Terminal & Capacity Manager of Maersk Line in Italy. Personal research through thematic websites concerning shipping (i.e. container shipping, international organization, etc.), specialized book regarding ship sector, particularly containership sector, are included in the analysis, and information from company's internal magazine as Maersk Post.

A.P. Moller – Maersk Group, and particularly Maersk Line, as leading company in container shipping industry, it will be introduce in the thesis through a company presentation, and taken as sample to analyse, whenever it will be required to use real data and/or information in order to elaborate and demonstrate the issues of thesis. The criteria used to choose A.P. Moller – Maersk Group as sample for the case company analysis, are mainly three:

1) Maersk Line, is the largest container shipping company in the world. Maersk Oil, is a leading independent oil and gas operator; Damco, is one of the world's leading providers of freight forwarding and supply chain management services. APM Terminals, operates in 50 port terminals in 34 countries and five continents. Maersk Container Industry (MCI) is a strong global supplier of cargo transportation equipment to a large group of leading shipping lines and leasing companies, mcicontainers.com. A.P. Moller – Maersk Group covers the full supply chain involved directly and indirectly to containersship, since even supermarket are part of the group, Fotex and Netto, for instance. A.P. Moller – Maersk Group has the entrepreneurial independence,

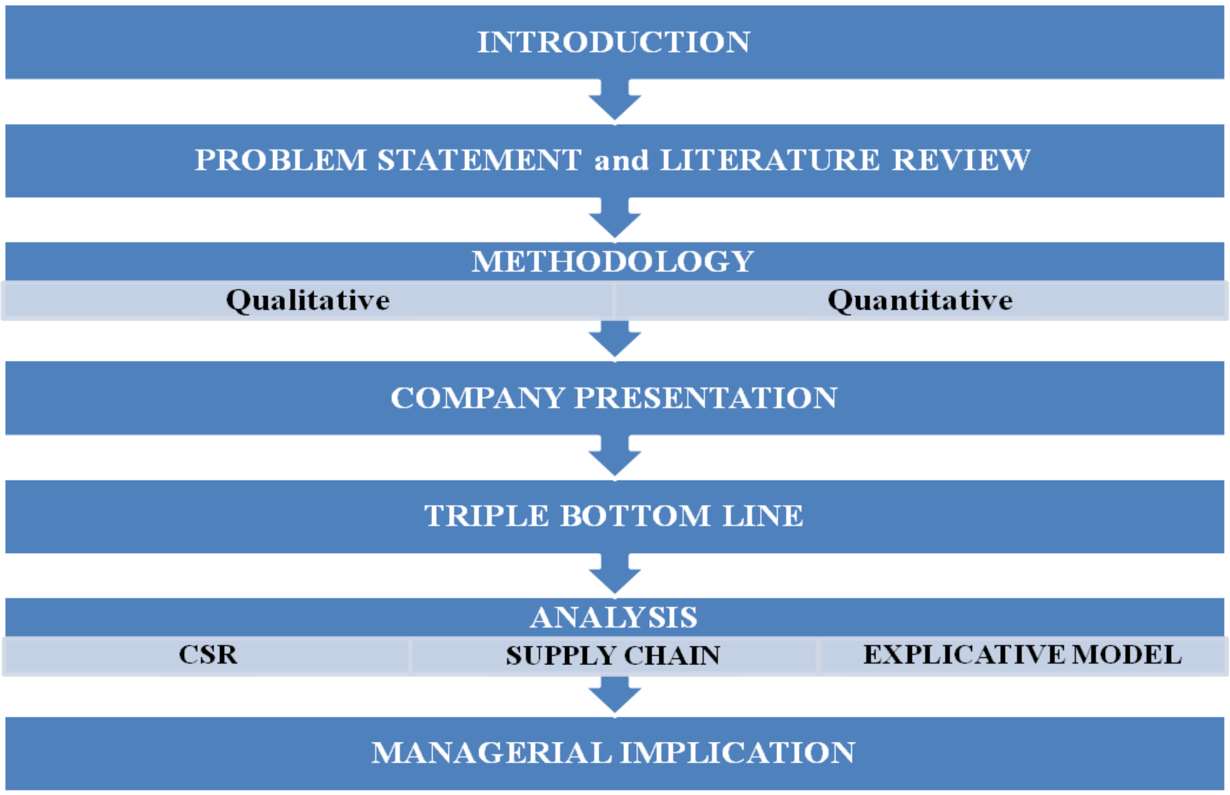
15 **Danske Maritime:** Danish Maritime, in english, is an industrial association formed in 1919 by Danish-rooted businesses within the fields of maritime production, development, research and service with the aim to collectively represent the interests of maritime and offshore businesses. The purpose of Danish Maritime is to bring together the leading Danish-based companies in maritime production, development and service in order to safeguard the common interests of the industry. (danskemaritime.dk)

and it could have the financial and operational autonomy to consider and eventually implement the system suggested in the thesis.

2) A.P. Moller – Maersk Group shows a real awareness concerning sustainability and it supports initiatives that promote environmental responsibility. A.P. Moller – Maersk Group Sustainability Report 2009, presents data that show decreasing GHG emission in the last years, and the company is involved in different lower footprint projects, at different level, as technical engineering innovations, or supply chain management solutions, maersk.com;

3) maersk.com and the related group´s division websites are exhaustive and full of relevant information required for the development of the thesis´ analysis, i.e. ship route map, vessel capacity, etc.

The structure of the thesis is resumed in the below schedule:



7. MARESK LINE: COMPANY PRESENTATION

7.1. The A.P. Moller – Maersk Group

The A.P. Moller - Maersk Group is a global conglomerate headquartered in Copenhagen, Denmark, with offices in more than 130 countries, and with over 115,000 employees. The Group was founded by Arnold Peter Moller and his father in 1904.

Maersk Line is a vital part and the historical core business of a highly diversified group operating in multiple businesses (shipping, retail, energy).

7.1.1. A.P. Moller – Maersk Group composition and Business Units

The Group deals with almost every aspect of container shipping: global transportation of containers by sea, planning efficient transportation for customers, and running container terminals in harbors across the globe. The A.P. Moller–Maersk Group comprises approximately 1,100 companies which feed into 18 primary business units. Besides the container and shipping segment, they operate in extractive industries, oil and gas exploration and production, as well as offshore services providing equipment, transport and other services to the oil and gas industry. Moreover, the Group owns companies within container production and plastics manufacturing, ship building, air cargo and retail. The core activities are in shipping and oil and gas exploration and production, both highly energy-intensive industries, in which the Group has reached a position of global player.

Below, a brief description of the main segments the Group operates in:

- **Container shipping and related activities** represents the core business of the Group. APMM is a market leader in worldwide container services, agency, logistics and terminal activities, operating under the brand names of: Maersk Line, Damco, Safmarine and Container Inland Services. Maersk Line and Safmarine run more than 500 container vessels, hereof more than 250 owned.

- **APM Terminals** develops and operates container terminals and related activities and is globally engaged in more than 50 terminals and terminal projects in 34 countries. The company provides port and terminal management and operational expertise to over 60 container shipping line customers.

- **Tankers, offshore and other shipping activities** offer solutions for the transport of crude oil, refined products and gas. This segment provides various supply vessel activities (including anchor handling, platform supply and cable laying), drilling activities with a variety of drilling rig types, production activities with Floating Production Storage and Offloading (FPSO) vessels and jack-up based production units, salvage and stowage activities as well as door-to-door transport and inter-European freight and passenger transport.

  The Business Units operating in this area are: Maersk Tankers, Maersk Supply Service, Maersk Drilling, Maersk FPSOs, Maersk LNG and Norfolkline. Excluding Svitzer's more than 500 vessels, the segment operates more than 260 vessels and rigs, with more than 140 owned.

- **Oil and gas activities** participate in production activities in Denmark, Qatar, United Kingdom, Algeria and Kazakhstan. In addition, Maersk Oil contributes in exploration activities in the North Sea (Denmark, United Kingdom, Norway and Germany), North Africa (Algeria and Morocco), West Africa (Angola), the Middle East (Qatar and Oman), Central Asia (Turkmenistan), South America (Brazil, Suriname and Colombia) and the US Gulf of Mexico.

- **Retail activity** comprises supermarkets and hypermarkets in Denmark, Germany, United Kingdom, Poland and Sweden. Dansk Supermarketed incorporates, among others, the Føtex stores, the Netto stores and the Bilka hypermarkets.

- **Shipyards, other industrial companies, interest in Danske Bank, etc.,** include shipyard in Denmark, Star Air engaged in contract parcel flying in Europe and a 20% interest in Danske Bank.

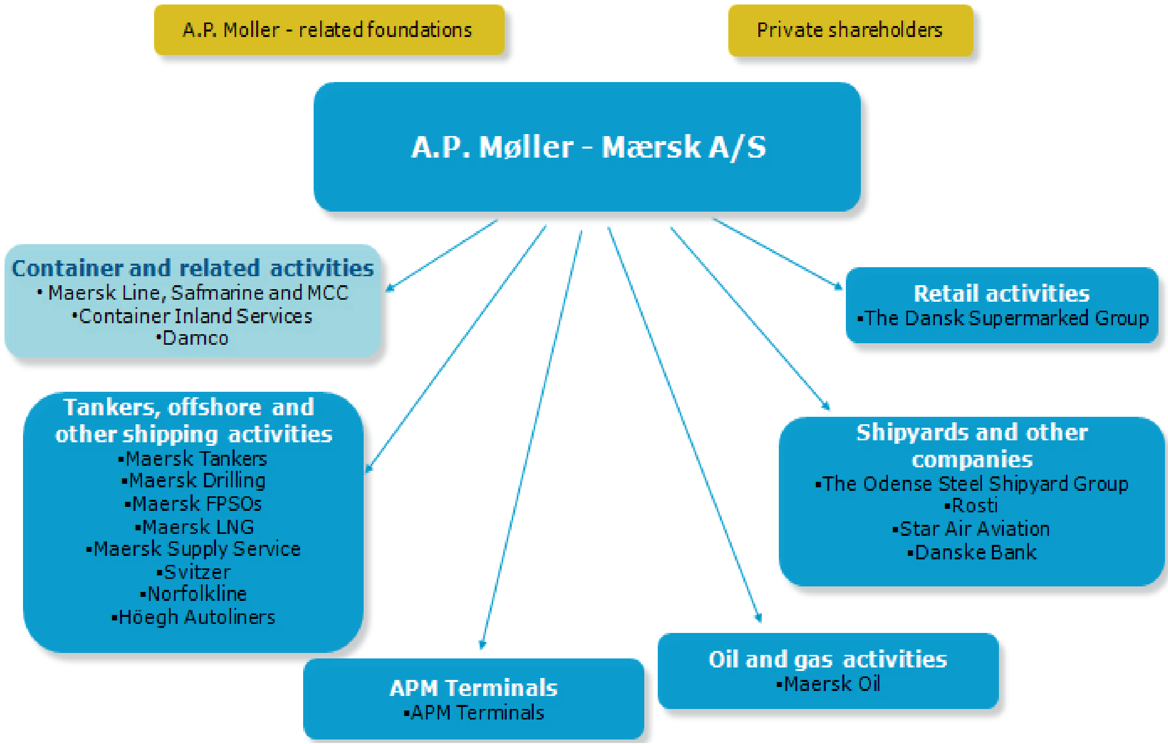


Figure 4: The A.P. Moller – Maersk Group Composition - Internal Source

Thus, the Group has adopted a strongly diversified strategy across business segments, to see figure 4 above, which enables to achieve sustainable global leadership (reducing vulnerability to industry cycles), geographical diversification (dampening effect of regional cycles), and industry diversification (reducing sector-specific risks).

7.1.2. The Group Ownership

The parent company of the Group, A.P. Møller - Mærsk A/S, is listed on the Danish Stock Exchange, and has around 67,000 shareholders. The company's main shareholder, however, is the A.P. Møller and Chastine Mc-Kinney Møller Foundation, which was established by the company founder A.P. Møller in 1953 to ensure that his life's work would always be owned by parties that held a long-term view of the company's development, in the spirit of the founder and according to his principles. The share capital is split between A and B shares, with only the A-shares carrying voting right. The Foundation holds more than 50% of the A-shares and consequently has the voting majority. The Foundation is mainly funded by the A.P. Moller - Maersk Group, but the Group has no influence on the Foundation's decisions regarding donations and investments. The Foundation aims to support Danish culture and heritage, Danish shipping, medical science and causes for the public good. Grants are only occasionally provided for non-Danish projects.

7.2. Container and related activities. Maersk Line

"Creating opportunities in global commerce"

Maersk Line operates in the core segment of the Group: Container shipping and related activities. This division includes four Business Units, making the business diversified across the brands:

- Maersk Line
- Safmarine
- Damco
- Container Inland Services

These separate and specialized entities perform following individual strategies and focusing on different markets (see figure 5), while – simultaneously - numerous synergies enable the Group to optimize business opportunities across brands and to provide the best product and solutions to the customers.

Figure 5: Container and related activities, overview - Internal Source

Maersk Line is present in more than 125 countries worldwide, employing over 21,000 people. The Company's strategy is characterized by pursuing local presence, while conducting global operations. The Company is, indeed, organized in eight geographical regions, as illustrated in figure 6, while the operational setup ensures smooth control around the globe.

