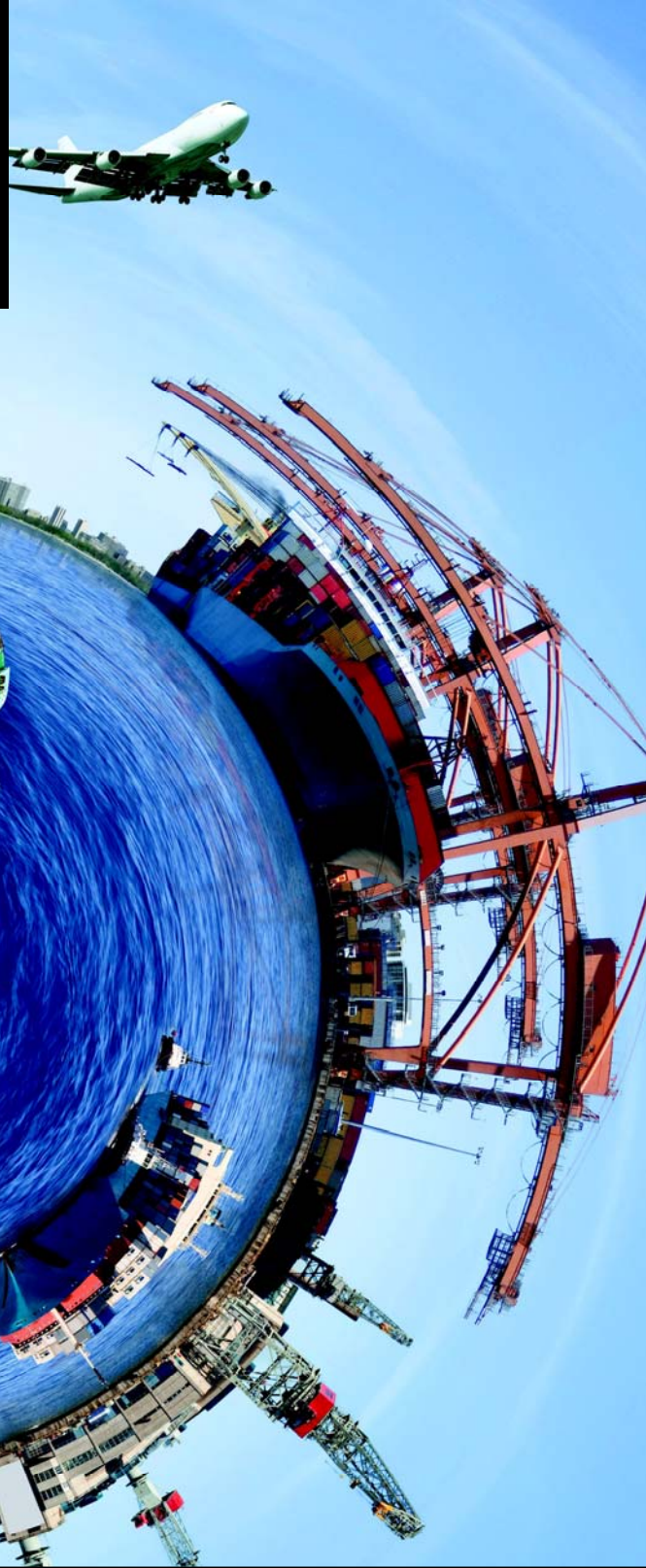


Assessment of Sustainable Investments in Shipping

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Assessment of Sustainable Investments in Shipping

By

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Preface

This thesis report is part of the final assignment of the master program Marine Technology, specialization Shipping Management at the Delft University of Technology.

The research done in the report has been completed in collaboration with ABN AMRO. I am very grateful to ABN AMRO for offering me the possibility to graduate on investments in sustainable innovations at the transportation department in Rotterdam. I felt challenge to work on such an intangible subject at an important financier in the shipping industry during these turbulent times in banking.

During my time at the transportation department I have enjoyed the pleasurable and professional atmosphere. I want to thank the transportation team, both in Rotterdam and abroad, for the nice collaboration and all the information that was shared with me. To the Risk and Portfoliomangement team especially I want to express my gratitude for adopting me in their team and providing me with essential insights. I am very grateful to my coach at ABN AMRO, Gust Biesbroeck, who enthused me about the subject of sustainability and motivated me during this research.

At Delft University of Technology I would like to thank the thesis committee for their guidance during this research. The criticism and instructions helped me during this research to view the assignment from a more abstract level.

Finally I want to express my gratitude to my friends who supported me during the course of this research, and to my housemates provided me with a place to ventilate ideas. Special thanks I want to express to Sanne, Henny, Alexander, Cyril, Michiel and Jeroen for reviewing parts of this report.

The Hague, 29th October 2013
Niels Voorham

Summary

The objective of this thesis is to contribute to the implementation of the sustainability strategy of ABN AMRO's Energy, Commodities & Transportation (ECT) and the *"Sustainability is part of our DNA"* project. This is done by providing insights that will help making the right investment decisions with respect to sustainable investments within the shipping industry. In order to determine the sustainable development resulting from an investment, the sustainable development should be measured. The objective of this thesis includes the develop of a measurement scheme and tool to assess sustainable development resulting from investments in sustainability on ships in order to aid ABN AMRO in its decision making with respect to these sustainable investments.

In order to be able to assess sustainability, first the term sustainability has to be defined. Different definitions were found, ranging from allowing no impact at all, to requiring only the substitution of resources such that human's well-being is maintained. It was concluded that, in order to have a 'workable' definition, the combined natural capital is required to be maintained. Therefore the definition of sustainability used in this thesis is defined as *'A state which maintains the combined amount of natural capital and assures maintaining human's well-being'*. In order to assess sustainability in a commercial perspective a third, economic dimension, is added.

ABN AMRO's sustainability strategy is based on two pillars, 'A Better Bank' and 'A Better World'. This thesis focuses on the second pillar with assessment of the financing client's investments in sustainability. ABN AMRO does recognize the sustainability risks in shipping and assesses its clients with the help of the Global Sustainability Index and the Sustainable Shipping Assessment Tool (SSAT). The SSAT assesses sustainability risk based on a questionnaire relating a company's sustainability policies. The SSAT differs from the assessment in this thesis because it assesses policies instead of real impacts and companies instead of investments on ships.

Shipping is a global oriented industry, essential in global trade, and transporting about 80% of that global trade. From an environmental point of view shipping has impacts due to the emission of CO₂, SO_x, NO_x, VOCs, PM and by emitting garbage and ballast water. The social impacts from shipping impact 1,2 million seafarers and many the people living close to the coast since about 44% of global population lives within 150km of the coast.

The shipping market is build up by demand and supply. The supply, expressed in ton-mile, may be changed by building or scrapping, laying-up or adjusting speed of ships. The owning structure of ships is complex and consists of a number of 'levels'. This makes investing in sustainability difficult since the costs and benefits may be borne by different entities.

Shipping is build-up out of a number of submarkets. The strong variations in demand for transport, the long time it takes between ordering a new ship and its delivery and limited scrapping capacity result in high volatility in the returns from shipping. This can be seen in time charter equivalents but also in second-hand prices.

With the exception of a few large shipping companies that went public, ship financing today is mainly supplied by bank loans, which are provided by a limited number of banks including ABN AMRO. Ships are financed against the security of a mortgage or sometimes against charter contracts.

The legislation of the shipping industry is complicated due to its international character. It is legislated internationally by the IMO, and the flag state where a ship is registered and the port

state or territorial seas it visits. Class societies have a special role because they class ships based on compliance.

Sustainability is a hot topic in shipping. Companies like Maersk, MAN Diesel and Volvo Penta are working on implementations and solutions. Pressure is increased by NGOs like Forum of the Future and Carbon War Room. The implementation of sustainability is enabled by for example Green Award and RightShip vetting ships.

Within shipping a number of trends can be observed. The trends outside the company's influence, change the industry and have made the investments in sustainable innovations saving fuel more attractive. The overcapacity in the market which caused by the extensive ordering of ships is reduced by the applying slow steaming simultaneously reduce fuel costs. This operational change introduced a demand for retrofits of engines operating in off-design conditions. Operational shipping companies have started to be more transparent because key stakeholders are expecting them to do so.

Most of the legislation with respect to sustainability relates to the environmental dimension. The emission of ozone-depleting substances and VOCs are to be prevented. The emission of SO_x is regulated by reducing the maximum sulphur in fuels. NO_x emissions of engines are regulated and apply to all new ships. For a number of emissions special areas with more stringent requirements are appointed. Norway has set-up a fund to stimulate the investments in NO_x reductions and financially aids companies based on the reduction of NO_x emissions in Norwegian waters. The regulation with respect to ballast water treatment are agreed upon, but has not been rectified yet and therefore is thus not in place yet. Harmful anti-fouling with organotin tributyltin are prohibited. Regulations with respect to garbage limit the disposal of garbage depending on the distance to the coast and the nature of the garbage.

CO₂ emissions are regulated based on an increasingly stringent theoretical emissions index called EEDI. Also ships are obliged to have a Ship Energy Efficiency Management Plan (SEEMP) in order to increase efficiency.

Ship recycling is becoming more and more regulated. The Basel convention is supposed to regulate exports of hazardous waste, but ships have circumvented this regulation. The Hong Kong convention could increase the requirements further but this convention is not rectified yet. Within the European Union proposals to regulate ship recycling are being made.

In this thesis investments in innovations on board ships are assessed. Therefore a number of these innovations are discussed. The innovations that are discussed can increase a ship's efficiency, for example when it is operating in a new, off design, profile or when it can reduce the resistance between the ship and water by reducing friction or due to designs better fitted to the operational profile. Two innovations try to reduce impacts by after-treatment of exhaust gases. Alternatively a ship could be provided with power from other fuels or other origins like kites or shore power. The systems that can be used to comply with ballast water treatment regulations are discussed. Also slow steaming, although this is not a technical innovation, is reviewed. Slow steaming is a reason for ships that are not operating in optimal conditions and to profit from new innovations to increase efficiency.

As previously stated, one of the objectives of this thesis is to develop a tool for ABN AMRO to assess sustainable development of investments in ships. The tool is required to assess sustainability internally and externally for the economic, environmental and social dimension separately. To do so the system boundaries will be drawn around the ship and flows crossing these boundaries will be assessed. Only the impact changes will be assessed from the first impact to the rest of the innovation's and/or ship's lifetime. The impact changes that are assessed are

based on indicators which will have to comply to the same requirements, while measuring the by the company influenceable real measurable impacts, except for the social dimension in which policies are included. The indicators have to be available and of sufficient quality to provide a complete overview of sustainability with the use of limited number of indicators while including both core business developments and philanthropic projects. Weighting adjustments can be done using Analytic Hierarchy Process (AHP).

Existing measurement methods of sustainability are build-up by a framework or index, fed with one or several values from a conversion method, which are combined and transformed based on indicators. Based on the insights gained from the assessment of the existing frameworks and indexes, conversion methods and indicators additional choices were found to be made. It was chosen to only include the internal economic, external environmental and both internal and external aspects of sustainability in the assessment each defined in a unit per dimension.

Based on the requirements, choices and reviewed measurement schemes a method of assessment is designed. The economic dimension will be assessed internally by assessing the investment, financing, cost and income related change in cash flows. This unit will be converted to a net present value (NPV). A footprint assessment is used for the external environmental impact changes. CO₂, SO_x, NO_x and VOCs are the air emissions that are assessed. Soil emissions are assessed based on waste generation and area used. Water emissions are not included because no data providing a footprint was available. The to a footprint converted environmental impact changes, are summed and monetized with a value of \$ 22,79 per hectare per year. Social impact change is assessed based on a score build-up from facilities on board, retention rate of crew, protection of health and safety, fair labour practises and prohibited labour internally. Externally companies transparency, corruption and bribery policy, transportation of weapons or (other) unethical cargo, anti-competitive behaviour, complain handling, influence in people's health, local partnerships, contributions to society, hiring of local staff and loss of life is used in the assessment. These indicators are assessed based on the population that is effected, the severity, the duration and reoccurrence and the relative importance which was acquired for ABN AMRO with AHP scores based on questionnaire taken from three key decision makers. Only the direction of development was assessed for the social dimension.

With the use of the indicators that were defined, a tool to assess the changes in the three sustainable dimensions was developed. The tool requires an euro/dollar exchange rate, cost per hectare, a discount rate and basis month in order to assess the impact changes in the economic, environmental and social dimension by the indicators that were defined. The results per dimension are presented in a bar diagram in either the unit defined per dimension or expressed in monetary units. The social impact is always shown as either positive, neutral or negative without a quantity or monetized impact.

The tool is presented and tested with a case study of a scrubber installation on an 8500TEU containership case study. Results show a NPV of \$ -16,3M, a reduced footprint by about 152 thousand hectares and a positive social impact.

Reviewing these results showed an overestimation of the environmental footprint by the assessment resulting in a too large area. However, both the environmental and the social impact are positive, which indicates that ABN AMRO could review the results in combination with the negative impact in the economic dimension and assess whether this is a good sustainable investment for which the bank wants to provide financing.

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1 Introduction

In this section the background of this research is explained. It is followed by the stating of the objective of this thesis. The third section of this chapter will explain the thesis structure.

1.1 Background

ABN AMRO is a bank and financial institution that resulted from a merger of Algemene Bank Nederland (ABN) and Amsterdam-Rotterdam Bank (AMRO bank) in 1991. The company has gone through some rough years. During the last economic crisis which started in 2007 the bank has been taken over by a consortium of three banks; Fortis Bank from Belgium, Royal Bank of Scotland from the UK and Banco Santander from Spain.

Some of the buyers got into trouble and eventually some parts of ABN AMRO, that were taken over by Fortis (*Private banking, Asset Management and Business Unit Nederland*) as well as the Dutch parts of Fortis, were bailed-out and taken over by the Dutch government. The ABN AMRO parts and Dutch Fortis bank are merged to the 'new' ABN AMRO bank since 2008 owned by the Dutch government.

The credit crunch, immediately caused by bursting of the housing bubble in the US, led along with other reasons to a global economic recession that started in 2007. In attempt to reduce the risk banks experience during situations like the credit crunch or the following crisis new more stringent standards or rules are implemented in Basel III. These new standards, resulting in higher capital requirements, making capital available for lending out scarcer.

Regardless the actual cause of the credit crunch and economic crisis, financial institutions have largely been blamed for the credit crunch and economic crisis. This has severely damaged their public image. As a result of this damaged image banks have to redefine themselves and have to regain trust from the public and their customers.

ABN AMRO has adopted a strategy plan for 2017. In this strategy the bank has set itself the goal to becoming a leading bank when it comes to sustainability. Therefore it is necessary that in every decision, whether it concerns an internal process or a service to a customer, the sustainability of the decision and, if available more sustainable alternatives, should be assessed.

Within the corporate bank of ABN AMRO the most important international activity is the division Energy, Commodities & Transportation (ECT). This division is active worldwide on financing within the complete energy and commodity supply chain. Within this division the Transportation Group is a leading financier of international shipping and has offices in Rotterdam, Oslo, Athens, Singapore and New York.

Within ABN AMRO every division has to find its own way of implementing the 2017 strategy plan. Also ECT is looking to find a way to implement this strategy. Within this strategy one initiative is called; *"Sustainability is part of our DNA"*. This initiative has led to a project intended to transform this initiative into a more concrete approach and to ensure future readiness.

Besides the need to work more sustainable ABN AMRO has acknowledged that the risk profile of investments in companies that are working in a more sustainable matter is lower. These

companies are more future orientated and therefore have more chance of surviving in the changing environment.

When looking at shipping companies one way of making the vessel more sustainable is the installation of equipment making the vessel more “green”. Until now companies could not get financing for these installations. However ABN AMRO could help and stimulate these investments by creating a financial product for this use.

To meet the new rules for banks as well as the ambition stated in the 2017 strategy plan the investments financed by the bank will have to be evaluated in a new and different way. The investments will have to have sufficient return on investment since the quantity of money which the bank is able to lend out is reduced by the new rules. Whenever investing the bank will look and opt for the most sustainable investing alternatives to be able to meet its own goals set by the strategy plan.

1.2 Objective

The objective of this thesis is to contribute to the implementation of the sustainability strategy of ABN AMRO’s ECT and the “*Sustainability is part of our DNA*” project in the Transportation department. Within Transportation the focus is with shipping and this thesis aims to provide the bank with insights that can help making the right investments decisions with respect to sustainable investments. These insights relate to the definition of sustainability, the sustainable developments within the shipping industry and methods to measure sustainability.

In order to assess the sustainable investment in this thesis the development of a tool for the measurement of sustainability is be part of the objective. The tool is to be used to measure sustainable developments resulting from investing in sustainability. The tool will help ABN AMRO to determine if it wants to be involved in an investment . Also it will help to make a decision between different investment opportunities and were to locate the available capital.

1.3 Thesis structure

This section explains the structure of this thesis by briefly discussing the contents and contributions of the individual chapters. Since the objective of this thesis is the development of a tool to measure sustainability the contribution of each chapter to that goal will be shortly discussed.

- 1 **Introduction**
This chapter will introduce the subject of this thesis. It also defines the background and the objective of this thesis will be defined.
- 2 **What is Sustainability? – A Literature Research**
To be able to assess sustainability the term will be defined by the use of a literature research. The history of the concept and different definitions are discussed. The chapter will conclude with the definition of sustainability that will be used in this thesis.
- 3 **ABN AMRO's Sustainability Strategy**
In order to assure compliance with ABN AMRO's strategy, with respect to sustainability this strategy is discussed. Emphasis in this chapter is put on the bank's policy and its current sustainability assessment relating to shipping is discussed.
- 4 **An overview of the Shipping Industry**
The complex industry of shipping is introduced, its relevance is argued and trends are discussed. This chapter should help readers to understand the demand for sustainable innovations and the financing thereof. Readers familiar with shipping might be advised to skip this chapter.
- 5 **Legislation with respect to Sustainability**
This chapter will provide an overview of the legislations imposed to shipping with respect to sustainability.
- 6 **Sustainable Innovations in Shipping**
The innovations that could be subject to financing and the assessment are discussed in this chapter. An overview of the impacts of each innovation is given.
- 7 **Measuring Sustainability – Requirements and Schemes**
In order to assess sustainability a method of measuring sustainability will be developed. In this chapter requirements for this measurement method are discussed as well as a number of existing measurement schemes.
- 8 **Designing a Measurement Method for the Assessment of Sustainable Investments in Shipping**
Using the requirements that are set, and the measurement schemes that are reviewed, the assessment of sustainability for sustainable investments in this thesis is developed in this chapter.
- 9 **Tool**
In this chapter the developed measurement method will be implemented in a tool. The tool itself and the results of a cases study with the tool will be discussed.
- 10 **Conclusions & Recommendations**
In the final chapter the conclusions from this research and the recommendation that arose from this research are formulated.

2 What is Sustainability? – A Literature Research

The goal of this chapter is to define sustainability for the use in this thesis. It is however not intended to determine the “real” definition of sustainability. However a framework of what sustainability is or what can be understood to be sustainability will be given. The definition to be used in this thesis should be applicable by different stakeholders and should be useable during daily operations within financing and shipping. It also should provide a guideline for systems or processes making choices based on sustainability.

The definition that will be formulated in this chapter will be used in the following chapters and when a way of measuring sustainability will be developed. It therefore should help to make the concept manageable.

2.1 Introduction

Over the last couple of decades sustainability has moved away from being a fuzzy and has become some kind of a buzz-term. It is a subject discussed frequently and according to Ediger et.al. “Sustainable development [...] has recently become a modern paradigm” (Ediger, Hosgör, Sürmeli, & Tathdil, 2007). The use of the term has shifted from mainly environmental organisations to a more trendy use by businesses for example in their marketing. Sustainability is often linked with environment protection and global warming. The term sustainability is widely used in many different areas of human’s activities (Globalization TrendLab, 2012). “Most people’s thoughts about the meaning of sustainability are [...]: sustainability is about human survivability and avoidance to ecological disaster.” (Jamieson, 1998)

Because of the many different definitions that are used for, and interpretations that have been given to the term sustainability, it is hard to find its ‘real’ meaning. The fact that the term is used for many different areas complicating the matter of its definition even further. What sustainability means has become therefore rather vague. The interpretation of the definition of sustainability may even differ between different stakeholders involved. However sustainability is often set as a (companies) value or goal to achieve.

To arrive at a workable, measurable, definition of sustainability the term sustainability first will be approached from its origin. The start and development of the sustainability debate by international commissions will be reviewed. Within sustainability certain distinctions have been made, these distinctions are used to derive the definition of sustainability in general. Finally a widely used, originally sustainability measurement definition will be reviewed.

2.2 The origin of the word “Sustainability”

The first approach on finding out what sustainability means, or used to mean, will be looking into the origin of the word itself. The meaning of the word and the implications of defining it will be reviewed. This paragraph will explore this approach and shows some problems arising by applying this definition.

2.2.1 Origin of the word sustainability

Sustainability can be defined as the ability to sustain. The English word sustain finds its origin in the Latin word *sustenare* meaning ‘to hold up’ i.e. to support (Sutton, 2004). Nowadays the word sustain is used in the meaning of ‘to maintain’ (continuing a certain state), ‘to support’ (in the meaning of providing or continues carrying) or ‘to keep going’ (continuing an action or process) (Dictionary.com) (Farlex). In the paper *Sustainability and beyond* Jamieson (Jamieson, 1998) argues that these meaning can be divided in two families. The first related to sustenance, “meeting the needs of the present” and the second meaning related to maintaining something in existence, “concern for interests of the future”. All these meanings have in common that they intend to express a property of a certain state.

When sustainability is defined as a certain state, ‘more sustainable’ or ‘less sustainable’ does not exist argues Sutton (Sutton, 2000). Sustainability as a property of a state cannot be relative. Something is sustainable or it is not. Whenever ‘more or less sustainable’ is used Sutton suggests that the number of parts being sustainable, a speed of decline of a system or the probability of sustainability of a system is meant. These are actually very different concepts.

2.2.2 Sustainability versus Sustainable development

Sustainability has been closely related to sustainable development. Sustainable development is development “that would allow ecosystem services and biodiversity to be sustained.” (Sutton, 2004) However, many people use the terms as synonyms (Sutton, 2004). In *Sustainability and beyond* (Jamieson, 1998) Jamieson argues that sustainable development has been used to define sustainability. And Sierra says “There’s been an attempt to redefine sustainability as ‘green growth’” (Globalization TrendLab, 2012). Basically, the main difference is whether sustainability is seen as a certain state of a system or as a property of a process, i.e. development.

2.2.3 Unsustainability defined

Helpful for defining sustainability is the definition of unsustainability. Unsustainability is used to define the opposite to be sustainability. Although claiming something is unsustainability is much easier one must keep in mind that “reducing unsustainability is not the same as creating sustainability” (Ehrenfeld, 2005). When this statement is believed the problem of defining either sustainability or unsustainability has not been eased by the use of both terms. Also one should keep in mind that when sustainability is being defined as a non-relative term unsustainable would also be non-relative. However what definition will be used later making sure it has an opposite with the characteristics as above might provide some guidance.

2.3 Course of the Sustainability debate

Another approach to sustainability is to examine the way it has been used and defined by others. Interesting is to review the way Elkington has noticed public environmental pressure waves as seen in Figure 2-1 (Elkington, 2004). These waves, as described by Elkington, can be illustrated by the reports that were part of the debate and discussed below.

In 1972 the Club of Rome's 'The Limits to Growth' is said to mark the beginning of the sustainability debate (Globalization TrendLab, 2012) and marks the first pressure wave. The first pressure wave came with public realisation that natural resources are limited (Elkington, 2004).

In 1987 the Brundtland Commission defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). The Brundtland report is part of the second 'pressure wave'. This second wave was the 'green' wave focusing on the environment and consumers (Elkington, 2004).

The definition of sustainability by the Brundtland Commission is quoted very often. It might be the most accepted definition. This acceptation is easy to understand since the definition allows more flexibility. The definition defines the state of sustainability which can vary under this definition as long as future generations can still meet their needs. However problems arise when the needs of future generations will have to be determined. How would one ever know the needs of generations in the future? (Solow, 1993) In fact "'needs' are a subjective concepts" (Beckerman, 1994) and therefore cannot be 'determined'. Besides, who could defend these needs and represent these future generations? (Globalization TrendLab, 2012)

Also other problems arise with the concept; not to compromise the ability to fulfil the needs of future generations. First, what is a generation? The biological term refers to those members of a population in the same stage in life. However the length of life and age when reproduced is not always the same. Therefore also generation lengths do vary over generations and locations (Bond & Morrison-Saunders, 2011). Secondly the care for the future generation would suggest one is afraid the future generation might get short-changed. One could think of a paradox arising when one is to care for future generations but by doing so reduce the care for the short-changed in the current generation (Solow, 1993).

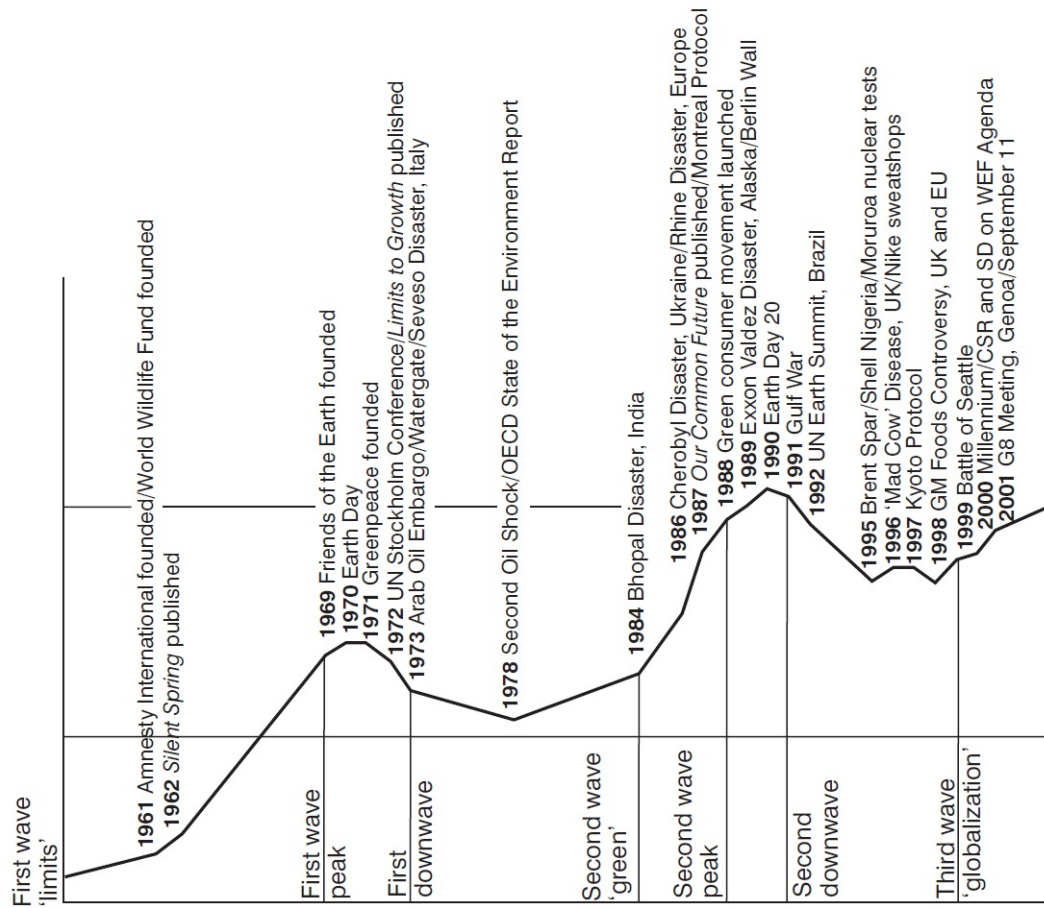


Figure 2-1: Public environmental pressure waves (Elkington, 2004)

2.4 Distinctions made of sustainability-types

The flexible interpretation of sustainability in for example the Brundtland Commissions report created problems of interpretation. Within sustainability it is to overcome these interpretation problems by the development of distinctions within the concept of sustainability to communicate more clearly what is meant. Two of these distinctions will be discussed below.

2.4.1 Weak sustainability versus Strong sustainability

The first way to make a distinction within sustainability is a distinction between weak and strong sustainability.

2.4.1.1 Weak sustainability

When looking at 'weak sustainability', one's focus is strictly on human's interests and activities. Human's well-being is leading. "In principle human well-being would not decline so long as other goods that are substitutable for [clear-cut] forests and [to extinction driven] species could be purchased with the money that these policies would produce" (Jamieson, 1998). These practises could therefore considered sustainable within the definition of weak sustainability. The concept of weak sustainability is based on compensation for used natural resources by the increase of other resources to maintain a state of well-being. Sometimes definitions of weak sustainability give even a little more space and allow a temporary decline in well-being (Beckerman, 1994). David Pearce defines sustainability in his search for economic evaluation of environmental impact; "'Sustainability' therefore implies something about maintaining the level of human well-being so that it might improve but at least never declines (or, not more than temporarily, anyway). Interpreted this way, sustainable development becomes equivalent to some requirement that well-being does not decline through time" (Pierce, 1993, p. 48).

Weak sustainability makes implementation of 'sustainability' possible and enables people to reach sustainability. In short weak sustainability focuses on the ability to continue a state of well-being (Jamieson, 1998). However focusing merely on weak sustainability would risk shifting the goal of sustainability to one of maximizing well-being (Beckerman, 1994).

2.4.1.2 Strong Sustainability

Strong Sustainability differs very much from weak sustainability. It is centred around the concept of substitutability of natural capital. According to Folke natural capital can be divided in three main components; "(1) non-renewable resources, such as oil and minerals, that are extracted from ecosystems; (2) renewable resources, such as fish, wood, and drinking water that are produced and maintained by the processes and functions of ecosystems; and (3) environmental services, such as maintenance of the quality of the atmosphere, climate, operation of the hydrological cycle including flood controls and drinking water supply, waste assimilation, recycling of nutrients, generation of soils, pollination of crops, provision of food from the sea, and the maintenance of a vast genetic library". His definition should be seen as being opposed to human-made capital which is "capital generated through economic activity, through human ingenuity and technological change – the produced means of production" (Folke, 1991) in (Jansson, Hammer, Folke, & Costanza, 1994)). "Strong sustainability asserts that it is 'natural capital' that should be sustained" (Jamieson, 1998) and is therefore much harder to achieve than weak sustainability where only well-being is required to be remained.

However strong sustainability still allows some freedom for interpretation. One interpretation of strong sustainability is looking at the purpose for use and the possible substitutes for this purpose of natural capital. In other words can energy supplied by oil (a non-renewable resource) be used to provide new energy sources (human capital) which make use of for example water or wind (renewable resources or environmental resources) to provide for future energy demand within the definition of strong sustainability? If not, is one allowed to use oil, minerals or other non-

renewable resources at all?

The second interpretation states that one has to look at the mere quantity of natural capital of a certain sort. This quantity should be maintained and natural capital cannot be used when they are consumed.

Whatever interpretation one uses; the basic question for both definitions comes down to; 'to what extent is natural capital substitutable' (Dietz & Neumayer, 2007). Strong sustainability only allows other forms of natural capital where weak sustainability only requires the maintaining of human well-being as a requirement for the substitution.

2.4.2 [Narrow sustainability versus Broad sustainability](#)

Another distinction made within sustainability is the difference between narrow and broad sustainability. Both narrow and broad sustainability would be part of the weak-sustainability definition. RIVM published a report with the definition of these two forms of sustainability (van Duijvenbooden & Poolman, 2002). Narrow sustainability is defined as sustainable development of ecological qualities. However economic and social-cultural aspects are also measured to make sure all preconditions for our existence do not decline (i.e. maintaining human's well-being). Broad sustainable development includes development of ecological, economic and social-cultural aspects of the quality of life as part of the equation. The report does not indicate how these should be taken into account or whether any of these aspects would be more important than others.

2.5 The Triple bottom line definition

A problem with many of the mentioned ways of defining sustainability is that it can be very hard to measure (Slaper & Hall, 2011). The last approach will explore sustainability from the accounting perspective and will derive the definition.

Following the Brundtland report and UNCED meeting in 1992 the environmental debate centralised around sustainable development which involved “the integration of environmental thinking into every aspect of social, political and economic activity” (Elkington, 1994). In 1994 Elkington shaped a framework now known as the triple bottom line to measure the performance of a company on these aspects. Also he had realised “that the social and economic dimensions of the agenda [...] would have to be addressed in a more integrated way” (Elkington, 2004, p. 1). This understanding was later put forward by the UN; “Economic development, social development and environmental protection are interdependent and mutually reinforcing components of sustainable development” (United Nations, 1997). However “nothing [...] suggests that these three dimensions must exhaust the field of sustainability” (Henriques, 2004, p. 27).

In his book *Cannibals With Forks* (1999) Elkington states that the “integration of the different dimensions of the emerging political agenda will be a central challenge for 21st century business” (Elkington, 1997). The Triple Bottom Line framework “went beyond the traditional measures of profits, return on investment, and shareholder value to include environmental and social dimensions” (Slaper & Hall, 2011) and is now being seen as a measure of sustainability and corporate governance (Elkington, 2006).

The triple bottom line approach is also known as the three pillars or ‘people, planet, profit’; or commonly called the 3Ps. Using the 3P expression proves to be problematic and partly in conflict with the triple bottom line definition. There is a significant difference to a company’s economics and its finance or profits. Since economics studies the deployment of resources a company’s economics has to include its impact on its environment and therefore is “inextricably linked to both the environmental and social elements of sustainable development” write Jennings (Jenning, 2004, p. 157).

For the triple bottom line approach no standard way of calculating a performance per aspect has been established (Slaper & Hall, 2011). Leaving the user freedom to adapt the way of measurement to its needs. On top of that the different aspects are not directly measureable (Lamberton, 2005). Complexity can be reduced when economic, social and environmental footprints are transformed to a single value, usually money (Richardson, 2004, p. 43). However Richardson argues that doing so would risk that for comparison “the sustainability accounts only include items that can easily be extracted or converted into monetary values”. If it is assumed that we know how to calculate and converted all social and all environmental into monetary units, and that we know the right economic or financial values of a company, does the fact that all aspects are measured in the same unit mean that they are exchangeable? (Richardson, 2004, p. 41)

Gray and Milne note that a triple bottom line reporting does not indicate how sustainable or unsustainable a company is. However it could be used to report progress towards sustainability. “A TBL report may be a necessary condition for sustainability reporting; but it is not a sufficient condition” (Gray & Milne, 2004, p. 76).

Concluding one could say that the triple bottom line approach is very practical. It states that sustainability (at least) consists of social, environmental and economic aspects. The triple bottom line is designed to be used in companies which want to measure sustainability. The definition leaves room for interpretation because no measures are defined. Also related to

the triple bottom line it has not been defined when something is either sustainable or not.
Making the triple bottom line only to be used for progress comparison.

2.6 Chapter Conclusion

In this chapter a literature research has been done to the definition or the different definitions of sustainability aiming to find a workable definition for use in this thesis. These different definitions will frankly be summarised below before concluding this chapter a final definition will be defined.

The authors following the roots of the word sustainability make note of the fact that sustainability is a state of being which can be maintained because it is self-supporting to infinity. One maybe could argue it is the ideal situation. However it is something one could try to achieve but what either is, or is not but is never relative.

Others define sustainability with the use of the term ‘sustainable development’ or ‘green growth’. These however do not provide an explanation of this development. These definitions do no longer see sustainability as a state but as a property of a process.

The definition by the Brundtland report expressed the concerns for future generations and their (future)needs. Expressing sustainability is such a way is an interesting concept. However it proves to be problematic to determine future needs and determine definitions for generation. Also a balance between shortchanged people now and in the future might be problematic.

Approaching sustainability with the use of distinctions made gives the possibility to choose between definitions of sustainability. The first option is to choose for a weak or strong sustainability point of view. Weak sustainability focuses on maintaining human’s well-being. The second distinction that has been made is between narrow and broad sustainability. Both can be seen as part of weak sustainability. Narrow sustainability does not cover the non-ecological aspects in depth but just assures prevention of their decline while broad includes these aspects in its analysis.

The strong sustainability is about balancing natural capital allowing and depending on the definition, the interchange between non-renewable resources, renewable resources and environmental services.

The last approach of defining sustainability that has been reviewed is the triple bottom line framework used to calculate sustainability. The calculation is done based on economic, social and environmental aspects or the three Ps; people, planet, profit. However nothing suggests these are all aspects involved in sustainability. The triple bottom line has not stated ways to calculate, compare or even compensate between the different aspect and thus allowing great flexibility. Also no threshold for achieving sustainability is provided.

The workable definition of sustainability for the use in this thesis, which this chapter aims to find does not has to mean this definition is the “real” definition of sustainability. Many different approaches of defining sustainability have been observed. Having explored the ways others define sustainability made very clear that there is not just one definition. In fact many different definitions are being used.

The literal definition is very straightforward. But it would not allow a path of becoming more and more sustainable as would be required in business. However a final definition should comply with the definitions as provided. Using the Brundtland approach gives a condition to be sustainable but may also be too conceptually to be practical for application in this thesis. It is recognised that for use in this thesis sustainability should include economic and social-cultural aspects. Therefore a narrow view in weak sustainability would not be appropriate. A broad sustainability definition however, could therefore be used with respect to this thesis. The last examined approach is the triple bottom line. The incorporation of economic, social and environmental aspects and the

freedom provided within this accounting framework together with an (other) clear definition of sustainability can be useful.

Combining the useful aspects of the definitions found should lead to a definition covering the aspect needed for this thesis.

Sustainability; is a state which maintains the combined amount of natural capital and assures maintaining human's well-being.

A system or process is sustainable; when it does not use more resources than the benefits returned from its undertaking and the resources restored during the same period of time in terms of natural capital while maintaining the well-being of all people affected.

Resources; are either non-renewable resources, renewable resources or environmental services.

Sustainable development; is development which moves a system, company or process to a state which is closer to a sustainable state.

3 ABN AMRO's Sustainability Strategy

In the previous chapter the definition of sustainability, as will be used in this thesis, has been discussed. Within this section ABN AMRO's strategy towards sustainability will be discussed as well as the current way of assessing sustainability. The work in this thesis is supposed to be used within the organization of ABN AMRO and therefore should be compliant with the internal strategy.

3.1 'A Better Bank for a Better World'

ABN AMRO's sustainability strategy named 'A Better Bank for A Better World' and is focused on two pillars (ABN AMRO, 2012). The first pillar focuses on the internal operations. The second pillar which focuses on ways ABN AMRO can contribute to a better world, will be given more attention within this thesis. The internal processes or the suppliers are not assessed. However clients within shipping that are looking for a finance supplier for their investments in sustainable investments are the subject of this thesis. Internal assessment of sustainability could be used to determine focus and importance. The strategy based on two pillars is graphically shown in Figure 3-1. In the next sections both pillars are discussed in more detail

3.1.1 'A Better Bank'

The first pillar, being an internal pillar, focuses on a "Better bank". A better bank means minimizing footprint and report the progress made while pursuing sustainable business operations. Clients' interests is put first and build sustainable long term relationships with them.

Within this first pillar social aspects relate to employees. ABN AMRO has tried to find long term employability for staff, find other jobs for redundant staff and helps staff by trainings and opportunities to develop themselves. ABN AMRO will therefore be an attractive employer for employees. Diversity within the staff and working conditions are two topics important for the bank and are being monitored.

With respect to the environmental part of the first pillar ABN AMRO is looking to reduce and minimise its ecological footprint. Banking itself has a limited environmental impact (ABN AMRO, 2012). But ABN AMRO has reduced the energy consumption as well as paper consumption. Flexible working space is one of the indicators reflecting the reduced impact of buildings and the power used is certificated to be green. ABN AMRO has set it as one of its goals to become more transparent about its accomplishments.

3.1.2 'A Better World'

The second pillar aims to contribute to a better world. ABN AMRO is doing so by employing ABN AMRO's financial expertise for the benefit of society and invest for clients in a sustainable manner. ABN AMRO has teamed up with a variety of initiatives where its financial expertise is set to good use.

Private wealthy clients are helped by ABN AMRO when they wish to put their wealth to philanthropic use. Special investment funds investing in sustainable companies are established by, or with the help of, ABN AMRO. Business clients are engaged in strategic conversations aimed to help clients understand the sustainability risks and opportunities in their industries and value chains.

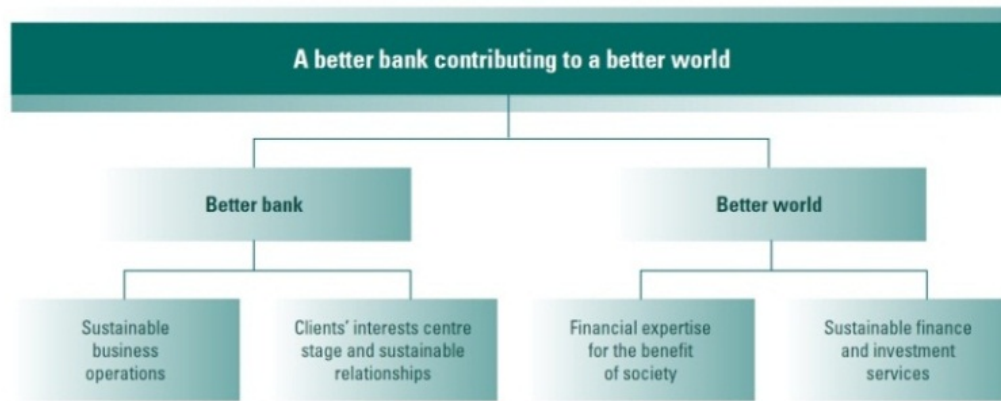


Figure 3-1: ABN AMRO Sustainability Strategy (ABN AMRO, 2012)

During the acceptance of new clients and credit approval process sustainability aspects that are relevant for the industry and sector are taken into account, considering the different ways of reporting strategy per industry. When a company is underperforming compared to the industry standard the client or facility can be declined or approved with additional conditions. The bank cannot solve sustainability problems within clients companies supply chains but does feel a responsibility to look closely and be informed in order to help find, and be involved in, sustainable solutions. ABN AMRO chooses to be in an on-going dialogue with companies that lag behind when it comes to sustainability in their industry.

ABN AMRO has made an environmental, social and ethical policy (ESE Policy), also known as the Sustainable Risk Policy (ABN AMRO, 2012b), to be used for the bank its finance and investment services. It is used to make sure the sustainable risk is in line with the banks moderate risk profile and appetite and by doing so reduce potential risks from financial, legal and reputational consequences. Within this policy ABN AMRO has defined five Sustainable Risk Principles which are described in the Sustainable risk policy (ABN AMRO, 2012b). The first principle expresses the bank's convincing that sustainable risk management contribute to make more balanced and well-informed decisions. With the second the bank declares it is responsible and takes responsibility for its actions and its decisions and the business relations it engages in. The bank acknowledges that these relations direct or indirect expose the bank to the activities of those relations. Good sustainability performance is defined as being the third principle. It is believed that ABN AMRO can help clients to perform better. Relationships will be helped by addressing sustainability risks and opportunities rather than businesses excluded when lagging in performance. The fourth principle the bank underlines the ESE (Environmental, Social and Ethical) standards and declares it will not engage in activities that do not meet their policy standards or excluded based on the exclusion list (ABN AMRO, 2013). ABN AMRO wants to maintain dialogues with many stakeholders and wants to demonstrate its engagement through a transparent process. This constructive engagement on sustainability is defined as being the fifth principle.

This exclusion list included in the ESE policy is a list with activities that undermined efforts to conserve the environment, activities that do no longer meet standards in specific fields or activities that are unethical, exploitative or abusive. ABN AMRO is unwilling to support companies engaged in these activities. When activities are not within the exclusion list ABN AMRO does an analysis on 'sustainability risk' trying to determine whether a company is operating in a more or less sustainable way compared to the industry standard. Annually the country and sector risk rating is formulated and used by ABN AMRO in the Global Sustainability Risk Index (ABN AMRO, 2012, p. 18). This index has been developed to determine social and environmental risks for a

combination of country and sector. The index helps to determine the level of comprehensiveness of the assessment required for a transaction. There is an on-going process of defining industry specific tools to measure sustainability performance. This thesis will contribute to that process.

ABN AMRO is aware that transparency is part of, and key to, sustainable development. The way ABN AMRO assess sustainability is therefore made online available for clients and others interested. Also ABN AMRO tries to contribute in the society by providing food parcels and 'sinterklaas packages' for those in need. Employees are stimulated to volunteer for social projects. The bank also contributes in sponsorships for enterprises, education and sports.

3.2 ABN AMRO's Sustainability policy in its Shipping activities

The focus of ABN AMRO's sustainability approach lies with the sectors where the risks related to sustainability are most evident. For these sectors special specific assessments are made. Shipping is one of these sectors. ABN AMRO recognises that shipping introduces a risk related to sustainability, especially with respect to air pollution, water pollution as well as health and safety.

The bank is very much aware that sustainable development is hard to achieve, especially in an international business like shipping is complicated further by conflicts of interests. It is acknowledged that effective legislation is an important part of the solution. It is aware of its responsibility in the overall value chain but takes the view simply redrawing funding is not a realistic option. However acceptance criteria and term sheet clauses are tightened on the subject of sustainability.

ABN AMRO has several reasons for a shipping policy and to assess the shipping client's performances. A policy could prevent engagement in activities potentially harmful for ABN AMRO's reputation. Also compliance with sustainability standards is seen as a sign of sound management and recognises it to be a prerequisite for commercial success. Clients incorporating sustainability have lower operational risk and therefore the credit risk of ABN AMRO is reduced. And finally the portfolio performance and client engagement can be improved.

Shipping clients are reviewed with the help of tools and the financing projects are reviewed by account managers and risk managers. Financing proposals for shipping will have to go to a risk management process. Within this process the first step is risk determination which includes checking for activities excluded by the exclusion list. Using the Global Sustainability Index to identifying and quantify risks based on sector and the location of business.

Based on the risk level further assessment is required. For shipping this will be always the case since it is classed as a medium risk industry. A shipping company's compliance with national and international laws is assessed and a specific sustainability tool is used for further assessment. This tool is called Sustainable Shipping Assessment Tool (or SSAT). In the next paragraph the SSAT will be discussed in detail.

In case a company scores below a certain predetermined level as defined by the bank additional conditions and measures will have to be put in place before a credit facility is approved. After a credit facility is granted the reporting for below par credit facilities will have to report their progress towards reaching par.

Choices of investments will ultimately still be made by the shipowner or operator, and not by the bank. However a bank can choose which investments to support and finance and which investments not to be involved. ABN AMRO wants to include sustainability in its choices of financing projects. And wants to encourage clients that lag behind industry standards when it comes to sustainable development and become a strategic partner. A way ABN AMRO can help these companies is with loans for investments in sustainable innovation that are guaranteed by government facilities like the Dutch 'Innovatief Borgstellingskrediet'.

3.3 SSAT and comparison to the assessment in this thesis

The Sustainable Shipping Assessment Tool (SSAT) is a tool used and developed by ABN AMRO in order to assess a company's sustainability risk by means of a questionnaire. It includes a general, social and environmental section. The tool is used to assess existing or new clients on a corporate level and thus is not designed to assess specific ships or equipment. The tool is under continuous development and can be extended for new developments in the field of sustainability, technology and regulations.

The tool has several sections in order to assess different sustainable dimensions. The first section of the tool is used to specify the business of the client assessed. It assesses the company's fleet size and type of vessels. The flags of the different vessels and their classes are assessed. The company's Corporate Social Responsibility (CSR) involvement with sustainability partners and local initiatives are the final questions of the part of the questionnaire which will be providing a view of a company's general approach related to sustainability.

The next section of the questionnaire focuses on the social aspects of sustainability. These social aspects are mainly related to crew. The working relations are assessed based on the people on own payroll and retention rates. Aspects such as training or other educational possibilities for crew play an important part in the assessment. The certification of vessels with respect to working conditions is included in the assignment. Finally the involvement from seniors on board in the vessels operating costs and voyage performance.

The environmental section follows the social section and covers environmental related questions. Certificates related to environmental performance and installed measures in order to reduce impact are assessed. Questions related to air-emissions and scrapping are included in the tool. The questions together help to get an overview of the company's efforts towards reducing environmental impacts.

The final part involves assessment based on a rating based on a third party company specialised in vetting ships and shipping companies. This rating involves 'normal' risk, environmental risks and CO₂ ratings.

The tool generates scores for the assessment based on the general, social and environmental sections. These three independent scores are planned to be used to calculate a combined or total score. However this is not done in the tool currently. The three scores together with the rating from the vetting company are used in the assessment of new clients and during reviews and new proposals.

In this thesis it is aimed to do an assessment of possible investments that contribute to sustainable developments. The SSAT tool developed and currently used by ABN AMRO is designed to assess a company's current sustainability policy. For this thesis a tool will be developed which will look in detail at the impact of an investment in a particular measure or equipment on particular ship. The new tool developed during this thesis will be aimed at assessing impact. This in the contrary to the current tool used mainly to assesses client's policies. In the current tool the focus is more at the sustainability related risks of clients but the current tool does not give proper insight in the choices a company can make when it chooses it wants to work on reducing its impact.

3.4 Chapter Conclusion

In this chapter the sustainability strategy is reviewed. The strategy is based on two pillars; 'A Better Bank' and 'A Better World'. The assessment in this thesis focuses on the second pillar, 'A Better World' because the objective of these thesis is to help ABN AMRO in making decisions so that the capital can be employed in the most sustainable way stimulating sustainable developments.

ABN AMRO has identified shipping as a sector with the most evident risks related to sustainability. This identification stresses ABN AMRO's effort for a sustainable shipping industry. The current assessment of clients in performance is based on operational location (country) and sector. Shipping companies are also assessed with help of the Sustainable Shipping Assessment Tool (SSAT) to determine their sustainability risk. This tool based on a questionnaire assesses companies' policies with respect to sustainability. It differs from the assessment in this thesis which is focused at the actual impact changes due to the investments in sustainable innovations.

4 An overview of the Shipping Industry

The goal of this chapter is to provide an overview of shipping. This overview will help to understand certain mechanisms that have led to the demand for innovations or measures on existing ships aimed at increased sustainability. It thus helps understanding the relevance for a research towards investments in these innovations.

Shipping is a large industry, its relevance in trade, environment and social aspects will be discussed. In this chapter the emissions that result from shipping are discussed and explained. This helps understand the concerns for these emissions as is being expressed later in this thesis as well as it helps to determine the impacts that will have to be included in the measure method for sustainability as will be designed.

A short introduction in the industry will be given aiming to provide a framework helping readers less familiar with shipping reading this report. Special attention will be given to the economic mechanisms and finance in shipping. This will show difficulties special for shipping with regards to shifting to a (more) sustainable operation.

Following the relevance and industry introduction trends that are being seen in shipping and examples of initiatives stimulating sustainable development in the shipping industry will also be discussed in this chapter. This chapter will therefore help the reader to understand what the position is of shipping with regards to a sustainable operation. In this perspective certain emissions will be discussed.

4.1 Relevance of shipping

In the following section the relevance of shipping is discussed. This is done based on the importance for shipping in the international trade, its environmental impacts and the social impacts. Understanding the relevance of shipping in global trade, the environment and with respect to social its impacts, will help to understand that shipping is a unique and irreplaceable industry. However it will also be shown that the relevance and impact in environmental and social dimension are significant. These impacts influencing a ships level of sustainability will have to be included in the measurement tool which will be developed later.

4.1.1 Relevance in global trade

Shipping is a very important way of transport. Around 80% of the world trade has been transported by shipping (UNCTAD, 2012, p. xiii). The global economic development, in particular the in- and export growth, are thus being reflected in the demand for shipping. This huge dependency of shipping on global trade and vice versa can also be seen when graphically expressed as in Figure 4-1. This figure demonstrates how closely both are related.

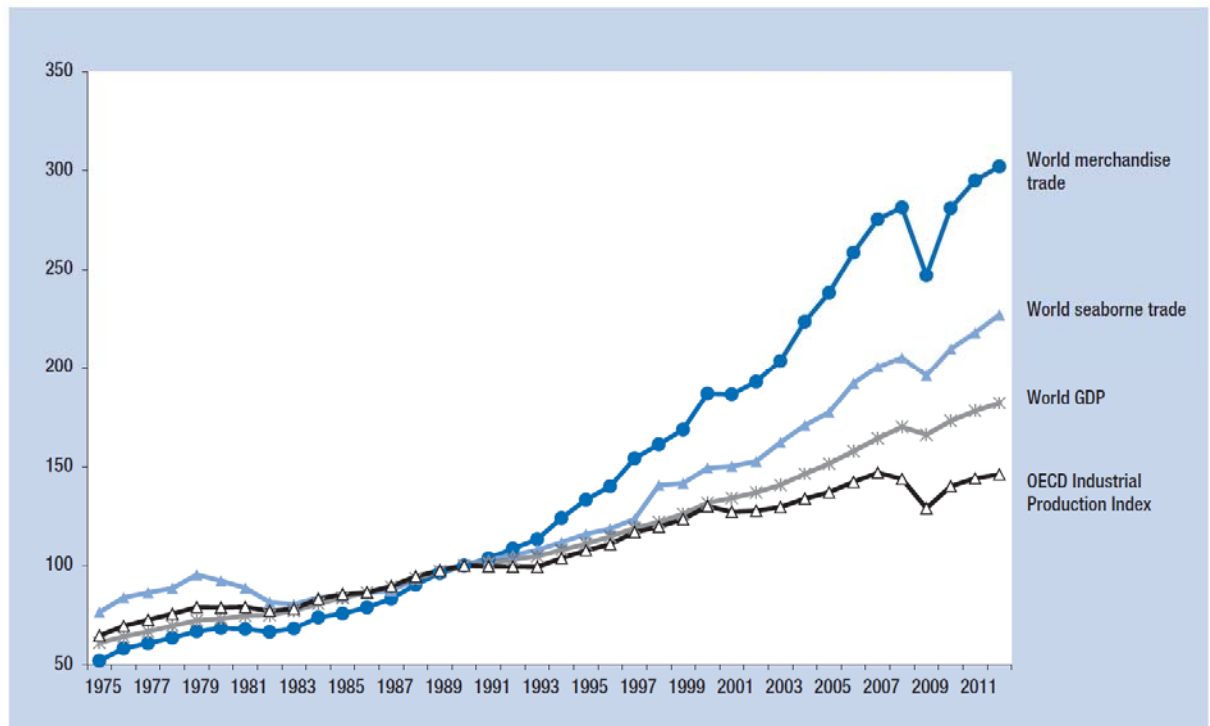


Figure 4-1: OECD Industrial Production Index, world GDP, world merchandise trade and world seaborne trade (1975-2012) (UNCTAD, 2012)

Developments in trade can have significant influence on shipping. Shipping transports raw materials, energy products as well as finished goods. It is therefore not hard to understand that globalisation, the rise of container transport, energy transition towards LNG and economic growth in developing countries have huge influences on the demand for shipping in general and more specific for certain ships. Some existing forecasts indicate that freight in tons per kilometre will triple between 2010 and 2050 (McKinnin, 2012), driven by the economic growth particularly in developing countries.

4.1.2 Relevance in environmental impact

Shipping contributed to globalisation and economic growth. However there is a downside to all this development and additional transportation. It has a significant contribution to global emission and is “strategically critical” (Lloyd's List, 2013) in a more sustainable economy. Large quantities of greenhouse gases like CO₂, CH₄, N₂O, HFCs¹, PCBs² and SF₆ are emitted. Greenhouse gases are substances that contribute to the greenhouse effect. The greenhouse effect is a process whereby substances within the earth's atmosphere do absorb thermal radiation and partly reflect that radiation back to the earth's surface. This makes the temperature of the earth's atmosphere increase.

Other relevant, and to the environment harmful substances, emitted by international shipping but which do not contribute to the greenhouse effect are NO_x, NMVOC, CO, PM, SO_x.

Shipping emissions are emitted by different systems. The main and auxiliary engines, boilers, incinerators (burning waste) and cargo can contribute to ships total emission. Within this research no distinction between the origins of the emissions is being made.

¹ Hydrofluorocarbons

² Polychlorinated biphenyls

The following section will show the relevance of shipping for, and its impacts on, the environment. The most significant emissions will be addressed and the way they can harm the environment will be discussed. In chapter 5 on legislation in shipping, focus will be on the regulations in order to control the environmental emissions.

4.1.2.1 *CO₂ and other Greenhouse gases*

International shipping emitted 870 million ton of CO₂, an important greenhouse gas, in 2007. That was 2,7% of the global total CO₂ emission (Buhang, et al., 2009, p. iii). A greenhouse gas is a gas contributing to the greenhouse effect. This effect makes that more heat radiation is reflected back to earth instead escaping earth's atmosphere into space.

The CO₂ emission is expected to grow with a factor 2 to 3 between 2009 and 2050 (Buhang, et al., 2009, p. iii). This significant contribution is mainly due to the huge size. Relative shipping's CO₂ emission per ton of goods transported 1 km is low compared to rail- and road transport as can be seen in the Figure 4-2. Transportation by aircraft is not included in this figure but is in the range between 435 and 1800 (Buhang, et al., 2009, p. 133).

The CO₂ emission can be mainly influenced by reducing power requirements because independent of the fuel (except non-fossil fuels) a similar amount of CO₂ is emitted. Within shipping a consensus exists that it may be possible to reduce CO₂ by 15 to 20% between 2008 and 2020 (COP15, 2009).

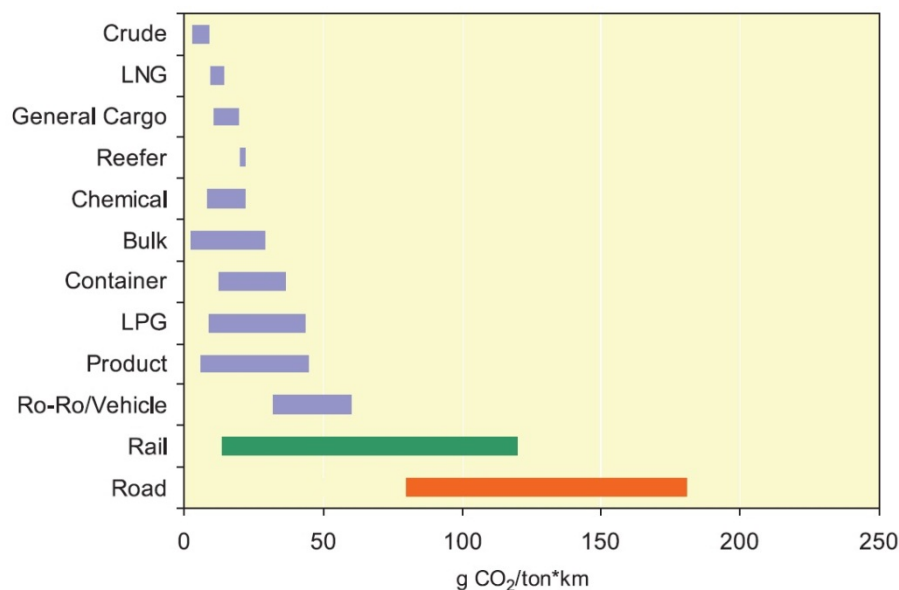


Figure 4-2: Range of CO₂ efficiencies (Buhang, et al., 2009, p. 133)

4.1.2.2 *SO_x Emissions*

Shipping is responsible for a large quantity and portion of the SO_x emission. In 1990 4,17% of total global SO₂ emission was emitted by shipping (Smith, Pitcher, & Wigley, 2001). In 2005 this percentage has risen to 8% (Olivier, van Aardenne, Dentener, Ganzeveld, & Peters, 2005) in (Lauer, Eyring, Hendricks, Jöckel, & Lohmann, 2007)).

However Amann et al found even more significant quantities. The report estimates that in 2010 4.278 tons of SO_x would be emitted by landbased sources while shipping at sea accounted for 2.722 ton (39%) within the EU. In an estimate for 2020 it is shown that in the landbased would have been reduced to 3.205 tons while the shipping SO_x emission without legislations would have increased to 3.526 tons (52%) (Amann, et al., 2005). These numbers show significance of shipping within the SO_x emission.

Sulphate emissions have a negative influence on human's health. Since this emission consists of particles it contributes to the PM emission as well (Burtraw & Szambelan, 2009). The emissions have been named in relation to asthma, bronchitis and heart failure. Also they have part in acid deposits in nature. SO_x emissions have more local effects on nature compared to CO₂.

4.1.2.3 NO_x Emissions

A third emission type are NO_x emissions. NO_x emissions exist for 90% of NO and 10% of NO₂ for most burning processes (v. Helge Rosenberg, 2005). The amount of these emissions that is created during sailing is mainly determined by the combustion process and less by the fuel (Corbett & Fischbeck, Emissions from Ships, 1997). NO_x gasses influence the forming of ozone. Ozone is unhealthy at ground level.

Shipping has significant influence on the NO_x emission. In Oceana report it is reported that shipping emits a total of 25,8 metric tons of nitrogen oxides and does contribute to approximately 30% of the global NO_x emissions. Within Europe in 4598 ton (37% of total) was estimated to be emitted in 2010 and to be grown to 5951 tons (50%) in 2020.

4.1.2.4 VOC Emissions

VOCs are any organic chemicals containing carbon that have a boiling point below room temperature making them volatile in 'normal' conditions (Wikipedia, Volatile organic compound, 2013). VOCs are emitted by oil tankers transporting crude oils and mainly occur during loading, laden voyages and Crude Oil Washing³. Losses can be significant and have been reported up to 1-2% of the cargo (DNV, 2010). The garbage emitted consists of a mix of hydrocarbonates and gases as N₂ and CO₂.

VOC (volatile organic compounds) helps forming ozone at ground level which can be harmful for vegetation and human's health (Lee, Choi, & Chang, 2013). IMO estimated the total VOC emission in 2006 six to be about 2,4 million tonnes (Buhang, et al., 2009, p. 32).

4.1.2.5 Particulate matter (PM) are

PM is a name for a combination of all sorts of small particle emissions. It is defined based on the release of particles with a certain mass and over a certain size range. The quantity of PM which remains or is generated during combustion depends on lubricating oils, amount of elemental carbon formed, organic material and sulphur in fuels. About 10% of the PM emissions are made up by elemental carbon (also known as black carbon or soot) (Lack, et al., 2009). Besides CO₂, and other greenhouse gasses also black carbon can contribute to global warming by increasing absorption of heat radiation in the atmosphere and by covering snow and ice with black soot or other matter on the ground (Harrould-Kolleb, 2008). Of all human black carbon emission about 1,7 present can be accounted for by shipping (Ramanathan & Carmichael, 2008). It was estimated that PM emissions from shipping cause about 60.000 deaths (Corbett J. J., et al., 2007).

4.1.2.6 Alien species (Ballast water)

Shipping has an impact on the environment not just through emissions arising from burning fuel. Also shipping has significant effect in the ecosystems by introducing new, alien species in waters outside their original environment.

The bacteria, microbes, small invertebrates, eggs, cysts and larvae of various species are unintended transported in ballast water used to stabilize vessels. When discharging this ballast

³ Crude oil washing (COW) is the cleaning of cargo holds of an crude tanker using the cargo itself. The empty tanks are sprayed with high pressure, preheated crude

water these organism may survive and establish a reproductive population. When this happens these organisms may become invasive and can out-compete native species. The effects of invasive species increased due expanding of trade volume. The effect can be devastating for biodiversity and may pose ecological, economic, and health problems.

4.1.2.7 Garbage

Shipping produces garbage and “garbage from ships can be just as deadly to marine life as oil or chemicals” (IMO, 2013b), especially plastics which may float for years.

Of all the waste about 25% is generated by cruise ships while these ships are only a limited share of about 1% of the global merchant fleet (Butt, 2007). The garbage production of the cruise industry is estimated at 13347 tons per year in 1998 (Mohammed, Torres, & Obenshai, 1998). In 1998 the number of passengers was 5.868.000 while in 2012 the number of passengers had grown with a factor 3,46 to 20.335.000 (Cruise Market Watch). Assuming the garbage generation per passenger has not changed the total garbage produced would be about 46.253 tons.

Assuming that cruise still contributes to maritime waste by about 25% the total wastes of the merchant fleet would be about 185 thousand tonnes in 2012.

4.1.2.8 Ship recycling

Ships carry all kind of (hazardous) wastes like for example used oils, asbestos and PCBs⁴. Many ships are being sent for dismantling every year. In 2012 over 200 ships owned by European owners or flagged in a European country were sent for dismantling (van Gelder, Hogenhuis-Kouwenhoven, & Klooststra, 2013). The dismantling of ships worldwide is estimated (based on the assumption of a representative European fleet) to produce about 475000 tonnes of hazardous waste between 2012 and 2030 (European Commission, 2012, p. 10). Because this dismantling is mostly done outside the OECD it is often not well regulated risking significant environmental impacts.

4.1.3 Relevance in social aspect

Shipping has had great influence on human development. Shipping has allowed the transportation of goods, trade, wealth, wisdom, culture, philosophies and beliefs, wars, death, disease and destruction (Raaymakers, 2003, p. 2). Shipping has had but still has impact on people’s life in many different ways. Later in this thesis a distinction between social impact within the (shipping) company (i.e. crew and passengers) and external social impacts (stakeholders outside the (shipping) company).

Internal social impact mostly impacts the seafarers working and living onboard vessels are most affected. ILO reports a total of over 1,2million seafarers sailing the seas and operating ships (International Labour Organization, 2013). These people are vulnerable because they work in environments with many nationalities and far from home. In fact “their place of work is also, for long periods, their home.” (Mitropoulos, 2006) This makes these people heavily depended on the shipping companies for providing a healthy and safe working environment and provide fair labour conditions and human development.

The external global shipping has most relevance when it comes to the impacts on human’s health. About 44% of world population lives within 150km from the coast (UN Atlas of the Oceans). And since about 70% of all ship emissions are emitted within 400km of the coast these emissions can

⁴ Polychlorinated biphenyls

have significant impact on land and people. Emissions contribute to ground-level ozone and other harmful emissions such as sulphur and particulate matter (Corbett J. J., et al., 2007). This is even more significant in harbour cities.

4.1.4 Intermediate Conclusion

This chapter has shown the positive effects of shipping in the world wide trade flows and its very important position there in since 80% of global trade is transported by shipping. The environmental impacts of shipping show the important impacts for determining the level of sustainability for a ship they will have to be included in the tool which will be developed in this thesis. Ships contribute to the environmental impacts by emitting CO₂, SO_x, NO_x, VOCs PM and due to ballast water containing alien species. Other impacts are impacts from garbage disposal and ship recycling. The impact on people's life has been illustrated by showing how many people have to depend on shipping for their everyday needs. The way these people are impacted by shipping will have to be examined in more detail for use in the tool however its significance has been shown.

The impacts shown here show that shipping is unique and important in global trade but that it has significant contribution to the emissions of harmful emissions, emitting of ballast water, garbage disposal and ship recycling. A vast number of people are affected by the shipping industry by working in it or living close to shore.

4.2 Shipping Industry in a nutshell

In the following section the structure of the shipping industry including the shipping market, shipping finance and industry legislation will be shortly explained. It is necessary for the following chapters of this report to understand the structure and organisation of these companies. Readers familiar with the shipping business might skip this chapter.

In the first section the mechanisms influencing supply and demand will be discussed, these mechanisms are part of the cause of the pressure on shipping. In the second section the owning structure of ships will be addressed explaining, the different levels of ownership and operational influence. In the shipping market section the different markets which influence shipping are reviewed. This section concludes with the cyclical behaviour that results from movements in the market and decisions companies therefore make. Having examined the shipping market the financing of this market will be assessed. This paragraph will be finalised with a section explaining the different legislation bodies that regulate shipping.

4.2.1 Supply and demand influence in shipping

As explained in section 4.1.1 shipping is very important for global trade. It is a cyclical and very volatile business with complicated supply and demand mechanisms. As shown 80% of the world's trade is transported by shipping. Shipping follows the world economic developments therefore very closely.

4.2.1.1 Demand

The demand for shipping is closely related and dependent on global economic developments. Besides economic developments other factors may influence the demand. These factors can for example be cost of shipping, seasonal influences (agricultural, holiday season and energy goods), political developments (e.g. a war resulting in closure of Suez Canal) or extreme weather (e.g. resulting in oil production fluctuation in the Mexican Gulf). But the demand is also influenced by the location of process plants or for oil refineries. Locating these plants close to production increases the demand for smaller and more specialised vessels while locating the process plants closer to the market increases the demand for large, single cargo bulk carriers.

The external factors influencing global markets as of which examples have been provided above, except for shipping costs are not part of this thesis and will not be addressed.

The amount of goods that are produced and need to be transported have direct effect on the demand for shipping. However, when production and consumption locations change the demand for transportation will also change. This happens for example due to movements in global trade due to developments of economies or production facilities. The demand can be measured in ton-mile (i.e. the number of tonnes to be transported over a certain distance). When the location of production and consumption become further apart demand for shipping in ton-miles will rise. When production and consumption become located closer together the demand will decline.

4.2.1.2 Supply

The supply in shipping is the capacity of shipping available. The available ships are the ships provided by shipowners. When demand for shipping is higher than supply, shipping-rates rise and shipowners will (if possible) increase supply by removing vessels from lay-up or order new ones to provide more shipping capacity i.e. supply. Fewer ships will be sent for scrapping and older ships will remain longer in operation due to the high shipping-rates and profitability. On the other hand supply can be decreased by demolition or scrapping, or temporary by laying-up vessels.

Besides adjusting the capacity of shipping by adjusting the number of tonnes that can be transported at a certain moment (by making more or larger ships available) shipping companies

can adjust capacity by adjusting sailing speed. Increasing the speed will allow vessels to complete more roundtrips per time. And thus increases the number of tonnes transported per time. Similar reducing the speed will reduce the total tonnes that can be transported per time.

Individual owners may try to increase the supply they can offer to the market by buying ships second-hand. The total supply is increased only by newbuilds.

4.2.2 Ship owning structure

In this thesis a ship or shipping operation will be seen as a whole. However there usually are different 'levels' of ownership based on the charter contracts. To understand certain problems faced by shipping companies working on sustainable developments it is necessary to understand these levels and contracts.

The levels shift from pure capital investment to the actual transportation of a cargo. Which costs will be charged per level varies as well as the risk that is bared. Large corporations do sometimes act on more or even all levels. Other companies may do only management of a vessel.

4.2.2.1 Ship Owner

The first level is the ship owner. The ship owner simply invests, bares the financial cost and will be the actual owner of the asset. The owner can effectively be just a financial investor and does not require any knowledge of shipping. The actual companies legally owning the vessels are often "single ship companies" or "special purpose vehicles" (SPV). These are companies that are specially setup for owning one (or a few) ship(s). SPVs are designed to reduce risks by splitting different vessels over different legal entities and protecting mother or holding companies. These companies thus can be part of a bigger holding or group structure. The main risk, except the normal client risk (i.e. a client going into default), bared by the shipowner consist of value fluctuations of the vessel value.

4.2.2.2 Bare boat charterer

The second level is bare boat charterer. A bare boat charterer has full operational possibilities but does not own the ship. The construction can be used for companies not able to secure enough cash or capital to buy a vessel. Bare boat charters are typically long term arrangements sometimes for the complete vessels lifetime. The bare boat charterer operates the vessel and pays all expenses of the vessel including maintenance. The charter also pays a bare boat charter fee to the ship owner. The bare boat charterer bares the operational and shipping (i.e. market) risks. However eventually the vessel will be redelivered to the owner.