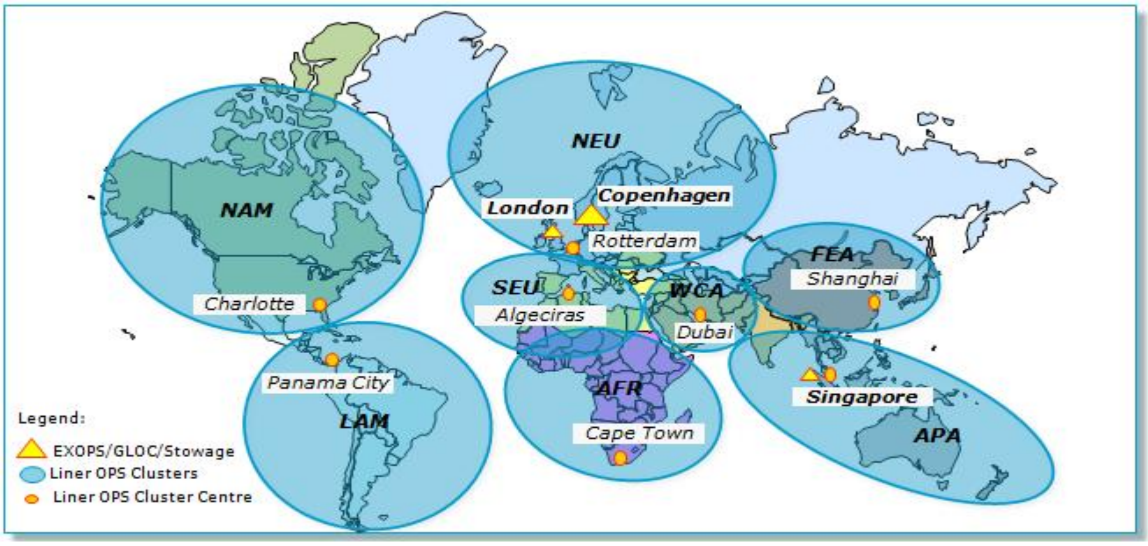


Figure 6: Maersk Line global presence - Internal Source

Maersk Line covers ports in almost every country in the world and offers multiple weekly sailings on all the major trade routes. The local offices provide the expertise necessary for coordinating customers' requirements across the modern fleet of vessels, containers, trucks, and trains. Maersk Line vessels are amongst the most modern, secure, and environmentally friendly to sail the oceans and the containers cover the straightforward dry boxes to state-of-the-art controlled atmosphere reefers.

The Maersk Line fleet comprises more than 500 vessels and a number of containers corresponding to more than 1,900,000 TEU (Twenty foot Equivalent Unit – a container 20 feet long). This ensures a reliable and comprehensive coverage worldwide.

7.2.1 Some facts about Maersk Line

Containerization is a global system of intermodal cargo transport using standardized containers, which can be loaded and sealed intact onto container ships, railroad cars, planes and trucks. Prior to the introduction of containers, cargo handling for sea transportation was both time consuming and expensive. Containers have changed that fundamentally. Transport is now safer and more affordable than ever before.

World trade would not be the same without the modern container, invented in 1956. Today, it carries more than 90 percent of all goods in world trade. Every commodity and type of goods can be loaded and carried in ‘the box’, as the container is often referred to. As a result, modern container shipping has changed the way we transport goods around the world and has played a key role in globalization.

Some interesting and curious facts about Maersk Line will help to better capturing the features of the container shipping industry:

- A single 20-foot container can hold about 48,000 bananas. So, in theory, a PS-vessel such as the EMMA MAERSK can transport approximately 528 million bananas in a single voyage - enough to give every person in Europe or North America a banana for breakfast.

- If all Maersk Line containers were placed one after the other, they would reach about 19,000 km. This is more than the distance from Copenhagen, Denmark to Perth, Australia, via Cape Town, South Africa or almost half of the earth's circumference or almost three times the earth's radius.

- If all the Maersk Line containers were stacked on top of each other they would reach approximately 2,500 kilometers high, equivalent to stacking 8,550 Eiffel Towers on top of each other.

- At any one point in time, Maersk Line is transporting cargo worth approximately three percent of the world's GNP (world GNP in 2005: USD 36,356,240,000,000).

- In 2009, Maersk Line vessels will make around 35,000 port calls - equivalent to approximately four port calls per hour or one call every 15 minutes.

8. Triple Bottom Line

Triple bottom line (from now, TBL) is the “antechamber” of Corporate Social Responsibility (from now, CSR), linking companies to the internal/external (people/environment) contests are interacting with.

Triple bottom line intersects the expanding of the traditional company reporting framework, to take into account ecological and social performance in addition to financial performance. In this specific case it is considered which economical opportunity could create for an international shipping company to lower environmental footprint and to consider CO2 trade as an opportunity of profitability.

A first description is to evaluate companies’ core decision has the result of an efficient cohabitation between financial performance (Economic Vitality); environmental awareness (Natural Environment) and people equity (Healthy Communities), as shown in Figure 7:

Figure 7: Sustainability - sustainability.ualberta.ca

The model above shows that as result of a TBL approach, it emerges Sustainability. Sustainability, referring to Brundtland Commission (1987) definitions: “it is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

In the model, the three constituent parts have been “moved” to join a common point together. The darker part in the middle of the model, it represents the consequence of this merger. This conglomerate is Sustainability from this TBL approach. The status of three different parts formally independents, through the TBL approach, they reach the common point where they can become interrelated.

In this direction, regarding CO2 emissions, IMO for instance has suggested the "Guidelines for voluntary use of the ship Energy Efficiency Operational Indicator" (from now, EEOI) that are defined as the ratio of mass of CO2 emitted per unit of transport work, MEPC.1/Circ684 (2010). In these guidelines IMO invites the Member Governments to bring the guidelines to the attention of all parties concerned and recommend them to use the guidelines on a voluntary basis. IMO also suggested to the Member Governments to provide information on the outcome and experiences in applying the guidelines to future sessions of the Committee.

This can be considered the transitional step to introduce shipping companies to more sustainable business approaches. To enable them to choose to apply which solutions that could aid to match the GHG emissions target that IMO on behalf of the entire sector coordinates to achieve. EEOI, as EEDI they enter in the package of the technical and operational measures that represent a very important step in ensuring to shipping industries the necessary mechanisms to reduce their GHG emissions.

TBL approach should become part of the company business strategy, in order to take decisions already embedded of CSR. The business decision itself, has to be the result of a profit-ability, into a responsible environment-mentality, through the human-ability, as a single thing, all-encompassing, as visible in figure 8:

Figure 8: Triple bottom line – sustainnovation.com

To assume this perspective, it means that companies should approach to business, no longer as a subjects unrelated to the surrounding context.

Companies can show a "formal" social responsibility, as to introduce charity events, or to join social initiatives, and in general promoting social activities outside the company core business

(i.e. The Copenhagen Opera House was donated to the Danish state by the A.P. Moller and Chastine Mc-Kinney Moller Foundation, in August 2000, virtualtourist.com).
There is nothing reductive in the previous observation, because these activities are honourable, at the same time expensive, and of public interest, Danish people in this case.
This case is an outsourced approach of CSR, and sometime such kind of company´s "externalization" to the communities, they can be misinterpreted. For instance some politicians at that time were offended by this private donation, in part because the full cost of the project would be tax deductible, thus virtually forcing the government to buy the building; but it was accepted by the Folketing (the Danish Parliament) and by the government in the autumn of 2000.

"CSR must be integrated in the whole of the company" Porter and Kramer (2006)

Companies shall rather behave as part of the environment, operating with awareness on business decisions and their consequences in the environment. Managerial decision strategies should be compatibles with the environment in which it operates. To achieve decision-making processes already embedded of social awareness, and to create solutions that are profitable, social and environmentally sustainable. According to Elkington (1998), economic prosperity, environmental quality and social justice will increasingly become the driving forces for transnational corporations.
Multinational are awared about the benefit that the balance between the entities composing the triple bottom line, it can represent for the future business development of the company. Elkington foresees the importance of a triple benefit integrating economy, ecology and people at a supply chain level, as companies "will increasingly be forced to pass the pressure on their supply chains".

From a company perspective A.P. Moller - Maersk Group core purpose says:

"*Through strong values, building on heritage, strong financials and success, in shipping, energy and retail, we will create opportunities for our shareholders, colleagues, customers and communities*".

And according to the previous declaration, the stated core values are:

- *Constant care*. Take care of today, actively prepare for tomorrow.
- *Humbleness*. Listen, learn, share and give space to others.
- *Uprightness*. Our word is our bond.
- *Our Employees*. The right environment for the right people.
- *Our Name*. The sum of our values, passionately striving higher.

To develop a successful triple bottom line, firstly, a company need a management board willing to do it. Second, a company need to be in a profitable situation, in order to be in the condition to invest and to reconvert what in the company required to be adapted from a technical, organizational, managerial, and all aspects involved to pursuit the "coordination" of:

- ◦ Economy/profit
- ◦ Ecology/planet
- ◦ Equity/people

Economy/profit: is not just referred on profitability, but to be an economically sustainable company, it means to deliver at any time cash flows that are sufficient to liquidity and to offer a constant return to the shareholders, that is above average. At A.P. Moller-Maersk Group because of the global financial crisis in 2009, the company focus has been on reducing costs and adjusting the company to the new market realities. Most importantly, the Group has worked to accelerate its commitment to become a more sustainable company.

"*We firmly believe that the pursuit of a leadership position within sustainability is aligned with our company values but also that it will award us with a competitive edge through constant innovation and new business opportunities*,"

Eivind Kolding, CEO of Maersk Line – Maersk Post (2010)

The efforts and improvements undertaken by the Group as a consequence of the economic downturn are nowadays showing signs of recovery results. In 2010, in fact, the Group has started again to make profits after the challenging crisis scenario.

Ecology/planet: to consume natural resources at a rate below natural reproduction, or at a rate below the development of substitutes. Ecologically sustainable companies do not cause emission that harms the environment. They are companies, whose managers are limiting the abuse of any type of resource as it is necessary to minimize any waste as much as possible. From a company point of view, it might also be clear, that the input into the company' production system are often natural resources, the output is not only a final product but also pollution and other forms of waste. Sustainable company can be characterized as a company that has incorporated ecological consideration in its daily operations as well as in its strategic planning. Maersk environmental footprint has been constantly reduced in the last years, and this became real also because of the managerial decision made it at an Economy/Profit perspective, as mentioned above. Fuel consumption have been decreased year by year, resulting in lowering GHG emission, where particular attention has been dedicated to CO2 emission, considered the gas with greatest environmental impact. Figure 10 provides a table of the last three years performance, Maersk Sustainability Report (2009). The table shows annual reductions of energy consumption with consequential reductions of GHG emissions and its members more pollutants, as CO2 emissions, Sulphur Oxide (SOx), Nitrogen Oxide (NOx), etc. And the emissions of all air pollutants linked to the combustion of hydrocarbon chemical reaction of the A.P. Moller-Maersk Group:

Energy consumption				
		2007[c]	2008[c]	2009[d]
Fuel oil	1,000 tonnes	13,848.00	13,017.00	**11,840.27**
Diesel	1,000 tonnes	577.00	422.00	**617.32**
Natural gas	1,000 tonnes	908.00	886.00	**804.51**
Electricity	1,000 MWh	737.00	1,581.00	**1,755.42**
Direct energy consumption by primary energy source	GJ	–	–	**536,698,281.23**
Energy intensity	MJ/USD turnover	12.20	10.90	**11.06**
Greenhouse gas (GHG) emissions				
GHG emissions	1,000 tonnes CO_2 eq	53,352.00	48,198.00	**44,888.33**
Direct GHG emissions (Scope 1 GHG Protocol)				
CO_2	1,000 tonnes	50,296.00	46,554.80	**43,419.87**
CH_4	1,000 tonnes CO_2 eq	852.00	130.96	**314.34**
N_2O	1,000 tonnes CO_2 eq	1,076.00	199.66	**263.19**
HFC	tonnes CO_2 eq	–	2,600.00	**4,021.02**
PFC	tonnes CO_2 eq	–	–	**0.00**
SF_6	tonnes CO_2 eq	–	–	**0.00**
Indirect GHG emissions (Scope 2 GHG Protocol)				
CO_2	1,000 tonnes	1,128.00	723.30	**856.33**
CH_4	1,000 tonnes CO_2 eq	–	–	**22.24**
N_2O	1,000 tonnes CO_2 eq	–	–	**8.32**
GHG intensity	kg CO_2 / USD turnover	1.00	0.80	**0.92**
Other air emissions				
SO_x	1,000 tonnes	656.00	652.51[e]	**851.79**
NO_x	1,000 tonnes	1,094.00	1,041.56[e]	**976.74**
VOCs	1,000 tonnes	16.00	31.85	**22.60**
Particulate matters	1,000 tonnes	45.00	28.90	**85.10**

Figure 10: Maersk Sustainability Report 2009 – Environmental and climate change

Equity/people: is embodied in the company social responsibility, CSR. It means a growth strategy without decrease job quality and it reflects internal as well as external effects. A relevant aspect is to increase the human capital of individual partners as well as advancing the social capital of their communities, in which they operate.

A.P. Moller–Maersk Group has improved the health management system by introducing a

Group Health Manual, which all business units must be in compliance by the end of 2010, and starting in 2011. According to Maersk Sustainability Report (2009), the health manual consists of management programmes to be in place to assess, control and document the identified health risks arising from the chemical, physical, biological, ergonomic and psychological hazards that may be associated with the work environment. This could be air quality, noise, exposure to potentially hazardous substances, work load, discrimination, etc.

"To be protected against circumstances that may be damaging health is a basic human right. At the same time, a healthy workforce provides more stable and efficient business operations."