4.2.2.3 Time charterer

The next level is time charter. Time charterer is chartering the vessel for a specified period of time ranging from a number of days to several years. The time charterer charters a vessel which is manned, maintained and repaired when necessary. A time charterer will have to pay for voyage costs like port charges, fuel expenses and other voyage related costs on top of a (daily) charter fee to the owner (or bare boat charterer). The vessel will be available to the charterer regardless of the market conditions. The shipping risk is for account of the time charter.

4.2.2.4 Voyage charterer or Contract of Affreightment

The lowest controlling and risk level are voyage charters arranging a freight to be shipped from one location to the other. The charter pays a fixed price for the transport which will be arranged for him. These costs usually include voyage costs (cargo handling may not be included). Alternatively a Contract of Affreightment (CoA) can be agreed upon. A CoA specifies an amount of freight to be transported within a certain time frame or with certain intervals. A CoA gives the ship

operator more flexibility in operating the ship in the most efficient way. The charter rates are therefore lower.

A voyage charter of CoA can be engaged by the cargo owner. Although one could argue a cargo owner is not involved in shipping but just buying a transportation service, cargo owners are able to choose companies that will transport their goods. The considerations for this choice made be pure financial but could definitely also include other aspects in order to protect the cargo owners reputation.

4.2.3 [Shipping market](#)

In the section about supply and demand the main drivers for changes in shipping supply and demand were discussed. This section will elaborate on the shipping market. The shipping market can be seen as the name for a combination of four submarkets (Stopford, 1997, p. 78). The shipowner can be seen as the spider in the middle of the web of these four markets. The markets will be explained below which actors are involved and what drivers influence these markets.

This section will end with a part addressing the time lag occurring in shipping making responses to developments usually lag behind and overshoot the actual changes that were caused by a certain development. This will help to understand the shipping cycle.

4.2.3.1 [Freight market](#)

On the freight market sea transport is being traded, Shippers find shipowners with vessel available in order to charter these ships and be able to utilize the transportation capacity.

The transport can also be arranged by a time-charter; chartering a ship per time unit (usually days) for a fixed time. During this time the ship is available for the charterer to be used. Another option is that a shipper finds a ship to provide them with a certain voyage. This arrangement is called voyage charter. On the freight market also freight derivatives are traded.

Sometimes shipowners operate as owner and charterer, chartering owned ships to other and charter in other ships. Charterer may be shipper and also own the cargo to be shipped. On the freight market also bare-boat charters can be traded. The ways of vessel owning, operating or controlling has been explained in detail in section 4.2.2.

The rates at the freight market are influenced by supply and demand and are represented for example by in the Baltic Dry Index (BDI) a “daily index made up of [charter rates on] 20 key dry bulk routes” (The Baltic Exchange, 2013). The volatility of the shipping market is reflected by fluctuating freight rates. These fluctuations influencing the shipowners’ decisions within the other submarkets.

4.2.3.2 [Newbuild market](#)

On the newbuild market owners buy ships from yards. Yards have a certain (limited) capacity. The costs of building a ship depend on the steel prices, wages and other costs for materials and supplied. The price of ships however is highly influenced by demand. In high markets owners can make large profits with vessels and therefore usually many vessels are ordered. This creates a high demand for steel and vessels, given the limited capacity prices rise. Vessels have long delivery times. During periods of economic prosperity yards will secure large order books and can ask high prices. However during an economic downturn prices are low because yards are trying to fill their building capacity.

In high markets so many vessels are ordered that some will not be delivered before the start of the next low market time following the high markets. During low markets Yards may offer ships (sometimes ships originally build for other owners) for a (much) lower price. This creates an

overcapacity of vessels in an already downturned market. This time-lag mechanism will be discussed at in section 4.2.3.5.

4.2.3.3 *Second-hand market*

Ships are often traded several times during their economic lifetime. On the second-hand market these vessels change owners. Vessels values, especially the values of delivered (second-hand) vessels, are largely determined by earnings ability. This influence is even stronger than for new vessels because they can be delivered in a very short time compared to newbuilding. Making second-hand values of ships volatile.

The earnings ability for vessels can be measured by the Time Charter Equivalent (TCE) development. This relationship is shown in Figure 4-3. It shows that the Market value of a second-hand bulk carrier of 80.000DWT, 5 year old shows very close resemblance with the charter rates for such a vessel.

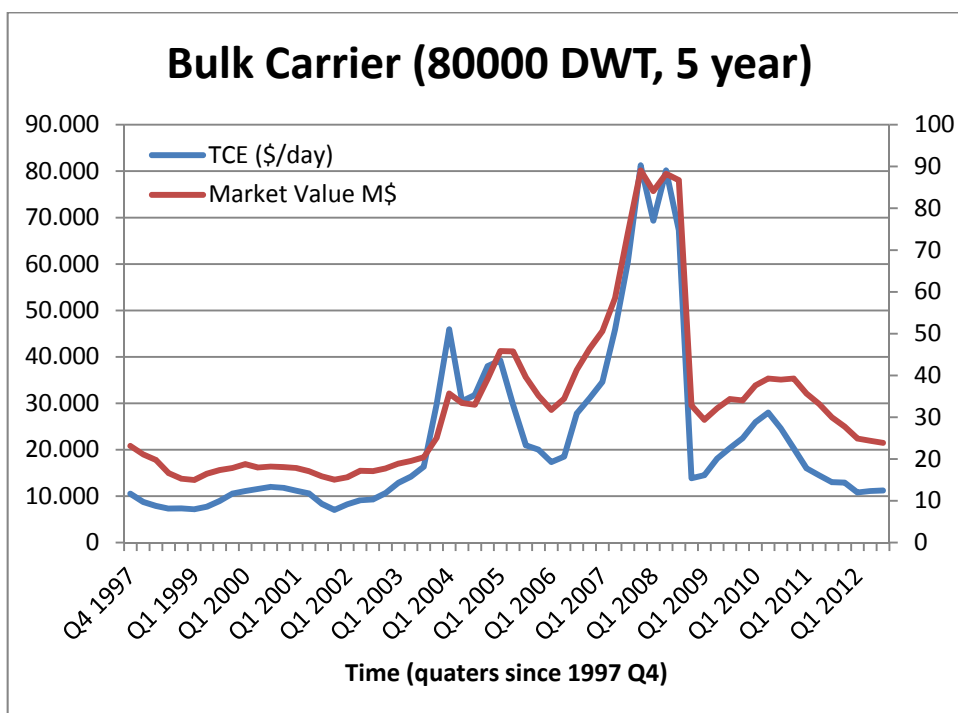


Figure 4-3: TCE (left axis) and Market value (right axis) of a 5year old 80.000DWT Bulk Carrier (ABN AMRO internal data)

This data on the vessel value and TCE shown above represent a certain vessel type size and age and will vary for other vessels. Also the volatility will be different for other vessel types. However most vessel types show close resemblance between their TCEs and second-hand market values. More graphs can be found in Appendix A.

4.2.3.4 *Demolition market*

Owners of ships reaching the end of their economic life will consider disposing vessels. This choice will depend on the money shipowners can still make from operating their old ships. The probability is directly related to supply and demand of transportation, the costs of new ships and the revenue possibilities from scrapping. Shipowners can sell their ships to a cashbuyer, a

company working as an intermediate between scrapyards (or sides) and owners, or sell their ships directly to these yards. Demolition yards pay shipowners for the old steel (scrap) the ship has been made of. The amount of money yards are willing to pay is mainly based on a ship's Light Weight Tonnage⁵ (LWT) and the steel price. The suitability of a ship for recycling is also of influence on the ship's price. Meaning that simple ships are worth more because they are easily recycled.

During high markets there will be a high demand for scrap steel and scrapping revenues are high. However during such a high market shipowners can make a lot of money by operating ships and newbuild become expensive. As a result fewer vessels are being scrapped.

4.2.3.5 *Volatility and in-elastically of the shipping market*

In the previous sections the different sub-markets combining the shipping market have been discussed. The mechanics driving these markets were indicated. It should now be understood that the demand for transportation by shipping can be very much fluctuating. But that on the other hand the supply of transportation by shipping is a very inelastic market and needs a significant time to adapt.

This results in a phenomenon in shipping known as time-lag. When the demand for shipping increases to higher levels many new ships will be ordered at yards. However the building of these new ships will take quite some time. Usually the delivery of a new vessel will take a year minimum. However when shipyards' order books have increased by many orders of ships delivery may take many years after ordering. As a consequence of this long delivery time ships that were ordered during an economic boom may be delivered during the economic slump that has emerged following the boom.

During economic downturns, when demand for shipping is low reduction of the fleet by scrapping will most likely increase. However to absorb the overcapacity will take quite some time. Add to this that also new ships, ordered before the downturn, will still be delivered.

The combination of in a case an economic downturn (and overcapacity) the number of ships will not be quickly reduced and in case of an economic upturn (and a lack of capacity) newbuilding cannot increase capacity quick enough. This makes the shipping transport supply quite inflexible. This inflexible supply together with a demand side which depends on volatile global trade makes it unable for supply to properly follow demand. It will make that supply will always lag demand and possibly even result in an overreaction still after the boom. This has strong influences on freight rates, and therefore ship prices (new and second-hand even more so) and making these rates very volatile.

This volatility that results in heavy fluctuations of ship prices is the foundation of the strategic buying and selling of ships known as asset play. The graph shows clearly that the market is depressed and values and revenues are low.

4.2.4 *Financing in Shipping*

The following chapter will explain the importance of finance in shipping. This chapter should thus help to understand financing importance and the dependency of shipping on institutions, such as banks to supply them with funding. ABN AMRO is an important player of the ship finance market. Its importance will be shown in perspective proving that ABN AMRO has the capability to influence the shipping industry.

⁵ LWT: The weight of the vessel itself without crew, consumables, bunkers and cargo

In brief a historical overview will be given. The status of financing and its origin will be explained as well as the banks that have the largest shipping portfolios. Following this overview of the ship financing industry the legal structure used by shipping companies is discussed.

4.2.4.1 *Ship financing industry*

Shipping is a very capital intensive industry. The cost of ships varies widely between age, type and size. Ship finance is a specialized business. Earnings and values in the shipping industry are, as has been explained, very volatile and cyclical. An additional issue to the volatility is the mobility of the assets which serve as securities for the finance providers.

Stopford has described a number of phases in historical ships financing. During the 1950's and 1960's financing for ships was backed by long-time charter contracts (Stopford, 2009, p. 272). Meaning future cash flows from these contracts were considered securities. However unforeseen developments during the charter period like currency changes and inflation could significantly reduce profits. Following these developments finance providers shifted to asset backed finance. Having the vessel itself as security, "bankers started to see shipping as a form of "floating real estate" (Stopford, 1997, p. 198). The fact that the financing of a vessel did no longer have to be backed up by a contract is an important change that broke the link of financing supply based on actual demand. This led to an oversupply of vessels, especially for tankers, and very low freight rates during the mid-1970's. The crisis that followed bottomed out in the mid-1980's. Asset play started to play a big role, buying ships cheap and sell them when the prices have risen. The capital needed was raised by Norwegian K/S partnerships and German KG companies. In the 1990's some large shipping companies raised capital by going public. This series of IPOs was followed by high-yield bonds of shipping companies appearing.

It is clear that shipowners can raise money in several ways and that the main source and the securities have changed the last century. Most ships are financed partly with equity and partly with debt. Equity is invested by the founders of the shipping companies, from investors or raised at the equity markets (i.e. selling stocks) or with designated partnerships as for example German KG companies (KPMG, 2012).

Funding with debt is mainly provided through long-term bank loans. These loans are the major source of financing and usually are mortgage backed. To fund these loan banks must secure long-term funding or face rollover risk. However it has become hard to find long-term dollar funding for banks making it less attractive to finance long-term project such as shipping (The Economist, 2012a).

Some companies have issued corporate bonds raising money directly from the market. Some larger companies are able to be financed by corporate bank loans (i.e. being financed with their balance sheet and not individual ships as security).

Because of the specialised business, cycles in revenues and high volatility not all banks are involved in shipping finance. Figure 4-4 provides an overview of banks involved in January 2012 is given. ABN AMRO shows a shipping portfolio of about 6 billion. And is thus, as shown in the graph, one of a limited number of financiers in shipping.

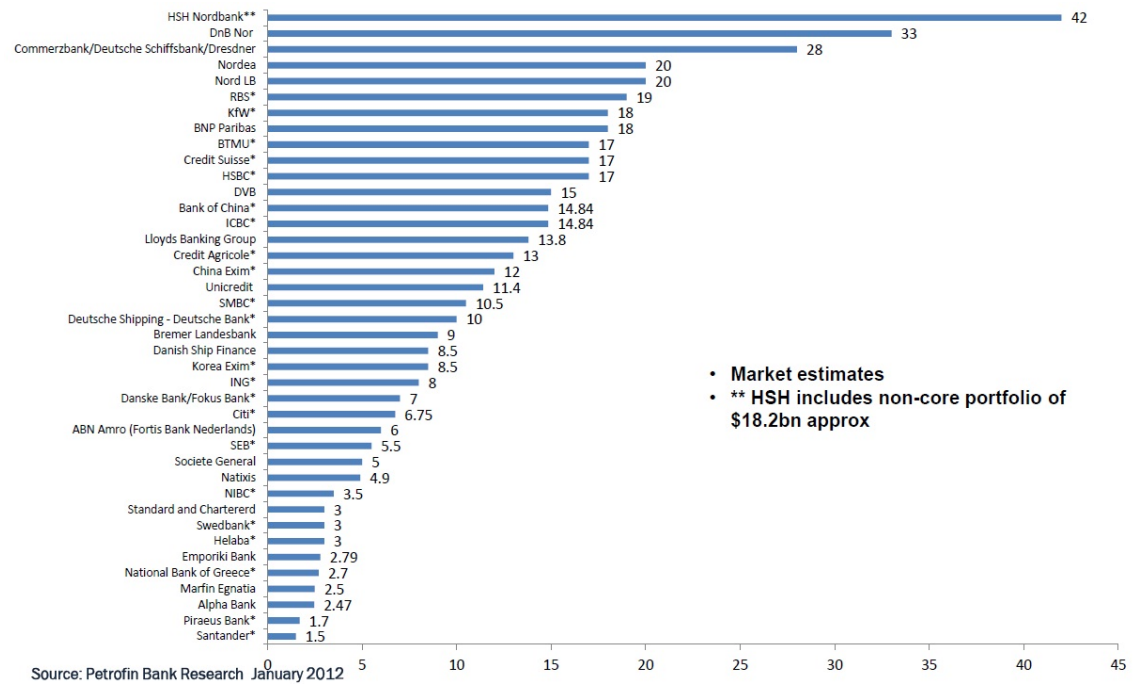


Figure 4-4: Top 40 banks lending to shipping - January 2012 (Petrpoulos, 2012)

For larger loans banks prefer to diversify the risk by forming syndicates. Within a syndicate several banks participate in a single facility. In cases a facility included several ships no ship is assigned to a specific lender. One of the banks specialised in shipping will be appointed as a syndicate leader. This bank will look for other banks that have an appetite for exposure to the deal. These other banks do not have to be specialized in shipping. Thus these syndicate structures allow non-specified banks to participate in ship financing.

Financing of a 'to-be-build' or unfinished vessel is slightly more complicated. Lenders are dealing with ships, acting as their security, which are not yet finished. These assets are located at shipyards that might go bankrupt or could run in other kind of problems (e.g. political problems like war). Technical problems or noncompliance with specifications, either of the owner or the charterer, can result in problems of acceptance regarding the vessels delivery. A refund guarantee from the shipbuilders bank or government might be required for a bank to accept the financing of a new-build vessel.

Another finance option is the shipbuilding credit, this is a credit provided not by a finance provider but by the shipyard. It is a service to provide shipowners with financing for their ships during construction and sometimes afterwards. Providing a shipbuilding credit can be done by shipyards for commercial reasons since during the construction period of a vessel is usually hard to finance. The reason for these difficulties has been discussed in the previous sections. .

A third option is export credits or export credit guarantees. These are credits or guarantees provided by governments or governments owned or guaranteed banks in order to stimulate exports by reducing credit risks for the finance provide. In case of a guarantee a commercial bank will still be providing the actual funds and loan.

Norton Rose has performed a yearly transport survey since 2009(Norton Rose Fulbright, 2013). This survey asks companies in aviation, rail and shipping their view on their position in the market, their expectations over the future and analysis trends. One of the questions in the survey is; "Which of the following will be the primary sources of funding for your sector over the next two

years?” .Figure 4-5 **Error! Reference source not found.** shows the answers since 2009 for shipping companies. The figure shows that after a significant shift following the financial crisis shareholder/equity and bank debt are expected to be the most significant funding sources for the surveyed shipping companies in the coming two years. Also the expectation of growth of export credit is an important shift of the last years in funding that should be noted.

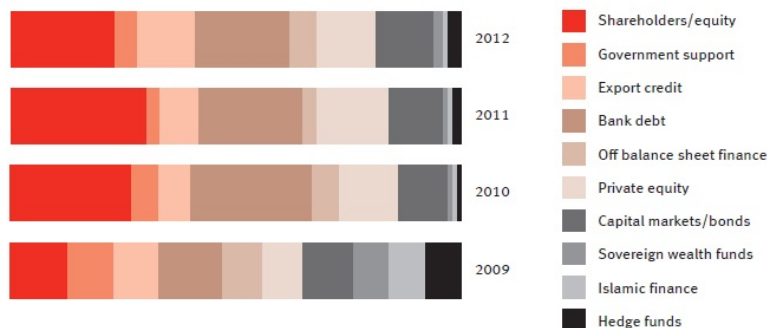


Figure 4-5: Answers to the primary funding survey (Norton Rose Fulbright, 2013)

4.2.4.2 Finance structure

Companies that request financing for acquiring vessels are usually not financed directly. The actual legal entity that will receive financing are Special Purpose Vehicles (SPV or Single Purpose Companies, SPC) and are created to own just one or a small number of vessels.

Ships, like for example houses, can be mortgaged. To be able to lent money against a security of a mortgage the asset should be ‘real property’ and be registered. The registration of ships is done in a country’s flag register. This flag register will be discussed in section 4.2.5 ships are registered in one country’s flag register. This enables lenders to mortgage a vessel and arrest and repeses the asset is case of default.

Besides the mortgaged security the finance provider usually requires assignment of charter (or all) income of the vessel and require the charter income to be deposited in an account with the finance provider .The finance provider will also require an assignment on insurance indemnities. And the finance provider can have a pledged on other (registered) assets like the company’s (i.e. the SPV’s) shares. Having a pledge on the shares enables a financial provider to, in case of default, takes over ownership of the whole SPV (and not just the vessel) and by doing so enables that company to maintain its (valuable) charter contracts⁶. The lender might also require a dividend stopper to make sure money will not leave the SPV to the equity holders instead of the finance provider.

The use of a SPV is useful for the mother company or holding to protect itself for (financial) risk. It is also useful for the finance provider because in case of default of the mother a pledge on the shares of the SPV can prevent other creditors to claim the (assets of the) SPV. The mortgaged ship (the asset) is not available for claims from any other creditors before the mortgage-loan is repaid.

⁶ Many charter contracts do however include a ‘change of ownership’-clause allowing the charterer to cancel the contract when the ownership of the vessel changes.

When a charter is assigned to a specific ship it might be awarded to the SPV. Finance providers prefer charters contracts with the SPV above a contract with the mother company allowing the vessel to keep performing under the charter contract when the company has defaulted and the pledged SPV has been repossessed.

4.2.4.3 Section Conclusion

This section showed the developments in shipping, from charter based in the 1950's and 1960's to asset based financing not based on employment in the 1970's. This development and that crisis that followed were followed by a period of financing via K/S partnerships and KG companies. A number of large companies went public during the 1990's. For most companies bank debt is one of the main sources of capital.

The number of banks that are involved in shipping debt is limited. ABN AMRO is part of this limited number of banks involved. The fact that ABN AMRO is one of a limited number of banks involved in ship financing shows its importance in the sector and indicates its capability to initiate changes.

Investing in a ship is usually done via SPV companies. This means that only the vessel can be used as security when a mother company has not given any guarantees. This results in the fact that for investment in new innovations the security also needs to be the vessel. It thus must have enough value to bare additional debt. In the previous chapter it was shown that values may change fast and significant. This could result in problems with respect to the financing of these innovations.

4.2.5 Legislation bodies

Regulation within international shipping are organised in a rather special way. This section will outline the most important organisations responsible for regulating shipping. Regulations can put significant pressure on companies and force them to invest. In the chapter 5 the regulations will be addressed showing more stringent regulations with respect to sustainable aspects.

Because shipping is a very international orientated business regulation will have to be organised in an international way as well. Additionally the regulation will have to provide sufficient regulation for a business where entities are involved. The origin of legislation can be divided into two parts. First part relates to the rights and obligations of states that are, in many different ways, involved in shipping. The second regulation part concerns regulations in order to provide frameworks for trade and are more focused on operational considerations for shipping.

4.2.5.1 United nations

International maritime regulation finds its roots in 'Mare Liberum' (*Latin for 'The freedom of the seas'*), a book by Hugo de Groot published in 1609. The book advocates that the seas belong to everyone but no-one will own it (Wikipedia, 2013b). This principle of the 'freedom of the seas' still exists outside territorial waters. The territorial waters have been agreed upon by the UN in United Nations Conference on the Law of the Sea (UNCLOS 1958, 1960, 1982) (Ocean Affairs and the Law of the Sea, 1998). UNCLOS is international law and is not applicable to individual ships.

The United Nations (UN) is an international organisation founded in 1945 to assure peace and security and had 193 member states in January 2013. The UN aims to develop friendly relations between nations (United Nations (a)). The organisation provides a way for countries to work together by convention. Nowadays the UN also puts effort in solving problems with respect to human rights, gender equality, environmental protection, fighting diseases and poverty (United Nations (b)).

4.2.5.2 IMO

Since 1948 the United Nations has formed an agency especially for shipping related activities. This agency, since 1982 called International Maritime Organization (IMO), provides by the use of conventions the safety, security, environmental and legal international legislation (Raaymakers, 2003). Within the IMO the Marine Environment Protection Committee (MEPC) is discussing the regulations with respect to environmental regulations.

The IMO does not enforce legislation. IMO conventions that are accepted by IMO members first will have to be rectified by a number of states and/or by states representing a certain amount of dwt registered in these states before the regulation in these conventions will come in effect. Ships operating under the flag of non-rectifying countries and only outside territories of states rectifying a piece of legislation have no legal bound to meet that piece of legislation. Compliance with regulations is enforced by port state inspections which will detain ships not compliant and by classification societies not accepting incompliant vessels in class.

4.2.5.3 Flag State

The most important regulation body on a ship is its flag state. Especially in international waters ships are under legislation of the country in which they are registered and of which they are flying the flag. In national waters the jurisdiction is for a large part still with the flag state (Stopford, Maritime Economics, 2009, p. 666).

Ship(owners) can choose their own flag as their regulator as long as they have a 'genuine link' with the flag nation. This 'genuine link' is not defined as is subject of different interpretations. The interpretation makes a register either a national register in which only companies actually operating in or from that country can register their vessels, or an open register in which all vessels can register. Owners may choose a certain flag based for a number of reasons like taxation or difference in requirements. In 2011 about 83 per cent of all vessels was registered in an open register (UNCTAD, 2012, p. 45).

Flag states are obliged to make sure ships comply with the with their own and the international rules which they have ratified. Classification societies play an important role during construction and operation of ships and survey vessels on behalf of flag states (OECD & Hübner, not dated).

4.2.5.4 Port State

Parallel to flag state also the port states, the state in which a port is where a ship with a certain flag visits, are allowed to inspect vessel during a 'port state control' and ensure their compliance with international regulations as rectified by the flag or port state.

Vessels showing deficiencies in their compliance can be granted some time to solve the problems. They are likely to be checked again in the next port. When a deficiency is serious a port state may detain a vessel preventing it from leaving the port before a deficiency has been resolved.

4.2.5.5 National

Besides the international regulations as opposed by IMO also national or regional regulations can be enforced by individual countries. It has been explained that nations have the possibility to influence shipping with legislation ships flying their flag. The UNCLOS international law allows coastal countries to legislate ships in their territorial seas and visiting their ports for 'good conduct' (Stopford, Maritime Economics, 2009, p. 685).

4.2.5.6 Class

Classification societies have a special role in the legislation regime of shipping but do not have an actual legal authority. Classification societies class vessels based on their properties and condition

to determine if and for what conditions a vessel is safe and sound. To be approved vessel may have to comply with technical standards, legislation of IMO, flag state or other regulations. Vessels are classed by plan review; an assessment of the building plans of a vessel. To verify the plans surveys are conducted during the building of vessels. After construction vessels are inspected by its class society in order to determine the condition of a ship, but also as a representative of third parties, for example governments. Classification societies perform periodic inspections or surveys on ships. Classification societies have become in more cases the representative for flag state. Many insurance companies and some governments require a vessel to be approved by class and be in possession of a certificate of a certain class (Stopford, Maritime Economics, 2009, p. 660).

4.2.6 Intermediate Conclusion

This section has shown the many mechanisms in the shipping industry. The demand for shipping that is being influenced by the global developments has been discussed. Also the supply which depends on the number of ships available but can also be adjusted by adjustment of the sailing speed.

Ships can be owned by investment firms which are not involved in the actual shipping. They bare the capitals costs, the ship is self may be chartered for a long term by a bare boat charter which bares part of the shipping risk. The rest of the shipping risk is borne by the time charter using the ship for a long term. He charters his ship for the use of a voyage charter or a certain shipment via a contract of affreightment.

In the shipping industry a number of markets are very important. The freight market were the employment charters are traded as well as the newbuild market representing the new ships that are to be build and its role in the overcapacity in a economic downturn were discussed. The second-hand market were second-hand ships are traded was discussed. The historical development and similar behaviour of second-hand values and Time Charter Equivalents was shown to show its volatility. The last market discussed was the demolition market where prices are based on vessels weight and the demand for (scrap) steel.

In the section in the volatility and in-elasticity of the shipping market the phenomena time-lag is discussed. Explaining that due to the order books of yards and ships under construction after the start of a crisis the combined tonnage still increases for some time. The fact that adjusting to the actual demand is difficult results in volatile second-hand prices and TCEs. Based on the reviewed data it can be concluded the market in 2013 is depressed.

The financing section showed that shipping still depends for a large part of its financing on bank debt. ABN AMRO is one of the limited number of banks providing this debt to shipping companies. Showing that ABN AMRO is an important player in the shipping finance capable of initiating changes.

The complex legislation structure of shipping has been explained showing the complexity in regulations and the many legislation bodies that may affect the business of companies within shipping. These bodies can put pressure on the shipping companies force them to invest in certain innovations or measures in order to comply with any of these regulations.

4.3 Trends

Within this paragraph observed “trends” in the shipping industry will be discussed. These “trends” are important to understand developments that are going-on. These developments shape the world shipping companies operate in and to what risks and outside pressures they are exposed.

The trends that will be discussed in this chapter are divided in a group that globally shapes the economic environment outside the control of shipping companies and a group of trends that resulted from the combined behaviour of shipping companies. The trends that will be discussed can provide conditions for, or on the contrary prevent, certain developments in the shipping industry. The sustainability measurement tool that will be developed should address sustainability in such a way that the results of the assessment can be used as an input for decisions facing the challenges as are to be discussed in this chapter.

The first section will discuss macro trends that influence the global economies as a whole or the shipping industry specifically. In the next part the ‘operational trends’ will be reviewed. These operational reactions are changes that shipping companies and shipowners have conducted in order to react on the developments.

4.3.1 [Global economic and market trends](#)

This section addresses trends in the markets and global economics relevant for shipping. These trends or ongoing changes cannot be influenced by a single shipping company and thus impose pressure on a company in order to adapt to the new situation as caused by these trends.

It is not said that the trends opposing pressure are limited to these trends especially since the trends discussed have focused a more on financial impacts since these research is part of an assignment by ABN AMRO.

4.3.1.1 [Global economy and emerging markets](#)

The GDP is still expected to grow the following 50 years, OECD is expecting an average growth of 3% (Johansson, et al., 2012). However OECD does note significant changes in relative economic growth between countries. And expects the difference of developments between emerging countries and the OECD countries to reduce. The relative size of economies will change radically over the next 50 years. The combined GDP of China and India will soon surpass that of the G7 economies”(Johansson, et al., 2012).

Also the world bank recognises the shift of economic importance. The share of emerging countries in the GDP is continuously growing and is expected to reach about 45% in 2025(The World Bank, 2011).

Because of the close connection between world economic growth and world trade, shipping will also continue to grow. Because shipping is an international business the average global growth is most important. However one should note that the trade flows can have significant impact on the transport demand. For example transporting oil from the middle east to China instead of Europe increase the transport distance and thus the ton-mile. This means it will require more shipping capacity.

4.3.1.2 Interest rate – influence of Libor⁷

Like for any other business, but even more so for a capital intensive industry as shipping, interest rates are very important. These rates determine costs of debt. Interest rates for financial products like ship financing are usually build-up by the cost of capital and a risk and profit premium. The cost is based on (one specific time based) Libor rate and the premium is based on the required return for the lender which again is based on, amongst other, risk. This combined pricing of debt results in the fact that debt cost for the borrowing company will usually vary with the Libor rate. The Libor rate is constructed based on quotes given by a number of banks on a daily basis. The margin (premium) is usually a fixed rate since it includes risk premium and returns for the lender.

Because of the importance of Libor for determining the cost of debt it is interesting to review the course of its rate. Figure 4-6 presents the 3-months USD Libor rates. It is clear that the most recent Libor rates are very low in historical perspective. As explained the cost of debt is influenced for a large part by this labour rate. The cost of debt can (since it is only one aspect) therefore be very low in historical perspective.

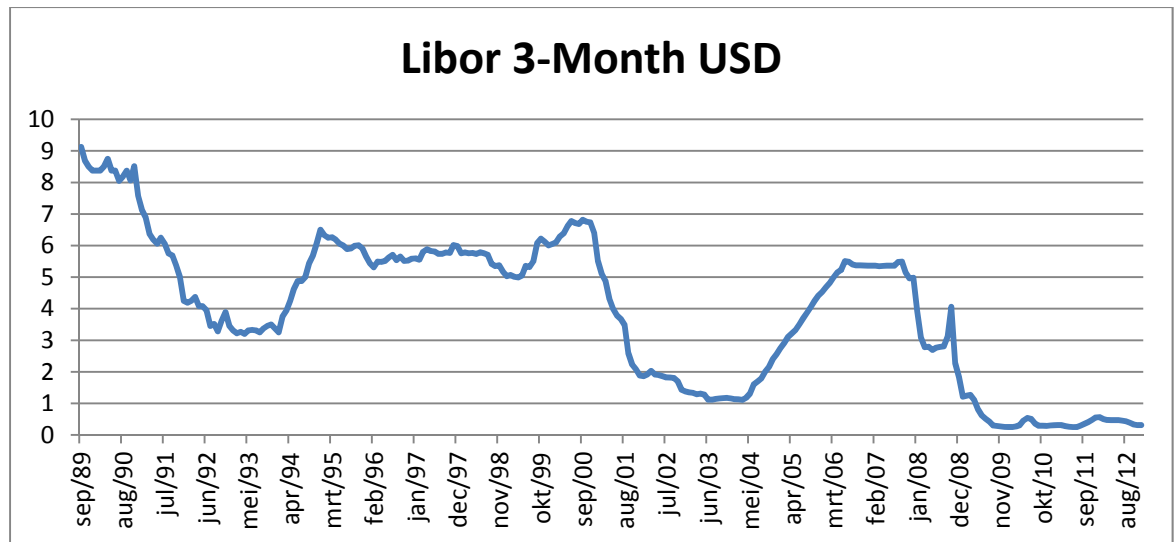


Figure 4-6: 3 Months Libor rate (US Dollar) (Fed Prime Rate, 2013)

4.3.1.3 Less capital availability

The environment of shipping has changed significant. Another influence shipping companies will have to cope with, especially when it comes to its financing, is the reduced availability of capital due to more stringent regulation on banks. One of the rules is the global regulation on bank capital adequacy known as Basel accord. The latest accord, known as Basel III will increase capital requirements for banks (Basel Committee on Banking Supervision, not dated). This will likely make investments in shipping less attractive. This has to do with the fact that shipping requires long-term financing. Basel III will require banks to fund these loans with long-term capital which is expensive (Watt, 2012). Secondly since shipping is almost entirely financed in dollars. For banks outside the US and especially European banks struck by the sovereign debt crisis it is hard to find these long term funding in dollars.

⁷ London Interbank Offered Rate, the interest rate used between banks when money is borrowed amongst them

4.3.1.4 Low TCEs and vessels values

Following the financial and global economic crisis the shipping market is very depressed. The easiest way to express this depressed condition of the market is by looking at the time charter rates and vessel values. As explained in the shipping market paragraph the development of these figures can be seen as a good indicator for the shipping market. Figure 4-7 shows an example of the TCE and vessel value between the 4th quarter in 1997 and 2012 for a Crude Tanker. In Appendix A more TCE and vessel values graphs during the same period can be found that show similar developments. One can conclude that the 2012 TCEs are low in comparison to the last 15 years. This means that the ships (assets) owned by the shipping companies have reduced in value and that their revenues, expressed in TCE, have also been reduced.

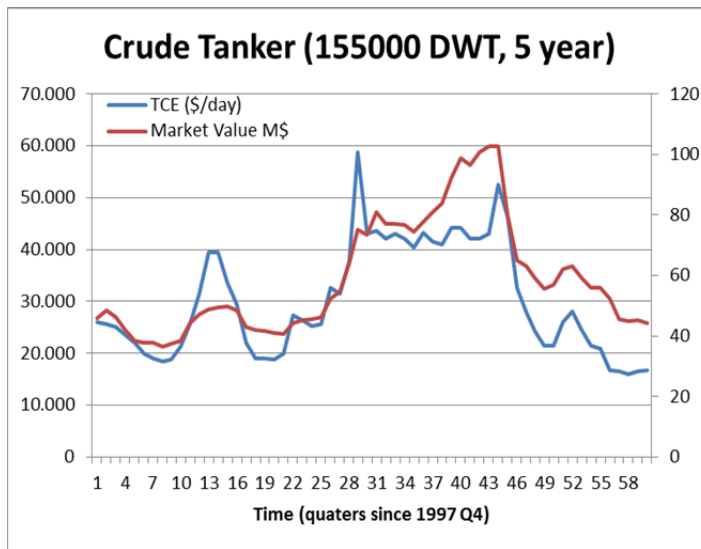


Figure 4-7: TCE (left axis) and Market value (right axis) of a 5Year old 155.000DWT Crude Tanker (ABN AMRO internal data)

4.3.1.5 Fuel prices

Fuel for ships is known as bunkers. Bunker cost are a significant part of the operational costs of shipping. The price of fuels and thus the cost of shipping are closely linked with oil prices. Based on 2005 prices Stopford calculated fuel costs to be 66% of the voyage costs and 26% of all costs for owning and running a bulk carrier (Stopford, 2009, p. 225). Prices have changes since 2005. In Rotterdam the average price per ton of 180cst was 255 while it has risen to 665 in 2012 (based on weekly quotes) (ABN AMRO internal data). This illustrates the volatility of these prices as does UNCTAD estimates which estimated the fuel to have made up 60% of total freight earnings in March 2011 while this share was only 36% in June 2010 (UNCTAD, 2012, p. 26).

It is obvious that (in the end) the shipper (the one that wants goods to be transported) will pay for fuel for example by additional fuel price depended levies (Notteboom & Carriou, 2009). As we have seen this does not have to be the same person as the one managing or the one owning the ship. This is an important fact because it makes that a shipper can only influence its fuel (and thus transportation costs) by operational changes (e.g. reduction in speed), investing in a ship he does not own or by choosing to charter a more fuel efficient ship. High fuel prices may reduce demand for transportation.

The quantity of fuel used during transport depends on power demand and the efficiency with which this power is produced. Power demand can be reduced by a more efficient ship or

operational changes like a reduced speed (slow steaming) . Efficiency in power generation can be achieved by better engines and propulsion line.

4.3.2 Operational trends

Opposed to the previous section in this section will focus on changes and trends in shipping that are being initiated by shipowners and shipping companies. These changes reflect the way they operate their vessels in the changing world and react to the trends discussed in the previous section.

4.3.2.1 Fleet size

In section 4.2 some key elements of the shipping industry were discussed. The time-lag that occurs due to the delivery times and limited capacity of fleet reduction have been explained. Due to this time-lag in the years 2008 to 2011, after the start of the global economic crisis, the world fleet still has grown. The fleet size measured in deadweight tons has grown with 37% during these four years while the international seaborne trade has grown by only 9,0% measured in ton-mile(UNCTAD, 2012, p. 12). This has resulted in overcapacity. The fact that supply of transportation have increased much more than demand for transportation indicates a declined supply/demand ratio. With this ratio also the market position of shippers has become weaker resulting in lower income and profits.

4.3.2.2 Fleet age

A clear trend has been observed over the past years of increase in the economic life of vessels. This increase has been demonstrated by the average age of vessel sold for demolition. Figure 4-8 shows that since the beginning of the millennium the average age of vessels sent for demolition has increased. It is clear however that since the economic crisis the average demolition age has dropped. This indicates an overcapacity in vessels.

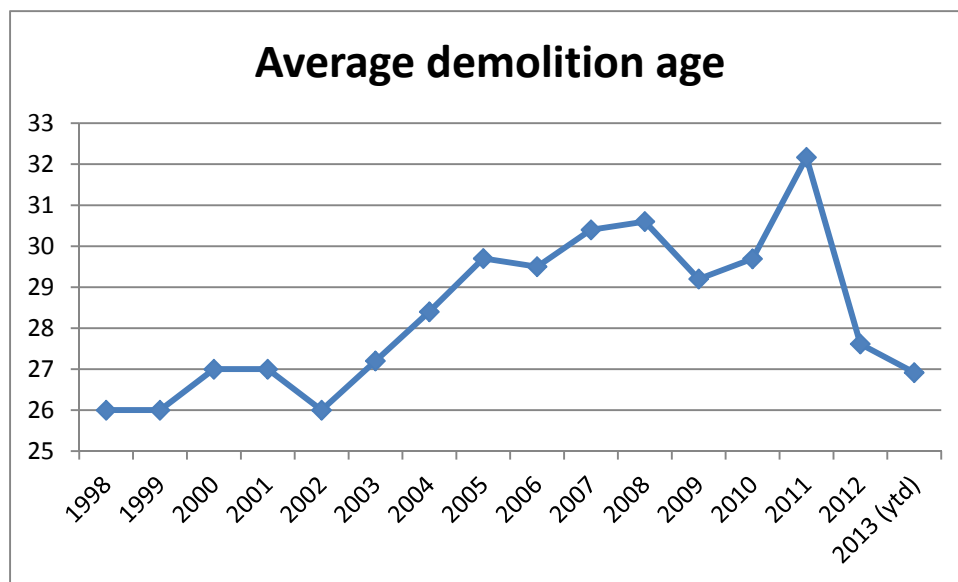


Figure 4-8: Average demolition age (1998-Jan 2013) (Clarkson's World Shipyard Monitor, 1998-2013)

The demolition age is a better measure for the economic life of ships than average ship age. This is because it prevents that the building of many new vessels (like the ones that have been ordered during the profitable years prior to 2008) deduce the average and present an unrealistic view . To illustrate this effect one can look at the average dwt age which was 11,5 years while the average ship age was 21,9 years(Clarkson's World Shipyard Monitor, 1998-2013). In April 2012 the order

book still consisted of an additional 21,3%, 27,8% and 13,1% of the international fleet for respectively containerships, bulk carriers and tankers(UNCTAD, 2012, pp. 39, 73).

The fact that ships are being used to an older age is important for owners and financiers. It allows investments to be repaid over a longer period. This will make investing in existing ships more interesting. Although the trend of increased age no distinction per ship type is made and is likely that some deviation between ship types will be found.

4.3.2.3 Ship size

Shipping companies have chosen over the last years to increase the vessel size and try to reduce cost, especially fuel cost, by benefiting from saving based on the economics of scale. Container ships for example have shown an increase average size from 1581 in 1997 to 3074 in 2012(UNCTAD, 2012, p. 36). And records for the largest container ship have been broken several times in recent years.

All other vessel types also show a higher percentage of “new” DWT capacity than the percentage of number of vessels. Also the average size for ships more recently build is higher than old ships. However it should be noted this concerns the current fleet. This means the data could also mean that large ships are scraped younger. Although this seems very unlikely given the trend of larger ships being delivered by yards.

Also in bulk carriers a trend of larger vessels is spotted. For example the company Vale, an Brazilian mining conglomerate, ordered 35 of the largest cargo carrying ships which have can carry up to 400.000 dwt.

World Economic Forum, recognising the importance of sea transport has observed the increase in ship size. Increasing ship size means concentrating transport the forum argues. They have expressed their concerns about the vulnerability of this concentration(World Economic Forum, 2011).

4.3.2.4 Slow steaming (fleet size, fuel price, interest rate)

During the last decade of the 20th century the focus in shipping has been on faster ships especially for passengers, car transport and high valued goods, i.e. containerised transport. Goods were to be as short as possible in transit. After the economic crash ship-operators needed to cut back on expenses. Due to increased bunker prices the fuel has become a bigger part of total costs. In order to reduce costs and increase profits, shipping companies chose to reduce speed. Change in speed has a significant influence in fuel consumption. The energy consumption is related to sailing speed by around the third power for diesel engines(Stopford, 1997, p. 170). A reduction of speed from 25 knots (at 80-85% MCR) to 21 knots would reduce engine power by 50%(MAN & Maersk, not dated).This relation is also shown in Figure 4-9 by Hamburg Süd.

Since 2010 a trend of reduction of operational speed has been noticed(Brünnner, et al., 2012). Ships have reduced sailing speed by slow steaming reducing speed knots to 17 knots. In some cases they slowdown even further and operate in a super slow steaming mode, sailing below 15 knots(The Economist, 2012). By applying (super)slow steaming the fuel cost were reduced.

Another positive effect form slow steaming is the reduction of the total shipping capacity measured in ton-miles. By applying slow steaming ships need more time for a single round-trip. More vessels are to be employed to realise the same transportation capacity. Therefore total world fleet transportation capacity is brought down by slow steaming.

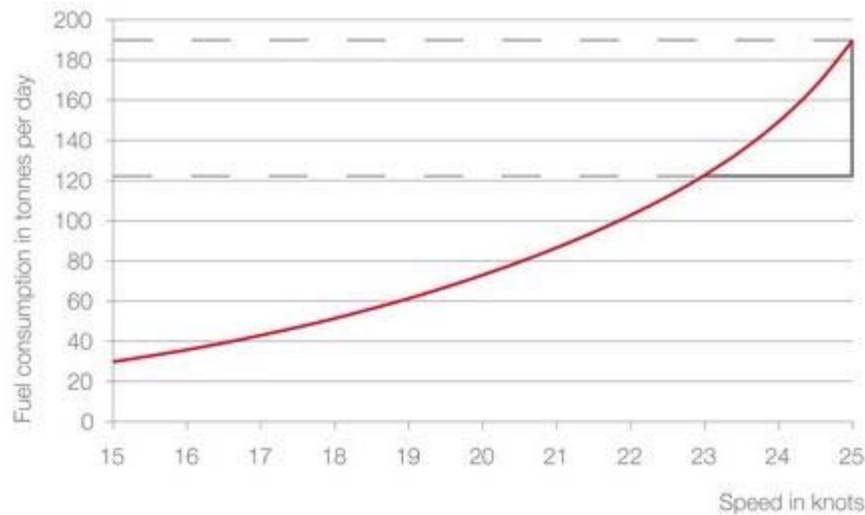


Figure 4-9: Fuel consumption in relation to ship speed (Hamburg Süd, 2013)

A last benefit is an increase in reliability of on-time deliveries. This is important especially for container liners. When a ship becomes behind on schedule it is able to temporarily increase speed in order to still make their schedule due to the spare engine power.

Shipping companies that chose to apply slow steaming are looking for an optimal speed. This optimal speed does not have to be the speed with the lowest cost per ton-mile but is based on the highest profits.

Ships engines usually operate most efficiently (fuel to power) around their design point, which lies between 70-90% MCR (Notteboom & Carriou, 2009). Changing engine power requirement by reducing speed, without engine adjustments can reduce engines efficiency. This non-optimal engine speed may partly reduce the savings of slow steaming. To prevent this a number of adjustments to the engine can be made.

Slow steaming means that less power is supplied to the propeller for propulsion. In case of a direct driven propeller, as applied in many larger ships, this means the engine is operating at a lower RPM. For engines operating in combination with a PTO requiring a fixed RPM and CPP the engine speed cannot be changed due to frequency restrictions in power generation. To be able to reduce propulsive power anyway the propeller pitch will have to be reduced. This means that per rotation less propulsion power is delivered. This results in a relative higher friction component in the power required for propulsion.

But slow steaming does impact shipping in a more broad than just fuel cost savings and efficiency cuts. Because while reducing the fuel consumption, emissions as a result of fossil fuel use are also reduced. The reduce of fuel usage results in a positive environmental effect of slow steaming.

Slow steaming is a trend which is being applied widely within shipping. At the end of 2011 MAN diesel did a survey showing almost half of containership owners questioned were applying slow-steaming, bulk and tanker over 80% of the owners questioned said to be operating ships in slow steaming mode (MAN, 2012). Notteboom & Carriou found a clear distinction between the percentage of slow steaming container vessels per route (Notteboom & Carriou, 2009). However in their paper they arrive at 53% of the observed ships applying slow steaming. A similar number as the MAN survey.

Slow steaming has benefits, as has been explained, and is now widely adopted. An obvious driver for slow steaming are the high fuel prices combined with less demand for transport. However slow steaming increases delivery times of goods. Increasing delivery time will mean an increase in time between production and sale. Since the costs for these products have been bared slow steaming will increase the demand for working capital. This working capital will need to be financed. As seen in the previous section the interest rates, due to low Libor rate, are low, making costs of (working-)capital low. However the speed of transportation will remain a trade-off between fuel cost savings and increasing (capital)cost required to finance goods at sea.

4.3.2.5 *Transparency*

A general trend towards increased transparency is being observed in shipping. Key stakeholders are increasingly expecting the disclosure of business operations including economical performance, impact on people and the environment. This trend is stimulated by the availability of information due to mobile internet on smartphones (Pruzan-Jorgensen & Farrag, 2010). It will put pressure on shipping companies to increase safety and security standards because breaches and accidents will more often lead to negative consequences for these companies in reputation and operation. Companies aspiring to follow the trend of transparency will need to collect and report appropriate data which will then have to be communicated to other stake holders.

4.3.2.6 *Fuels*

Traditionally large ships have operated on HFO (Heavy Fuel Oil). It is the end product of a refinery and its quality is highly sensitive to the quality of the crude oil and refinery process. Requirements for the fuel is a maximum sulphur content of 4,5% but since 1 January 2012 3,5% and a maximum viscosity (Kalli, Karvonen, & Makkonen, 2009). However the fuel still needs to be heated to be able to flow to pipes on board and to the engines.

4.3.3 *Intermediate Conclusion*

The paragraph aimed to show the trends that put pressure on shipping companies. Globally the development of emerging markets will contribute to a shift in transport routes and growth of demand for transport. Since the economic crisis started in 2007 the TCEs and vessel values have dropped. This means that owners invested in ships before the crisis may now have vessels with values below the debt level making it unprofitable to sell these. However due to low income they may struggle to cover the costs for financing these huge investments.

Fuel prices have despite of the economic crises remained high. Regulation forcing companies not to use the cheapest (and dirtiest) fuel increase these cost further. These increase cost are a reason for companies to be willing to invest in innovations that can save fuel. One way of saving fuel is applying the scale of size larger ships use relative less fuel. A trend has been observed in larger ships in order to save fuel. However other investments in fuel saving may be slowed down by a limited amount of capital available because banks will have to comply with new Basel requirements.

The international fleet has continued to grow after the start of the economic crisis. This can be explained by the time lag as was discussed in section 4.2.3.5. This growth of the fleet will need to be compensated by increase in demand, demolitions or reduced speed before prices will rise again. However ships are becoming older. Before the crisis but still after an increasing trend was observed in the average demolition age. Showing that investments in ships have a longer period of time to be repaid making these investments more attractive.

A very important operational trend seen in shipping is slow steaming. Slowing down ships to increase the profitability has several effects. It reduces the available shipping capacity, reduces

fuel usage and costs and stimulates innovations. Slow steaming is also stimulated by low Libor rates. These low Libor rates reduce the costs of goods being in transit.

Shipping companies were used to be very undisclosed. However companies will have to comply with requirements from stakeholders demanding increasing transparency. This will make companies more exposed and more likely to work on sustainability.

These trends change and have changed the world where shipping companies operate. These changes oppose difficulties for shipping companies and since the tool will be used to assess solutions to these problems the understanding of the trends is important.

4.4 Sustainable Initiatives within the Shipping Industry

In this section the actual movements in shipping will be discussed. This shows that shipowners are actually starting to take action and take measures or install equipment in order to comply with new, more stringent regulations. But also media and public pressure can stimulate companies within the shipping industry to take voluntary initiatives. A couple of companies have voluntarily chosen to invest in sustainable developments. The way they have done so will be discussed in this section.

Besides the shipping companies self other organisations such as several Non-Governmental Organisations (NGOs) are getting involved and start sustainable initiatives in an attempt to create a (more) sustainable shipping industry. The aim of these initiatives is to initiate industry change. Initiatives like these “helped define what ‘beyond compliance’ means for a ship”(Sustainability initiatives and standards, 2012). The involvement of such organisations proves an increasing pressure on companies to become sustainable. In this section three of these initiatives are being discussed. The initiatives have different approaches and goals but all of them are aiming to help the shipping industry develop towards sustainability.

Additionally a vetting bureau and its environmental rating will be discussed. This again shows the movement of the other players in and around the shipping industry getting ready to be part of a more sustainable shipping industry.

4.4.1 Sustainable choice of shipping companies

Sustainability has become a ‘hot topic’ within shipping and is the subject of much of the news related to shipping companies. The application of ‘sustainability’ in the shipping context has focused mainly on environmental impacts. A number of choices of companies towards sustainability that were seen in shipping will be discussed. One will notice that also these developments will mainly focus on the environmental dimension.

Over the past years regulators have become more stringent and tightened the regulations for ships. These regulations with respect to emissions and sustainability are discussed in chapter 5. Shipping companies are acting on both current and future expected regulations.

Companies are investing in fuel saving. This can be very cost effective and may, in some cases, be besides an improvement towards sustainability, also profitable. An example is Maersk. This company has paid the refitting costs for chartered-in vessels. Maersk recognised that this retrofit allows the company to reduce fuel usage and cost such that it is interesting to invest in ships not owned by the company. The company will benefit from the higher fuel efficiency for the remainder of the contract but will redeliver the vessel back to the charter with the retrofitting equipment still in place (Lloyd's List, 2012).

MAN Diesel has reported an increased interest in its retrofitting packages and other fuel saving equipment. MAN also offers a financing scheme which makes the investment cash neutral. The payments are made by money saved due to fuel saving. When the entire investment is paid back, in about 2 year according to MAN, the owner is left with an increased cash flow (Lloyd's List, 2013a).

Within the shipping business several other companies are working on projects or designs trying to increase sustainability and develop a more sustainable business model. for example EcoShip, which is a consortium led by Volvo Penta, designing a small ‘environmental friendly’ containership. The vision within the EcoShip consortium is that a vessel with the minimal emissions during its entire life-cycle is to be aimed for. This includes for example new hull design, electric propulsion and environmental suitable materials and production methods (Pike, Butt,

Johnson, & Walmsley, not dated). Class societies have developed special environmental classes for which in order to obtain a vessel have to comply with standards beyond IMO requirements (Sustainability initiatives and standards, 2012).

In order to increase transparency several companies, including Maersk, have started to report CO₂ emissions in their annual reports. However PricewaterhouseCoopers urges shipping companies to start reporting on CO₂ emissions and provide a sustainability report (Lloyd's List, 2013b).

Besides the actual operational issues another issue which is pressing in the shipping industry with relation to sustainability is the demolition or recycling of ships. According to the Shipbreaking Platform 80% of about 800 ships that are being demolished each year are beached ashore on tidal beaches in developing countries (NGO Shipbreaking Platform, 2013a). These ships are recycled in an unsafe and environmentally harmful way. The legislation on shipbreaking (as will be discussed in section 5.12) has become more stringent. The NGOs are however not yet satisfied with these more stringent regulations (NGO Shipbreaking Platform, 2013). Actual green ship recycling is far from being the standard. Only one yard has received a certificate proving its compliance with the Hong Kong convention standards for ship recycling (Lloyd's List, 2012a).

4.4.2 [Forum of the future – Sustainable Shipping Initiative](#)

Forum of the future was founded in 1996 (Forum for the Future, 2013). It is a non-governmental organisation (NGO⁸) working globally with business to inspire new thinking. Its mission is to accelerate the change to sustainability. Forum of the Future is active in many different fields, like food, energy, finance, ICT, health, fashion and transport (Forum for the Future, 2013a). The organisation does aim for practical solutions and encourages partnerships to be created within their projects.

In 2011 a “heavyweight coalition of 17 operators from across the shipping industry” have committed themselves to challenge the slow pace of environmental regulation (Lloyd's List, 2011). Together with Forum of the Future Sustainable Shipping Initiative was initiated. SSI is a project currently in its fourth and final stage bringing companies from the shipping industry together.

The project has four “workstreams”; Credible Benchmarking, Energy technology, Financing sustainable shipping and Closed Loop Materials Management (Sustainable Shipping Initiative, 2013). Each of the workstreams has its own objective and has different members based on their expertise. Companies that have joined the SSI are; ABN AMRO, Akzo Nobel, BP Shipping, Bunge, Cargill, Carnival Corporation, China Navigation Company, Daewoo Shipbuilding & Marine Engineering, DNV, Gearbulk, Lloyd's Register, Maersk Line, Rio Tinto Marine, RSA, U-Ming Marine Transport Corporation, Unilever, Tsakos Energy Navigation, and Wärtsilä (Sustainable Shipping Initiative, 2013a). ABN AMRO has joined the Financing sustainable shipping-workstream which aims to provide a structure of commercial financing retrofitting.

4.4.3 [Carbon War Room & ShippingEfficiency.org](#)

Carbon War Room is, according to its own website, a “do-tank” which has chosen shipping efficiency as one of its main operations (Carbon War Room, 2013). It has been founded by Sir Richard Branson in 2009 who brought together entrepreneurs together trying to reduce the CO₂ emissions (Virgin, 2013). The focus of the organisation is on “market barriers that [...] prevent capital from flowing into sustainable solutions” (Carbon War Room, 2013a). Removing these

⁸ NGO's are in this thesis referred to as being non-profit, non-governmental organisations.

barriers market-driven solutions are supported. Carbon War Room focuses thus on existing solutions that beside reducing CO₂ emissions also reduce cost and

Shipping Efficiency.org, an initiative of Carbon War Room and industry-leading partners (including RightShip). Like the Carbon War Room itself its goal is to reduce CO₂ emissions. This initiative is indented to be used for comparison of vessels by the use of an energy or CO₂ label.

4.4.4 [Green Award](#)

Green Award is an independent foundation which provide certificates to “extra clean and extra safe” ships (Green Award, 2013). The scheme is available for certain vessel types including oil- and chemical tankers, dry bulk carriers and LNG carriers. In several ports vessels awarded the green award receive a reduction on port fees. Ports that grand these reductions are located in Belgium, Canada, Latvia, Lithuania, the Netherlands, Oman, New Zealand, Portugal and South Africa. Large shipping companies such as Maersk, Teekay and NYK have received the green award for vessels (Green Award, 2013a).

4.4.5 [RightShip](#)

RightShip is a vetting company established in 2001 and provides a classification of vessel risk to for example ship and cargo owners, ports state control authorities, insurers, financial institutions and terminal operators helping them to manage their risk (RightShip, 2013).

In December 2012 RightShip announced to start with a rating on Greenhouse gas emissions, especially CO₂ emissions. The CO₂ rating is fairly similar to the EEDI regulations for new ships as have been determined by the IMO. However the RightShip CO₂ rating scheme, called Existing Vessel Design Index (EVDI™), is designed to be applicable for existing ships where the EEDI scheme is designed only for new ships. Assumptions used by IMO are kept similar for the RightShip scheme (RightShip, 2012).

The Green House Gas emission rating is done on an A-G scale. This scale has been established by converting the EVDI rating by logarithmic calculation to a bell shaped curved which then is used to determine the rating on the A-G scale by comparison of the peer group per vessel type. This curve is show in Figure 4-10. The peer group consists of 100 vessels most similar in size, where 50 smaller and 50 larger vessels are taken. When there are not 50 vessel larger in the peer group the vessel will be compared to a larger number of smaller vessels to be able to compare the vessel still to 100 peers.

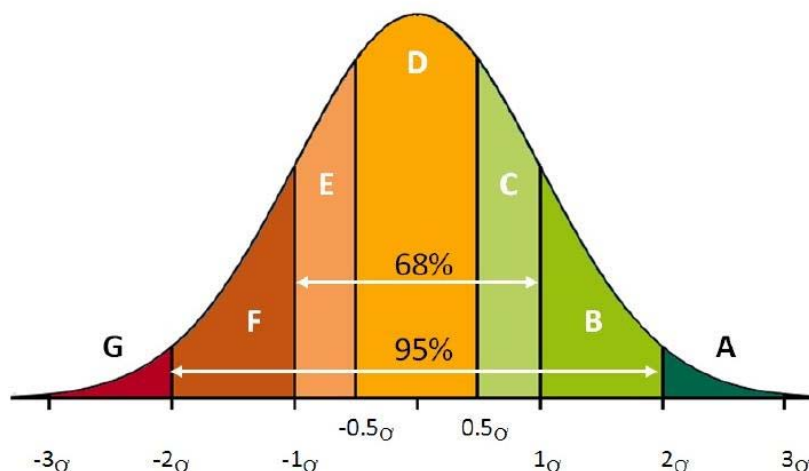


Figure 4-10: Normal Peer Distribution EVDI (RightShip, 2012)

Retrofit and other upgrades can be reported to RightShip in order to be incorporated in the determination of the EVDI rating. However operational measures, e.g. slow steaming, are not taken into account.

The scheme developed by RightShip is based on peers. Global improvements, the building of better ships performing ships or demolition of ships performing worse would make the rating shift and stimulate companies lagging to increase performance.

4.4.6 Intermediate Conclusion

This chapter has shown that sustainability is a topic within shipping which is addressed by different companies and organisations. However it shows that actual developments are taking place. Maersk shows that it expects that the repayment profiles of a number of retrofits is short enough to be profitable to install on chartered-in vessels. And MAN has reported an increased demand for retrofitting. But also class societies are developing special environmental standards or classes. A number of companies has become more transparent and started to report emissions.

Other organisations like forum of the future are stimulating sustainability in shipping and involve important players in the industry. Carbon War Room is focusing on efficiency and wants to bring down barriers allowing capital to be used for sustainable solutions that lower CO₂ emissions. Green Award has another approach. It vets ships and certificates them. These certificates are accepted in ports and entitle ships to discounts.

Finally RightShip is a vetting company and has introduced a new environmental rating scheme based on CO₂ emissions of ships.

These organisations are regarded to represent the realisation in shipping that something has to be done. And that the movement towards a more sustainable shipping industry has begun. At the very least it shows the wide spread view of importance of the sustainable issues related to shipping.

4.5 Chapter Conclusions

The goal of this chapter was to provide an overview of shipping. This will help the reader to understand why research of investments in sustainable solutions is relevant.

It was shown that shipping is very important in global trade but also is a significant polluter. Ships emitted vast quantities of CO₂, SO_x, NO_x, VOCs, Particulate Matter and may cause harm to the environment by releasing Alien species from ballast water, produce garbage and causes risk while being recycled. Besides environmental impacts also the social impact was discussed although no means of impact were discussed.

Also a short overview of the shipping industry was given in this chapter. It was shown that the supply of shipping is influenced by the number of ships but also by the ships speed. The shipping owning structure showed a problem for investing in innovations since the costs and benefits may not be located at the same company in the owning structure.

The shipping markets were discussed. The new build market showed that the production of ships lags behind the demand due to long delivery times. This results in deliveries even after economic downturns has set-in and delay in response to improvements in global trade. This is known as the time-lag. The second-hand market does not have this problem but has proven to be very volatile because the supply of shipping capacity is rather difficult to adapt significantly. The TCE shown a similar and volatile profile compared with second-hand values and a depression since 2008.

The financing of shipping is still done mainly with debt by a limited number of banks. ABN AMRO is one of these banks and thus an important player in the shipping industry. The legislation structure of shipping is complicated. These many entities put pressure on shipping companies and require them to invest in innovations in order to comply with new regulations.

Pressure on shipping companies comes from many sources, vessel values and TCEs have dropped. Making companies' investments in some cases worth less than the loan outstanding. Also income has dropped while still expensive financing is in place. Fuel prices are another source of pressure resulting in solutions like bigger ships and fuel changes. Other fuel-saving investments are also an option although banks have less capital to be located due to the new higher Basel requirements. An operational solution to reduce fuel is slow steaming. This development is seen in the market also being enabled by low interest rates. Making the good being in transit less expensive.

The global fleet has grown significantly and continued to grow due to the time-lag. This means a lot of this excess in capacity will need to be compensated by demand, demolition or reduced speed before prices will restore. Shipping companies used to be very undisclosed. Under stakeholders' pressure this is changing.

The last section described a number of sustainable initiatives from companies in the shipping industry like Maersk, MAN Diesel and Volvo Penta as well as NGOs and rating and vetting companies. The fact that all these companies and organisations are preparing for a more sustainable shipping sector proves a change in the perspective on sustainability is taking place.

5 Legislation with respect to Sustainability

In the previous chapter the legislation bodies that regulate shipping were discussed. In this chapter a number of the regulations with respect to sustainability that were imposed on shipping, or will be in the future will be discussed. These regulations help the reader to understand the focus of regulators in shipping and the pressure on shipping companies to change to more sustainable operations. It will help form a view of what are the relevant aspects with respect to sustainability

New rules put pressure on companies to comply with these rules. They might require investments from companies or could increase their cost. Rules do however stimulate a level playing field because all players will have to comply with the same standards. And are therefore essential in guiding the shipping industry to a state closer to sustainable operations.

The developments in the regulation with respect to sustainability follow each other in a fast pace. This chapter will discuss regulations as they were after the 64th MEPC meeting in October 2012. One will notice that regulations discussed in this chapter mainly focus on the environmental dimension of sustainability.

Previously, in the chapter 4, on shipping's relevance in environmental impact the emissions and environmental impacts were discussed. This chapter will therefore not focus on the impacts but merely on the regulations controlling the emissions. However one has to keep in mind that "not all pollution drivers are regulated"(Cabezas-Basurko, Mesbahi, & Moloney, 2008). In 1997 a new protocol was adopted including the new MARPOL ANNEX VI(IMO, 2013e). This legislation entered into force may 19th 2005. Several regulations as were determined in the protocol are discussed below. Also other environmental or sustainability related regulations are discussed.

5.1 Ozone-depleting substances

Within regulation 12 of MARPOL annex VI it is prohibit to deliberately emission ozone-depleting substance or use these with the exception of new HCFC⁹s installation which may be used until January 2020(IMO, 2013f). This legislation has been adopted in 1997 and has become effective since May 2005. The prohibition on ozone-depleting substance has meant for ships to change refrigerants. A ship should keep a record of the ozone-depleting substances on-board when its size is above 400GT.

5.2 Sulphur Oxides (SO_x)

In MARPOL annex VI, regulation 14, IMO has started to implement rules limiting sulphur emissions(IMO, 2013g). Sulphur emissions are chemical compounds with sulphur. The amount of sulphur emitted is directly linked to the sulphur in fuel. However the sulphur existing in fossil fuels

⁹ Hydrochlorofluorocarbons

can be reduced or removed. Sulphur present in fuel will during the combustion process react with oxygen (O_2) to sulphur dioxide (SO_2). A small quantity will react again to sulphur trioxide (SO_3). Sulphur emissions cause harm to human health and the environment (Transport Committee, 2012).

Figure 5-1 shows the global sulphur emission by ships in 1997. One can clearly distinguish the busy shipping routes. One can notice that many routes with significant emissions are close to shore.

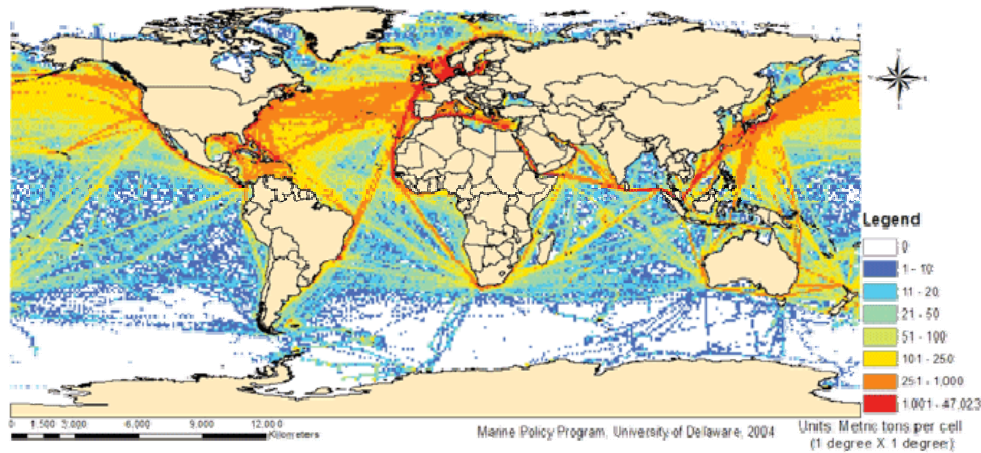


Figure 5-1: Global SO_x emission for shipping in 1997 (College of Marine and Earth Studies - Delaware)

In MARPOL regulation, a global limit to sulphur content in fuels was set to 4,5%. In an amendment of annex VI in 2008 it has been decided to reduce the 4,5% limit to 3,5% in 2012 and to 0,5% in 2020. The introduction of the limit of 0,5% in 2020 can be extended to 2025 (DNV, Marpol 73/78 Annex VI, 2009).

Special areas were defined by IMO. For sulphur SO_x Emission Control Areas (these SECAs will be discussed in section 5.4) are defined (IMO, 2013h). In SECAs the requirements for sulphur content in the fuel are more stringent Sulphur mass in fuel may not exceed 1,5%. Just as outside the SECAs the limit will be reduced. In SECAs in 2010 the limit is reduced to 1,0% and 0,1% in 2015. These limitations have been graphically shown in Figure 5-2.

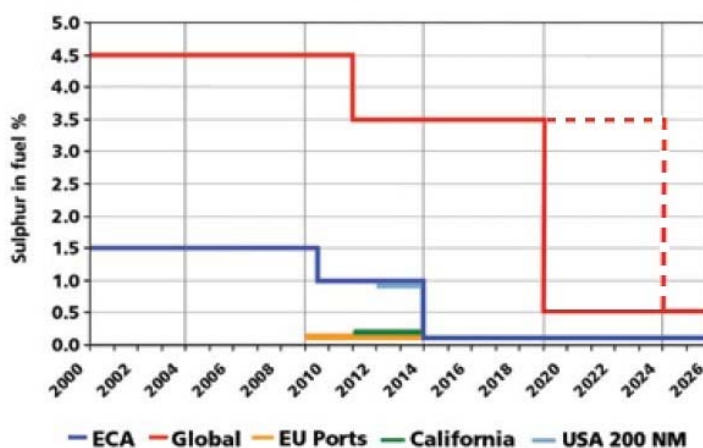


Figure 5-2: Sulphur limits in fuel (Adapted from (Hombravella, Kılıçaslan, Péralès, & Rüß, 2011))

As alternative for low sulphur fuel approved by IMO ships may make use of a gas scrubber system to remove sulphur (and other contaminations) of the exhaust gases. Sulphur will have to be removed to a level comparable with emissions when low sulphur fuels would have been used.

5.3 Nitrogen Oxides (NO_x)

Just as for sulphur emissions, also for emissions with nitrogen compounds, restrictions have been set by IMO. The rules apply to larger vessels (over 130kW output power).

The set requirements from MARPOL annex VI, regulation 13, which apply for ships constructed after 2000 are known as Tier I (IMO, 2013i). For vessels build before 1 January 2000 no NO_x rules are to be met.

Tier I limits the emissions of NO_x based on the engine rotation speed. For newer vessels more stringent rules may apply according to the amendments of annex VI rules. For vessels build after 1 January 2011 Tier II applies, for vessels build after 1 January 2016 while operating in ECA areas Tier III will apply. The later date will be reviewed and could be delayed in 2013. Also it has been determined that certain engines build before 2000 will have to comply with the Tier regulations once it is technically possible to do so. This will be announced by authorities.

The rules are summed in Table 5-1 and Figure 5-3.

| Tier | Ship construction date on or after | Total weighted cycle emission limit (g/kWh) n = engine's rated speed (rpm) | | |
|------|------------------------------------|---|---|----------|
| | | n < 130 | n = 130 - 1999 | n ≥ 2000 |
| I | 1 January 2000 | 17.0 | $45 \cdot n^{-0.2}$ e.g., 720 rpm – 12.1 | 9.8 |
| II | 1 January 2011 | 14.4 | $44 \cdot n^{-0.23}$ e.g., 720 rpm – 9.7 | 7.7 |
| III | 1 January 2016 | 3.4 | $9 \cdot n^{-0.2}$ e.g., 720 rpm – 2.4 | |

Table 5-1: NO_x limitations (IMO, 2013i)

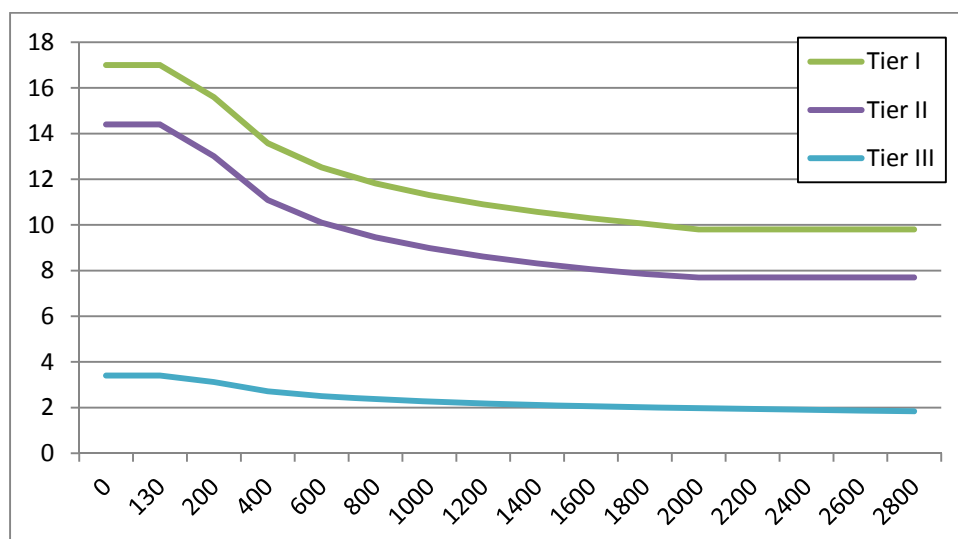


Figure 5-3: NO_x limitations in g/kWh for engine's rated speed (rpm)

5.4 Special areas

A number of regulations have marked specific areas that are more vulnerable for harmful emissions or are located in such a way that harmful emissions can do relative more harm. These areas or zones where regulations may differ were mentioned in previous sections and will be briefly discussed below.