Monitoring compliance with national statutory requirements is mandatory for all aspects of health management, Maersk Sustainability Report (2009).

Why shipping companies should pursuit a triple bottom line approach?

These three aspects and the interrelation of them can lead to more sustainable supply chain.

"Collaboration among supply chain members within all activities, that are connected with delivering environmentally and socially responsible products and services to the end customers, as well as attaining acceptable profit and information in the supply chain."

Rabs&Bohn (2003)

Sustainability is a reality that in the last decades has faced many companies, the solution does not seem to be unique, since that different business areas can require different sustainable business models. To talk about sustainability does not cost anything, implement sustainable solution, in order to reduce environmental footprint, can become challenging for many companies, which want to keep competitiveness in the market and also be profitable being sustainable.

Globalization pushes companies to be more concerned on the environmental effects. Carbon emission in particular and its relation to climate changes has driven many companies to arouse the interest on lowering carbon emission in the supply chain, but this goes for all levels of the supply chain.

9. Analysis

This chapter includes theoretical bases concerned to Corporate Social Responsibility (CSR), and subjected to explain the operational implementation suggested by the thesis. Three aspects are been analysed in particular, CSR, Supply chain Management and the implementation of the Innovation in the containership supply chain. Through the analyses of those topics it becomes possible to provide an exhaustive overview concerning potential advantage of an actual weigh system able to measure containers weight, as part of the ordinary port-terminal´ supply chain. The implementation of a CO2 emission monitoring system could create an informative database able to improve customized services to clients, CO2-oriented.

9.1. Corporate Social Responsibility (CSR)

9.1.1. Intro & Problem Area

Sustainability is one of the aspect that compose CSR, which also includes company awareness, as not only held responsible for the own environmental performance, but also for the performance of their suppliers, subcontractors and partners. Almost 90 % of the world trade is carried by ship according to UNCTAD[16] (2007), which over 70% of the value of world trade is today shipped in containers, and for the vast majority of this trade there is little or no alternative to transport by ship.

This percentage highlights even more the CSR definition mentioned before, regarding sustainability in containership sector that can be linked with suppliers, subcontractors, partners, and all customers that availing of the use of containers to transport their goods.

"There is a natural scepticism toward companies because politicians and the general population suspect that we will pursue pure profits at the expense of the environment"

Nils S. Andersen, CEO A.P. Moller - Maersk Group - Maersk Post (2010)

Sustainability it should not be a label to achieve prestige in front of the others, but an approach that tries to keep in consideration during managerial discussions, for instance, the environmental impact of own decisions. To consider the effects that those decisions have on

[16] **UNCTAD:** United Nations Conference on Trade And Development, was established in 1964 as a permanent inter-governmental body. It is the principal organ of the United Nation General Assembly, dealing with trade, investment, and development issues. (unctad.org)

the environmental quality within the company is working to. Sustainability must become a core part of the company´ mission.

9.2. Interpretations of CSR

The definition of CSR has many faces, the concept of CSR derives from moral and ethic. It constitutes a term that covers the responsible relationship between the corporation, the society and the environment in which it is embedded. In international container shipping, this context is the globe.

For Parker (2003), contemporary philosophers are not interested or simply have not been able to elaborate new theories or critical analysis about the lack of moral in the way of making business in the last two centuries. This lack of interest was present also in business context, including marine sector, where the catalyst to consider this matter with interest, it has been the currently large oversupply of maritime transport capacity, caused partly by the recession and partly by the fact that ship orders were at highs record, just before the recession struck.

Bauman (1993) proposes a post modern view on ethics which say that as a part of an organization you are able to behave unethical since your personal moral values will move to satisfy the moral values dictated by the organization. Thus the personal moral reflects the one of the corporate. This gives reason to apply ethics into business as it is a part of acting responsible towards the society. If a CEO acts responsibly, this it will reflect upon the entire organization. The development of CSR during the past decade has move from pure philanthropy to a strategic tool.

"We want to be profitable, responsible and sustainable business. It is in line with our values, and is expected by our shareholders, customers, employees and society in general."

Nils S. Andersen, CEO A.P. Moller - Maersk Group - Sustainability Report (2009)

Friedmand (1970) and the liberalism view argued that there is no place for CSR in the business economy. Companies that act virtuously are in fact not responsible as they spend money borrowed from shareholder´s. For the liberalists, companies are responsible when it maximizes shareholder value and the single bottom line, as maximization of profit will generate a maximization of the social welfare. The social aspect of a society has to be ruled

by a democratic elected government rather than corporations, as they are neither competent nor democratically elected.
The economic situation of the last decade and the instability of oil prices have accelerated sustainable solutions in maritime sector.

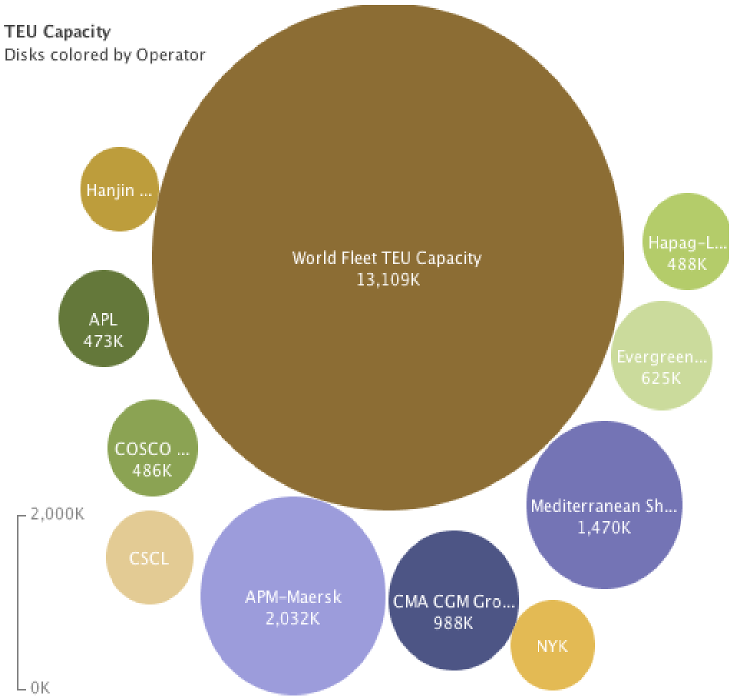
The neo-liberalism idea collapses the distinction between the economy and the society. Shamir (2008) develop the vision of a marked-embedded morality. This approach tends to moralize the market, to ground social relation within the economic rationality of the market. Here the government is seen as regulator, corporation and government are sharing the responsibility by shifting the power control to those closest to the problem.
This neo-liberal perspective should points out the IMO position, as the International Maritime Organization in charge to regulate international shipping transport. IMO has the power to guide all member states through international regulations. Regarding the specific topic of the thesis, IMO is in charge to develop the basis of legislative/technical instruments, able to support the controls and the limits of GHG emissions regime (in particular CO2 emissions), for international shipping, to improve the maritime environment.

9.3. Strategic CSR

Porter and Kramer (2006) make a distinction between responsive CSR and strategic CSR. Some companies have a responsive approach to CSR due to society-push or simply they just engage in pure philanthropy and attempt to be good citizen.
Vogel (2005) writes that still there has been no prove of CSR as a business case. He analyses the researches done in this matter and conclude that there might be a connection between virtue and financial performance but this is hard to prove.
The missing evidence between CSR and CSP (Corporate Social Performance) does not prove that CSR cannot be profitable; rather it is misleading trying to measure CSR activities on business performance, Porter and Kramer.
Vogel concludes that SRI (Social Responsible Investments) might not be more profitable than normal investments though they are not risky. And by performing CSR activities, companies might attract more and qualitative investors, and the effect hereof creates a win-win situation for both companies in form of liquidity and reputation, thus company value.
Campbell (2007) contributes to the discussion of using CSR as a strategic tool. His aspect in this matter emphasizes that the engagement and the necessity of CSR is very dependent on

company situation. Weak and strong companies have different preferences and the weak company might be more focused on survival than any other aspects.

A.P. Moller - Maersk is the world largest container shipping company by TEU capacity, in figure 9 is showed the containership market share:



Rank	Operator	TEU Capacity	Market Share	Ships	Market Share
1	APM-Maersk	2,031,886	15.50%	539	8.91%
2	Mediterranean Shg Co	1,469,865	11.20%	425	7.03%
3	CMA CGM Group	988,141	7.50%	378	6.25%
4	Evergreen Line	624,536	4.80%	176	2.91%
5	Hapag-Lloyd	488,135	3.70%	128	2.12%
6	COSCO Container L.	485,796	3.70%	148	2.45%
7	APL	473,170	3.60%	131	2.17%
8	CSCL	450,928	3.40%	143	2.36%
9	NYK	433,000	3.30%	119	1.97%
10	Hanjin / Senator	378,282	2.90%	91	1.50%
	World Fleet TEU Capacity	13,108,859	100%	6,048	100.00%

Figure 9: Container Shipping Companies – The Ten Largest (2009) - gcaptain.com

A.P. Moller - Maersk has the strongest market position as world largest shipping company by TEU capacity and by Ships, according to the market share percentages.

From a CSR perspective A.P. Moller - Maersk is showing effort in the direction of sustainability:

"Our largest business unit and contributor to our carbon footprint, Maersk Line, has set an ambitious goal of a 20% reduction of CO2 per container transported by 2017"

Maersk Sustainability Report (2009)

To demonstrate that CSR is also depending from company strong or weak position, for instance the second largest shipping company, Mediterranean Shipping Company (MSC), does not have any Sustainability Report, either in the own website mscgva.ch, and neither in internet, it is not possible to find data or material of any sort concerning CSR and sustainable awareness by the company. This lack of information could not mean anything, and may be a missed promotion about CSR and sustainable activities by MSC, or maybe could mean that at the moment sustainability it is not a MSC main objective, and MSC has other priorities, i.e. to increase TEU capacity or the number ships in the market share, etc. Other shipping companies present in the above list in figure 7, they show at least apparently more interest about sustainability and friendly environment solutions, at least at a formal level, showing links about those subjects in the company websites.

A competitive environment can also play a role, and CSR activities might or might not be necessarily vital for company survival. Whether companies choose to express their CSR activities explicitly or keep them at an implicit level it differs globally due to National Business Systems.

9.4. CSR approaches

Matten & Moon (2008) tried to clarify the reasons of differences between the U.S. style CSR and EU style CSR, and especially between the two approaches, the “explicit” CSR of United States, and the “implicit” CSR of European. They argue that national differences in CSR can be explained by historically grown institutional framework that shape national systems, the National Business System approach (NBS). NBS key features are the varieties of capitalism approaches that distinguish liberal market economies and coordinated market economies with specific social systems of production

The distinctive underpinnings of both approaches, explicit and implicit CSR, are four key features of historically grown national institutional frameworks:

1. the political system;
2. the financial system;
3. the educational and labour system;
4. the cultural system.

9.4.1. Political System

The key distinguishing features of American and European political system is the power of the State; European Governments generally are more engaged in economic and social activity (e.g. national insurance system for health, pension, etc.). U.S. has greater scope for corporate discretion since the government is less active.

According to tradecouncil.baltics.um.dk (2010), the newly released European Economic Sustainability Index (EESI), places Denmark and Estonia as the second most economic sustainable European countries. The European Economic Sustainability Index is compiled by the European Policy Center (EPC) think tank. This Index makes Denmark as a favourable context for companies awarded to move to sustainability, since at a National level the awareness is internationally acknowledged. A.P. Moller - Maersk Group headquartered in Copenhagen, might have had the opportunity to benefit more than its competitors located elsewhere, from Danish Government policies sustainability-oriented. Policies concerning sustainability, for instance can be to legislate tax deduction, routed to investment in sustainable solutions, i.e. to lower company environmental footprint; and/or also to attract foreigner companies to invest in sustainability in Denmark, because has favourable taxation conditions in the European area.

Better Place A/S, a global company specialized in sustainable transportation, particularly electric car transportation wants to build its electric vehicle network, where are provided battery supply and management, battery switch stations and standard charging, and all services related to betterplace.com. Better Place A/S is headquartered in Copenhagen, the European electric car experience. This choice could be influenced also by a favourable taxation that Danish Government has concerning sustainable businesses, compared to the other European countries. Danish taxation, the Danish high living standard, as an average high salary, an high technology society profile with environmental awareness by the citizens, makes the country attracting for many sustainability-oriented companies.

9.4.2. Financial System

In U.S. the stock-market is the central financial resource for companies, which are strongly focused on shareholders. Corporations need to provide high degree of transparency and accountability. European capitalism model has corporations embedded in network of smaller number of large investor, because banks play an important role. Within network of mutually interlocking owners, central focus is on long term preservation of influence and power. Stakeholders instead of shareholders play important role, sometimes equivalent or above shareholders.

The parent company of the Group, A.P. Møller - Mærsk A/S, is listed on the Danish Stock Exchange, and has around 67,000 shareholders. The company's main shareholder, however, is the A.P. Møller and Chastine Mc-Kinney Møller Foundation, which was established by the company founder A.P. Møller in 1953 to ensure that his life's work would always be owned by parties that held a long-term view of the company's development, in the spirit of the founder and according to his principles. This aspect play a crucial role in decision processes, since the company can have the last word on crucial decision, and not necessary be strongly focus on shareholders profit, that of course it is not secondary. The share capital is split between A and B shares, with only the A-shares carrying voting right. The Foundation holds more than 50% of the A-shares and consequently has the voting majority. The Foundation is mainly funded by the A.P. Moller-Maersk Group, but the Group has no influence on the Foundation's decisions regarding donations and investments. The Foundation aims to support Danish culture and heritage, Danish shipping, medical science and causes for the public good. Grants are only occasionally provided for non-Danish projects.