5.4.1 SECA & ECA areas

One special set of special areas are the Sulphur Emission Control Areas (SECAs) and Emission Control Areas (ECAs). These are areas defined by IMO and have rules that are more stringent. SECAs have additional regulations with respect to sulphur while in ECAs more emissions are regulated. During the amendments in 2008 the existing SECAs were changed to ECAs. This allows the IMO to include more stringent rules on other emissions than sulphur as well.

Since May 2006 the Baltic Sea has become a SECA and since November 2007 also the North Sea has become a SECA. In August 2012 North America area became an ECA with regulations for (SO_x, NO_x and PM)(IMO, 2013j). The US Caribbean Sea is will become an ECA in January 2014(IMO, 2013h). In March 2011 DNV created a map indicating the ECA-areas as they were at that time and a number of areas that according to DNV could become an ECA. The possible ECAs that were indicated were the Mexican coast, Japanese coast, Norwegian coast and Mediterranean Sea (see Figure 5-4)(Rysst, 2011). Robin Meech has also indicated the Arctic and Antarctic areas as well as the seas surrounding Australia as possible ECA areas(Meech, 2010). Wäertsilä expects Canada and Alaska to become ECAs as well(Santala, 2012).

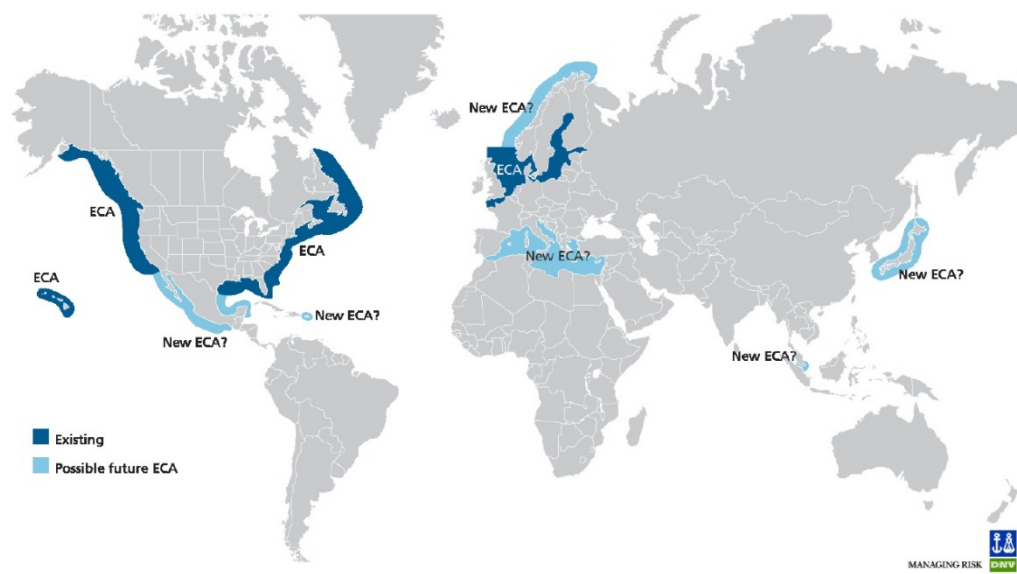


Figure 5-4: ECAs and possible ECAs (Rysst, 2011)

5.4.2 European Requirements

In 2005, independent from IMO the European union has set stringent rules for ships berthing in European ports. The rules include requirements for sulphur emissions which apply since 1 January 2010(UK P&I Club, 2009). The rules state that vessels have to operate on a fuel with a limited sulphur level of maximum 0,1%. Rules do not apply to vessels which make use on-shore power (cold-iron) or stay in port for less than two hours.

The rules are applicable for all ships berthing in port or anchored within ports limits. And vessels have to comply to these rules “as soon as possible” after berthing and may only change back “as late as possible” allowing crew enough time to safely make the fuel change-over (European

Parliament, 2005). Rules apply to all EU ports, also outside of SECA zones (e.g. Lisbon) but not to non-EU ports within SECA (e.g. St. Petersburg).

Besides the requirements in ports, Europe also has requirements regarding sulphur emissions in European waters put in place. Regardless of the IMO decision Europe will enforce a limited of sulphur of 0,5% from 2020. This decision does decrease the likelihood that IMO will delay sulphur limits to 2025 (DNV, 2012b).

5.4.3 [California ports](#)

In July 2009 regulations have been put in place requiring cleaner fuels in California ports. These regulations have been amended and the amendments have come in force in December 2011. The amendments should make regulation more aligned with the North American ECA. The regulations in California were defended based on the impact emissions may have on land. Fines are given to vessels not compliant (DNV, 2011).

5.4.4 [Turkish waters](#)

Similar to the European port requirements also Turkey has set stringent requirements to emissions of ships sailing in their territory, flying their flag and calling Turkish ports (DNV, 2012). These more stringent regulations are similar to the regulations in European waters. Vessels passing through without calling Turkish ports are not subject to these new rulings.

5.5 Volatile Organic Compounds (VOCs)

VOCs are organic chemicals that usually have a boiling point below room temperature making them volatile in 'normal' conditions (Wikipedia, 2013). Regulation 15 of annex VI addresses the emissions of these compounds (IMO, 2013k). The regulations apply to tankers and gas carriers when carrying cargo (possibly) emitting VOCs. Ports can require vessels to have vapour emission control systems. These are special installations to be installed to prevent the emission of these volatile organic compounds.

Vessels carrying substances emitting VOCs are required to have a management plan relating VOCs.

5.6 Ballast water treatment

In 2004 IMO adopted regulations obliging ships to have a ballast water and sediments management plan and will have to carry a Ballast Water Record Book (IMO, 2013l)(IMO, 2013m). Also individual states may take additional measures within a number of criteria. This can be seen as a first step towards regulations that will order ships to have treatment facilities on board.

The convention in which these regulations are agreed upon will enter into force when rectified by at least 30 member states representing 35% of world merchant tonnage (based on flag). However at the end of July 2013 the convention has been rectified by 37 countries. These countries represent however only 30,32% of the world merchant tonnage (IMO, 2013p) and therefore the regulation is therefore not yet effective.

5.7 Antifouling

In 2001 the Convention on the Control of Harmful Anti-fouling Systems on Ships was adopted (IMO, 2013n). Antifouling are paints used to prevent or delay sea life attaching to the hull. When

attached the sea life increases drag and thus fuel consumption. The convention regulating and prohibiting the use of harmful antifouling entered into force in 2008. The convention banned antifoulings with metallic compounds or organotin tributyltin (TBT) (IMO, 2013). As of 2003 “organotins compounds which act as biocides” are prohibited to be (re-)applied on all ships with the exception of fixed and floating platforms or storage units.

5.8 Energy Efficiency Design Index (EEDI)

In 2011 IMO adopted in the 62nd Marine Environment Protection Committee (MEPC) session the Energy Efficiency Design Index (EEDI) (IMO, 2012). EEDI aim to reduce greenhouse gas emissions (in particular CO₂) by ships by setting a theoretical limit of this emissions for newly delivered trade ships above 400 GT. EEDI determines the theoretical CO₂ emission per transport work carried out. Per vessel type maximum emission limits are set. Transport work is measured per DWT-mile.

$$EEDI = \frac{CO_2 \text{ emission}}{\text{transport work}}$$

Equation 5-1: Simplified EEDI formula (IMO, 2012)

The EEDI scheme does not dictate how a certain level should be reached and what measures should be used. EEDI will enter into force in January 2013 and is scheduled to be tightened every 5 years and should therefore keep-up with technological developments. However administrations are able to waive the EEDI requirements for a maximum of 4 years (Longva, 2011). Existing vessels will during the first intermediate survey have to be issued an International Energy Efficiency Certificate (IEEC) (DNV, 2011b).

Devanny has raised several issues with respect to the EEDI in a critical report (Devanney, 2011). It was reported that vessels can be made compliant by installing smaller engines. Installing a smaller engine may however be dangerous because it reduces reserve power important for manoeuvring or bad weather. During the MEPC meeting in march 2012 this problem has been partly solved by adding a limiter on the shaft power. Another problem raised by Devanny is that the formula is biased in favour of smaller ships while larger ships are by nature more effective due to reduced wetted surface relative to its volume (and thus cargo capacity) (Devanney, 2011).

5.9 Ship Energy Efficiency Management Plan (SEEMP)

During the 62nd MEPC session in 2011 also the requirement for a Ship Energy Efficiency Management Plan (SEEMP) has been adopted (MEPC, 2012). The SEEMP will be mandatory for all vessels, including existing vessels. It aims to help companies measure their energy use and therefore environmental performance and compare performance with best practise. To measure the SEEMP an Energy Efficiency Operational Indicator (EEOI) can be used. SEEMP has come into force in January 2013.

5.10 Norwegian NO_x reduction fund

As a way to reduce NO_x emissions vessels that are enroute from or to Norwegian ports are obliged to pay a NO_x taxes proportional to their NO_x emissions (Norwegian Customs, 2007). For the NO_x calculations the fuel consumption of a certain ship is multiplied with an emission factor. This calculation gives a maximum emission of NO_x. However businesses in certain sectors (including shipping) can ask for an exception from the Norwegian government of these taxes and pay (a lower fee) to the NO_x fund instead. Companies choosing to pay to the fund instead of the tax will have to report on NO_x emissions as well.

This fund gives support to companies that have joint the fund, investing in installing NO_x reduction methods. This support from the fund can be requested by national and international companies. When investing in LNG/gas propulsion systems in ships reducing NO_x emissions or battery powered propulsion of car- and passenger ferries a support up to 80% of investment or up to NOK 350,- per kg NO_x reduction can be received from the fund. NO_x reduction by other means can receive a support up to 80% of investment cost and up to NOK 225,- per kg NO_x. Selective catalytic reduction(SCR) measures can receive support up to 60% and NOK 100,- per kg NO_x. Other measures where NO_x can be classified as a side effect may receive up to NOK 50,- per kg NO_x reduction(NHO, 2013).

The NO_x fund has reduced income from NO_x taxes for the government significantly. However the result in terms of reduction in NO_x was also very significant. A total number of 530 projects between 2008 and 2011 were supported by the fund and together reducing the NO_x emission by 23.000 tons over these years(Nortrade, 2011).

5.11 Garbage

To protect the environment from the harmful effects from garbage from ships the disposal of garbage has been regulated by the IMO. Within MARPOL Annex V the disposal of plastics in sea has been prohibit for all ships everywhere(IMO, 2013b). Other wastes like food, cargo residues, cleaning agents and carcasses of animals may be discharged. However restrictions may apply in special areas and close to coast (Kairis, 2012).

5.12 Ship recycling

In this section regulation regarding ship recycling is discussed. The section is split per regulation. Presenting the legislation as determined in the Basel convention, the Hong Kong convention and by the European Union.

Ship recycling concerns the disposal of unwanted ships by a shipowner. Often ships are sold to an agent, a cashbuyer, specialised in the selling of ships to demolition sites. When a ship is sold to a demolition yard the yard pays for the materials onboard the ship that carry value. The yards and the countries they are in have a demand for the recycled materials. Thus the countries it is important ships are demolished within their borders(Basel Convention, Ship Dismantling, 2013).

5.12.1 The Basel Convention

The Basel convention or in full “the Basel Convention on Control of Transboundary Movements of Hazardous Wastes and their Disposal” (which should not be confused with Basel accords regulating banking standards) have set rules regulating the international movements and disposal of hazardous and other waste. The convention was adopted in 1989 and came into force in 1992.

The convention requires 'Prior Informed Consent' procedure for international waste transports (van Gelder, Hogenhuis-Kouwenhoven, & Klooststra, 2013). Requiring an approval for arrival of a transport for it to be legal. Secondly parties that are part of the convention are obliged to make sure waste is treated in an environmental save and sound way.

Ships carry all kind of (hazardous) wastes like for example used oils, asbestos and PCBs¹⁰ (Basel Convention & UNEP, not dated). When a ship is transported to a demolition location it is usually moved over country borders and since it often does not fly the flag of the country of demolition the Basel regulations should apply. However it is recognised these regulations are often circumvented (Basel Convention, Ship Dismantling, 2013).

5.12.2 [Hong Kong Convention](#)

During the 'Hong Kong Convention' in May 2009 regulations specially regarding ships demolition has been adopted. The convention aims to prevent any unnecessary risk to human and environment (IMO, 2013c). It was recognised that the international nature of shipping made application of other rules (like Basel) difficult (IMO, 2009). The convention has not yet been rectified.

The convention tries to address all issues regarding ship dismantling. Design, construction operation and preparation of ships are included to facilitate safe and sound recycling. It states the requirements for flag state, shipowner and recycle state and site. When rectified ships will need to carry a list with hazardous materials on board. Yards will have to specify the way they will recycle the vessel. Also the demolition yards will be subject to the regulations and will have to provide a Ship Recycle plan

5.12.3 [European Union](#)

The European Union has made a proposal to implement the Hong Kong Convention as part of European law even before the 'real' convention would come into force (European Commission, 2012). Also the European union has included more stringent regulations regarding recycle facilities and contract between those facilities and owners. This proposal of new regulation has not yet been approved.

Within the rules of the European Union as well as the Hong Kong Convention is a problem concerning to vessels changing flag to avoid complying with the rules. Changing a flag is easy and cheap resulting in owners selling their vessels to cash buyers abroad who sail the vessel to demolition location and do not have to comply with European Union regulations or Hong Kong Convention regulation once implemented.

In February 2013 another proposal was made by the European Commission to start a fund were European flagged vessels and vessels entering European ports will have to contribute to during their life. At the end of working life this fund will contribute to the recycling of ships in a safe and sound matter and would create work for ship-recycling facilities in Europe (Lloyd's List, 2013c).

¹⁰ Polychlorinated biphenyls

5.13 Chapter Conclusion

This chapter has shown that over the past years and in the years to come new and more stringent regulations with respect to sustainability, especially within the environmental dimension, will put pressure on shipping companies. It has been shown that pressure is put on companies both in administrative way, with the logging of for example substances on board, as well as by the need to invest in new equipments.

The regulations with respect to the emission of sulphur oxides and nitrogen oxides does differ based on the location of the ship. Special areas have been identified close to heavily populated areas, in ports and at environmental vulnerable locations. This difference in regulations based on a ship's location introduces an additional consideration based on the expected trade locations of vessels.

The ballast water regulations have shown another issue with the international regulations. Because even when a regulation is formulated and agreed upon, the implementation may be delayed due to the fact that not enough countries with enough tonnage have rectified the regulation yet. For the ballast water regulations it is uncertain when this regulation will thus become into force.

On ship recycling a number of regulations are in place. However in February 2013 another new proposal from the European Commission was filed. This development indicates that possibly regulations will be stringent once more. For shipowners this increases insecurity about the (scrap) value of their older vessels because ships scrapped environmentally friendly may be sold for less.

The aspects that are regulated show the priorities of the legislation bodies and provide a level playing field for all companies. It makes sense to include these aspects in the measurement of sustainability. However the actual compliance is not included in the tool because compliance is assumed to be required for all players and not a voluntary choice. However different ways to comply could be assessed with the tool.

6 Sustainable Innovations in Shipping

In this thesis a tool will be developed in order to assess the impact of investments in innovative, sustainable, equipment onboard a ships. In the previous chapters a number of developments and regulations concerning sustainability and their impact on shipping have been discussed. The tool should be applicable in the assessment of different methods which can be used to comply with these regulations. In this chapter will evaluate innovations and their impacts. It are these impacts that need to be able to assess by the tool.

Innovative equipment that contributes to a sustainable industry is not new in shipping. Several organisations and companies have made innovative efforts towards a more sustainable shipping industry. This chapter will illustrate several measures and innovations that can be applied on or to ships in order to reduce impact and to move closer to a sustainable state. Most of these innovations on ships focus on the environmental dimension of sustainability.

Besides providing an overview of the impacts, which need to be addressed by the tool, this chapter will also provide a view on existing solutions to the sustainability issue within the shipping industry. It shows that several companies have noticed the importance of the issue and have started to develop a (part of the) sustainable solution. In 2010 DNV published a report stating that a combination of innovations can cut CO₂ emissions in a cost effective way by 15%(Alvik, Eide, Endresen, Hoffmann, & Longva, 2010). Figure 6-1 from that report shows these findings in a graphical way.

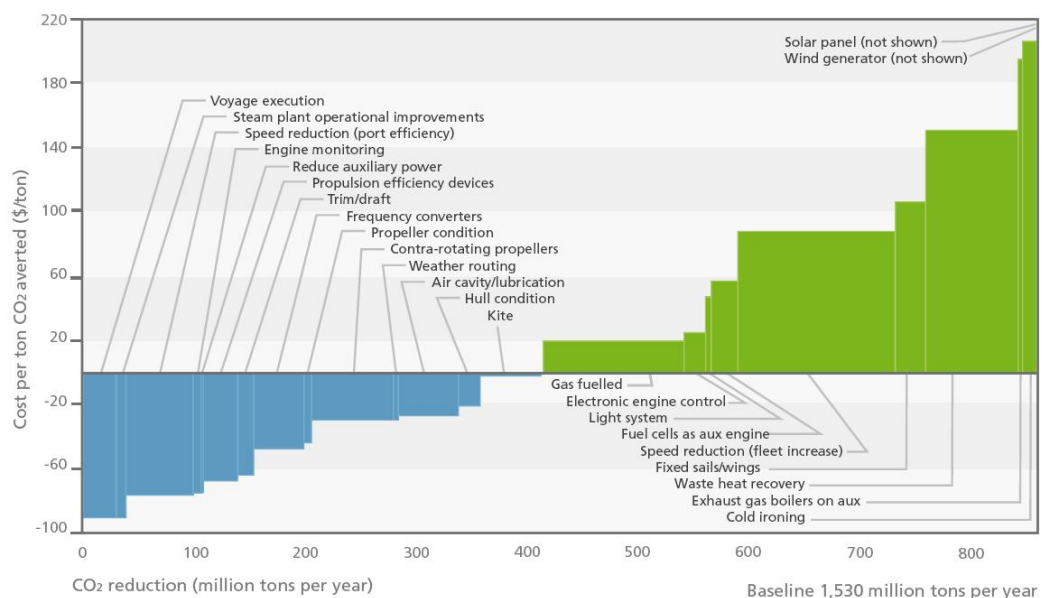


Figure 6-1: CO₂ reduction and cost per ton averted (Alvik, Eide, Endresen, Hoffmann, & Longva, 2010)

In the first paragraph of this chapter some fundamentals from shipping will be explained in order to understand why and how the later discussed innovations work. Afterwards the innovations themselves will be discussed.

6.1 Fundamentals of a Ship and its propulsion

Vessels are floating structures and are often designed to be moved by its own means. The mere fact that a vessel floats does tell one that its weight and displacement ('underwater volume') are to be equal. The weight thus determines the submerged volume of the vessel. For vessels with hydrofoils this is not the case since they create lift to be raised partly from the water. These special high speed vessels are not within the scope of this thesis.

In order to move a vessel through the water propulsion is needed. Once the vessel is in motion the power demand is mainly determined by two components of resistance. The first resistance component is caused by drag from the water the vessel moves through. The wetted-area and thus displacement and hull-form are dominant factors. This part of resistance is dominant at lower speeds measured in the Froude number¹¹.

Second resistance component is the residual resistance. This component is mainly a result of pressure components(form resistance) and waves. Especially due to the wave resistance this component takes a larger share of the total resistance for higher speeds.

To make ships more efficient one can either reduce resistance components or one can increase the propulsion. In the next paragraphs measures to accomplish this will be discussed.

6.2 Turbo Charger Cut Off (TCCO)

A turbocharger is a device designed to increase pressure of the air for intake in an engine. It allows more air (by mass due to a higher density) and fuel to be injected per cycle allowing an engine to become more powerful and fuel efficient. A turbocharger is driven by exhaust gases from the engine.

The Turbo Charger Cut Off is an innovation to improve the fuel efficiency of propulsion by improving the engines efficiency whenever in partial load. Engines are usually optimised for a certain cruise speed at about 80-85% of full load. As discussed in section 4.3.2.4 many vessels have reduced speed in order to save on fuel. High fuel costs, low demand and low interest rates have contributed this speed reduction. Because energy demand increases significantly with increasing speed, a reduce of speed from 25 knots (at 80-85% MCR) to 21 knots would reduce engine power by 50%(MAN & Maersk, not dated).

In partial load the 'normal' advantages of a turbo are not utilised because not enough air flow is provided. Having a turbo connected at the engine does however require additional power. A TCCO can be applied disabling one or more turbos improving the flow and performance of the other turbos and thus the overall efficiency.

Two types of TCCO can be installed on vessels. The first is a semi-permanent system that is used to re-matched turbo-chargers to the new conditions. It cuts out a certain number of turbos. During the voyage no adjustments can be made to the system. In port the number of turbos disabled can be changes. This is a simple type of TCCO and therefore relative less expensive.

Another type is a flexible TCCO. This type of TCCO will make the ship more flexible in operation modes and more fuel efficient in several modes. This improved flexibility can be beneficial in all

¹¹ Froude number is a measure of speed expressed in speed-length ratio.

kinds of operation, for example in ships with different cargos quantities (crude tankers) or different speed demands (container carriers). A ship equipped with this type of TCCO will be able to change the number of turbos that are 'cut out' without manual labour. It can switch easily to the most efficient operation of its engines during a voyage. Thus when the ship wants to speed up it can change setting to an optimum for full load instead of partial load. This system is more complex due to its flexibility and the system is also more expensive.

A TCCO is used for ships sailing at partial load. In chapter 4.3.2 the trend of shipping companies choosing for slow steaming has been discussed. Applying slow steaming or sailing at lower speeds make the ships engines operate in partial load. The TCCO is a response to this trend, increasing efficiency at this new lower operational speed. An actual example of a TCCO applied to a 12K98MC engine running at 40% MCR showed savings of approximately 5%. The installation of a TCCO can be done in about 48 hours (Turbo, not dated).

6.3 Waste Heat Recovery (WHR)

Although marine engines can be very efficient, a lot of energy is still lost in the form of heat leaving through the chimney. Of the energy generated only about 49% is available at the shaft. About 25% of energy is lost due to exhaust gas. MAN claims it can recover 8-11% of the total energy (MAN Diesel & Turbo, 2012). Waste Heat Recovery is a system designed to utilize the energy in the form of heat from the exhaust of the main engine. The heat in the exhaust can be used in steam turbines producing electrical power. This saves fuel otherwise required to power de auxiliary engines. According to Green Ship there is a potential of up to 14 % of the power available at 85% MCR with an optimized Waste Heat Recovery System (Green Ship, not dated). Since less fuel is used similar reductions of CO₂, NO_x and SO_x will be achieved.

6.4 Air lubrication

Air lubrication is a technique where the energy consumption of vessel is reduced by reducing the drag resistance. This reduction is achieved by bubbles or a sheet of air between the water and the vessel.

This method works best for vessels with large flat bottom hulls, where friction resistance can be reduced for a large area. Because this method aims to reduce drag it is most efficient in situations where drag is the major resistance component, i.e. lower Froude numbers¹². The air lubrication method reduces emissions by reducing the energy consumption and therefore fuel usage.

Several different suppliers have air lubrication products. Two main types can be distinguished. These types will be shortly discussed.

The first type is the air cushion (Stena Bulk, not dated). This type creates a sheet underneath the vessel preventing a large area to come in contact with water while moving through water. Air cushions are created within a certain cavity or cavities in the bottoms of the vessels hull preventing air from escaping. The design of these cavities varies between the suppliers and prototypes.

¹² Froude number is a measure of speed expressed in speed-length ratio.

For this type of air lubrication a flat bottom is important to be able to create sufficient area where the cavities can be positioned. On the Figure 6-2an installed system is shown.



Figure 6-2: Air cushion (Stena Bulk, not dated)

The second type works with micro bubbles or film layers (Mitsubishi Heavy Industries, 2012). The most important difference is the fact that it does not need to have cavities in the hull. By air outlets in the bottom a layer of bubbles is created that will move along the hull because of the vessels speed. These bubbles will follow the water flows. Another option is creating a film layer along the ship's hull. A film follows the vessels hull form better than bubbles that do mainly follow water flows. A graphical representation is given in Figure 6-3

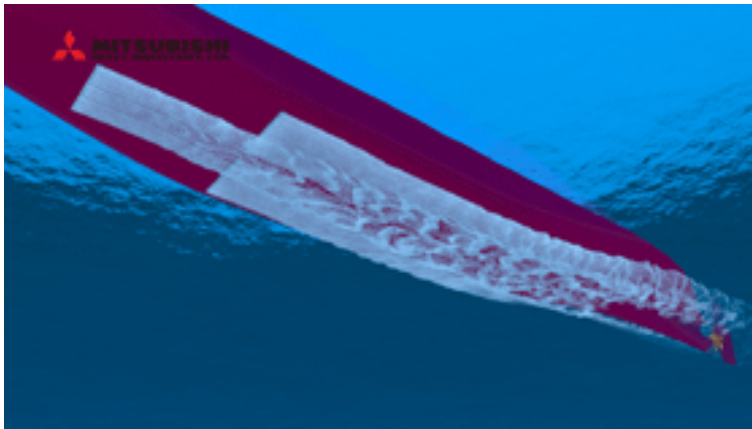


Figure 6-3: Micro bubbles (Mitsubishi Heavy Industries, 2012)

Combinations of the types mentioned above are being used as well. The cavities are in those cases are supposed to be 'overflow' with air creating a strip of bubbles after the cavities. For the installation of an air lubrication system a ship will have to go into dry-dock for approximately 14 days (Motorship, 2010).

The savings that the manufactures expect are significant. The companies providing the data that is presented have commercial interests with respect to the data. The reported savings differ significantly between manufactures as the data below will show. This is probably caused by the stage of development of the systems and the limited experience of actual application of the system.

The Airmax system provided by Stena Bulk is still in its prototyping and small scale phase. Stena reports savings in the range of 20-25%. However this system is designed for new slow speed bulkers with a flat bottom and is not suited for retrofitting (Fathom Shipping, 2013).

For the Air Cavity System designed by the DK Group savings up to 15% are claimed for tankers and bulkers. For other types like container vessels savings around 7,5% are reported and for LNG carriers savings between 7 and 9% are reported (Fathom Shipping, 2013).

The Mitsubishi Air Lubrication System (MALS) have reported over 5% (MarinkeLink.com) and 7% (Mitsubishi Heavy Industries, 2012) on installations of the system on ships.

Damen shipyards developed a system for inland ships. Damen claims that the system has showed savings between 5 and 40%, dependent on vessel speed. Better savings were realised at lower speeds which could be expected due to the higher fraction of frictional resistance within the typical ranges of operating speed and conditions an average of 15% savings could be realised. (Damen, not dated).

6.5 Coatings

Friction resistance is an important component of the total resistance. It has relative more influence at lower speeds. The friction resistance depends mainly on the wetted surface and roughness of this area. In order to reduce drag coatings are applied.

Hull coatings on vessel have two functions. The first function is the protection of the vessel against corrosion by forming a barrier between the vessels steel hull and sea water. Secondly, coatings are used to reduce roughness and thus drag. This drag reduction results in savings in demand for propulsive energy and therefore fuel and thus fuel costs up to 9% (JLA Media, 2010). The drag reduce is accomplished by creating a smoother surface as well as by preventing biofouling on the hull.

Previously many ships used of tributyl-tin (TBT) self-polishing co-polymers. These TBT coatings could keep the hull clean for 5 years. However, IMO has prohibited the use of TBT coating because it is harmful to the environment (IMO, 2013). Other legislation with respect to antifouling was discussed in section 5.7. Different types of coatings are now used to solve the fouling problem.

6.5.1 Ablative coating

The first type is ablative or self-polishing antifouling. It is a type of fouling that usually contains biocides and dissolves slowly in seawater creating a fresh layer of paint with biocides.

6.5.2 Fluoropolymer antifouling coatings

Another type are new fluoropolymer antifouling coatings. These coatings do not contain chemicals preventing organisms to attach to the hull. However it creates such a smooth surfaces that biofouling is unable to stick to the hull at speeds above 10 knots. This type of antifouling is known as Foul Release Coating (FRC). Intersleek, a coating produced by International Paint¹³ is such a coating. FRC coatings are not suitable for stationary vessels or vessels operating at very low speeds because some water flow is needed to wash the fouling of the coating.

The Energy and Environmental Research Associates (EERA) published a report on the fuel savings that can be achieved with Fluoropolymer Foul Release Hull Coating. In the report the savings are

¹³ A subsidiary of AkzoNobel

calculated based on a reference speed on two existing vessels, one oil tanker and a bulk carrier, and five new vessels. The existing vessels showed significant fuel savings of 10 and 22%(Corbett J. J., Winebrake, Comer, & Green, 2011). However one should note these savings compare the fouled hull with the clean and repainted hull. It is therefore difficult to determine the actual fuel saving due to the new type of coating. For a specified 4200 TEU container ship Hoolenbach reports that a cleaned hull can reduce energy consumption by 5,9%(Hollenbach & Friesch, not dated).

6.5.3 Surface Treated Coatings

Coatings that are based on surface treated coatings system are hard coatings designed to withstand many cleanings. It might last for 20 years but the coating does not contain biocides. Due to the lack of biocides these coatings are less harmful to the environment. However the coating does need regular cleaning. Hull and/or propeller cleaning is not a preventive measure against fouling but a measure that removes the fouling. Usually ships go for dry-dock every 5 years, during that dry-dock the hull is cleaned and painted reducing drag resistance. Hull cleaning happens in between dry-docks trying to achieve a similar effect. Suppliers report savings from 1 to 12% with an average of 5%(SeaRobotics)(CleanHull).

6.6 Optimised Hull and Bulbous bow

Wave resistance, being the major resistance component at higher speeds, is mainly influenced by the shape of the vessels hull and the bow. Relative small changes in the shape of the vessel can influence the resistance.

The efficiency gains are especially interesting for new ships because it is easier to make adjustments to a hull still to be constructed. By choosing for an optimised hull design an energy saving of “4-5% can easily be gained and 1-2% improvements are feasible even on [...] highly ‘optimised’” hull designs ((Abt & Harries, 2007) in (Hochkirch & Bertram, not dated)).

The portion of resistance due to wave resistance may increase for vessels sailing in an off-design condition. Ships that have an optimised design for a certain speed but operate at lower speed due to slow steaming can benefit from a refitted bulbous bow optimised for the new operational speed. This hull adjustment is also interesting for existing ships. The trend of slow steaming was discussed in section 4.3.2.4. Operation in such a way with only 40% engine power a bow adjustment can save 2,5%. Adjustment costs for the bow would be in the range of \$ 450.000 (excluding dry-dock)(Hochkirch & Bertram, 2008). One problem that might arise is to have access to the original contractual hull plan since yards are not always willing to provide detailed plans on their designs to prevent imitations.

6.7 Rudder

Appendixes can have significant influences on the resistance of ships. Rudders, being one of the most significant one of these appendixes, introduce added wetted area resulting in extra frictional resistance. And because rudders are located in the wake of a propeller and rotational forces will act on the rudder. Because of these effects the rudder poses opportunities of efficiency gains. In the paper of Hollenbach and Friesch (Hollenbach & Friesch, not dated) a twist ruder with rudder bulb is mentioned indicating a possible gain of 4%. A high efficiency rudder from Wärtsilä or Rolls Royce may gain 6% according to the same paper.

6.8 Optimise propeller

Propellers are usually matched with a vessel based on engines RPM and power requirements. However when a vessel's power need changes due to lower speed or due reduced resistance, or when the propeller was not properly matched in the first place, the propeller might not work in its optimal operating point.

Shipowners have the choice for a Fixed Pitch Propeller (FPP) which have better performance at its optimal design point and is cheaper. Propulsive power of a FPP can only be changed by changing the engines RPM. In other cases a shipowner may choose for a Controllable Pitch Propeller (CPP) which can optimise the pitch of the propeller to match different operational profiles and does not require the RPM to be changed. This allows the usage of a Power Take Off (PTO). CPPs are more expensive than FPPs. However the efficiency is lower for a CPP at any given point than for a FPP. The overall efficiency with a CPP is however better for ships operating over a wide range of operational points. Re-matching the propeller to be optimal for the operational profile may save fuel. "Several retrofit projects have been reported, with savings up to 17% quoted due to new blades on CPPs (Propulsion, 2008) in (Hochkirch & Bertram, not dated)". Below three different options are given to increase a propellers efficiency.

6.8.1 Reduce propeller friction losses

CPPs can be used to a main engine which operates at a constant speed. A reason to operate at a constant speed is a power-take-in (i.e. a generator also connected to the main engine). A CPP can change the propulsive power delivered by changing pitch. However at low speeds (but the same RPM) this can result in a propeller turning relative fast with little pitch. The fast rotation still creates significant friction on the blades. At low speeds CPPs can therefore be inefficient.

6.8.2 Reduce of rotational losses

Propellers are designed to increase water speed and thereby creating thrust pushing the vessel forward. However, while creating this thrust the turning movements of the propeller through water also makes the water rotate. These rotational flows require energy and thus energy is lost this way. Losses due to water rotating are called rotational losses. Special fins attached to rudders can reduce these losses. "Typically 4% fuel savings are claimed for all these devices by manufacturers." (Hollenbach & Friesch, not dated). Other options like a Contra Rotating Propeller (CRP) or Poddred drives have claimed savings of 13% (Ueda, et al., 2004).

6.8.3 Better wake; improved hull design

The third option to increase a propeller's efficiency is by improving the inflow of water in front of a propeller. This is called the propellers wake. The wake is important for a propeller's performance. A propeller in a homogenous wake will perform better and vibrations will be lower. Improving the ship's hull design, or adding nozzles or ducts can help achieving this. "The Mewis duct combines pre-swirl fins and wake-equalizing duct, [it can reach] 4% savings for full hulls like tankers or bulkers"¹⁴ (Hochkirch & Bertram, not dated).

¹⁴ Compared for fast ropax ferry with original 2 shaft design

6.9 Weather Routing System

A rather simple measure to reduce the overall power demand for a voyage is the implementation of a Weather Routing system. This system optimises the route of a vessel based on the weather (forecasts), weather statistics and parameters as safety, potential damage of cargo and limitations in arrival time. The systems costs are between \$ 5.000 and \$ 10.000 and can achieve fuel savings between 2-4%(Skjølsvik, Andersen, Corbett, & Skjelvik, 2000, p. 89). For experienced crews, making well informed routing choices the reduction might be less.

6.10 Reduction effects from wind

Wind may have significant influence on vessels. This influence is even more present for vessels with large airdrafts, like container ships, car carriers and cruise ships. Wind can act as direct aerodynamic resistance and may also result in drifts (off course) which will need to be corrected with the use of (additional) propulsive power. The influence of adds about an average of 27% to the power demand based on different wind conditions according to estimates by Hollenbach(Hollenbach & Friesch, not dated) for a 4200 TEU container vessel. The possibilities of increasing efficiency by reduction of wind resistance have been estimated to be able to reach overall power demand between 3-5%¹⁵. However not many wind influence reduction measures have been installed so far.

6.11 Scrubber

A scrubber is a type of after-treatment of exhaust gases from a combustion engine aiming to remove sulphur from these gases. The scrubber will be dealt with extensively in this thesis because the investment in a scrubber is an investment that is actually made by some shipping owners. Owners choose to install scrubbers because regulations requiring very low sulphur emissions in ECA areas will come into force within 1,5 years on 1st of January 2015. These regulations were discussed in section 5.2.