9.4.3. Education and Labour System

EU and U.S. differ in regulation and production of human resources at post secondary school level. European publicly led training, active labour market policies and corporations participated according to customs or regulation, where in US corporations themselves developed strategies. Europe has historically more relatively integrated, nationwide structures of business and labour interests, and Europe has historically higher level of union membership. Labour related issues are negotiated rather at sectoral or national level corporate level.

Denmark is concerned regarding the education in Sustainability, and the society seems to be embedded, compared other nationality of a particular environmental generalized awareness. Even at Academic level are provided Minor/Seminar as part of the education, or entire line based on Sustainability. This creates opportunities to educate new generation of managers, always business oriented, but potentially with interrelated sustainable mind-orientation.

9.4.4. Cultural System

Between US and EU are been generated very different broad assumptions about society, business and government. US have a relative capacity for participation, philanthropy, business people philanthropy, a relative scepticism about big governments, and a relative confidence about moral worth of capitalism. Strong American ethic of stewardship and "giving back" to society means social responsibility of wealthy business person evolved into the corporation.

European system instead has greater reliance on representative organizations, political parties, unions, employers associations, churches and state.
Some cultural aspect as already been mentioned in the paragraph above, other issues are outlined through institutional factors that informed about US and EU Natural Business Systems, specifically:

- Nature of the firm, as market-based, or direct/alliance ownership. A.P. Moller-Maersk Group for instance is listed on the Danish Stock Exchange, and A.P. Møller and Chastine Mc-Kinney Møller Foundation, has the majority of A-shares carrying voting right. This aspect becomes relevant considering that decision making processes are not only dictated by the market.
- Organization of market processes, how relations between actors are organized and coordinated, where the two extreme are Market and Alliances. US are market self-organization upheld by government and the courts (e.g. through antitrust laws). European system is organized by producers group alliances, which either reflect consensual representation and mediation of labour and capital or strong government leadership;

- Coordination and control system, in the way companies are governed, the degree of integration and interdependency of economic processes, the anatomy of employer-employee relations. The degree of delegation and trust governing relationships, and the degree of manager´ responsibility towards employees. In Europe, employee's representation and participation is guaranteed by dense employment regulation and protection covering a significant number of issues, which in the U.S. would be part of explicit CSR. U.S. CSR approach is embedded in U.S. institutions and culture, particularly in traditions of individualism, democracy, moralism and utilitarianism. Thus, distinctive elements of European CSR approach are embedded in European NBS, such as industrial relations, labour law and corporate governance.

9.5. Explicit CSR and Implicit CSR

According to Matten & Moon (2008), for "explicit CSR" is reported to corporate policies that assumes and articulates responsibility for some societal interests. They normally consist of voluntary programs and strategies by corporations that combine social and business value, addressing issues perceived as being part of the social responsibility of the company. For instance, after the Hurricane Katrina in 2005, many US companies, as Wal-Mart, FedEx, etc. provided a disaster relief for the victims, raising more than $792 million in few months, exceeding in speed and scope the initial response by the US government. Another case of explicit CSR may be responsive to stakeholder pressure, as the case of consumer and activist responses to labour conditions in Nike's Asian supply chains, or as previously mentioned the case of A.P. Møller and Chastine Mc-Kinney Møller Foundation, that donated to the Danish state the Operaen (the Copenhagen Opera House). Explicit CSR rests on corporation discretion, rather than reflecting either governmental authority or broader formal or informal institutions.

On the contrary for “implicit” CSR is reported to corporation´s role within the wider formal and informal institutions for society's interests and concerns. Implicit CSR normally consists of values, norms, and rules that result in (mandatory and customary) requirements for corporations to address stakeholder issues and that define proper obligations of corporate actors in collective rather than individual terms. Previously it has been exposes what is happening at A.P. Moller-Maersk Group regarding the implementation of the Health Manual submitted by all business unit of the group.

The two approaches differ, firstly, in the corporation language used to address their relation to the society, companies practising explicit CSR use the language of CSR in communicating their policies and practices to their stakeholders, whereas those practising implicit CSR, normally not describes their activities in this way. Secondly, the difference in the intent, wherever implicit and explicit CSR have similar practices, the nature of the behaviour makes the distinction. According to Porter and Kramer (2006), implicit CSR is not conceived as a voluntary and deliberate corporate decision, but rather, as a reaction to, or a reflection of the corporation's institutional environment. Explicit CSR is the result of a deliberate, voluntary, and often strategic decision of the corporation.

The conclusion hereof is that many different society factors affect the way of using CSR. US companies are to a much higher degree explicit about their CSR activities compared to EU, but the tendency is now moving in EU. The reason for the differences can be found in the social aspect of government involvement, where in North European countries, particularly in

Scandinavia, and in the specific case in Denmark, there is a cultural awareness concerning respect of environment, reducing GHG emission, and particularly CO2 emission.

"Copenhagen is to be the world's first CO2 neutral capital in 2025. That is according to the climate strategy of the Municipality of Copenhagen. Great efforts lie ahead for both city and citizens, but Copenhagen is well on its way." kk.dk - Klimaplan (2009)

Vallentin and Murilla (2009) are exploring the concepts of governance and "governmentality" within the liberal and the neo-liberal approaches. They are describing the role of the state regarding CSR applications within the society. They argue that we must be aware of the role and the influence of governments in regard to CSR governance in a positive and negative way. They also point out the ambiguous role of government in the context of exploding growth of CSR activities due to the proliferation of competitiveness.

9.6. CSR Critiques

Many authors from different schools are criticizing CSR from several angles. Milton Friedman (1962, 1970) brings a direct critique to CSR saying that in a free economy there is one, and only one social responsibility of business. This responsibility is to use its resources and engage in activities designed to increase its profits as long as it stays within the rules of the game, which is to say, engages in open and free competition, without deception or fraud. Friedman argues that corporate executives are persons in their own right and they can spend their own money on "social responsibilities" but cannot spend the money of someone else (stakeholders, customers, employees, etc.) for a general social interest, this is the role of the state.

Further, the question is, when companies act on behalf of the society, are they then able to actually articulate the voice of the public, do they know what the public want?
In the article by Margolish and Walsh, "Misery loves companies" (2003), the authors emphasize that companies choose their "misery". Sometimes companies invest in social initiatives for reasons that do not even have anything to do with the instrumental consequences, an act of "doing the right thing" rather than increasing shareholder value. This is the problematic as companies should in a high degree attend to their business, if they are not profitable they will not be able to make a difference after all. Companies should take into

notion the benefits of social engagements and how much and when to engage, when evaluating the options. The authors clarify that no real relation between Corporate Social Performance (CSP) and Corporate Financial Performance (CFP) has ever been proven. The result of a 127 studies shows that what appears to be the definite link between CSP and CFP may turn out to be illusory. But the authors argue that the impact of social performance on the bottom line of the firms, have to be moved to the effects of the society. Companies engaged in CSR activities are doing it mostly to get rewarded, in some ways they overtake the role of the government as they carry out social responsibilities.

"We believe that sustainable development is essential for society and business to thrive and grow. We are committed to integrating sustainability into all our business operations and making our performance transparent to our stakeholders."

Nils S. Andersen, CEO A.P. Moller - Maersk Group - Sustainability Report (2009)

For Reich (2007), the capitalism has become in recent years so powerful that it has started to take over democracy. Corporations are often said to have more power than nation government, the author refers to the term "supercapitalism". The author argues that the increase of CSR is related to the decreasing confidence in democracy through governments. But more generally, several members are responsible for "supercapitalism": the companies, who embrace CSR for reputation, risk avoidance, cost reduction and increase of profits; the customers, who claims that they care about social responsibility but are in practice not willing to pay more for it, then there is a lack of coherence between consumer's ideals as citizens and their acts as consumers; the investor, who are failing to favour companies that have tried to be socially responsible, the investors demand higher returns, and do not punish companies which act irresponsibly. Further, authors argue that the critiques towards CSR can have other origins than companies-, customers-, investor- or government's behaviour.

Kuhn and Deetz (2008) explain that effective moves towards CSR cannot rely only on managerial goodwill, government regulations or consumer choice alone. CSR can be enhanced by the inclusion of multiple social values into the decisional premises, processes and routines as well as in the development of communication processes.

"We should not forget that making a profit is the purpose of business, but I believe society is on a journey towards sustainability and so we, as a group of businesses, must make our contribution by integrating sustainability in our business practices. Doing business in a way that damages society will not be tolerated in the future and will therefore threaten the existence of the company."

Nils S. Andersen, CEO A.P. Moller - Maersk Group - Sustainability Report (2009)

These aspects utilize the situations of conflict and difference in order to generate creative win-win responses. CSR can better be advanced by new forms of inclusion and discussion, rather than ideological critiques of standards, audits, sustainability programs and awards. CSR is about incorporate diverse social and business values in decisional processes, then finding a system of inclusion is central. The corporation might be the right place to concentrate on developing the decisional processes needed for CSR in order to incorporate and foster the necessary variety of social values.

10. Container shipping supply chain

The information reported in the following chapter are extrapolated from two interviews with an ex Marine Terminal & Capacity Manager of Maersk Line Italy.

10.1. Container path from the terminal gate to the load on the containership

This chapter shows the path which is subjected each container from the Terminal gate, reached by train or by truck, until the moment the container is loaded on the containership.

1st Step – Gate in

The shipping company in export operation is in charge of the container booking to the Terminal booking clerk under the terms of trade provisions in the consignment of goods within a certain period of time before the fill container cargo consignment, necessary to let get in the container once it reaches the Terminal (Container Booking Note). When the container arrived to the Terminal gate, the responsible in charge must register the container number and check the container seals, inserting the related information in the Terminal system and check if they match with the booking. The last operation before get in the container is to control external evident visible damages. Once the container get in the Terminal, the shipping company is informed of the arrival. If the container is not booked, it cannot get in. Terminated this part the container can get in and be placed in the container pile field, container freight station; the Export stacking area.

The container booking note must indicate those basis required elements:

- Booking
- Container code
- Container size and type
- Container weight (type of commodity)
- Origin
- Final destination
- Port of loading (POL)
- Port of discharge (POD)

10.1.1. Container code

The codification of the containers is standardized by ISO[17] 6346 and requires that each container has to be registered with a code inclusive of eleven alphanumeric characters (4 capital letters of Latin alphabet; and 7 Arabic numeric digits) structured as follow, see Figure 10 below:

- 3 letters - the owner code, known as BIC code, must be registered at BIC[18], that ensures the uniqueness worldwide;

- 1 letter - recognizing the equipment category identifier, and must be one of those three letters (U: for all freight containers; J: for detachable freight container-related equipment; or Z: for trailers and chassis);

- 6 numbers - the serial number, assigned by the owner or operator, uniquely identifying the container within that owner/operator fleet;

- 1 number - (called "check-digit"), providing a means of validating the recording and transmission accuracies of the owner code and a serial number.

Figure 10: BIC codes, ISO 6346 - ocrtech.com

[17] **ISO**: is the International Organization for Standardization, is the international-standard-setting body composed of representatives from various national standards organizations. Founded on February 23, 1947, the organization promulgates worldwide proprietary industrial and commercial standards. It is a non-governmental organization. (iso.org)

[18] **BIC**: means International Container Bureau (from French, Bureau International des conteneurs) oversees standards for intermodal containers, commonly referred to shipping containers. BIC has been elected in the late 1960's as the single registrar office in charge of the registration and protection of the containers owners and operator's identification code (BIC code) later standardized as ISO 6346 standard. ISO 6346 is the international standard managed by BIC for coding, identification and making of intermodal containers (shipping containers) used within freight transport as part of containerization. (bic-code.org)

ISO 6346 standardizes “Freight Containers - Coding, Identification and Marking”. This standard describes some technical complementary markings such as size and type code, country code and various operational marks, bic-code.org.

The ownership of the container is detected by the registration at BIC, through the ISO-Alpha code as unique identity marking of containers recognized from all international transport and customs declaration documents, bic-code.org.

10.1.2. Container size and type

Container became the standard used for transportation of goods worldwide. The international standardization of container' dimensions makes containers the best and easiest way of goods transportation. The same container can be transported by truck, by rail and by ships, because they are already conformed to standard shipping size, and they are designed to resist harsh environments; such as on ocean-going vessels sprayed with salted water, or while transported on roads.

Containers can present different lengths, the standard used is TEU (Twenty-Equivalent-Feet) 20' Feet (long 6,096m), and FEU (Forty-Equivalent-Feet) 40' Feet (long 12,192m). Both containers sizes keep the same height 8' 6” Feet (2,591m) and the same width 8' Feet (2,438m).

Different types of containers are boarded on the container ship, and they can differ for type, or for size. The types of containers are, maerskline.com:

- Dry freight containers
- Reefer containers
- Flat racks
- Open tops

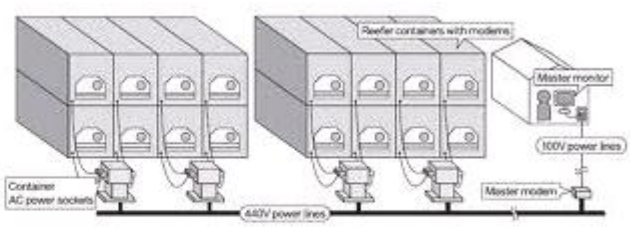
10.1.3. Dry freight containers

Dry freight containers are used to carry dry products, not organic goods; in general all kind of not biodegradable products, or too sensitive to temperature variation. Containers must be cleaned inside, in order to do not affect the delivering of other products the next time are used. Containers are made to transport different kind of products and for many times.

10.1.4. Reefer containers

Reefer containers are dedicated to transport products that require to be maintained at a certain temperature, or between a certain ranges of degrees until the final destination. These containers providing different setting for all kind of commodities, in order to do not modify the freshness of the products delivered. A refrigerated container is an intermodal container used in transportation of temperature sensitive cargo.

Reefer containers have integrated refrigeration units, but anyway they rely on external power, from electrical power points at a land based site, or on the containership or on the quay.



When transported over the roads on a trailer they can be powered from diesel powered generator ("gen sets") which is attached to the container whilst on road journeys.

Some reefer is equipped with a water cooling system, which can be used if the reefer is stored below deck on a vessel without adequate ventilation to remove the heat generated.

Water cooling systems are expensive, so modern vessels rely more on ventilation to remove heat from cargo holds, and the use of water cooling systems is declining.

The impact of reefer containers in the society is vast, allowing consumers all over the world to enjoy fresh products at any time of the year, experiencing fresh produce that previously were unavailable from many other parts of the world.

10.1.5. Flat racks

Flat racks are made for cargo not suitable in standard container. Companies provide flat racks for specific equipment, as heavy cargo that requires special attention, or that does not fit into standard container. Flat racks length of 20’ and 40’ Feet, with fixed or collapsible end-walls, maerskline.com.

10.1.6. Open top containers

Open top containers are fitted with a solid removable roof, or with a tarpaulin roof so the container can be loaded or unloaded from the top.

10.2. Container´ weight

Container' weight is inserted in the container booking note. The weight is the criteria to position the container in the pile container field and afterward to load the container on the containership. The weight is crucial for the safety of the containership, and of all cargo.

2nd Step – Stacking area

10.3. Stacking Area

The heavier containers must be located on the bottom of the pile, and the lighter ones on the top, to prevent damages to the containers and the cargo. Reefer containers are stowed separately because they must be connected to electrical power. Containers carrying dangerous goods are stowed in the IMO area, because more controlled (i.e. Fireman are present 24/7 hours in order to intervene for any emergency/accident).

The containers imported are stored in the stacking area, spending average of 4 to 5 days, because the Terminal after 5 days charges fee for the extra time.

Containers to export are stored in the stacking area for average of 6 days. Container shipping line providing usually weekly sevices and the container to export can get in the Terminal, maximum 15 days before the containership arrival date.

Reefer containers used to remain for shorter period in the stacking area, because the goods are perishable.

The stacking area it is divided in area/yard:

- Import area;
- Export area;
- Transshipment area

10.3.1. Import area

As the containers are unloaded, they are stocked between containers to be delivered via truck, and containers to be delivered via rail.

10.3.2. Export area

All containers to export are stocked and separated by containership and by port of arrival, but not by container shipping line, because on the same containership they can be loaded containers from different container shipping lines.

10.3.3. Transhipment area

Transhipment area is designed for the transfer of cargo from one vessel to another It is often included as part of the export area, since they are also divided by containership, and by port of arrival.

3 Step – Vessel stowage plan

10.4. Vessel stowage plan

The weight of the container is the criteria determining the place of the container in the containership hold, the same happening in the stacking area piles. The heavier containers are filled up at the bottom of the hold, and the lighter ones on the top of each slice. A slice is a vertical section of the hold. The hold of the containership is divided in sections, where each one is filled up by containers to be unloaded at the same discharging port. Example of vessel stowage view, see figure 10:

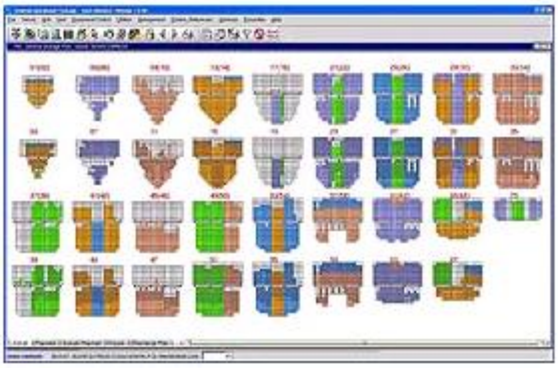


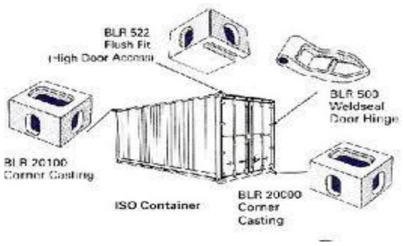
Figure 10: Vessel stowage view - rbs-it.com

Figure 10 shows the succession of level whereby is divided the hold of the containership, from the stern of the vessel to the prow. Different colors in the stowage plan, indicates the different port of freight unloading.

The stowage plan must be sent from the shipping line to the Terminal planner, at an agreed predicted time before the arrival of the vessel to the port. The stowage plan used to be sent by paper mail, but now is sent as .pdf file. In this way the planner has the time to organize the logistic and the necessary mass of work to optimize all operations in the Terminal. Those operations concern the people required, the cranes, the trucks, the trains, etc. to be synchronized in order to respect the delivering timetable, without delays, which involve extra costs.

The importance of container´ weight is due because the stern and the bow of the vessel must be balanced, as also the port and the starboard. If we look a containership from the top, and we divided the vessel into four: the weights must be balanced between the 4 sections (front left with front right; rear left with rear right; and the total weight of the stern with the total weight of the prow). The logistic software through elaborated algorithms is responsible of the placement of containers in the ship. When the containership is not balanced:


FEU must be loaded above TEU, because the total weight of one FEU is lower than the one of two TEUs, and also because FEU does not have middle corner casting, where to hook the twislock. The corner castings are placed on the corner of the container.



Twistlock and corner casting together form is standardized by ISO 1161 as rotating connector for securing shipping containers.


11. Bunker Delivery Note

MEPC in the MARPOL[19] Annex VI[20] by Regulation 18, places requirements to fuel oil suppliers and their control by the appropriate authorities together with other regulatory aspects. All member states are invited to adopt the procedures concerning fuel oil supplier registration schemes. From the full document the relevant part for the thesis is the point 3, that states the details of fuel oil for combustion purposes, delivered to and used on board ships shall be recorded by means of a bunker delivery note, which shall contain at least: name and IMO number of receiving ship; the port; the date of commencement of delivery; the name, address and telephone number of marine fuel oil supplier; product name(s); quantity (Tons); density at 15^{o}C (kg/m3); sulphur content (% mass/mass) and a declaration signed and certified by the fuel oil supplier representative that the fuel oil supplied is in conformity with the required MEPC regulation.

11.1. Bunker

Containership burns Bunker, technically called Heavy Fuel Oil (from now, HFO). HFO is a type of fuel denser than fuel used for cars. Each type of fuels created trough oil-refining has different boiling points, and consequently different carbon contents, according to MEPC 61/5/3 Annex 2 (2010) further information in Appendix 2, see Figure 11:

[19] **Marpol 73/78:** is the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978. ("Marpol" is short for marine pollution and 73/78 short for the years 1973 and 1978). Marpol 73/78 is one of the most important international marine environmental conventions. It was designed to minimize pollution of the seas, including dumping, oil and exhaust pollution. All ships flagged under countries that are signatories to MARPOL are subject to its requirements, regardless of where they sail, and member nations are responsible for vessels registered under their respective nationalities. (wikipedia.org & imo.org)

[20] **Annex VI:** Regulations for the prevention of Air Pollution from Ships, entered in force on 19 May 2005. Basically the code covers the following, (marinediesels.info):

Regulation 12 – Emissions from Ozone depleting substances from refrigerating plants and fire fighting equipment

Regulation 13 – Nitrogen Oxide (Nox) emissions from diesel engines

Regulation 14 – Sulphur Oxide (Sox) emissions from ships

Regulation 15 – Volatile Organic compounds emissions from cargo oil tanks oil tankers

Regulation 16 – Emissions from shipboard incinerators

Regulation 18 – Fuel Oil quality

Type of fuel	Reference	Carbon content	C_F (t-CO_2/t-Fuel)
1. Diesel/Gas Oil	ISO 8217 Grades DMX through DMC	0.875	3.206000
2. Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.86	3.151040
3. Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.85	3.114400
4. Liquified Petroleum Gas (LPG)	Propane Butane	0.819 0.827	3.000000 3.030000
5. Liquified Natural Gas (LNG)		0.75	2.750000

Figure 11: MEPC 61/5/3 – Annex 2

HFO is the second last bottom part from Oil petrol distillation[21], above the bitumen. HFO also called bunker, is the fuel burned by containership power engine. Different varieties of Fuel Oil are available, it depends on the mixture density, where higher density means higher percentage of HFO, i.e. HFO 180 is compound from 95% of HFO 380 (really dens) and 5% of Diesel Oil.

11.2. Bunker and Ships

Old ships burn HFO 180, while new ships burn HFO 380, as previously explained, denser. The fuel burned depends from the technology of the containership power engine. A different aspect concerns the generator power on board, almost all ships (exception for those built from 2007/2008), to power the generators burn Marine Diesel Oil (from now, MDO), which is similar to Diesel Fuel for cars.

The last generation of containerships (newest and bigger), burn HFO 380, for both engines and generator. This provide a big economic advantage, since, for instance in the major international ports, according to BWI (Bunker World Index) HFO 380 is quoted between 537 and 657 USD per tonne; HFO 180 is quoted between 556.50 and 670 USD per tonne; and MDO is quoted between 839 and 945 USD per tonne, bunkerworld.com.

[21] **Oil Petrol Distillation**: Distillation is a physical separation process, is a method of separating mixtures, based on differences in their volatilities (boiling point) in a boiling liquid mixture. Thus, through the Oil Petrol distillation, on top there are lighter fuel, as liquid petroleum gas, Kerosene, Naphtha Oil; in the middle of the distilled Oil Petrol, there is Diesel Oil; above there is the Heavy Fuel Oil (HFO); and on the bottom there is the Bitumen (or asphalt) is primarily used, when mixed with mineral aggregates, to produce paving materials, and is the refusal of petroleum distillation.(wikipedia.org)

Average consumption of MDO in containership is around 2 tons per day (maximum 5 tons per day). MDO is used in two situations, into the containership is used for input and output operation from/to the port; and at the port is used to supply power to the generator of reefer containers.

Smaller vessels, with average capacities of carrying from 300 TEU to 500 TEU, burn HFO 180 (i.e. Feeder vessel in the Mediterranean), and they can consume between 20 to 35 tons per day. This depends on the size of the vessel, but also on the average speed.

Larger vessels, with capacities of carrying from 6,000 to 15,500 TEUs, burn from 80 to 300 tons of Bunker per day, at normal speed.

11.3. The Bunker Delivery Note

The Bunker Delivery Note is the receipt issued to the ship Captain. On this document are filled the technical details of the oil supplied to the containership, as the amount of bunker (Tons) and the quality of the bunker. The quality of the bunker is indicated by the sulphur percentage present, because from 2008/2009, the percentage of sulphur must be reduced, IMO (2005), the main changes to MARPOL Annex VI - Air Pollution, entered into force on 19 May 2005.

A progressive reduction in Sulphur Oxide (SOx) emissions from ships on a global basis and in defined protected areas called Sulphur Emission Control Area[22] (from now, SECAs). High percentage of SOx in the atmosphere determines the acid rain. See figure 12 below:

[22] **SECAs:** MARPOL Annex VI - Regulations 14, defines the method of controlling Sulphur Oxide (SOx) emissions on a global basis and in defined protected areas called Sulphur Emission Control Areas (SECAs). The aim of the legislation is to reduce SOx emissions from ships to reduce the acidification of the atmosphere and the resulting acid rain. (severnesnow.com)

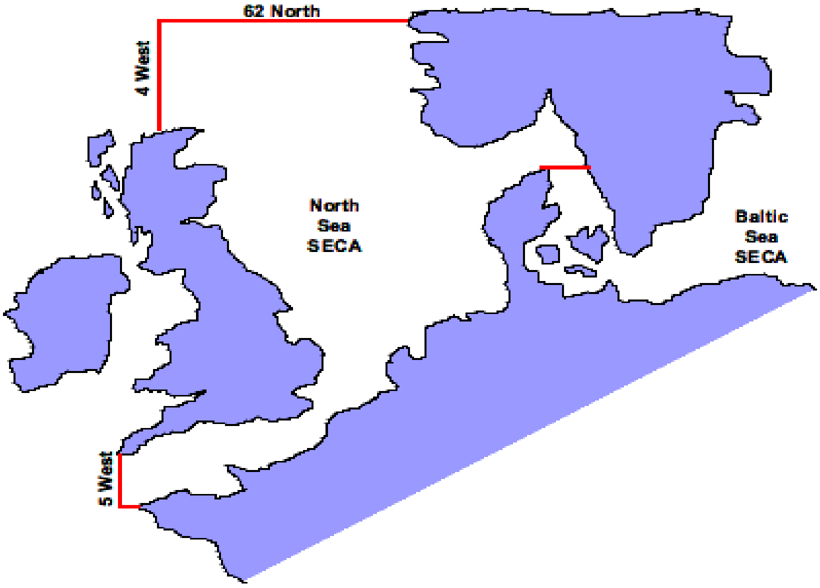


Figure 12: SECAs Area - severnesnow.com

In SECAs, ships must switch to use fuel with a sulphur level of <1.5% or fit an exhaust scrubber system that will achieve equivalent reductions. Under Annex, the maximum sulphur level in fuel will be progressively lowered as follows:

1. 1.00% mass/mass on and after 1 July 2010; and
2. 0.10% mass/mass on and after 1 January 2015.