A scrubber is a significant investment. However it allows a ship operator to use cheaper fuels with more sulphur. It has been discussed in the legislation section that for certain areas (ECAs) additional more stringent regulation apply with respect to the used fuels. This will cause an increase of the demand for distillates while the demand for residual fuel will decrease. The price gap between these fuels is therefore likely to increase. This means thus that HFO¹⁶ will become relatively cheaper. Installing a scrubber saves one the costs of using more expensive MFO¹⁷ or MGO¹⁸.

Scrubbers can be installed on new ships as well as on existing ships. However scrubbers are large and need to be so in order to be efficient(Kalli, Karvonen, & Makkonen, 2009). Not all existing ships have sufficient spare space for a scrubber to be installed. For example for a 10MW scrubber a space of 3,5m wide and 6m high will have to be available(ABS, 2011).

¹⁵ Based on a 4200 TEU container vessel

¹⁶ Heavy Fuel Oil

¹⁷ Marine Fuel Oil

¹⁸ Maritime Gas Oil

Two types of scrubbers exist. The first is the seawater scrubber. Which guides exhaust gases through seawater where the sulphur, particulate matter and some other contents are absorbed by the seawater. That water is not re-circulated and, after passing through a filter, it is released into sea. The salt content in the water has influence on the alkalinity, the ability to maintain a certain acidity. A low salt content requires the addition of alkaline compounds or an increased flow of sea water.

Freshwater scrubbers work in a similar way but additionally lye or caustic soda is added to the fresh water in order to maintain the PH about neutral in order to absorb the sulphur. A fresh water system can be used as a close loop, so without any discharge to wash water. Wash water from scrubbers might be an environmental risk since it may contain hydrocarbons, metals or nitrous compounds. Therefore this wash water will have to be treated with a purifier.

A scrubber will remove almost all, about 95%, of SO_x from emissions. Particulate matter is also reduced significantly with about 80% and soot is almost completely reduced (Wahlström, Karvosenoja, & Porvari, 2006)(Trozzi & Vaccaro, 1998).

Reports differ on the effects of scrubbers on NO_x emissions. “No reductions” to significant changes were reported(Wahlström, Karvosenoja, & Porvari, 2006) (Ritchie, Jonge, Hugi, & Cooper, 2005). CO_2 emission is not reduced but will show some increase due to energy demand of the scrubber. The scrubber power demand is estimated by Wärtsilä to be 0,4 – 0,6%. With a maximum of 1% at top ship speed(Wärtsilä, 2012).

6.11.1 Costs of a Scrubber

In this section a number of details on a scrubber’s costs and operational performance will be discussed. The scrubber capacity and its size are usually based on the main engine. However emissions from auxiliary engines may need to be ‘scrubbed’ as well.

The cost of a scrubber and its installation were estimated by Entec based on a 27MW main engine to be about € 168/kW for retrofitted scrubber and € 118/kW for a new vessel(Ritchie, Jonge, Hugi, & Cooper, 2005). These costs were reported in 2005 and will have to be corrected for inflation. Based on the price index in the Euro area the correction factor in order to convert the 2005 numbers will be 1,1768 (Eurostat, 2013). Resulting in a cost of € 198/kW and € 139/kW for retrofits and installation on a new vessel respectively. The operating and maintenance costs per year of a scrubber are expected to be around 1% for large vessels to 3% for smaller vessels of the new build price of the scrubber (Ritchie, Jonge, Hugi, & Cooper, 2005). The same report estimates the life span of a scrubber to be 15 years.

Greenship reported a retrofitting cost of a scrubber for a ship with a main engine of 9480kW vessel to be \$ 2,6M with an additional \$ 2,4M for modifications (Klimt-Møllenbach, Schack, Eefsen, & Kat, 2012). These costs were based on information from several shipyards in Denmark, Germany and China. Figures are to be corrected by factor 1,025 for inflation in 2012 based on the Euro area (Eurostat, 2013).

| Number of engines & Power (kW) | Power (kW) | Scrubber (Million €) |
|--------------------------------|------------|----------------------|
| 1* 3.500 | 3.500 | 1,8 |
| 2* 5.000 | 10.000 | 2,3 |
| 4* 5.000 | 20.000 | 3,0 |
| 1*20.000 | 20.000 | 3,0 |
| 1*40.000 | 40.000 | 4,4 |

Table 6-1: Scrubber costs for specified engine power (van der Klip, 2013)

Wärtsilä, an well know engine and marine machinery manufacturer, has provided detailed information on the cost of a scrubber. A scrubber installation will cost about € 1,6M basis and additionally € 70 per kW. This price does not include an additional 50-75% for the installation(van der Klip, 2013). For a number of engine cases the scrubber costs that were calculated by Wärtsilä are presented in Table 6-1.

The data by Wärtsilä is the most recent and detailed enough to be used in a large number of cases. Prices are comparable with the price estimated by Entec. It is chosen to use the data provided as by Wärtsilä for the case study later in this thesis.

6.12 Selective Catalytic Reduction

Selective Catalytic Reduction (SCR) is, like a scrubber, an add-on equipment designed to reduce the NO_x emissions by after-treatment in the exhaust of ships. A SCR system can be fitted on existing ships exhaust system and is engine manufacture independent. It uses a catalytic converter and urea or ammonia to transform NO_x into N₂ and H₂O. The chemical reaction below can be found just below.



For SCR equipment reductions of NO_x have been reported between 80 up to 99%(Wahlström, Karvosenoja, & Porvari, 2006). The system does not influence the main engine's combustion or efficiency. However the running cost of the system can be significant. Estimated with 1998 prices about 7 to 10% of the fuel cost are to be added as additional costs estimated with(Trozzi & Vaccaro, 1998). Like the scrubber a SCR installation is a significant investment. However the price per kW reduces for larger engines as Figure 6-4 shows.

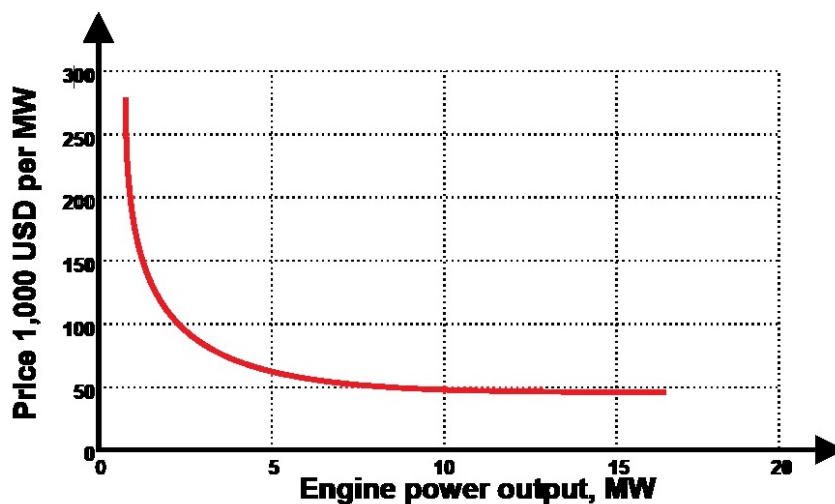


Figure 6-4: Price SCR per Engine output (MW) (v. Helge Rosenberg, 2005)

SCR can be used to comply with regulations with respect to NO_x emission. Although the regulations as discussed in chapter 5 only apply to new vessels, change in operational location or expansion of ECAs could lead to vessels being required to reduce their NO_x emissions.

6.13 Alternative fuels

The previous innovations or measures are focused on a more efficient power production process or on the reduce of power demand. Scrubbers and selective catalytic reduction reduce the emissions resulting from the combustion. The following measures and innovations focus on power supply from other sources. This section will show alternative fuels that can replace traditional HFO with a relative large quantity of sulphur.

6.13.1 Low Sulphur HFO

The Sulphur content in a ship's emission is proportional to the sulphur content of its fuel. Reducing a ships sulphur emission can thus be done without any adjustments or installations by using a fuel with less sulphur. Using a fuel with less sulphur reduces, besides sulphur emissions, also particulate matter and machinery wear.

In 2005 the average sulphur in HFO was 2,7% (Wahlström, Karvosenoja, & Porvari, 2006, p. 43). As was discussed in chapter 5 it was decided to decrease the limit of global sulphur to 3,5% in 2012 and 0,5% in 2020 or 2025 and for special areas (SECAs) the limited is set at 1,5% and reduced to 1,0% in 2010 and 0,1% in 2015(Wahlström, Karvosenoja, & Porvari, 2006). Changing to low sulphur fuels is one method to comply with the more stringent regulations on sulphur emissions.

Fuel with low sulphur contents can be produced by blending high sulphur content fuel with low sulphur fuel. However it is not likely this process will produce enough fuel when 0,5% limit becomes in place. Another option is to use low sulphur crude oils. This is a more expensive solution than blending. A third possibility is to desulphurise oil during refining. Desulphurising or removing sulphur from HFO is the most expensive option(Wahlström, Karvosenoja, & Porvari, 2006).

6.13.2 Liquefied Natural Gas (LNG)

LNG is a natural gas, and like oil a fossil fuel. The quantity available is therefore finite. Although LNG has a similar emission of CO₂ the fuel is 'cleaner' since using it for combustion reduces SO_x and NO_x emissions compared to oil based fuels. The reduce of SO_x and NO_x is the reason for shipowners to consider changing to LNG. For them it solves the potential problems with both the SO_x regulations and NO_x regulations simultaneously.

The storage of gaseous fuels such as LNG requires more space than is required for fluid fuels. About four times the space needed for regular fluid fuels is required to store the same amount of energy in LNG (Florentinus, Hamerlink, van de Bos, Winkel, & Cuijpers, 2012, quoting MAN B&W Diesel 2007). Ships will therefore need to either refuel more often or have larger tanks. For ships on routes with limited refuelling locations and limited space the application of LNG will be less suited. The availability of LNG is often said to be insufficient. However when looking at the Baltic the infrastructure able to provide LNG is being developed (Rysst, 2011) "It is expected that the use of LNG will increase in the years to come" (Blikom, 2011). In Norway LNG has been successfully applied on coastal ferries and other vessels (Boylston, Smart, & Wise, not dated).

LNG can be used as the sole fuel but by mixing with some diesel efficiency is increased. It is an alternative for the use of low sulphur distillates or installing expensive exhaust treatment equipment such as scrubbers and selective catalytic reduction.

6.13.3 Biofuels

Another 'alternative' type of fuel is biofuel. Biofuels are fuels not made from fossil fuels but from natural grown mass such as palm oil, coconut oil, rapeseed oil and soy oil. But also waste from for example the food industry could be used. These fuels exist in many types; for example biodiesel which is suited for medium speed engines, DME¹⁹, bio-LNG or bio-methane gas, bio-ethanol and pyrolysis bio-oil for low speed engines. And can be produced from a wide range of natural organic materials. Some types are liquid other are gaseous.

Biofuels have become globally available. However these are mainly traditional biodiesel and bio-ethanol. In Europe biofuel is available close to all major ports. And "does not seem to be a bottleneck for [...] biofuels in ships" (Florentinus, Hamelinck, van den Bos, Winkel, & Cuijpers, 2012). The fuels can be produced from different sorts of biomass. However the application within shipping is still in its early phases. Many countries have set mandates to ensure a larger share of their fuels will be supplied by biofuels. These mandates are mainly in Europe and North-America but also Brazil and China have indicated they want more biofuels in their energy mix.

Depending on the engine biofuel, or biofuel blends, can replace fossil fuels. Properties of these fuels important for application in engines may vary between the different types. Blending fuel up to 20% with biodiesel would not damage an engine (Florentinus, Hamelinck, van den Bos, Winkel, & Cuijpers, 2012). However the use of biofuels will have to be approved by engine manufactures and guarantees are needed before owners will start to use biofuels. The technology for doing so does exist. MANs, quoted in Florentinus paper, claiming; "All MAN Diesel medium-speed engines which are basically designed for Heavy Fuel Oils are ideal for reliable and efficient use of liquid biological fuels."

In order to use biofuel blends the actual blending has to be done. This can be done onshore or on board. However "Ship owners are not in favour of on board blending". On board blending requires additional crew skill and training and on board testing and sampling. Blending is already taking place on board bunker-ships to ensure bunkered fuel stands up to standards. However for blending biofuels and conventional fuels an on-board blending is preferred in order to maintain better fuel properties.

Biofuels in general have a lower density in respect to energy (J/kg) as well as per weight (kg/m³). And therefore the bunker volume will be higher. The cost of biofuels per energy delivered is higher than conventional fuels.

6.13.3.1 Savings with Biofuels

The use of biofuels effects the environment in a direct and indirect way. Directly the increase in biofuel usage encourages cultivation of previously uncultivated land to increase biofuel (i.e. biomass) production. Indirectly the usage of biofuel usage could increase biofuel production by changing the production type of land from food production to biofuels.

In the table below the typical change in emission for a number of biofuels is compared to fossil fuels.

The emissions of biofuels depend on the specific type of biofuel used. The CO₂ emitted due to combustion is similar. However the CO₂ emitted was previously captured from the atmosphere by the biomass which was used to produce the biofuel. It is therefore argued that biofuels do not add

¹⁹ Di-methyl ether, a gas used as alternative to diesel and LPG

CO₂ or carbon in general to the system. Biofuels may also cause reduction for PM and SO_x but increase the emission of NO_x. The benefits and cost will thus have to be evaluated on a case by case situation and may be beneficial based on the specified reduction goals.

| Blends | NO _x | PM10 | SO _x | HC |
|--|-----------------|------|-----------------|------|
| Diesel engines | | | | |
| B100 | +10% | -50% | -100% | -65% |
| B20 | +2% | -12% | -20% | -20% |
| DME | - | - | - | + |
| BTL | - | - | | |
| Gasoline/ otto engines¹⁾ | | | | |
| E85 | -60% | - | | +30% |
| M85 | -30% | - | | +25% |
| CNG | -33-97% | -95% | -100% | + |

1) Gasoline is the reference fuel for ethanol and methanol (E85 and M85) in Otto engines, Otto engines are generally speaking much cleaner than diesel engines. Although the CNG is technically used in a Otto engine, this concerns a modified diesel engine and the reference fuel is diesel.

Figure 6-5: Emission reduction with biofuels compared to oil based fuels
(Florentinus, Hamelinck, van den Bos, Winkel, & Cuijpers, 2012)

6.13.4 Dual fuel

Pressure on the shipping industry requires the industry to start thinking about changes. However the same solution is not applicable in every situation, i.e. sufficient supply of all alternative fuels may be difficult. Manufacturers such as Wärtsilä have developed a solution in the form of a dual-fuel engine. These engines can run on different blends ranging from 100% HFO to a blend of diesel and 97% gas. However different fuel systems and bunkertanks are needed onboard for the different fuels.

6.14 Sky sail

Based on the idea that wind is powerful, unlimited and free, kites have been developed as a way to partly propulse ships (SkySails). This invocation thus reduces the need for fuels in propulsion of a ship. The company SkySails has a patent on this innovation. The kites are automatically deployed and recovered, and fly at a distance of 280 to 420 meters(SkySails). The kites fly relative low and are therefore in uncontrolled airspace.

The SkySails company claims that a kilowatt-hour of energy can be supplied for just 6 cents. In good conditions the kite can deliver 2000kW of propulsion power. Fuel savings in excess of 10% quoted by the manufacturer apply for slower ships(Hochkirch & Bertram, not dated).

6.15 Cold ironing

A solution which aims to reduce harmful emissions, especially in ports, provides power to ships when berthed. This power, provided from shore, reduces the need for a ship to use its auxiliary engines while berthed. This practise of shore connected power is often referred to as 'cold ironing' or 'Alternative Marine Power' (AMP).

Ships can be supplied with high voltage 10kV,. However significant investments on shore are necessary to be able to transform the high voltage delivered by the grid to 10kV as used on ships. The power supplied should match the ships electrical systems frequency. The frequencies used on ships are either 50 or 60Hz (each about 50%) (Smits, 2008).

The investments required to be able to use cold ironing are significant. An investment of € 500k to € 700k per ship is required. Additionally € 4,3M is required to be invested in equipment on shore. By the use of shore power emissions can be reduced significantly. NO_x emissions may be reduced by 92%, PM₁₀ by 100%, SO₂ by 100% and CO₂ by 9%. The reductions are based on switching the production from the ships auxiliary engines to energy supply by a gas burning power plant(Smits, 2008).

The use of cold ironing aims to reduce emissions in ports. In section 5.4 a number of ports that have set additional stringent regulations were discussed. Cold Ironing can be beneficial for companies that often visit ports with strict regulation like the European, Turkish or Californian ports.

6.16 Ballast Water Treatment System

A ballast water treatment or management system is a system installed on board a vessel in order to clean ballast water. Ballast water may contain aquatic organisms that can be harmful to environments when newly introduced in these environments. A ballast water treatment or management system prevents the transportation of aliens species in ballast water to new environments.

Ballast water systems can work in different ways. The most simple way is the continues washing of ballast tanks or refreshing a complete tank using the sequential method, and discharging ballast water in the deep oceans(Akiyama, Uetshuhara, & Sagishima, not dated). Fresh water is pumped in the ballast tanks continuously. This continues washing prevents organisms to be displaced over long distances. Other systems work on the basis of filters and/or chemical cleaning. A third option is the treatment with ultra-violet light in order to kill any organisms in the ballast tanks. The costs of a ballast water system are significant and range between \$ 500k and \$ 1 million(Parker, 2012).

Thus a ballast water system will contribute to the protection of the environment. It prevents local ecosystems to be disturbed or invaded by alien spices. It therefore can be considered to be a sustainable innovation. Due to the high costs and less viable benefits it is not likely that many systems will be installed unless required by regulation. In section 5.6 the status of regulations with respect to ballast water treatment were discussed. It was shown that even though the IMO has agreed on regulations the implementation is still uncertain due to the requirements of rectification of the legislation.

6.17 Reduced speed or Slow steaming

The trend of slow steaming being applied was discussed in section 4.3.2.4. Although slow steaming is not a technical innovation it is an important and proven way to reduce fuel consumption and thus emissions and is therefore mentioned in this section. Also because slow steaming is a reason for engine adjustments that have been discussed in this chapter it is useful to shortly review this operational choice.

Speed is one of the many trade-offs to be made by a shipper when choosing a transportation mode (i.e. choice between truck, train, aircraft or ships). Reducing speed means that the goods are in transit for a longer time and are, during this time, not available for trade. In effect making the time between expenses and income longer. During that time the goods (i.e. the working capital) will need to be financed. The cost of this financing has to be traded-off against fuel savings. However often the fuel costs are not (directly) with the cargo owner.

Speed has a significant influence on the fuel used for a journey. The energy consumption is related to speed to the third power (Stopford, Maritime Economics, 2009, p. 234). A reduction of speed from 25 knots (at 80-85% MCR) to 21 knots would reduce engine power by 50% (MAN & Maersk, not dated). However the vessel might be operating in a sub-optimal range of (hull-)design and engine efficiency point of view. This sub-optimal operating might decrease the savings effect of cruising at a lower speed.

A number of innovations discussed in this chapter are designed, or can help to reduce the effects of operating in a sub-optimal operation point.

6.18 Chapter Conclusion

In this chapter discussed a number of innovations that contribute to a more sustainable shipping industry. These innovations have different types of impact with respect to sustainability. It is necessary to examine these impacts in order to be able to include these effects in the tool.

The Turbo Charger Cut Off is an innovation driven by changes in operation, especially a shift to lower operational speed. The TCCO makes that a smaller number of turbos still work efficiently at lower operational speeds. It increases operational efficiency of ships in these conditions. These changes in operation of ships have also caused the need for optimised hull and bulbous bow for the new, slower sailing conditions of ships.

Other innovations that were discussed are aimed to reduce the impacts of a ship by reducing its resistance and thus the demand for power. Air lubrications, weather routing, reduction of wind effects and are examples of innovations that aim to do so.

Two of the innovations that were reviewed aim to reduce emissions by providing power in other ways. The first is by the application of alternative fuels. Low sulphur fuel can be applied without (much) modifications and reduces the emission of SO_x . The application of LNG requires more adjustments onboard a ship but it cuts the emissions of SO_x and NO_x significantly. A third option, the use of biofuels, mainly aims to reduce CO_2 emission. Although the CO_2 emission itself is not reduced the CO_2 that is emitted has been caught first during the process of producing biofuels.

Besides innovations driven by trends or by the need of emission and energy reduction, innovations can also be driven by regulation. Cold ironing provides a solution to reduce emissions in port as is required in certain ports. The ballast water treatment system is an example of an innovation that seeks to solve the problems for companies to comply with regulations. Similar new coatings on ships are developed to protect the ship because previously used coatings may no longer be applied for environmental reasons.

Finally scrubbers and selective catalytic reduction are innovations that do not change the operation of a ship. They are systems that clean the emissions after combustion. Scrubbers aim to reduce sulphur emissions while selective catalytic reduction aims to reduce nitrogen-oxide emissions.

The data shown in this chapter is in some cases provided by companies that have commercial interest with respect to this data. Also a number of innovations are still in an early stage of development. Because of this the data presented in this chapter may be less trustworthy.

This thesis will set-up a measurement method and tool which can be used to determine the development towards sustainability that result from an innovation of measure. The tool will thus have to be able to assess the impacts of the innovations as were discussed in this chapter. Impacts that were addressed in this chapter were the reductions in the emission of CO_2 , SO_x and NO_x . Other environmental impacts that were addressed are alien species invasions due to ballast water and environmental friendly coatings. Many innovations will also affect the fuel usage which will have an effect on the voyage costs. By assessing these impact the tool will provide aid with the decision making process of the investment in a new measures or innovations.

7 Measuring Sustainability – Requirements and Schemes

In the previous chapter sustainability was defined. Literature research showed that sustainability is a stable state which either is or is not. It is not a relative concept. Definitions agree something has to be maintained. However what exactly has to be maintained differ. Sustainability is assessed in several dimensions. One may choose to only assess the environmental dimension or to include social and possibly economic dimensions as well. One should determine if, and if so in which form, exchange or trade-offs between these dimensions is allowed within a sustainable system.

The definition of sustainability for the use in this thesis was determined so it would be workable whilst including both the environmental and the social dimension. The definition of sustainability that incorporates both dimensions and is used in this thesis: *“Sustainability is a state which maintains the combined amount of natural capital and assures maintaining human’s well-being.”*

Because this definition is still rather abstract it will have to be translated into a concept of sustainability that allows ABN AMRO to apply it in its ship finance business.

In order to be able to incorporate sustainability or the sustainable development within ABN AMRO it should somehow be measured. Measurement of sustainability can be difficult (Slaper & Hall, 2011).

In order to be able to properly assess sustainability in this chapter the rather abstract concept of sustainability is made more practical. This chapter will in doing so provide a basis for the measurement of sustainability by this research. The “characterising and measuring [of] sustainability involves making choices about how to define and quantify what is being developed, what is being sustained, and for how long” (Parris & Kates, 2003). These choices will be made and the defining will be done in this chapter. The different dimensions of sustainability applicable for ABN AMRO are discussed and determined. Also a number of requirements for measurement will be determined.

To get a view on existing measurement schemes a number of several schemes providing some sort of measurement or comparison of sustainability will be discussed and analysed. They will be reviewed based on the requirements that were formulated before.

In the third section two choices that came up after reviewing the schemes and have to be made for the assessment will be discussed. Based on the analysis in this chapter a way of measurement for sustainability in the context of investments on-board of ships will be designed in chapter 8.

7.1 Requirements for a measuring sustainability

In order to be able to measure sustainability a measurement method or scheme is required. To determine what this scheme should measure and how it should measure, this paragraph formulates a number of requirements for the measurement scheme and indicators.

7.1.1 Dimensions of sustainability

The definition of sustainability that is used in this thesis is; *'sustainability is a state which maintains the combined amount of natural capital and assures maintaining human's well-being'*. This definition incorporates the environmental and social dimension of sustainability. However in this section a third dimension of sustainability will be introduced to be able to use sustainability in a commercial context.

Sustainable development is the shared responsibility of governments, consumers and business(de Burgos Jiménez & Céspedes Lorente, 2001).To apply sustainability in business it will have to be incorporated within the commercial choices business make. This incorporation requires sustainability assessment to include the (other) goals or objectives of a commercial company like ABN AMRO or its clients. Most companies are designed with the purpose to make a profit in order to provide a return to their owners. At the very least a company will need to operate at breakeven and make sure not to lose any money for it to stay in business. When a company cannot exist it obviously cannot contribute to sustainable development(Labuschagne, Brent, & van Erck, 2005).

Assuming (for now) that being profitable is the sole aim of a company, sustainability becomes only interesting when by operating in a sustainable way (future) income will increase or will reduce (future) (potential) cost. Examples of cost reduction are an increase in efficiency, reduced risk and insurance premiums, quality improvement, employers involvement and stimulated innovation. External benefits are for example a better image, improved consumer loyalty, access to new markets, and improved stakeholder communications(de Burgos Jiménez & Céspedes Lorente, 2001). It is not within the scope of this research to determine whether the increased interest of companies for sustainability and/or sustainable development is only originated from (future) financial performance or also from a non-financial motive.

Besides the companies own financial performance a company cannot exist without the economic environment it operates in(Labuschagne, Brent, & van Erck, 2005). The economic-environment in which a company operates will influence its (financial) performance. For most companies a healthy economic environment allows the possibility for increased returns and therefore increased profits. Companies therefore benefit from good performing economies. A good functioning economy allows competitiveness between companies creating a fair playing field.

When a company's financial performance is to be taken as part of sustainability a problem that arises is that economic events (such as a global economic downturn or changes in the company structure) could change economic performance. When financial performance is included as being part of sustainability the changes in the financial performance will also change a company's sustainable performance.

The assessment of sustainability including financial performance could become even more complicated when one realises that an economic downturn could also lead to sustainability become a less of a priority within a company. Although the inclusion of an economic dimension might cause difficulties it is essential to include the impact sustainable investments have financially on companies. For a commercial company financial impacts may be the most important reason to chose to invest or not to invest in sustainability. The inclusion of financial impacts on companies introduces a third dimension of sustainability.

Now three dimensions are identified as being essential part of sustainability. These three dimensions will be used in this thesis. However as was already mentioned in section 2.5 that “nothing [...] suggests that these three dimensions must exhaust the field of sustainability” (Henriques, 2004, p. 27).

The definition of sustainability requires a clear separation of the social dimension. Humans-well-being is to be assessed separately and is required to be maintained. Environmental and financial aspects are assessed for very different reasons. Where environmental aspects are assessed in order to determine the maintaining of natural capital the economic dimension is used to assess impact on the company’s performance. Therefore economic, environmental and social dimension will have to be present separately in any sustainability measurement used in this thesis.

7.1.2 Boundaries

For an assessment of a system it should be determined whether the system is an open or a closed system. So in effect; ‘does the system interacts with its environment?’

To be able to determine whether a system interacts a distinction between the environment and the system itself should be made. This is done by determining the system boundary. Interaction between the system and the environment involves input or output crossing this boundary. The system boundary is very important for a system since it does determine what outputs and what inputs of the system are to be assessed and which are just internal flows. These boundaries, for example the environmental boundaries of the assessment, may conflict with political ones. The boundary can be chosen freely and is primarily based on the goal of the study (Veeke, Ottjes, & Lodewijks, 2008). The choice of the boundaries can have significant influence on the final outcome of any assessment. However is mentioned by the Global Reporting Initiative the assessed entity should have control or significant influence over policies to be able to obtain the benefits from activities (Global Reporting Initiative, 2011).

It is rather obvious that for a sustainability assessment, where the impact in the environment is assessed in a number of dimensions, an open system is assessed. In order to be able to develop a tool and do a proper assessment of sustainability boundaries will have to be determined.

For companies there are several ways to work on sustainable development. Of course internally a company can adapt for example its own processes, systems, methods, offered products and consumption (i.e. resource usage). This change of process will change the flows that cross the systems border. A company can also work on sustainable development by assessing the chain originating from a flow at its boundaries. It can adapt its choice of suppliers and clients as part of its sustainable development and/or stimulate the companies it does business with to adapt their systems. This is no different for a bank like ABN AMRO or its shipping clients. The flows at the system borders will not change due to change in supplier. The sustainable development due to these choices is not included in the measurement used in this thesis.

The choice to transport goods, the modal choice or any other choice, that have led to choosing to transport goods transported by ABN AMRO’s clients are assumed not to be within the influence of a company and are not taken into account. However the image of a sector or company may influence these choices, this type of influence is not included.

The exclusion of choices leading to the demand for transport makes that the actual demand for transportation becomes fixed. Only the sustainable impacts at the client’s side are assessed. The internal processes of ABN AMRO or its clients not related to the operation of the ship and not affecting the flows at the systems borders are not included in the assessment.

Not including effects outside the ship introduces a problem in creating a sustainable system. A sustainable system is defined as being a system that *“does not use more resources than the benefits returned from its undertaking and the resources restored during the same period of time in terms of natural capital [...]”*. Shipping is about transportation, it may be part of a supply chain but does not actually produce a product nor does it create natural capital. So only when the value of the transported goods is higher on the location of destination in terms of natural capital creation of natural capital would be possible. These and other benefits from transportation itself are not with ABN AMRO’s client, the transporter or the tonnage provider, but with the cargo owner. The benefits within the defined boundaries will be limited to economic benefits and would therefore make a system in most cases not sustainable.

To assess sustainability or sustainable developments it is chosen to draw boundaries around the ship. This way the processes onboard in order to provide transport are assessed as well as the flows crossing the border. The flows that are reviewed are input (e.g. fuel) and output (e.g. emissions). The assessment of the location of capital, costs and benefits (i.e. allocation to a certain level of ownership) will not be done within these boundaries in this thesis. However it is noted that these levels of ownership can oppose serious problems for the actual implementation of measures or innovations.

7.1.3 [Time scope](#)

With respect to time also some borders should be determined. This time scope should be so that it is wide enough to capture the effects of sustainability target measures or policies but not too long leading to results that would become very inaccurate.

As the beginning of the time scope will need to be the moment a sustainability project starts. What the start of a project is will depend on the project and could be defined as the first impact in any of the dimensions. This impact may be caused by the purchase of equipment, the installation or implementation of the measures or policies. The time scope is chosen to include the rest of the life of ship starting from the installation or implementation. Impacts at the end of life, during demolition, either positive or negative, should be included in the assignment.

Because emissions affecting the environment or having effects relate to climate change may have influences lasting (much) longer than the end of life of the ship it is chosen that a method will have to be used capturing these long-time influence without the need to include this long scope in the assessment.

For social impacts the inclusion of long term (future) impacts might be difficult. Therefore effects are calculated based on a yearly impact and multiplied by the number of years they will impact.

Also the reporting will be done in yearly time frame. Indicating the yearly impacts on the different dimensions. For financial impacts the Net Present Value (NPV) method will be used to make all impacts current.

7.1.4 [Assessment of change](#)

In this thesis a tool is to be developed aiming to help determining the sustainable development due to an innovation. A problem which arises when assessing client’s sustainability is the determination of a baseline. The baseline or current levels of sustainability and the sustainability level after the installation of an innovation or implementation of measure is difficult to determine.

To overcome the problem of the determination of a base level of sustainability, it has been chosen to only assess the differences or change (both positive and negative) in sustainability, i.e. ‘sustainable development’, as a result of certain measures, policies or installed innovations. It is not tried to determine a ship’s level of sustainability (as far as such a thing would exist). In this

thesis options of sustainable developments will be assessed for clients of ABN AMRO. In this respect it is chosen to only assess the changes resulting from the implementation of a measure or installation of innovations in sustainable operational performance of the ship.

When investments in measures or application of certain policies are required by rules or regulations only the difference between the methods to achieve compliance and efforts surpassing the regulations should be accounted for in the assessment. Compliance to these rules and regulations is assumed to be the bare minimum and not an additional investment in sustainability.

7.1.5 [Requirements for indicators](#)

In the next section existing measuring methods for sustainability will be reviewed. In this section the input for the measurement are discussed. These inputs are called indicators. This section will determine what the requirements are for the indicators used for measuring sustainability.

Indicators used to measure sustainability will have to be focused at a specific aspect with respect to sustainability. To be able to quantify sustainability per dimension indicators will have to be used which measure an aspect with respect to one dimension. When certain impacts (e.g. emissions) have influences in a number of dimensions these influences should be accounted for separately. Indicators should measure aspects relevant per dimension. Impacts of equipment or measures are assessed in this thesis. The assessment of impacts should be reflected in the choice for indicators. For social sustainability policies are of such an importance that excluding all policies in the assignment would not provide a comprehensive view of the social dimension. Thus it is chosen to focus on indicators in this thesis which express a real measurable impact on sustainable development unless real impact cannot be represented by an indicator. In those cases policies will have to be included.

Indicators are used to measure a company's sustainable development. In order to give a good image of a company's effort on sustainability only indicators should be included that can be influenced by the company. This issue was briefly addressed in section 7.1.1 with respect to the economic dimension. It was argued that when companies' economic performance is measured these values will be influenced by changes in macroeconomic climates. This macroeconomic development is outside the control of one specific company and should therefore not to be included in the measurement. However a company's economic performance is a key dimension to sustainability. In this thesis this issue is not further addressed and demand for transported is assumed not to be influenced by changes in impacts.

In Labuschagne's paper it is argued that a separation between sustainability efforts within a company's core business and philanthropy programs is to be made. Only sustainable development in a company's core business may be regarded as true sustainable development (Labuschagne, Brent, & van Erck, 2005). It can very difficult to find out what the actual motivation is for a company to invest in improving sustainability. Also non-core business choices may contribute to sustainable development. Therefore all efforts, either core business or philanthropy programs, are included in the sustainability assessment within this thesis and no distinction between indicators has to be made based on the companies motivation.

The different indicators that are used should provide a balanced and representative view of the aspect with respect to sustainability that is assessed. Choosing and applying indicators involves quality and availability of data. Data that cannot be obtained from direct sources might be obtained from indirect sources. The data is normally only applicable to a certain scope. This means it represents a certain area (spatial scope) and time (temporal scope). These scopes are important

for interpretation of data and should match the boundaries and time scope determined for the assessment.

In the paragraph 7.2.4 several indicator schemes will be discussed. These indicators should provide a complete overview of sustainability. Because when one wants to assess sustainability “the consideration and evaluation of all relevant environmental impacts” is required (EPLCA, 2007). However the use of a large number of indicators risk overlapping and double counting. The use of many indicators will also provide an “unwieldy view” of sustainability (Mayer, 2008). And thus usually only a limited number of indicators is used, Krajnc and Glavic write “it is very difficult to evaluate the performance of the company on the ground of too many indicators” (Krajnc & Glavic, 2005).

Using a limited number of indicator means making a selection of indicators used to assess sustainability. Bell et al. write about the selection of these indicators; “The selection and measurement of SIs[Sustainability Indicators] is hardly a fine art and is subject to many pressures, agendas and biases”(Bel & Morse, 2008, p. 41). To provide a proper build-up and correct unequal importance or double counting of indicators a weighting can be applied. Krajnc and Glavic suggest this can be done by analytic hierarchy process (AHP) (Krajnc & Glavic, 2005).

7.1.6 Summary

This paragraph has provided an overview of a number of requirements that a measurement scheme for sustainability will have to comply with. In the next section a number of such schemes will be discussed and the methods will be assessed based on the requirements as were stated in this section.

It has been determined that a measurement tool should contain three dimensions of sustainability. Economic, environmental and social aspects are to be assessed separately.

The scheme should be used within the defined system boundaries being drawn around the ship and should assess the flows crossing this boundary. Only the change of flows is assessed based on the impacts during the life of the investment. The assessment should start at the first impact in any dimension and should end at the end of life of the ship or equipment. Impacts lasting longer than this time frame will need to be converted to a value within the time frame. To prevent the need of determining a base level of sustainability the change in sustainability or the sustainable development will be assessed.

In the next section a number of indicator schemes will be discussed. With respect to these indicators a number of requirements were stated. An indicator will have to measure a real measurable impact with respect to one dimension. For the social dimension policies are of such an importance they will need to be included in the assessment. The indicator should be influenced by behaviour of a company and not by impacts outside the control of a company to be useful for the assessment of the sustainable development of a company. The reason a company works on sustainable development is not taken into account. Meaning that both core business developments as philanthropic projects are included.

Of course the indicators will have to comply with the requirements of boundaries and time scope as were discussed in the first few sections. The data used for indicators will have to be available and of sufficient quality. Together all indicators should provide a complete overview of sustainability. However the use of a large number of indicators should be prevented. To adjust weightings the AHP method can be applied.

7.2 Measurement and Conversion schemes

In section 7.1 requirements for a measuring scheme or for indicators used to measure sustainability were formulated. This section will provide an overview of literature discussing measurement tools or schemes that can be used to assess sustainability. The different schemes will be assessed based on the defined requirements. It is important to understand the way frameworks are used, indexes are calculated, the actual weightings, the location of boundaries, the intended applicability, scope and scale (Mayer, 2008). It is not suggested that the selection in this section would discuss all schemes or schemes of all types.

With this overview is intended to aid with designing an appropriate measurement scheme for assessments of sustainable investments on ships complied with all requirements. It should be noted the actual method of measuring impact changes, i.e. the determination of the indicator values, is not discussed within this thesis.

The first section will explain the differences between frameworks and indexes schemes, conversion schemes and the indicators schemes. The role and connections of each of these schemes will be discussed. Following this explanation of the structure a number of frameworks and indexes will be discussed. The next section will show a number of conversion schemes and the last will look into indicator schemes.

7.2.1 Levels of Assessment Methods

Within the literature three levels of assessments were found. In this thesis the distinction between these three levels of assessment is used. Figure 7-1 illustrates graphically these levels. In practice this distinction may not be as strict and in some cases names of schemes can be somewhat confusing or misleading.

The difference and relations between the different levels will be discussed below. It is chosen to start with the most abstract level and work ‘downwards’ to the actual measurement. In the following sections each of the three levels of assessment will be discussed in more detail.

The most abstract levels are the frameworks and indexes. Frameworks and indexes usually dictate an applicability for the framework or index and may provide guidance and standards on how to assess sustainability, how to compare or rank and prescribe ways to present results with respect to other peers or assessment within another time frame. Frameworks differ from indexes since a framework focuses on providing qualitative representations (Mayer, 2008). While an index is used to compare different performers and/or sets a benchmark. Frameworks and indexes are fed with data from conversion schemes.

Conversion schemes, being the next ‘level’ of assessment, may be used to assess data concerning for all sustainability dimensions or in some cases only for one dimension. Sometimes a conversion method has been integrated within the framework or index. And certain conversion schemes do include instructions on reporting. Making the distinction between conversion schemes and frameworks or indexes in some cases not to clear.

A conversion scheme is designed to help translate and combine and convert data which has been provided by indicators. It provides one or several values that can be used in an index or framework. The data for conversion schemes is provided by indicators. Conversion schemes are often revert to as accounting schemes. Accounting schemes are a form of conversion schemes that includes the expression of different dimensions in monetary units. Because this thesis is not based on the assumption of monetization and used different forms of output besides money the term conversion scheme is used.

The most concrete level of assessment consists of the indicators. Indicators represent information on a certain state of one property in a single value. The results presented by these indicators may result from actual measurements and are usually sorted per dimension.

In the following sections the different levels will be discussed in more detail.

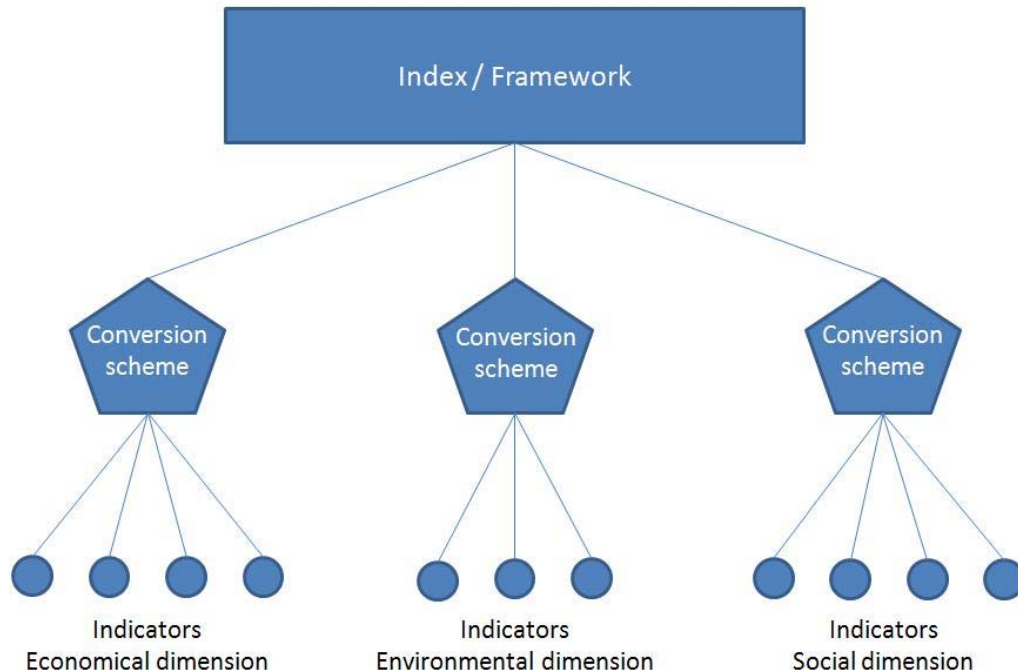


Figure 7-1: Levels of assessment methods

7.2.2 Frameworks and Indexes Schemes

Frameworks and Indexes are the most abstract level of the sustainability assessment levels. Quite some frameworks and indexes exist to assess performance with respect to sustainability (Walmsley, Palmer, & Horwood, 2012). They can provide standards and guidance how a sustainability assessment should be conducted and results are to be presented. The frameworks or indexes are fed with data from conversion schemes. Provided with data frameworks are used to give a qualitative representation (Mayer, 2008) while indexes are usually used for comparison, ranking and benchmarking.

Frameworks and indexes usually indicate applicability for the framework or index. Difficulties drafting an index or framework might be experienced since “there are real problems in crafting standards that are general enough to be widely relevant; specific enough to be actionable; flexible enough to endure; and stringent enough to secure improvement” (Oakley & Buckland, 2004). The next section will present examples of indexes and frameworks used in literature to assess sustainability.

7.2.2.1 Sustainability Impact Assessment (SIA)

SIA is a framework and therefore has no specific measuring methods but can be used as a guideline while choosing these methods. It uses a distinction between three pillars of sustainability; economic, environmental and social. The intention of SIA is to use its assessment to reduce undesired impacts while maintaining desired impacts and using this for aiding the development of integrated policies before they have been formulated. The tool is thus in fact a

forecasting assessment of policies. Using SIA enables the user to include intangibles short- and long-term considerations and special impacts. SIA is able to use quantitative as well as qualitative methods. The framework has not a fixed approach but uses methodologies depending on the scoping to identify synergies, conflicts and trade-offs across these impacts. Several forms of presentation are suggested. Ranging from traffic light resulting in only three possible results (green, orange or red) to a spider diagram graphically presenting impacts per sub criteria (OECD, 2010).

One approach for SIA is the capital approach. In this approach the values of different types of capital are determined. Changes in financial capital, produced capital, natural capital, human capital or social capital are assessed. This approach leaves the user with the possibility to determine for certain capital to be maintained and the possibility to choose to either allow or deny trade-offs in the assessment (OECD, 2010).

The SIA framework is special as it is used to forecast based on policies and allows quantitative and qualitative methods. In this thesis the focus is not with policies but with actual measurement of impacts. This conflicts with SIA. The choice for presentation is free and representations as with a traffic light are possible.

7.2.2.2 Sustainable National Income (SNI)

SNI is an assessment method used to determine the current national consumption level and the sustainable consumption level. The focus is on environmental impacts, especially pollution reduction and resource usages. The difference between these two levels is a measure for the distance from sustainable consumption levels. The method assesses a certain region over a certain time to measure the maximum sustainable consumption and actual consumption.

SNI discounts the national income with the costs to reach a sustainable level both within the assessed region in order to come to an adjusted national income which is regarded to be 'sustainable'.

The assessment method of SNI can be seen as a method following a strong sustainability approach, maintaining natural capital, but from a functional point of view. It allows certain type of natural capital to be replaced by another type when it can fulfil the same function. However two problems may arise. The assessment assumes it is known what the maximum sustainable consumption is. Also "the preference for sustainable use of environmental functions is assumed to be absolute" (Kuik, not dated). This means it is assumed not to be subject to utility curve ("i.e. independent of the cost of achieving this sustainable use" (Kuik, not dated)).

SNI is designed for national use. It uses a certain area to determine a maximum consumption. For companies or ships this is relevant since it is unlikely they possess enough land to provide in their consumption. Next the income is discounted such that it reaches a sustainable level. This means combining the economic and environmental dimensions, without including the social dimension.

7.2.2.3 System of Environmental-Economic Accounting (SEEA)

The SEEA is a multipurpose framework describing environmental and economic relations (United Nations, not dated). One of the strong points is the integrating of physical and monetary data. The original version (from 1993) has been revised twice and latest version has been adopted by the UN in 2012. It is intended to be used by countries and does not specifically include social aspects. However social aspects can be used as an "enhancement" of available information when related to economic or environmental data (e.g. transform total emissions into emissions per capita). The use of only a limited number of variables or indicators is required.

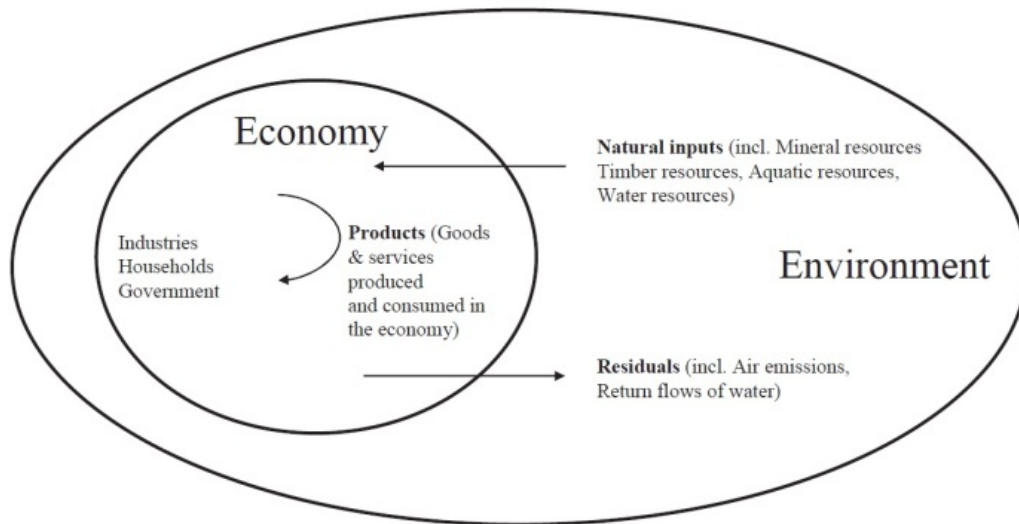


Figure 7-2: SEEA, Flows (natural inputs and residuals) (European Commission, et al., 2012, p. 13)

SEEA works on the basis of physical flows, input, products and residuals. It assesses economic and environmental flows and assets (or stock of natural or economic capital). Economic transactions which are environment related are measured. Assets are valued based on their economic value. Change of their value can be calculated by the different flows. The measured flows are represented in Figure 7-2. Countries can choose, based on what is most appropriate to work with SEEA based on assets or based on flows. Flows in monetary units are accounted for in these monetary units (money). Flows in physical terms are accounted for in the most appropriate form.

SEEA uses its own definition of environment; “Environmental assets are the naturally occurring living and non-living components of the Earth, together comprising the bio-physical environment, that may provide benefits to humanity” (European Commission, et al., 2012, p. 13). This definition focuses on material benefits provided by ecosystems. A second perspective also includes non-material benefits; “Ecosystems are areas containing a dynamic complex of biotic communities (for example, plants, animals and micro-organisms) and their non-living environment interacting as a functional unit to provide environmental structures, processes and functions” (European Commission, et al., 2012, p. 13). Both perspectives view the environment as being a utility to humanity aiming to preserve those benefits. This can be regarded as being a form of weak sustainability (i.e. maintaining human’s welfare).

As in many schemes the transforming environmental aspects into monetary units can be difficult. Doing so has been called new and experimental (UNSD EEA & World Bank, 2011). For environmental stock it could be fairly easily transformed by the use of its economic value or the future cash flows the natural could provide. Changes in the stock can then provide flows values. And since this scheme is based on benefits, benefits from flows can be evaluated. Change in well-being is influenced by received benefits. Non-produced benefits not part of the economic markets are monitored separately.

In addition to SEEA also an SEEA Experimental Ecosystem Accounts has been developed, it is designed to show the assets, the flows and services and the overall ecosystems health and combine these in a conversion scheme to account for environment. For accounting more and detailed information is required. Characteristics like structure, composition, processes and functions as well as location including extent and landscape should be considered. Ecosystems can

be decomposed per function and one pricing method is applied to convert to monetary units. A number of pricing methods will be discussed in section 7.2.3.1.2. SEEA Experimental Ecosystem Accounts recognises that this price should include direct use value²⁰, indirect use value²¹, option values (i.e. value related to possible future demand)²² and Non-use values²³.

The combination of different services provided by ecosystems requires a weighting. Possibilities are simply equally weighted, weighted by market price for service or weighted by a common 'currency' (e.g. hectares, CO₂ emission). These weighted values can be made into an index or a (weighted) summation.

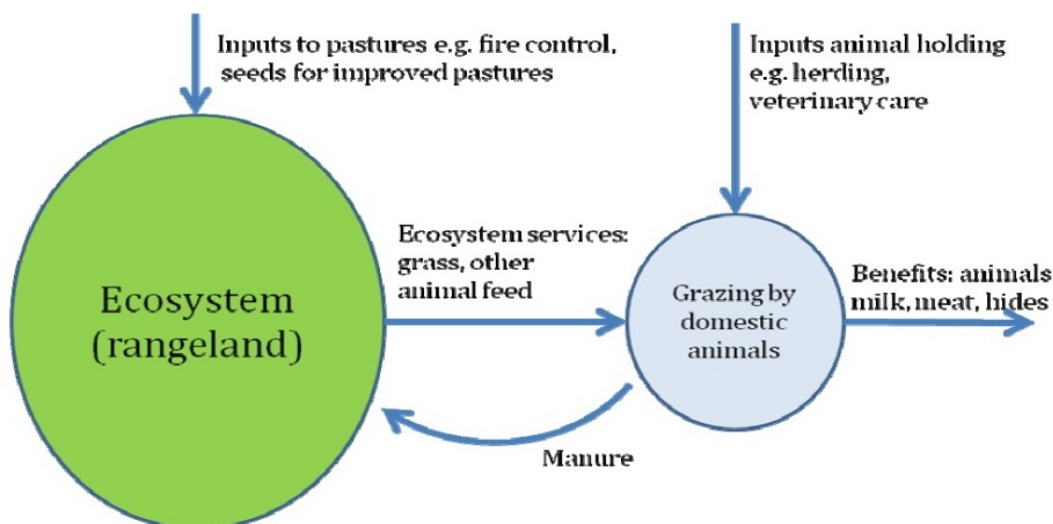


Figure 7-3: Provision of fodder for livestock (United Nations, not dated, p. 118)

Another addition to SEEA will be the SEEA Extensions and Applications. This extension will present monitoring and analytical approaches that can be used in policy analysis.

SEEA focuses on the relation between economy and environment, where environment is seen as a commodity that “may provide benefits to humanity” and therefore needs to be maintained. This Social aspects are however not specifically included because change in well-being is based on the received benefits. These principles are not in accordance to the three dimensional split as for in this thesis. SEEA can be assessed based on both flows and stock and these are valued based on their economic value. SEEA recognises that the different functions are to be assessed separately with appropriate weightings measuring one aspect at the time.

²⁰ “Direct use value arises from the direct utilisation of ecosystems, for example through the sale or consumption of a piece of fruit.”

²¹ “Indirect use value stems from the indirect utilization of ecosystems, in particular through the positive externalities that ecosystems provide, for example clean air and water.”

²² “Option values relate to people’s responses to uncertainty. Because people are unsure about their future demand for a service or the longer term implications of a current decision, they may be willing to pay now to retain the option of using a resource in the future (e.g. placing a value on a forest reflecting the potential to find plants for medicinal purposes) or they may be willing to pay now for insurance against possible future losses.”

²³ “Non-use value is derived from attributes inherent to the ecosystem itself. Three aspects of non-use value are generally distinguished: existence value (based on utility derived from knowing that something exists), altruistic value (based on utility derived from knowing that somebody else benefits) and bequest value (based on utility from knowing that the ecosystem may be used by future generations). These different types of non-use value may be reflected, for example, in the value of iconic species such as giant panda. The different categories of non-use value are often difficult to separate from each other and from option values, both conceptually and empirically.”

7.2.2.4 Sustainability Reporting Framework (SRF or GRI)

This framework provides guidelines for sustainability reporting (Global Reporting Initiative, 2011). It is sometimes called Global Reporting Initiative Framework, after its developers, the Global Reporting Initiative (GRI) which “is a non-profit organization that promotes economic, environmental and social sustainability” (Global Reporting Initiative, 2013). The goal of the SRF is to deliver a generally accepted framework in order to create a report. This reporting is subject to certain principles and guidance. The extensiveness of this report depends on the engagement level of the entity assessed.

The framework provides protocols for standard disclosure indicators and on technical issues as well as sector supplements. These indicator protocols provide information to ensure consistency in reporting, for example definitions. Sector supplements are used as addition to the standard disclosure indicators and indicate additional performance indicators for certain specified sectors. The technical protocols and principles and guidance help researchers in reporting and other technical issues (e.g. reporting boundaries). Also units to report are suggested. In general reporting is done in ‘generally accepted international metrics’. Conversion to monetary units is not required. Part of this framework are sheets indicating which information is to be collected.

SRF reports within the three dimension of sustainability; economic, environmental and social aspects. To process indicator values the framework applies a three step process of identifying, prioritising and validation. Also it requires the used information to be disclosed ensuring a certain level of transparency. A SRF-report is consistent with other SRF-exports so it can be used for comparison.

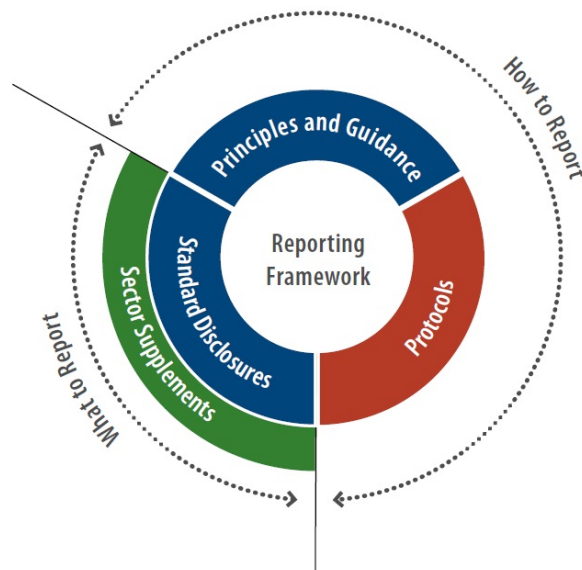


Figure 7-4: Sustainability Reporting Framework (Global Reporting Initiative, 2011, p. 3)

SRF is a reporting tool with specific sector dependent supplements. It defines certain boundaries and uses a dimensional split for reporting.

7.2.2.5 *Environmental Sustainability Index (ESI)*

ESI is an index designed as a comparison tool, to benchmarks the ability of nations to protect the environment. It assesses the approximate 'distance' from a sustainable level and can be used to measure the "overall progress towards environmental sustainability" (Esty, et al., 2005). The index assesses environmental impacts and humans vulnerability to environmental stresses on a fundamental level. Economic and most social aspects are not included. ESI allows, due to the assessment on a fundamental level, the comparison of a wide range of countries, both developing and developed. The assessment uses a method comparing countries on five categories: Environmental Systems, Reducing Environmental Stresses, Reducing Human Vulnerability to Environmental Stresses, Societal and Institutional Capacity to Respond to Environmental Challenges and Global Stewardship.

For the ESI a special set of indicators has been designed. This set will now be discussed briefly and will be more discussed in more detail in the indicators section. The ESI-indicators are used to indicate the performance in one of the five categories. The (weighted) average of these 21 indicators combined is the ESI score.

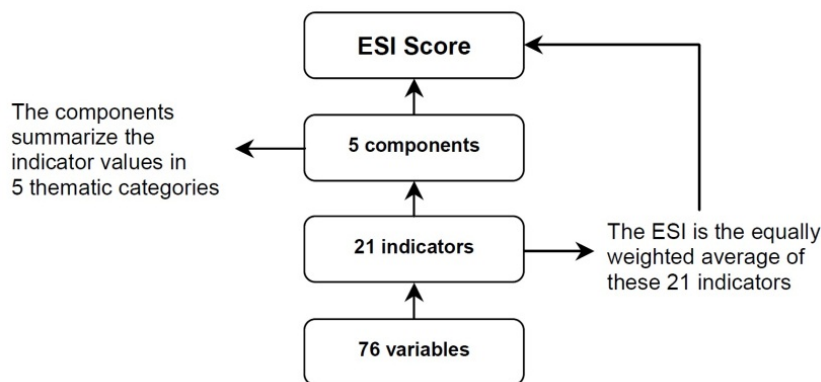


Figure 7-5: Environmental Sustainability Index (Esty, et al., 2005, p. 13)

The ES-Index, in combination with its indicators, provides a powerful tool for environmental decision-making and could provide an alternative to GDP and Human Development Index during the assessment of national projects. It can help in identifying the most significant issues and trade-offs introducing or following a certain policy. Also it allows countries to address issues by comparing their efforts to full sustainability to other countries.

The ES-Index is a part of a complete assessment scheme used to benchmark nations. Boundaries are thus defined based on country borders. ESI does not include all dimensions but assesses only environmental and social-environmental aspects. The assessment assesses a process towards sustainability and is very fundamental allowing a wide applicability. Indicators are specifically designed for this scheme and are discussed in section 7.2.4.3.

7.2.2.6 *Summary on Frameworks*

In this section a number of frameworks were discussed. It was shown that frameworks are rather abstract.

Frameworks are used as guidelines to the assessment methods. They determine what to be assessed, like for the SIA where the focus was on assessments of policies. SIA uses both qualitative and quantitative methods and allows different forms of presentation, as for example a traffic light. Other frameworks, like the SNI base the assessment on consumption. The assessment compares

the national income with the adjusted sustainable national income. The economic and environmental dimensions are thus combined while the social dimension is not included.

SEEA is a framework also describing interrelation between the economy and the environment while it excludes social aspects. It uses its own definition of environment; where the environment is regarded being a commodity to be maintained. The flows of assets (natural or economic capital) are assessed and the natural capitals are transformed to monetary units.

Other than the SIA, SNI and SEEA the SRF focuses on the reporting of sustainable developments. Its goal is to create a general accepted way of reporting and does so by defining boundaries and using a dimensional split.

The last scheme discussed was the ES-Index. A comparison tool benchmarking nations sustainable processes which focuses strongly on environmental impacts. Economic aspects are completely excluded while some social-environmental aspects are included. Countries can use the scheme to compare themselves with other countries and identify the most significant issues.

Frameworks are used to present results from assessments. They do so in most cases by comparing environmental impacts with economic ones and thus do not apply a dimensional split. The comparison of impact is being done in capital or in income. Other frameworks only focus on benchmarking or reporting. None does include the social dimension specifically. Frameworks are too abstract to be properly assessed on the requirements that were defined in section 7.1.

7.2.3 Conversion Schemes

Conversion schemes provide data used to feed the frameworks or indexes. This data usually consist of a single value or single values per dimension that is used for valuating, comparison or trade-offs between different dimensions. In some cases the conversion scheme has been integrated within the framework or index and certain conversion schemes include instructions on reporting. Making the distinction between conversion schemes and indexes or frameworks is in some cases not very clear.

A conversion scheme is designed to help translating, combining and comparing data which has been provided by indicators. A conversion method indicates how trade-offs or comparisons could be made and instructs on the appliance of boundaries scope of time and ways on how a certain sustainable-values should be calculated. This includes for example the choice to normalise values or the appliance of weightings. The conversion method is used to determine which data is to be included or excluded from the assessment. Conversion schemes may be used to asses data concerning for all sustainability dimensions or in some cases only for one dimension and in what unit the results will be measured. Below several conversion methods are discussed.

7.2.3.1 Full Cost Accounting (FCA)

Full Cost Accounting (FCA) is a name for a group of conversion methods designed to measure the entire impact using monetary units for a certain process. ‘Full cost’ refers to costs bared by all stakeholders within and outside the organisation assessed and within three dimensions; economic, environmental and social.

FCA can be used to reduce ‘unsustainable’ behaviour by allocating costs of all stakeholders. These costs include direct costs like taxes imposed by governments in order to correct companies or people’s ‘unsustainable’ behaviour or charges for waste handling. But also external costs not charged to an organisation resulting from ‘unsustainable’ behaviour or waste processing and undesirable effects to the environment and society. “Full cost accounting describes how goods and services should be priced to reflect their true costs (including environmental and other social costs)” (Conway-Schempf, not dated).

In order to determine all costs the costs of damages will have to be determined. It is recognised that it might be problematic to assign costs to all types of impacts transform them in monetary units. Especially for intangibles it is hard to determine the true costs. Problems arise when one tries to determine how to value attributes like value of a pretty view, biodiversity or even a human life. Calculating these costs can for example be done by the use of restoration or avoidance cost calculating methods. A third method uses a balance sheet approach where economic, social or environmental values and resources are located as being assets. Decline in these values indicate costs. But still the assets first need to be evaluated.

However difficult, calculating costs can increase FCA acceptability and sustainability awareness. Full implementation of FCA would extend the concept of full cost accounting to the consumer which would be paying the ‘full cost’ (Conway-Schempf, not dated). Companies could reduce prices of their products by reducing impacts of their products or services and thereby compete also based on impact.

FCA can apply to a certain period or to the full ‘life’ of a product or system. Looking at the full life is known as Life Cycle Assessment or LCA. LCA is also known as life cycle cost accounting or cradle to cradle principle. It is a conversion approach where the most important issue is; determining the time scope in order to include assessment from production to disposal. It includes the impacts during the full life of a product or asset including raw materials, production, transportation, usage

and disposal. Full Cost Accounting combined with Life Cycle Assessment assesses all impacts over the life of a product or system.

Below two Full Cost Accounting will be discussed in more detail. First the Sustainability Assessment Model (SAM) will show to provide a method including many aspects but presenting impacts for each dimension separately. In the section on 'Accounting for sustainability for Higher Education Institutions' FCA is applied on an Institution providing higher education. The methods provided and used for this assessment are presented.

7.2.3.1.1 Sustainability Assessment Model (SAM)

SAM has been developed in the UK as a full cost accounting tool with the possibility to address different dimensions of sustainability. This separation per dimension can be seen in contrast to a cost-benefit analysis (CBA) combining all dimensions in one figure. According to Sinden a cost-benefit analysis “flattens our most profound emotions, beliefs, and values into the dull gray of dollars” and gives a “false patina of scientific accuracy and objectivity” (Sinden, 2004). Within literature it is however recognised that “there is a need for distributional analysis that identifies costs and benefits to particular parties” (Brown & Frame, 2005). When customer behaviour is reviewed “CBA confuses the preferences people have as consumers with the values they hold as citizens” (Brown & Frame, 2005), i.e. confusing customers willingness to pay (or possibly ability to pay) for prevention as a fair compensation for the same.

SAM identifies the main controllable activities within the borders. SAM does acknowledge activities not controlled or influenced by a company should not be include in the assessment. Data is collected in order to be able to quantify impacts and monetize activities within one of four distinctive categories: social, environmental, resource and financial impacts. These ‘categories’ can be compared with dimensions of which SAM thus introduces a fourth of.

SAM does require the monetization of impacts within each of these categories in order to represents the impacts in terms of monetary units. The SAM method prevents the trade-off between the different categories by presenting values separately and thus does not allow the reduce in social or environmental performance to be compensated by an increase in economic performance. However it still could allow trade-offs within each of these categories meaning it allows for example reduced health of people being compensated by the creation of jobs (both within the social category). SAM gives a graphic representation of positive and negative factors of a project (Davies, 2009). Figure 7-6 shows such a graphical image of a SAM assignment.

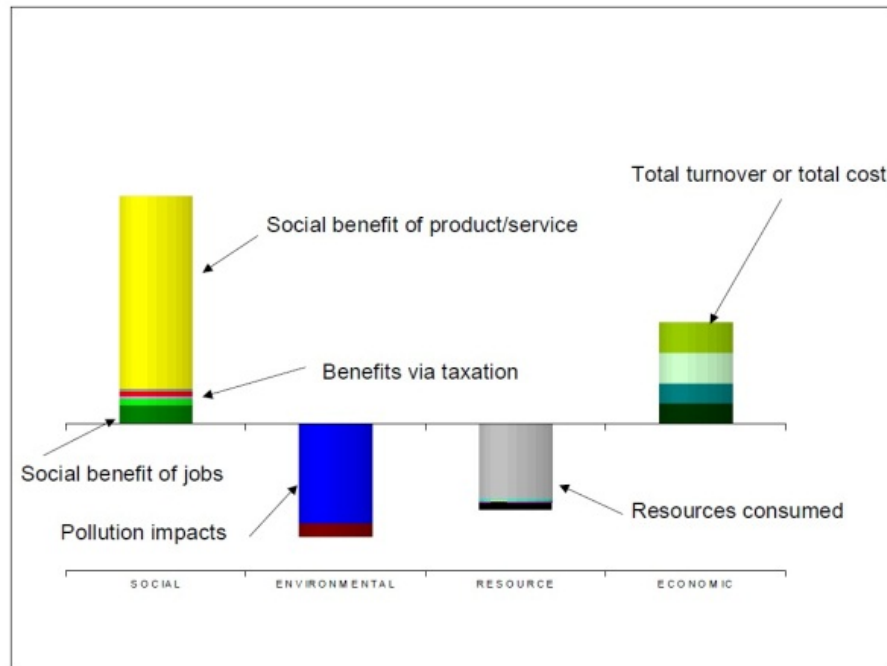


Figure 7-6: Sustainability Assessment Model (SAM) (Brown & Frame, 2005, p. 40)

SAM, being a Full Cost Accounting method, shows the impacts over different dimensions separately. The split is made over social, economic environmental and a resource dimension. This is more extensive than is needed since resource uses could be assessed using the environmental dimension. SAM defines the main controllable activities within its borders and thus assesses only what can be influenced.

7.2.3.1.2 Accounting for sustainability for Higher Education Institutions

This conversion method has been developed by the Higher Education Partnership for Sustainability, an initiative of 'Forum for the Future' aiming to make sustainability assessments of Higher Educational Institutions (Parkin, Johnston, Buckland, Brookes, & White, 2003). Part of the assessment is the so called 'at the same time' test. This basic test tests whether economic, social and environmental consequences are considered at the same time.

For the accounting purpose 5 types of capital have been identified; natural, human, social, manufactured and financial capital. For all types of capital both the stock and the flow is to be assessed to determine the current state and developments. The impact inside the institution as well as the external impacts are assessed.

The 5 types of impact are divided in three dimensions. All impact aspects are graphically represented by the use of a 'Sustainability Accounting Cube' show in Figure 7-7. When all types of impacts are assessed this conversion method can be regarded to be a full cost accounting method for sustainability. It is suggested that the scope of stakeholders should be "as wide-reaching as possible" (Parkin, Johnston, Buckland, Brookes, & White, 2003). The time scope of the assessment can be chosen when using this method.

When only stock is assessed a stationary assignment is made on the current state and scope of time is not applicable. The assessment of the different types of capital can be used for the 'at the same time' test and could even indicate priorities when investing. With respect to the discussion about substitution of capital or trade-offs between dimensions no choice is made by the designers of this scheme.

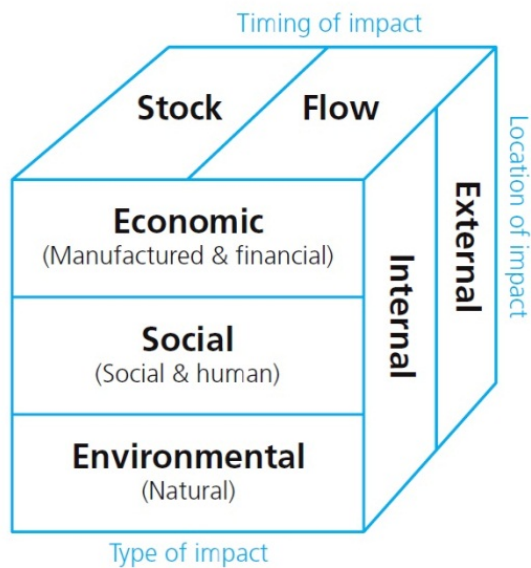


Figure 7-7: Sustainability Accounting Cube (Parkin, Johnston, Buckland, Brookes, & White, 2003, p. 23)

For the accounting for sustainability method the conversion of non-monetary values into monetary values is required. This can be done by several approaches. Proven from examples given in the report *Accounting for sustainability*, environmental impact values may vary significantly depending on valuation method which is chosen (Parkin, Johnston, Buckland, Brookes, & White, 2003). For example for NO_x the 'forum of the future' report show prices ranging from £19 (willingness to pay based damage cost) (CWRT (1999, p 3-64) in (Parkin, Johnston, Buckland, Brookes, & White, 2003)) to £12.610 per ton (damage cost approach) (ExternE Project in (Parkin, Johnston, Buckland, Brookes, & White, 2003)). Showing the difficulty of proper valuation. This report has been written in 2003, in this thesis no research has been done whether pricing methods have been improved since.

The conversion methods used to convert values into monetary units are either supply or demand based. The three supply side methods are;

Productivity approach calculates the costs borne by the lost productivity and higher costs of production.

Preventive expenditure method uses the costs to prevent certain deterioration of a type of impact.

Replacement cost method is a method that calculates cost to restore or replace a certain unit of capital.

On the demand side also three methods are addressed;

Hedonic pricing uses price information on surrogates to estimate a valuation of an impact.

Travel cost method (Willingness to pay) is a method based on the costs and time people are willing to spend to be able to access certain capital.

Contingent valuation method (CVM) uses surveys, questionnaires and experiments to derive people's hypothetical behaviour in order to value impacts.

The Accounting for Sustainability for Higher Education Institutions assessed all three dimension based on five types of capital using an 'at the same time' test. For a FCA assessment impacts internally and externally are assessed. External impact can also be influenced by companies. The different types, location and timing of impacts are presented in a cube. No guidance on borders or timeframe has been given.

7.2.3.2 *'CATCH' and CO₂ equivalent heating (global warming potential)*

This conversion method is focused around the problem of global warming. The scheme is designed to evaluate measures which should reduce Green House Gas (GHG) emissions, this are the emissions known to contribute to global warming. To be able to include effects on all types of GHG a CO₂ equivalent is calculated. This CO₂ equivalent is based on the 'heating capacity' per ton of GHG compared to the 'heating capacity' of one ton of CO₂.