12. Operational problem

The operation of weighing the containers must not affect the regular container shipping supply chain, and this is an imperative of the thesis. The shipping service provided to the customers must not be affected (i.e. delivery delays; rise of transportation costs, etc.) by the implementation of a new operation in the supply chain. From the shipping company perspective, the implementation of a new operation in the regular supply chain must not become charged on the customers until it is not realized the real utility or competitive advantage of the new solution.

In international sea freight transport, the shipping cost is a strong element of competition, although there may be special services requirements that can influence the choice. Container shipping lines have a low specificity, because the services offered are standardized.

If this is true, how it is assumed in the thesis, that the operational implementation suggested, designs additional information as: certified container's weight in a real time; real time calculations of the total weight carried on the containership; to supply of fuel related to precise real energy need for the route, in order to fill just of the required fuel necessary to be burned for the travel in the lightest way. Such kind of information they could improve and they could create competitive advantage over others shipping competitors. Presumed this, now the question becomes how it could be possible to weigh the containers in the harbour, without to affect the regular port terminal supply chain. First of all, the aim of the thesis is not to provide a technical engineering solution, but instead, to suggest which they could be the operational moments, where a technical solution could be implemented, in order to weigh the containers in the Terminal before they are loaded in the containership.

12.1. The reason to weigh the containers

This operation seems useless and time consuming, useless because the information it is already provided by the customer, and time consuming because current method to weigh container requires extra time from the regular port supply chain. Usually containers are never weighed in the Terminal. For instance, one of the way to weigh the containers, it is through the comparison between the weight of the truck carrying the container, and the weight of the truck without the container. Thus, nowadays to weigh the containers, it is considered an extra operation, and not particularly relevant from ship operator, in order to accomplishing the transportation service required by the customers. In the thesis is assumed to relate the weight of the container, to the actual CO2 emissions for its transportation. To make this report reliable, the container' weight must be precise, and officially certified, as for instance, from IMO.

To weigh the container is not a lack of trust against the data provided by the customers in the container booking note. The reason is instead to negotiate in the climate market, stocks based on actual CO2 emissions and not on estimation, since 1 Ton of CO2 emission becomes a carbon credit. If the estimation not reflects actual emissions, this could make the stock market less efficient, because this falsifies the spread between actual emission and estimated emission, becoming a bad approach of speculation.

"As with any complex financial market, the ETS is a haven for those who can work around the system."

greenleft.org.au (2011)

12.2. Third-Parties Logistics Providers

The assumption to provide actual CO2 emissions that can become internationally approved and certified is a service that could be implemented by the container shipping line, or by the Terminal, or could also be provided by a third company that takes the responsibility on behalf of the shipping company, or the customer, etc. to weigh and to certify the actual weight of the container.

According to Berglund (1999), we can define three main typologies of Third-Party Logistics Providers:

- Asset-based logistics providers
- Network logistics providers
- Skill-based logistics providers

12.2.1 Asset-based logistics providers

They are typically operators of owned or leased logistics services assets, such as trucks, airplanes, warehouses, terminals and containers. They offers third-party logistics services as a natural extension of their core businesses. For example, in the case of transport companies, they may provide dedicated trucks, transport management and information services to a shipper. Declining margins and tougher competitive environment in the traditional transport market have been the main drivers for those companies to enter the third-party logistics market. Some of these providers used the additional logistical services and third-party logistics arrangements to secure volume for their basic services.

12.2.2 Network logistics providers

These third-party logistics providers started as couriers and express parcels companies and built up global transportation and communication networks to be able to expedite express shipments faster and more reliably. Supplementary information services typically include electronic proof-of-delivery and track-and-trace options from sender to receiver. Example are DHL, Damco, UPS, TNT and FedEx. Recently, these players have moved into time-sensitive and high-value-density third-party logistics market as electronics, pharmaceuticals and are competing with the traditional asset-based logistics provider in these high-margin markets.

12.2.3 Skill-based logistics providers

They typically do not own physical logistics assets, but provide consultancy and financial services, information technology, and management skills to the clients. These new players are often subsidiaries or joint ventures. An example of skill-based logistics provider is Damco, a subsidiary of the A.P. Moller – Maersk Group. Damco provides customized supply chain solutions (more information in chapter 6 and 7).

If we consider the case of a third party logistics company in charge to weigh the container, the solutions that seems to be more suitable for our case, it can be a mixed combination between the asset-based and skill-based logistics providers. The asset-based logistic it could be the one in charge of the operational aspects in the Terminal, providing the technical instrumentation required to weigh the containers, or implementing in the crane and container lift the solutions to weigh the containers.

On the other hand, the skill-based logistics as already mentioned in the paragraph it could be provided by Damco, supporting the logistic and IT aspects, becoming the network between shippers and clients, and managing the related information.

The certification for instance it could be delivered by IMO clerks, since IMO offices are located in all ports of the member states. Thus, IMO becomes guarantor of the weight attested, and internationally responsible of the certification.

It has been used IMO as example of third-party, but the concept can be applied to any third-party that can provide the same presence worldwide, being able and reliable to provide a standardized service worldwide in order to avoid incongruence in the measurement.

12.3. First supply chain moment to weigh the containers

The first situation that seems to be suitable, is for instance to implement in the “forklift” used to move the container from the truck or the train, a sensor weigh that through the power used by the hydraulic valves to move the container from one place to the to the stacking are, it can at the same time also calculate the weight. This information could be detected by a code scanner, as for instance already happen with barcode[23] and QR code[24], to recognize the product. Afterword the information could be sent trough a wireless connection or by Bluetooth to the database, that should be in charge to match the information provided in the container booking note and the weight calculated by the system.

(Sample of barcode) **(Sample of QR code)**

One of the objections of this solutions could be that containers are not furnished of barcode, and neither of QR code, but it is also true, that instead it could be used the container code, to match the weight information. If the information are matching, the CO2 emission calculation is based on the data provided in the container booking list, moreover if the two data do not

[23] **Barcode:** is an optical machine-readable representation of data, which shows data about the object to which it attaches. Originally, barcodes represented data by varying the widths and spacings of parallel lines, and may be referred to as linear or 1 dimensional (1D). Later they evolved into rectangles, dots, hexagons and other geometric patterns in 2 dimensions (2D). Although 2D systems use a variety of symbols, they are generally referred to as barcodes as well. Barcodes originally were scanned by special-optical scanner called barcode readers, scanners and interpretive software are available on devices including desktop printers and smartphones. The first use of barcodes was to label railroad cars, but they were not commercially successful until they were used to automate supermarket checkout systems, a task for which they have become almost universal. (wikipedia.org)

[24] **QR Code:** is a specific matrix barcode (or two-dimensional code), readable by dedicated QR barcode reader and camera phones. The code consists of black modules arranged in a square pattern on a white background. The information encoded can be text, URL or other data. Common in Japan, where it was created by Toyota subsidiary Denso-Wave in 1994, the QR code is one of the most popular types of two-dimensional barcodes. *QR* is the abbreviation for *Quick Response*, as the creator intended the code to allow its contents to be decoded at high speed. (denso-wave.com)

match, the one calculated in the Terminal replaces and updates the one provided in the container booking note, and the CO2 emission are calculated according to this data.

The weight measured is the total weight (gross weight) of the container, this mean the weight of the container steel box, and the goods transported. The calculation is made on this weight.

The required type of technology already exists in the market, and is called Automatic Container Code Recognition (from now, ACCR). ACCR is manufactured to read ISO 6346 codes, that as mentioned previously, are the international standard for assigning unique codes to freight containers, commonly known as BIC, ocrtech.com. ACCR are mostly used, for the following operations:

- Building a comprehensive database of traffic movement;
- Automation and simplicity of airport and harbour logistics;
- Border control management;
- Inventory management;
- Container surveillance systems.

This technology exactly match with, what it is required from the operational implementation suggested in the thesis, and it seems to be the technology that could solve the containers detecting aspect, and it is provided also the software platform, necessary to collect, to order and to update the database, in a real time, as request.

This first solution from my personal perspective seems to be the most intuitive. The weak points of this solution could be the implementation of a detecting system in a large scale making the software system efficient. It is also possible that this system already available in the market, cannot match ship company requirements, for technical or logistic reason. The second weakness could be the creation of the software that could manage the data, matching the different information sources, creating a platform to insert data that can be automatically replaced and updated when incongruous.

12.4. Second supply chain moment to weigh the containers

Another suitable moment it could be to create in the Terminal a street circuit where the containers can be weighted when carried by trucks, and afterward to weigh the truck itself without the container, measuring the weight of the container, trough the difference of the two weights.

Firstly, this option would require a different treatment for containers carried by trains. Secondly, it would require the creation of driven circuit inside and/or outside the Terminal that all trucks must follow. In order to do not interrupt the regular in/out containers flow in the Terminal, it must be created a kind of First In – First Out system to do not switch the container delivered and the truck transporter, calculating the weight of the wrong container through the weight of the wrong truck.

The weakness of this solution, it could be that seems is time consuming and probably it is “incompatible” with the Terminal daily routine. It does not seem acceptable to imagine queues of trucks inside the port waiting to be weighed. Also, it does not seem a realistic solution to create new areas dedicated just to weigh trucks and containers. In the case it is possible to manage the traffic of trucks in the Terminal, there is still to solve the problem concerning the containers transported by trains. This point could involve a different technical/mechanical solution to weigh those containers, creating two heterogeneous methods (one for trucks, and a different one for trains) of measurement. Anyway the two methods should be equivalent.

13. Explicative model

13.1. Model of transportation

The idea of the thesis is to monitor the CO_2 emission of each container transported by sea freight. The relevant criteria that can make this calculation possible is the container's weight, as basis of evaluation, and the Bunker Delivery Note as document that certify the amount of fuel supplied to the containership. As sample, it has been taken a containership route from Asia to Europe, Westbound route (AE11), Figure 13, maerskline.com.

Figure 13: AE11 Westbound – Maersk Line - maerkline.com

The reason of choice this route map, is due because it includes seven of the 30 world's busiest container seaports, for total mass of actual TEU (in thousands) transported through the port in 2009, according to hafen-hamburg.de (2009) (#2. Shanghai 25,002 | #3. Hong Kong 20,983 | #9. Qingdao 10,260 | #13. Port Klang 7,309 | #17. Tanjung Pelepas 6,000 | #27. Salalah 3,490 | #28. Port Said 3,470). The port of Genoa is one of the most active in the Mediterranean, and in terms of traffic and size is the largest industrial and commercial Italian port. Route AE11 linked these crucial commercial ports worldwide, and it has been chosen compared to others, also because in this route the containership transits "homogeneously" between the ports from China to France, to see figure 14:

Port	Arrives	Departs	Transit
Lianyungang, China		WED	--
Qingdao, China	WED	THU	1
Shanghai, China	FRI	SAT	3
Fuzhou, China	SUN	MON	5
Hong Kong, China	TUE	WED	7
Chiwan, China	THU	THU	9
Yantian, China	THU	FRI	9
Tanjung Pelepas, Malaysia	MON	TUE	13
Port Klang, Malaysia	TUE	WED	14
Salalah, Oman	WED	THU	22
Port Said, Egypt	TUE	WED	27
Piraeus, Greece	THU	FRI	29
Genoa, Italy	SUN	TUE	32
Fos Sur Mer, France	WED		35

Figure 14: AE11 Westbound – Maersk Line - maerkline.com

In others route the containership, directly navigate from Asia to Europe without any stop in the Middle East, and even if the concept does not change, it has been considered that it could not provide the same clarity about the potential utility of the idea developed, as it is visible in the Maersk Line AE2 route, see figure 15. “Homogeneous” means that the transit days from one port to the next, in AE11 are on average 2,7 days and the biggest exception is the route from Port Klang (Malaysia) to Salalah (Oman), that takes 8 days.

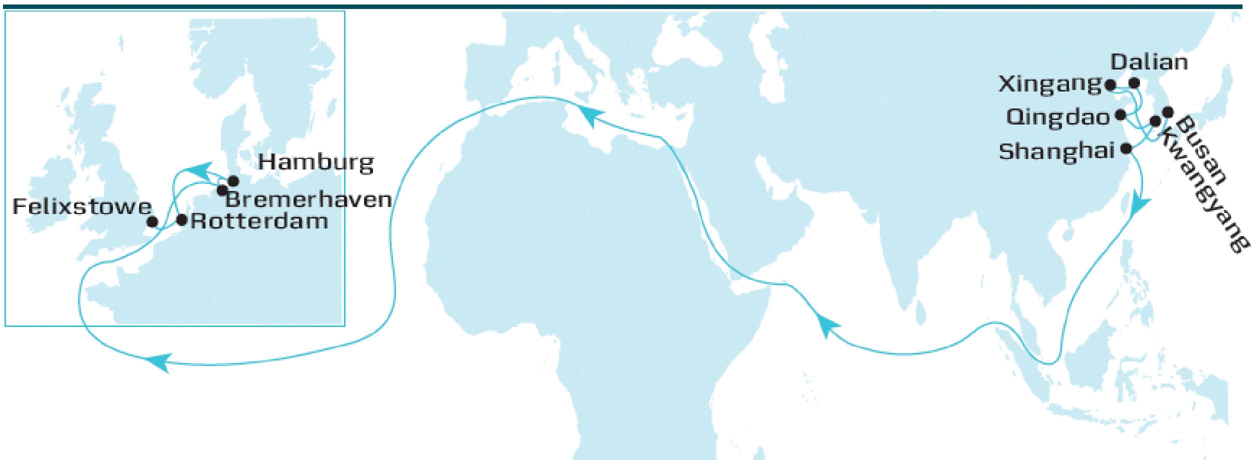


Figure 15: AE2 route Westbound – Maersk Line – maerskline.com

In AE2 the days are on average 4,3 between the ports, with the exception of 24 days from Shanghai (China) to Bremerhaven (Germany), that covers almost 70% of the total transit time, according to AE2 route, maerskline.com.

PORT	ARRIVES	DEPARTS	TRANSIT
Busan, South Korea		THU	--
Xingang, China	SAT	SUN	2
Dalian, China	SUN	MON	3
Qingdao, China	TUE	WED	5
Kwangyang, South Korea	THU	FRI	7
Shanghai, China	SAT	SUN	9
Bremerhaven, Germany	TUE	WED	33
Hamburg, Germany	THU	FRI	35
Rotterdam, Netherlands	SAT	SUN	37
Felixstowe, United Kingdom	MON		39

Figure 16: AE2 route Westbound – Maersk Line – maerskline.com

The containerships that travel this route have nominal TEUs capacity around 8.112 TEU, according to maerskline.com, i.e. Cornelius Maersk (8.160 TEU), Maersk Tukang (8.112 TEU), and Maersk Tanjong (8.112 TEU).

A new generation of containerships are in the market, since few years ago, and they are the biggest one worldwide, like Emma Maersk, and others eight similar containerships, all owned by Maersk Line, with nominal TEUs capacity of 15.500. Moreover it is easy to assume that there are already in plan even bigger containerships. The reason of building bigger containerships is based on the assumption that energy consumption and thereby the CO2 emissions of the ships is strongly dependent on ship size and ship service speed, i.e. the larger the vessel capacity the lower the CO2 emissions per container.

"With room for 18,000 TEU (twenty-foot containers), the Triple-E has a capacity for 2,500 more containers than Emma Mærsk, meaning less carbon dioxide emitted per container moved."

maerkline.com (2011)

13.2. Model assumption

AE11 Westbound can be considered an important commercial route, and has by Maersk Line an average frequency each 6 days from China to Europe, covering 3 different continents in 35 days, maerskline.com, of which approximately 31,3 days of actual shipping. The model makes the following assumptions:

1. The model is based on the AE11 route of Maersk Line, Westbound from Lianyungang (China) to Fos Sur Mer (France), see Figure 12.

2. The model assumes an 8.112 nominal TEU capacity container vessel.

3. The vessel has a constant speed, at 21 knots (nautical miles) between the ports equal to the average speed given as input. For ports arrivals and departures, the speed is reduced to 10 knots two hours in advance. This is to standardize port in/out operation, and to reduce distortion that could affect the quality of the analysis.

4. At the average speed of 21 knots it has been estimated a Bunker daily consumption of 150 Tons, independently of the amount of containers on board on the ship. The fuel considered for the calculation is HFO, and the CF used is the related one of 3,1144 (Tons of CO_2/Tons of Fuel), see figure 12.

5. Only dry cargo containers are considered in the model, i.e. reefer containers are not considered, because they involve to carry MDO, necessary to power the refrigeration of reefer containers. Excluding reefer containers, the only MDO required is the one for input and output operation from the ports.

6. The harbour costs along the route are averaged to all containers.

7. Transportation costs per container are not supposed to be affected from the amount of emissions connected with.

8. Solely container weight is taken into consideration for the analysis, regardless of the type of commodity and declared value.

9. Ship speed is not considered as a variable of the equation, and it is not taken in consideration for calculations. This assumption is not supposed to affect the quality of the analysis, that it is based on fuel consumption, and transit time (in days). Speed directly affects fuel consumption, and consequently it affects CO_2 emission.

10. The containers used for the model are only TEU (20 Feet), with a range of total weight (container steel box plus the net weight), estimated of 15 Tons and 25 Tons.

13.3. Model of container carbon emission allocation

Any type of technology implementation in the port terminal supply chain, which it supposes to improve its efficiency, it must be directed to the achievement of useful data able to be elaborated through a model that makes good use of the data obtained. Those data must become useful for the CO_2 emission calculation. In this chapter the CO_2 emissions for the shipment of containers it is described in detail.

A simplified CO_2 emission model based on transportation, where the bunker consumptions are assumed on a Maersk container route AE11, which it is used for the evaluation of the relation between the bunker's consumption for the transportation and the related carbon emissions of the container. The carbon emission model is simplified as follows, where the summation ($\sum$) concerns the data in the brace { }, and the subscripts **D**, **A**, **W**, **w**, **CF** and **CO2 emission of the container** are:

(D) express the data related to the port of Departure, and the related number 1, 2,...,x , means the succession of the ports reached until the last port considered for the calculation (i.e. x), involving the fuel amount at the departure (in Tons of Fuel).

(A) expresses the data related to the port of Arrival, and the related number 1, 2,...,y , means the succession of the ports reached until the last port considered for the calculation (i.e. y), involving the fuel amount at the arrival (in Tons of Fuel).

(W) expresses the data related to the total weight carried during the voyage between each port (in Tons), and the related number 1, 2,...,z , means the succession of the ports reached until the last port considered for the calculation (i.e. z).

(w) expresses the weight of the container taken in consideration (in Tons).

(CF) is a non-dimensional conversion factor between fuel consumption measured in Tons, and CO_2 emission also measured in Tons based on carbon content, (in Tons of CO_2/ Tons of Fuel), the data is provided by MEPC 61/5/3 Annex 2 (2010), to see Figure 10.

(CO2 emission of the container) is the actual amount of CO_2 emission allocable to the container. It is related to the weight of the container itself; the different total weight which the container has been part in the containership hold during its voyage from the port of departure to the port of arrival; and it is also related to the total fuel burned during the whole voyage, until the container is landed at the port of arrival. The result is expressed in Tons of CO_2 emitted. Thus the equation becomes:

CO_2 emission of the container =

$$\sum_{D,A} \{ [(\text{Bunker level at departure port}_{(D1,D2,..,Dx)} -$$

$$\text{Bunker level at arrival}_{(A1,A2,...,Ay)}) /$$

$$\text{Total weight of the containers}_{(W1,W2,..,Wz)}] *$$

$$\text{Weight of the single container}_{(w)} \} *$$

$$\text{CF (Tons of CO2/ Tons of Fuel)}$$

$$= \{ [(D1\text{-}A2) / W1] + [(D2\text{-}A3) / W2] +................+ [(Dx\text{-}Ay) / Wz] * \mathbf{w} \} * CF$$

$$= \{ [\text{Tons of Fuel / Tons}] * \text{Tons} \} * (\text{Tons of CO2 / Tons of Fuel})$$

$$= \text{Tons of CO2}$$

The bunker burned emits the carbon dioxide for the transportation, i.e. carbon emission of the container on a given route. The carbon emission model it applies for the shipment of goods from the origin to the recipient, but in this context the carbon emissions are limited to the transportation of one container (standard TEU) along the sea passage. The emissions are indirectly associated to the speed, because the model does not include the speed of the containership as a variable in the equation, but is considered exclusively the fuel consumption. Thus, the emissions for inland transportation and of handling or, of feedering of the containers to the departure port or from the arrival port are not considered.

13.4. Construction of the analytical model

The following sample case, it has been made to demonstrate with a practical example, what it has been explained in this chapter. All data used in the model concerning the container's weight and fuel consumption are given, and they are not related to any specific company case. Anyway it has been tried to keep a logical criteria that could link distances and fuel consumption with a thoughtful approach, assuming a daily fuel consumption of 150 Tons of

Bunker, adopting "slow steaming" with an average speed of 21 knots, independently from the amount of containers on board.

The model has on the top of the schedule, the first horizontal lines, **PORT** (red colour), listing the names of the ports included in route AE11, named with the international acronym, **INT. CODE**. The **NUMBER** of the port indicates the ports order of succession, see Figure 17:

PORT	INT. CODE	LYG	TAO	SHA	FZN	HKG	CWN	YTN	TPT	PKG	SLL	PSD	PIR	GOA	COU
	NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Figure 17: Model for the development of the analysis – PORT detail

The vertical column on the left side of the table states six different types of information. From the top, as follow, see figure 18 below:

- First, it is the amount of bunker in the tank of the containership, **BUNKER**, pink colour (in Tons of Fuel);
- Second, the transit time of the containership from one port to the next, **TRANSIT**, blue colour (in days);
- Third, the daily consumption of bunker, **CONSUMPTION**, orange colour (in Tons);
- Fourth, the amount of containers transported between the ports, **CONTAINERS**, green colour (in TEU);
- Fifth, the weight of the total amount of the containers, actually shipped by the containership, **CONTAINERS**, yellow colour (in Tons);
- Sixth, the CO_2 emission of the single container shipped between the ports, by the containership, **CO_2 EMISSIONS**, violet colour (in Tons)

BUNKER (Tons)	START (D)
	ARRIVAL (A)
	REFUEL
TRANSIT (Days)	Avg= 2,4 days
CONSUMPTION (Tons)	1 Day = 150 Tons
	BOARDED
CONTAINERS (TEU)	LANDED
	NET AMOUNT
	WEIGH 25 (60%)
CONTAINERS (Tons)	WEIGH 15 (40%)
	GROSS WEIGHT (W)
CO2 EMISSIONS of the container (Tons)	WEIGH 25 (w1)
	WEIGH 15 (w2)

Figure 18: Model for the development of the analysis – Technical detail

13.4.1. Amount of bunker in the containership tank (BUNKER)

The variable indicates the amount of bunker in the tank of the container ship, and it is compound of three moments, all expressed in Tons of bunker:

- START (**D**) indicates the amount of bunker in the tank of the containership, when the ship leaves the port of departure, the data is given, not calculated;

- ARRIVAL (**A**) indicates the amount of bunker in the tank of the containership, when the ship reaches the port of arrival. It is assumed that it must always be 150 Tons, as the amount of bunker assumed to be carried by the ship to guarantee delivery delays of up to 1 day;

- REFUEL indicates the amount of bunker refilled in the ship, and it is certified by the Bunker delivery note. The data is calculated assuming the fuel required for the navigation to the next port, calculated multiplying per the daily consumption, it is assumed to be 150 Tons per day, plus 150 Tons, as stock for unexpected events, evaluated for a delay of up to 1 day.

13.4.2. Transit time (TRANSIT) *and bunker consumption* (CONSUMPTION)

This variable concerns the days spent by the containership, from the moment it leaves the port of departure to the moment it reaches the port of arrival, and it is expressed in days. The importance of this data is due to the assumption that the daily consumption of fuel is 150 Tons. The multiplication between the number of days of transit and the daily consumption of 150 Tons, it permits to obtain the containership voyage CONSUMPTION. This result to be the fuel burned from the START to the ARRIVAL.

The fuel amount in the tank of the containership is measured to be the required in order to guarantee the regular voyage of the containership according with the set schedule.

The assumption concerns the amount of bunker necessary for the navigation, and they are also considered unexpected delays due to natural, instead of technical or human causes, which they could lengthen the journey of an estimated time of a one extra day maximum. This assumption justify why the amount of bunker at the ARRIVAL port is always 150 Tons. This assumption has been made according to a personal assumption, since they are not been found data about such kind of emergency scenarios.

13.4.3. Amount of containers carried by the containership (CONTAINERS)

The variable indicates the amount of containers in TEU that has been boarded on the containership. This situation it is compound of three moments, all of them indicated in TEU, and through the second step of the analysis, the information will be linked to the weight of the containers, thus in Tons:

1. LOADED: indicates the amount of containers on the containership when the ship leaves the port of departure;

2. UNLOADED: indicates the amount of containers unloaded from the containership when it is reached the port of arrival;

3. NET AMOUNT: indicates the net amount of containers on board of the containership, after the operation of on loading and unloading, which the containers are subjected, between the ports that are part of the route, to the final destination.

13.4.4. Weight of the containers (W) *carried by the containership* (Tons)

From the amount of containers in TEUs loaded by the containership, assuming to share the containers single weight in two main categories, container that weigh 25 Tons (**w1**), that represent the 60% of the full amount carried; and containers that weigh 15 Tons (**w2**), that represent the remaining 40% of the full amount carried. From this assumption it is possible to calculate the total containers weight. The single weight of the container, at the moment the container is unloaded, in the port of arrival, is the data used to allocate the CO_2 emissions.

13.5. Development of the analysis

The relevant data required to make the analysis are, first, the amount of containers carried from one port to the next; and the arrival port where the container is suppose to be landed. Secondly, the bunker consumption is the difference between the amount of bunker in the tank of the containership, at the port of departure; and the amount of bunker in the containership at the port of arrival, see figure 19 next page:

PORT	INT. CODE	LYG	TAO	SHA	FZN	HKG	CWN	YTN	TPT	PKG	SLL	PSD	PIR	GOA	COU
	NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14
BUNKER (Tons)	START (D)	195	285	330	450	195	480	750	225	1350	1050	450	600	285	0
	ARRIVAL (A)	0	150	150	150	150	150	150	150	150	150	150	150	150	150
	REFUEL	0	135	180	300	45	330	600	75	1200	900	300	450	135	0
TRANSIT (Days)	Avg= 2,4 days	0	0.3	0.9	1.2	2	0.3	2.2	4	0.5	8	6	2	3	0.9
CONSUMPTION (Tons)	1 Day = 150 Tons	0	45	135	180	300	45	330	600	75	1200	900	300	450	135
	LOADED	1,500	2,000	3,500	500	3,000	1,500	500	600	500	1,000	2,000	300	200	0
CONTAINERS (TEU)	UNLOADED	0	0	1,000	0	1,500	2,000	0	1,500	1,000	2,000	1,500	2,000	3,000	1,600
	NET AMOUNT	1,500	3,500	6,000	6,500	8,000	7,500	8,000	7,100	6,600	5,600	6,100	4,400	1,600	0
	WEIGH 25 (60%)	22,500	52,500	90,000	97,500	120,000	112,500	120,000	106,500	99,000	84,000	91,500	66,000	24,000	24,000
CONTAINERS (Tons)	WEIGH 15 (40%)	9,000	21,000	36,000	39,000	48,000	45,000	48,000	42,600	39,600	33,600	36,600	26,400	9,600	9,600
	GROSS WEIGHT (W)	31,500	73,500	126,000	136,500	168,000	157,500	168,000	149,100	138,600	117,600	128,100	92,400	33,600	33,600
CO2 EMISSIONS of	WEIGH 25 (w1)	0	0.048	0.083	0.103	0.139	0.022	0.153	0.313	0.042	0.794	0.547	0.253	1.043	0.313
the container (Tons)	WEIGH 15 (w2)	0	0.029	0.086	0.067	0.103	0.013	0.098	0.167	0.023	0.404	0.357	0.109	0.227	0.188

EXAMPLES:

CO2 emissions of a container shipped from Lianyungiang (LYG) to Port Said (PSD), that weighs 25 tonnes are: 2.245

CO2 emissions of a container shipped from Port Klang (PKG) to Piraeus (PIR), that weighs 25 tonnes are: 1.636

CO2 emissions of a container shipped from Lianyungiang (LYG) to Genoa (GOA), that weighs 15 tonnes are: 1.683

CO2 emissions of a container shipped from Shangai (SHA) to Salalah (SLL), that weighs 15 tonnes are (Tons): 0.960

Figure 19: Complete model for the development of the analysis

To explain how to read the schedule, different examples explain the development of the logic of the data.

13.5.1. Example:

A certain containership, name Cornelius Maersk, with a nominal 8.112 TEU capacity, starts its navigation, from the Chinese port of Lianyungang (LYG). A client has already booked his shipping at Maersk Line, to move its container that weight 25 Tons, to Port Said (PSD), in Egypt, and he wants to know the CO_2 emission related to its container, concerning the ocean freight, once the container is delivered to Egypt.

The containership at the moment of departure from LYG, it was carrying 1.500 TEU, among which the one taken in analysis (25 Tons; (**w1,** in the tabulation)). When the containership reaches PSD, the ship has already docks nine different ports to load and to unload containers. This continuous containers loading and unloading affects the total weight carried by the containership during the shipping, so the fuel consumption becomes affected from the total weight carried, and consequently the CO_2 emissions too. And this is what happens to the containership until it is reached the Port Said Terminal, and in this case to the container taken in analysis, before to be unloaded.

BUNKER

Bunker START (Tons of Fuel) at Lianyungang: 195 Tons, the data is given, according the assumption about bunker amount previously explained in the paragraph 11.2.

TRANSIT days: the transit time from Lianyungang to Port Said: 25,4 days , as the sum of the transit day to arrive to Port Said, of actual navigation. It is excluded the time spent by the containership in the ports, to load and to unload the containers, or to be supplied of fuel, etc.

CONSUMPTION (Tons of Fuel): 25,4 days at a daily consumption of 150 Tons, 3.810 Tons of Fuel burned.

Bunker ARRIVAL (Tons of Fuel) at Port Said: 150 Tons, as assumed.

CONTAINERS TRANSPORTED

Containers LOADED (TEUs) in Lianyungang: 1.500

Containers UNLOADED (TEUs) at Port Said: 1.500

These 1.500 containers are taken in consideration to make the analysis. It is assumed that at the port of arrival taken in examination are unloaded 1.500 containers but this does not mean that all containers are the same loaded in Lianyungang. The container taken in consideration, it was loaded in LYG and it is one of the 1.500 containers unloaded at Port Said.

DEVELOPMENT

The containership navigates the route from Lianyungang to Port Said, burning a total amount of 3.810 Tons of Fuel. Now we can apply the model, calculating the carbon emission of the container, as previously explained, in paragraph 11.6. using the data from figure 18:

CO_2 emission of the container weighing 25 Tons =

$$\sum_{1,11} = \{[\ (\text{Bunker level at the port of departure}_{(D1,D10)} - \text{Bunker level at the port of arrival}_{(A2,A11)})\ / \text{Total weight of the containers}_{(W1,W10)}\ ] * \text{Weight of the single container}_{(w1)}\ \} * \text{CF (Tons of CO2/ Tons of Fuel)}$$

$$= \{[((D1-A2) / W1) + ((D2-A3) / W2) + ... + ((D10-A11) / W10))] * w1\} * CF$$

$$= \{[((195-150) / 31.500) + ((285-150) / 73.500) + ... + ((1050-150) / 117.600)] * 25\} * 3{,}1144$$

= 2,308 Tons of CO_2

CONCLUSION

Few considerations regarding the first example and the result of the CO2 emission related. The result obtained can be considered a reasonable amount, and not too far compared to other CO2 emission calculator, as the one provided by coscon.com (COSCO Container Lines, the sixth largest containership company in the world, see figure 9) that provides an estimation of 2,214 Tons of CO2, for a similar route, and for a container weighing 25 Tons, see figure 20. The reasons of this spread are multiples, as the quality of the data used in our model; the approximation of the containership consumption by days and not by distances, as it is instead in the COSCON model; the fact that the Maersk Line route taken in examination, the AE11 route, it docks ten ports in total before to reaches Port Said; and the route navigated by COSCON containership, the CJ3,NE4 route docks six ports before reaching Port Said, so a difference of 4 ports more compared to the route navigated by Maersk. It is unknown if the COSCON calculation aims the gross weight or the net weight of the container, and probably there can be other criteria that I did not have the opportunity to investigate.

From: Lianyungang To: Port Said
Cargo WT : 25.0 Ton

	LoadingPort	DischargingPort	Lane	Distance (km)	TotalDistance (km)	CO2 Emission (kg)
1	Lianyungang	Qingdao	CJ3 ,NE4	187.05	14,517.83	2214
	Qingdao	Shanghai		755.62		
	Shanghai	Ningbo		259.28		
	Ningbo	Hong Kong		1,361.22		
	Hong Kong	Singapore		2,663.18		
	Singapore	Suez Canal		9,226.66		
	Suez Canal	Port Said		64.82		

Figure 20: COSCON Carbon Calculator – coscon.com

13.5.2. Other examples:

The other examples are provided just to show other cases within different container´s weight and with different departure ports and arrival ports, always through the same AE11 route. The amount of CO2 emission related to each container are the sum of the single CO2 emission of the container during the transit between ports, as indicated by the related “green flow”, which goes from the port of departure to the port of arrival, until the moment it is reached the container final destination.

14. Managerial Implication

The managerial implication that is considered to be relevant from the implementation of this carbon calculator system is the opportunity to provide a complete overview on actual CO2 emissions of all clients supplied by the shipping company.

This information could become strategic for instance creating contract “CO2-oriented” with the customers.

A contract “CO2-oriented” is the creation between the shipping company and the customer of a solution tailored to specific customer requirement concerned CO2 emissions. This is supposed to add value to the service already provided, because of the quality of the information provided to the customer, the actual emission of the transportation. The actual CO2 emissions can become a bargained, to be included in the contract, as part of transportation service provided.

What does it means?

From a client perspectives these information become relevant in the moment they are awarded and interest to lower own emissions. And from a shipping company perspective this can become an opportunity to implement itself a form of customized emissions trading.

Assuming that a shipping company is emitting CO2 lower the own cap. The way which it can become a considerable opportunity, for instance, considering a big client as IKEA-International that according to Special Report (2007), has imported to U.S. 98.500 TEUs from Asia via container transport in 2006 (1.894 TEUs each week).

We assumed that IKEA International is interested to lower own total CO2 emission by transportation, in this case ocean freight transportation.

In order to be considered as an opportunity for both parties, both must take a benefit creating a contract “CO2-oriented”.

IKEA is committed to ensuring an above or below TEUs carried per frequency, i.e. each quarter, by Maersk Line. The TEUs imported to US from Asia per quarter can be estimated by IKEA International using expectation of production for the related quarter.

The shipping company can provide upon the amount of TEUs defined in the contract by IKEA, irrespectively of the weight of the containers (range of container´s weight use to be between 10 Tons to 27 Tons), a defined amount of total emissions attributable to the agreed amount of containers.

Maersk Line in order to be able to offer this kind of contracts to more than one client must be awarded of the own CO_2 emissions capability expected, and be in the position to cover the eventual excess of own CO_2 emissions, or eventually be sure that the price of carbon credits can guarantee them to keep a profitable situation from this type of deal.

Conclusion

A shipping company that has a complete overview of the own CO_2 emission, has the opportunity to allocate CO_2 emission to each container, thus to each client. This condition may provide more bargaining power concerning the own CO_2 emissions, and the CO_2 emissions assignable to their clients, amenable to the sea freight transportation provided.

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- http://www.maerskline.com/link/?page=brochure&path=/our_services/vessels
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Appendix 1

Global Warming - Atmospheric Composition

Most Global Warming reports make it sound like most of the atmosphere is made of carbon dioxide (CO_2). In fact, it is only 0.03% (and seasonally variable). Actually, water vapor (another Green House gas) is a larger percentage of the atmosphere (0 to 4%) and completely swamps the effect of CO_2.

(http://mc-computing.com/qs/Global_Warming/Atmospheric_Composition.html)

Though all atmospheric gases contribute to the Greenhouse effect, only 2 are significant to this argument.

- Increased CO_2, increases only the winter temperatures (because of the low humidity - it has no significant effect when water vapor is present)
- In the summer, only water vapor (humidity and clouds) affects the temperature

(http://mc-computing.com/qs/Global_Warming/Atmospheric_Composition.html#gh_gases)

PERMANENT gases in the atmosphere by percent are:

Nitrogen	**78.1%**
Oxygen	**20.9%**

(Note that these two permanent gases together comprise 99% of the atmosphere)

Other permanent gases:

Argon	**0.9%**
Neon	**0.002%**
Helium	**0.0005%**
Krypton	**0.0001%**
Hydrogen	**0.00005%**

VARIABLE gases in the atmosphere and typical percentage values are:

Water vapor	**0 to 4%**
Carbon dioxide	**0.035%**
Methane	**0.0002%**
Ozone	**0.000004%**

Appendix 2

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

1. The Marine Environment Protection Committee, at its fifty-ninth session
(13 to 17 July 2009), agreed to circulate the Guidelines for voluntary use of the Ship Energy
Efficiency Operational Indicator (EEOI) as set out in the annex.

2. Member Governments are invited to bring the Guidelines to the attention of all parties concerned and recommend them to use the Guidelines on a voluntary basis.

3. Member Governments and observer organizations are also invited to provide information
on the outcome and experiences in applying the Guidelines to future sessions of the Committee.

CALCULATION OF ENERGY EFFICIENCY OPERATIONAL INDICATOR (EEOI) BASED ON OPERATIONAL DATA

1. General

The objective of the Appendix is to provide guidance on calculation of the Energy Efficiency Operational Indicator (EEOI) based on data from the operation of the ship.

2. Data sources

Primary data sources selected could be the ship's log-book (bridge log-book, engine log-book, deck log-book and other official records).

3. Fuel mass to CO_2 mass conversion factors (C_F)

C_F is a non-dimensional conversion factor between fuel consumption measured in g and CO_2 emission also measured in g based on carbon content. The value of C_F is as follows:

Type of fuel	Reference	Carbon content	C_F (t-CO_2/t-Fuel)
1. Diesel/Gas Oil	ISO 8217 Grades DMX through DMC	0.875	3.206000
2. Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.86	3.151040
3. Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.85	3.114400
4. Liquified Petroleum Gas (LPG)	Propane Butane	0.819 0.827	3.000000 3.030000
5. Liquified Natural Gas (LNG)		0.75	2.750000

4. Calculation of EEOI

The basic expression for EEOI for a voyage is defined as:

$$\text{EEOI} = \frac{\sum_{j} FC_j \times C_{Fj}}{m_{cargo} \times D} \qquad \text{Equation 1}$$

Where average of the indicator for a period or for a number of voyages is obtained, the Indicator is calculated as:

$$\text{Average EEOI} = \frac{\sum_{i}\sum_{j} (FC_{ij} \times C_{Fj})}{\sum_{i} (m_{cargo,i} \times D_i)} \qquad \text{Equation 2}$$

Where:

- j is the fuel type;
- i is the voyage number;
- FC_{ij} is the mass of consumed fuel j at voyage i;
- C_{Fj} is the fuel mass to CO_2 mass conversion factor for fuel j;
- m_{cargo} is cargo carried (tons) or work done (number of TEU or passengers) or
- gross tons for passenger ships; and
- D is the distance in nautical miles corresponding to the cargo carried or work done.

The unit of EEOI depends on the measurement of cargo carried or work done, e.g., tonnes CO2/(tonnes • nautical miles), tonnes CO2/(TEU • nautical miles), tonnes CO2/(person • nauticalmiles), etc.

It should be noted that Equation 2 does not give a simple average of EEOI among number of voyage *i*.