The costs and possibly benefits of measures or installations meant to reduce GHG are being compared to the total amount of emissions reduced measured in CO₂ equivalent. This way a so called 'CATCH' (Cost of Averting a Tonne of CO₂ Heating) is determined. The 'CATCH' value is used to determine the measures or installations to reduce GHG in the most cost efficient way. Eide suggests that companies should invest in measures which cost less than \$ 50 per tonne CO₂ and that when doing so a 30% GHG reduction can be achieved (Eide, Endresen, Skjong, Longva, & Alvik, 2009).

Global warming is an important problem that besides environmental impacts. Shipping is a significant contributor of emissions contributing to global warming. The scheme assesses the change in environmental and economic dimension by measuring the impacts due to new GHG reducing measures. The social dimension is not included.

7.2.3.3 *Conversion schemes based on Footprint*

Schemes based on footprint determination try to assess the impact of certain systems on the planet. It is often used for countries since they have a clear defined available land area and consumption. The term footprint is sometimes used as a synonym to impact but is also used for assessments that express impact in terms of an area in relation to the available area.

7.2.3.3.1 *Ecological Footprint*

The ecological footprint conversion method is a 'replacement cost method' for ecological impacts based on available land area and consumption. Ecological footprint combines the ecological impact and presents this in one single value (Mostafa, 2010).

The Ecological footprint can be used in two ways; the first way, a bottom up approach, calculates 'costs' of resources used and emissions emitted in terms of area (in hectares). It presents a footprint being the area requirement in terms of land area needed to produce, restore damages, compensate for emissions, processing of waste and restore the energy for services and products used by consumers is calculated.

The second top-down approach can be used to determine a limit on emissions, energy use and waste produced based on available area in a defined region (e.g. a country), the types of land and the equivalence factor presenting the suitability of types of land. Doing this assessment one determines an area's total biocapacity (i.e. its maximum carrying capacity). This can be applied to local areas, communities, countries or worldwide ((Rees, 2002) quoted in (Mayer, 2008)).

An ecological footprint can be used to calculate human's pressure on the planet for a certain time (Global Footprint Network, 2013). When assessing the area needed (bottom-up assessment) to cover people's needs one assesses the area needed for energy, settlement, timber and paper, food and fibre and can be used to express this 'consumption' to the ratio related to biocapacity provided (top-down assessment) by an area expressed in carbon uptake, built-up land, forestry, croplands, pasture and fishing grounds, as can be seen in Figure 7-8.

The method suggests that when the total footprint of the world population exceeds the productive area of earth "we start to erode national capital" (Burns, 2013). The 'consumption' of natural resources would be exceeding the maximum production and stock of ecological capital is

depleting and/or waste is accumulating. For a sustainable state the ratio Ecological Footprint/Biocracy should not be larger than one (Moran, Wackernagel, Kitzes, Goldfinger, & Boutaud, 2008).

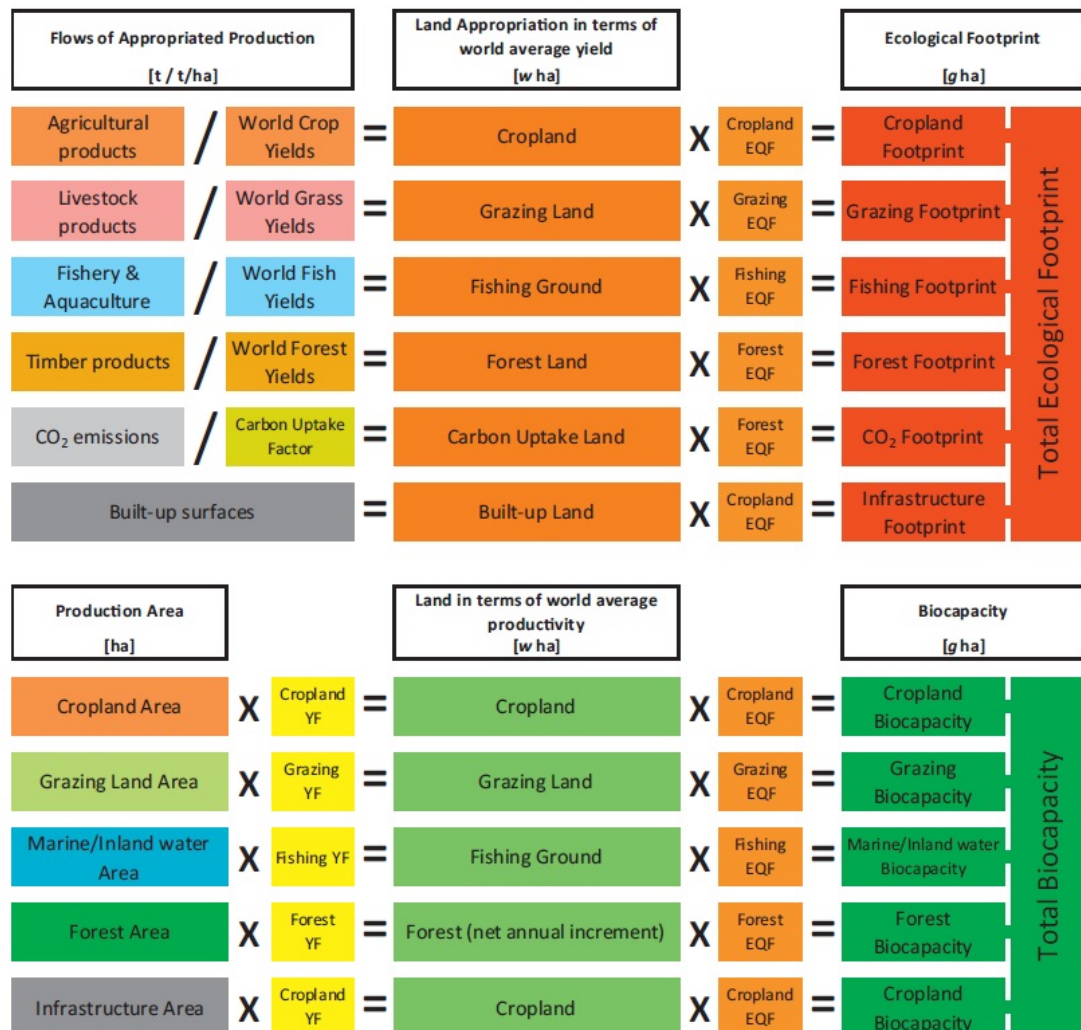


Figure 7-8: Ecological footprint components (Borucke, et al., 2012)

Ecological footprint assesses only the environmental dimension. It assesses the flow of production for a specific period of time. These flows are actual measurements. Boundaries are not defined for a bottom up approach. For a top down approach a certain area is assessed. Footprints can be used to show a certain overconsumption and irreversibility.

7.2.3.3.2 Carbon Footprint

The Carbon footprint (or CO₂ footprint) is a very similar methodology as the ecological footprint. The difference is that a carbon footprint only assesses the impact from CO₂²⁴ and area to compensate for that particular form of impact. Carbon footprint can be used to combine carbon impacts and report them in one single value or as ratio to the area available for CO₂-absorption (EPLCA, 2007).

²⁴ About 54% of total impact source: (Global Footprint Network, Carbon Footprinting, 2013)

In some cases the impact of other GHGs is included. This can be done by using the Global Warming Potential (GWP) of gases. This method is similar to the CO₂ equivalent heating that has been described before. It uses the global warming potential of one ton of CO₂ and uses that as a reference value of one. Other gasses GWP reflects the relative impact with respect to global warming per ton. The used GWP will be based in the 100 years values as presented by the UNFCCC²⁵. Using GWP effectively combines both the concept of transforming emissions in CO₂ equivalents and expressing CO₂ impacts by a footprint area in order to restore the effects.

Although Carbon Footprint allows the inclusion of other gases than CO₂ in its assessment by the use of its Global Warming Potential (GWP). The scheme only addresses flows related to global warming impacts. The assessment is thus limited to the environmental dimension. Boundaries or time scope are not defined. The flows of CO₂ or GHGs are assessed.

7.2.3.4 *Emergy analysis*

The emergy analysis is a conversion method mainly aimed to convert goods and services (environmental and economic) in a common unit. The scheme is special in the way it uses a conversion into a common energy units and not in monetary units. Products and services are measured the energy used to produce, transport, use and dispose the service or product and the energy supplied by it and expresses this in embodied energy: 'emergy' (Mayer, 2008). Also the emergy value destroyed in ecosystems is taken into account.

The method uses a theory of limited emergy absorption from ecosystems. It asses flows of emergy moving through the system. An emergy analysis may result in other outcomes compared to other conversion indices since "emergy value and monetary value may not be correlated" ((Ayres, 1998) & (Hau & Bakshi, 2004) in (Mayer, 2008)).

The emergy conversion method assesses environmental and some economic impacts. Social impacts are not included. The assessment converts all data in one emergy value. Omitting the separate assessment per dimension.

7.2.3.5 *Fair Bank Guide*

The Fair Bank Guide (Dutch: 'Eerlijke Bankwijzer') is an assessment of banks. It assesses criteria used by these banks in their operations and the banks policies used for their financing and investing project as well as their actual investments (Eerlijke Bankwijzer, 2013). It has so far assessed banks with respect to a number of subjects and their involvement is certain industries. The 'Fair Bank Guide' is an initiative started by a number of charities in 2009. Oxfam Novib, Amnesty International, the Dutch labour union and Friends of the Earth were involved from the start.

In November 2012 the 'Fair Bank Guide' published a report on shipscrapping (van Gelder, Herder, Küpper, & Spaargaren, 2012). Which is used as a relevant example of the format used by 'Fair Bank Guide'. Banks are interviewed and asked how they assess shipowners they finance with respect to scrapping. This interview answers are verified by documents and/or tools that were used by banks to assess the clients. The answers of the questionnaire which have been verified are used as indicators. Depending on qualitative answers in combination with the documents and tools to verify them and compliance with 8 elements set by 'Fair Bank Guide' as minimum

²⁵ United Nations Framework Convention on Climate Change

standard two scores from 1 to 5 (where 5 is best) are awarded. One of these scores for investments (including financing) and a second for investment management.

The 'Fair Bank Guide' is an unusual conversion method. The fact that many input indicators that are supplied for this method are actual qualitative data and that answers are manually validated and rated with scores (ranging from 1 to 5) make this a qualitative conversion method. This method will not be used in the development of a measurement tool in this thesis. However the fact that it focuses on banks makes it valuable to include this method in this overview.

7.2.3.6 *Summary on conversion methods*

In this section conversion methods were discussed. Conversion methods are used to provide data for frameworks based on values received from a number of indicators.

First the full cost accounting methods were discussed these methods include all impacts to every affected in monetary units. One way of applying FCA is by the Life Cycle Assessment where all impacts during the life of a product, from raw material to disposal are included. Two examples of full cost accounting methods are discussed.

The first SAM identifies the main controllable activities within the borders as determined and presents sustainability in four separate dimensions. Impacts are selected for the controllability by companies and are monetized and presented per dimension.

Another scheme has been made for use in Higher Education Institutions. The impacts are expressed in 5 types of capital divided over the three dimension based on a 'at the same time' test. These capitals are assessed for both stock and flow as well as internal and external. The different types, location and timing of impacts are presented in a cube. The borders are however not defined. The scheme does not describe whether or not tradeoffs between different dimensions are allowed. To convert all impacts into monetary impact a number of methods are suggested but results may be very different based on the scheme.

Another conversion scheme discussed used the CO₂ equivalent heating. This scheme determines relative impacts of other GHGs on global warming and determines a cost for averting a ton of CO₂ heating (CATCH) for a certain technology or innovation. Based on the CATCH a decision on whether or not to implement that innovation should be made. CO₂ equivalent heating prepares a trade-off between the economic and environmental dimension but does not include social aspects.

A group of schemes discussed in this section are the footprint conversion schemes, expressing impacts based on a certain area or footprint. The first is the ecological footprint using a replacement cost method determining the environmental impact expressed in a footprint area. It can be used to determine the footprint of a certain entity (Ecological Footprint) or the maximum consumption based on an available area (Biocapacity). An extensive method is developed to determine human pressure on the earth split over a number of production categories, their impact and effectiveness of production.

A second footprint method is based on CO₂, it is aimed to measure global warming impacts and shows some similarities with CO₂ equivalent heating. Only environmental impacts are addressed and time scope nor are boundaries defined. The aim of this method is not to determine the impact of an innovation but to determine the footprint of a certain impact, this footprint is based on restoration of the impact.

Emergy analysis is a scheme that for the assessment converts goods and services in a common unit of energy. Social aspects are not included and no distinction between environmental and economic

impacts is made. The emergy used to create the good or service is assessed and compared to a maximum absorption of emergy by ecosystems.

Fair Bank Guide is totally different type of conversion method and will therefore not used for the development of the tool in this thesis. It is aimed to assess banks policies regarding for example sustainability. The method is qualitative since it is supported by questionnaire answers and rated with a 1-5 scale. Because this assessment is focused at banks it is included.

The assessed conversion methods had very different approaches. None of the assessed conversion methods complied with all requirements. Many did not include the social dimension or failed to assess dimensions separately. Not all conversion methods had the same goal. A number aims to do or prepare a trade-off present the cost effectiveness. Other schemes present a detail view on resource usage or sustainable impacts.

7.2.4 Indicators

Indicators are required to provide data for a conversion method. As discussed before with these conversion methods frameworks or indexes are provided with data. Indicators are the actually 'measurement' presentations of certain aspects of sustainability. They represent information of a certain state of one aspect or property in a single value. These values will provide the data for the assessment of sustainability. In this section indicator schemes will be discussed. The focus will be on which data is to be represented. The actual ways of measurement are not discussed within this thesis.

Below four sets of indicators are discussed. The CSA indicator set has been designed by SAM to provide data on company's sustainability position within the Dow Jones Sustainability Index DJSI²⁶. CSD indicators are designed to assess countries. The set was suggested by the UN. Part of earlier discussed ESI framework was a set of indicators. The final set of indicators, the Socio-ecological indicator set, focuses on socio-economical aspects.

7.2.4.1 Corporate Sustainability Assessment (CSA)

CSA is a by RobecoSAM developed assessment of corporate sustainability and is used as a 'backbone' for the construction of the Dow Jones Sustainability Index (DJSI) (SAM, 2012) (RobecoSAM AG, 2013). About 3200 companies are invited to take part in the assessment. The goal of RobecoSAM is to incorporate sustainability as part of the consideration when constructing an investment portfolio and uses the CSA to look "for company awareness of sustainability issues and for indications that it has implemented strategies to address them" (SAM, 2012). The CSA is based on the assumption that sustainable business practice is critical for long-term value creation and represent opportunities and risks that companies should address. It is designed to "capture both general and industry-specific criteria covering the economic, environmental and social dimensions" (SAM, 2012). The assessment is done over three dimensions and consists of a number of criteria which are assessed using a questionnaire. This questionnaire is build-up with a number of questions of which at least 50% is industry specific. The answers represent the indicators indicating a company's awareness for sustainability. Depending on the answers a company give the weighted score may add-up to a total sustainability score of 100 points. Additionally SAM also performs a Media and Stakeholders Analysis assessing media coverage on the in the CSA assessed companies and incorporates the results in the CSA, possibly reducing its rating.

The indicator scheme that is used by RobecoSAM assesses sustainability for the environmental, economic and social dimension. However the scores are combined to get a total sustainability score. The assessment limits to the company it assesses. However a questionnaire is used not only and not only real measurable quantitative results are used. Weightings are applied to provide a well balanced assessment.

7.2.4.2 CSD Indicators of Sustainable Development

Another example of a set of indicators are the 96 indicators for sustainable development as decision making aid for countries suggested by the Commission on Sustainable Development (CSD) part of the UN (United Nations, 2007). Since it is focused on countries assessing sustainable development most of the indicators are also primarily assessing national impacts. The CSD is able to measure overall process towards sustainable development and can be used to provide a reference. The impacts that are at the basis of the indicators are divided over fourteen themes

²⁶ The DJSI is an index with valuations of sustainability of companies making up this index (like at stock markets).

within three categories of sustainability; *poverty, governance, health, education* and *demographics* can be regarded as being social oriented themes, *natural hazards, atmosphere, land, oceans seas and coasts, freshwater, biodiversity* can be regarded as environmental oriented themes and *economic development, global economic partnership* and finally *consumption and production* patterns can be regarded as economic oriented themes. The indicators are linked to one (sometimes two) primary themes indicating a direct influence on these themes. For some indicators also one or several secondary themes are appointed acknowledging their indirect relation with that theme.

The CSD Indicators for Sustainable Development scheme suggest that based on the purpose of an assessment a number of indicators can be chosen to be used. It is noted that it is often not useful to assess sustainability of a certain policy or certain country with all indicators since some indicators might be irrelevant (e.g. percentage of total population living in coastal areas is not applicable for land-surrounded countries). It is recommended to assess data availability. Data that is not available and cannot be derived or calculated within reasonable time and/or costs should be excluded according to CSD.

CSD is focused on national development stating country borders as boundaries. Most of the 96 indicators are real measureable values. Of this large number of indicators an appropriate set may be chosen to use. An assessment to the availability is recommended which will also reduce the number of indicators. The indicators are focused at nations and divided in fourteen themes. However each of these fourteen themes could be classified within one of the three dimensions.

7.2.4.3 *Environmental Sustainability Index Indicators (ESI-Indicators)*

The ESI-Indicators are the set of 21 ‘indicators’ constructed from a total of 76 underlying data sets for application in the Environmental Sustainability Index (ESI) (discussed in section 7.2.2.5) which benchmarks a nation's ability to protect the environment (Esty, et al., 2005). In the terminology used in this thesis the 76 data sets are closest to what is used as indicator. The transformation to 21 ‘indicators’ is considered to be the first step in a conversion process.

The ESI index and indicators focus mainly on environmental impacts but includes social impacts and use these indicators to benchmark a country's ability to protect the environment. Economic impacts are not included in the indicator set. The average of all 21 groups of indicators is the ESI score. It is chosen to use an equal average for the sake of simplicity and transparency. The indicators are normalised by transformation using a logarithmic function so the set will have closer resemblance with the normal distribution and less extreme values. Many indicators are measured not as absolute values but use as a certain rate per capita.

The indicators were chosen “through an extensive review of the environmental literature, assessment of available data, rigorous analysis, and broad-based consultation with policymakers, scientists, and indicator experts” (Esty, et al., 2005) and are able to indicate a performance in one of five categories; Environmental Systems, Reducing Environmental Stresses, Reducing Human Vulnerability to Environmental Stresses, Societal and Institutional Capacity to Respond to Environmental Challenges and Global Stewardship

Since the goal of ESI is an intercountry comparison the indicators need to be available (direct or derivable from other data) for all or most countries. Any indicators that would not be available for most countries are not suitable for this index. Also indicators that would fluctuate significant per country based on ecological or geographic factors are excluded.

The ESI indicators, named data sets, is a group of 76 variables for the assessment of nations. This defines the border of the assessment. The variables are what is called indicator in this thesis. The

scheme uses the term indicator for small groups of variables. The indicators focus on both environmental and social dimension but lack economic assessment. Not all indicators are actual measurable values. Different indexes are used in order to compare performance to other countries. Since the goal of ESI is comparison (it is an index), the indicators used need to be available for most countries to be used in the assessment.

7.2.4.4 *Socio-ecological indicators*

As an alternative to pure environmental indicators Azar et al. suggests in the paper ‘Socio-ecological indicators for sustainability’ (1996) (Azar, Holmberg, & Lindgren, 1996) the implication of socio-ecological indicators. In this paper Azar wrote that until then most indicators of sustainability have focused on environmental aspects. In the paper a method for developing socio-ecological indicators is presented. For this thesis the indicators that are formulated within four socio-ecological principles are reviewed. The indicators are designed in such a way they can be used in the planning process and therefore focus on an early assessment in the casual chain.

The first principle reflects the subtraction of resources from the earth. According to this principle the subtraction may not lead to emissions and a systematic accumulation of this element in the earth’s ecosphere. For this principle 3 indicators are suggested; the first indicator, the “lithospheric extraction rate” calculates the ratio between the extraction and the natural sedimentation process. A ratio above 1 would indicate extensive extraction. The second indicator; the “accumulated lithospheric extraction” indicator, compares the accumulated extraction to the pre-industrialised content. A high value can be viewed as a warning sign for possible shortage in the future. The third indicator within the first principle is the “non-renewable energy supply”, this indicator shows the ratio of the total energy supply being supplied by non-renewable sources.

Where the first principle focuses on extracted natural resources the second principle focuses around the non-accumulation of society-produced substances. Within this second principle two different categories of indicators have been formulated. The first category are indicators with respect to man-made substances that also naturally exist. These disruptions of ecosystems should be limited to such size that they will avoid systematic accumulation. The first indicator relates the human production to the natural production. A value above one would indicate that human production would be higher than natural production. This indicator does not measure accumulation, the second indicator, the “long-term implications of present emissions”, takes in account the removal from product from atmosphere.

The second category of indicators provides a view on substances (chemicals) that are foreign to nature. The first indicator suggested is simply monitoring the volumes of production of these products. The second indicator, “long-term implications of emissions of substances that are foreign to nature” can be applied for substances for which the decay can be described by a mathematical equation. The production of is then related to the decay with the present contents.

The third principle of indicators should help to secure and prevent deterioration the physical conditions for production and diversity within the ecosphere. Manipulation of natural systems is being monitored. This principle differs from the first principle in the fact that this principle reviews natural systems (e.g. deforestation or soil erosion) where the first category focused around earthly deposits (e.g. oil, coal ores and certain minerals). The principle deals with “manipulation and harvesting”; displacement of nature (forcing away nature, e.g. building cities), reshaping nature (e.g. damming rivers, deforestation) and guidance of processes (e.g. gene manipulation and animal breeding). The first indicator for this principle is “transformation of lands”, looking at the way land is being used and could be combined with a comparison to a base line (e.g. pre-industrialisation). Another indicator is “soil cover” used to indicate the extend of soil erosion. The indicator suggested compares sufficient covered cropland with the total cropland. Besides soil

itself the quality of soil is important, the indicator “nutrient balance in soils” indicates changes in stock of nutrients and should be used for many different nutrients. The last indicator for this principle calculates the ration between harvesting a certain populations (e.g. trees, fish) and the natural growth of that population. When this ratio is 1, the population can be sustained while harvesting continues.

The fourth and final principle discussed states that “the use of resources must be efficient and just with respect to meeting human needs”. The first indicator, “overall efficiency” there is not one single way of calculating the indicator suggested. One way is taking a base line of service delivered by a certain amount of power and compares that with the current service compared with the current power demand. The second indicator “intergenerational justice” is an indicator to determine whether the distribution of resources and services is evenly. A certain area’s supply is divided by the supply of a reference area (e.g. the world). Similar is the “intergenerational justice” determining whether the distribution of services and resources is even over time. This indicator divides the “loss” in resources by the available resources both to be extracted and extracted (and recycled). The last indicator covers ‘human needs’ in general. The indicator indicates for which percentage basic needs are either fulfilled or not fulfilled.

The Socio-ecological indicators were designed to oppose against the mainly environmental assessment. The limited number of indicators combines the social and environmental effects in an early stage. No separation between these dimensions is maintained which conflicts with the requirements that were formulated. Also the economic dimension is not included in this indicator set.

7.2.4.5 *Summary on Indicators*

The actual measuring is done by the use of indicators which are usually divided per dimension. Only a limited number of indicators representing a balanced view on a company’s state with respect to sustainability should be used. Overlapping should be corrected. All efforts effecting sustainability are included regardless of the company’s motivation.

The first set discussed was CSA, used as a backbone for the Dow Jones Sustainability Index. A questionnaire is used to get the indicator values in the three dimensions of sustainability for one company. The indicators used do not consist of only real measurable impacts. A part of the indicators are general and a part industry specific. A weighting is used to get a balanced view.

The second set of indicators discussed are the CSD indicators. The large set of 96 indicators is used as a decision making aid for countries. The scheme suggest to choose a certain number of indicators and to prevent using irrelevant ones. The indicators are placed in 14 categories which again could be split over three sustainable dimensions.

The ESI framework was discussed in the frameworks section. Here the set of indicators is discussed. The indicators are constructed of 76 data sets which in the terminology used in this thesis will be called indicators. These indicators focus, like the framework on the comparison of countries and thus use countries borders as boundary. Indicators that are selected will therefore have to be available for most countries. The focus is with environmental impacts but also some social impacts are included. Weightings are not applied on the normalised values.

The last set of indicators is the set suggested by Azar et.al. is a set of social-ecological indicators. The assessment assesses ecological and social dimension combined while the economic dimension is not included. The number of indicators is limited. Indicators are used to assess either one of four principles. These principles are subtraction of resources, non-accumulation of society-

produced substances, prevent deterioration of the physical conditions for production and diversity, efficient resource use with respect to needs.

The different schemes of indicators have shown that depending on what was aimed to measure and for what purpose, choices can be made on indicators that can be selected. Boundaries are drawn when national assessment is done around the country border. The dimensions that are included in the assessment differ. When more dimensions are assessed the results are sometimes combined. For indicators weightings or normalisation may be applied. None did completely comply with all requirements.

7.3 Choices with respects to the measurement of sustainability

Section 7.2 showed, divided per assessment level a number of measurement schemes. The schemes were assessed based on the requirements. Of the assessed schemes none complied with all requirements. For the measure a new measurement scheme will have to be developed.

In order to do so this section will assess a two more choices that will have to be made and one issue that still has to be considered.

7.3.1 Internal and external impacts per dimensions

In this section the first of two remaining choices will be discussed. This is the choice with respect to which parts of sustainability will be part of the assessment. The reason why certain aspects of a dimension are excluded will be explained. This is done while keeping in mind the goal of assessing investments by clients in sustainable development which can be financed by ABN AMRO's.

Sustainability in this thesis is approached based on three dimension; the economic, environmental and social dimension. The impacts in these dimensions will be assessed separately for each. Except the three dimensions sustainability can be divided based on timing of impact and location of impact. This division was shown by the Accounting for sustainability for higher education (Parkin, Johnston, Buckland, Brookes, & White, 2003) that was discussed in section 7.2.3.1.2. These different type, location and timing of sustainability were graphically indicated by a cube. For each dimension or type of impact the location of this impact (i.e. internal or external) and the timing of impact (i.e. impact on stock or flow) were presented in the cube. Traditionally companies focused on the economic, internal impacts. Figure 7-9 shows the cub for traditional accounting.

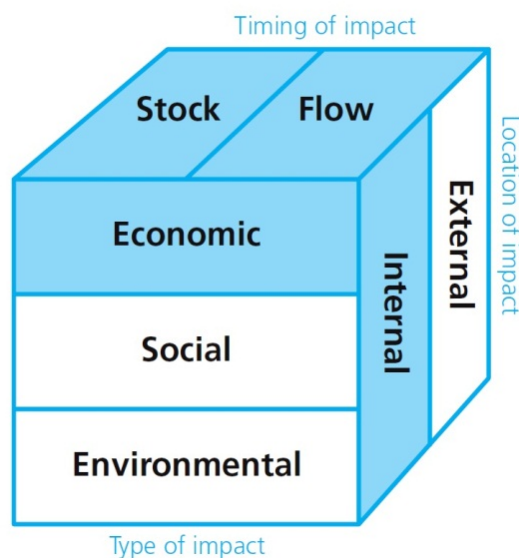


Figure 7-9: Traditional Accounting Cube (Parkin, Johnston, Buckland, Brookes, & White, 2003, p. 23)

7.3.1.1 Dimension definition and classification of aspects

In the next section a selection of the aspects per dimension that are to be assessed or to be excluded will be made. In order to do so in this section each dimension will be defined in more detail.

Within this thesis the direct impacts are addressed. The goal is to provide a tool for ABN AMRO to assess a sustainable investment of a client. This way ABN AMRO can determine if it wants to be

involved and were to locate the limited available capital to contribute to sustainable development within the shipping industry. Therefore direct impacts are assessed.

The economic dimension is defined as the financial impact. Internally this refers to the change in cash flows within the borders of the ship. Because cash flows are (in most cases) not tangible internal refers here to changes in cash flows that directly relate to the investment or the consequences of it. Externally refers to all cash flows that result from the choice of a company to invest outside of its borders. This could be the oil companies when other types of fuel are bought or governments investing in new infrastructure.

The environmental dimension assesses the change of impact natural on the natural environment. The impact on the condition of the environment is assessed, not the utility retrieved from it. These are in this thesis regarded to be secondary effects resulting from the impact on the environment. Internally this means the natural environment onboard a ship. Externally these are the impacts the ship has on its environment. These are in effect substances or influences otherwise crossing the system boundary.

The social dimension is used to assess human well-being. Internally, within the borders of the ship this reflects on the people onboard, i.e. the crew and passengers. Externally this can be almost anyone. The influence on the well-being of these people is the external social dimension.

It is chosen to assess only changes in direct consequences from the measure or equipment that is installed. In a number of cases distinguishing economic impacts and environmental impacts from their influence on other dimensions, for example the social dimension (e.g. living conditions) of people can be difficult. Boundaries may not be completely clear or oblivious. Below a few examples are given to address these problems and show the way these are addressed in this thesis.

The first example is paid salaries. These can be regarded as internal social contributions since they affect crew's well-being but could also be regarded as external-economic effects since these salaries paid allow more spending in the (local) economy.

In this research salaries, being measured in monetary units are assumed to be economic internal impact in the form of costs.

Another example of cross-dimensional impacts are (harmful) emissions. The impact of these emissions on the populations health (a social impact) could be translated into economic impacts (reduced economic productivity) but when further extrapolated even in environmental secondary impact due to a reduce of demand for consumption and therefore the resource demand. Also harmful emissions can reduce the productivity from fields, this is regarded an environmental impact but again this could be expressed as an economic impact as well. Harmful environmental emissions are thus only included in the environmental dimension.

A last example is taxes. Taxes have an impact on the company's cash flow and returns (profit after taxes). However this money is transferred to a government that is again able to spend this money. Taxes can therefore be regarded being either internal-economic costs or external-economic benefits, or both. In this assessment only the internal-economic impacts from taxes are included. Secondary impacts from taxes (when spend by governments) are not part of this assignment.

7.3.1.2 Selecting dimensions for assessment

When looking at nations or public organisations, as has been done by the Accounting for sustainability for higher education paper, all different types of impacts are meaningful when assessed. However certain impacts might be less relevant for the assessment of a sustainable

innovation of measure on a ship. Based on the two locations of impact used in the paper and the dimension defined before (but also used in the paper) the impact types that will have to be assessed will be determined in this section. Each dimension will be addressed independently.

External-Economic impacts (e.g. investments infrastructure) are not part of traditional accounting. These impacts are usually assumed to be outside the control and scope of operations of a commercial (shipping) company. This assumption will be continued in this thesis and external economic impacts are not included. The Internal-Economic are relevant because reflect a company's own financial position, profits and cash-flows. As explained in section 7.1.1 companies will have to be financial healthy to be able to have an impact with respect to sustainable developments. Therefore internal economic impacts will be part of the assessment.

Environmental impacts are almost exclusively external. A ship has, for example due to its emissions, influence on the environment it operates in. However this environment usually changes constantly due to the mobile character of shipping. The influence on the environment onboard a ship is limited²⁷. The relevance of internal environmental aspects is further reduced due to the fact that the external environment a ship operates in has significant influence on the internal environment risking double counting for the environmental impacts. The internal environment is therefore not assessed within this thesis.

Also the social sustainability dimension can be split in an internal and an external impact. It "reflects the attitude of the company to the treatment of its own employees, suppliers, contractors and customers, and also its impact on society at large" (Krajnc & Glavic, 2005). Internally social impact includes the crew, because "their place of work is also, for long periods, their home" (Mitropoulos, 2006), and, in case of passenger ships, passengers. Since ABN AMRO is (almost) not involved in financing passenger ships it has been chosen to exclude passengers in this thesis and merely focus on crew's interests.

Companies have besides internal social impacts also external social impacts. For example when they are influencing living conditions or populations health. These impacts are mostly outside normal corporate objectives but are important consequences from the operation of a company. These effects are also important from the sustainability assessment point of view.

In Table 7-1 the locations of impact for each dimension are show. For the included locations examples of impacts are presented.

| | <u>Economic</u> | <u>Environmental</u> | <u>Social</u> |
|----------|---|---------------------------------|--|
| Internal | Financial position Profitability Cash-flows | <i>Not Applicable</i> | Crew (conditions onboard, fair labour practise) Passengers |
| External | <i>Not Applicable</i> | Emissions (air, water, soil) | Impacts on society, ethics and health Local positioning |

Table 7-1: Assessed dimensions and locations of impact

²⁷ Note that the environment represents 'natural' environment. Living conditions of crew or passengers is regarded part of the social dimension.

7.3.2 [Conversion to a unit for reporting](#)

The indicator schemes discussed in section 7.2.4 showed measured values expressed by indicators. Most of these indicators are reported in the units they are monitored in. However for processing, conversion methods transform these individual indicators for the use in frameworks and indexes. The underlying indicators will need, at least to some level, to be converted to a common unit. The review of measurement schemes has shown that different units of comparison could be used. In this section an approach for reporting units for the use in this thesis will be discussed.

Most of the schemes that were reviewed have converted the indicators from all dimensions into monetary units. These monetary units are used as reporting unit. Having one common unit for all sustainability dimensions allows easy trade-offs between the dimensions. A cross comparison in the same common unit between the different dimensions is however not one of the requirements. It may even not be desirable since it suggest the approval of trade-offs.

One conversion scheme that is special in its way of reporting is SAM. Although SAM reports in 4 different dimensions of sustainability separately, the impacts in those four dimensions are all converted to monetary units. Trade-offs between these dimensions is not allowed due to the strict dimension split. It is recognised that the dimension split as applied by SAM prevent relative valuations of the sustainability dimensions and therefore conflicts between stakeholders with interests focussed on these different dimensions. SAM shows that reporting of sustainability can be done for each dimension separately.

The way the common unit is calculated differs per scheme. Several methods of monetization are suggested by the Accounting for sustainability for Higher Education Institutions (Davies, 2009). The choice of conversion method can influence outcomes significantly as was shown in the same paper. Reporting can also be done using other techniques. This way a different unit per dimension can be maintained. Choosing not to pursue one common unit allows more appropriate unit selection for each dimension.

Some conversion schemes focusing only on environmental impacts have chosen to report in environmental-related units (i.e. land area, footprint (ratio), embodied energy or CO₂ heating equivalent). Reporting in a unit that is specifically representative for a certain dimension results in a calculation that reduces the discussion about conversions and results in a measure that better resembles the actual impact.

For this thesis a measurement and a conversion system will be required. It has been recognised that different, appropriate conversion schemes can be chosen for different dimensions. Also separately reporting of these dimensions belongs to the possibilities. For this thesis it is considered useful to present each of the three dimensions separately in appropriate units per dimension.

As a final step one can still convert the outcome of a certain dimension (in the unit per dimension) into a general unit like money. This could be done when for an assignment it is required to perform a trade-off based on a single unit. Or when for another reason impacts are to be expressed in more understandable units like financial ones. The monetization has certain drawbacks. So could one wonder of certain impacts, like the value of life or biodiversity have an infinite value (Davies, 2009). But also it could be questioned whether people do really understand environmental or social impact when expressed in monetary units. It is of the most importance to realize that environmental and social 'costs', also when expressed in money, are (in most cases) not direct cost for a company or charged to a company. And therefore from a company's point of

view the costs and benefits over the different dimensions could not be simply traded off against each other.

In the next chapter the requirements formulated, measurement schemes reviewed and choices made with respect to a sustainable measurement will be used to develop a good measurement scheme for the assessment of sustainable investments in shipping.

7.4 Chapter Conclusion

In this chapter in order to development of a measurement tool for sustainability of investments in shipping, the environmental and social dimension of sustainability that were present in the definition were complemented with an economic dimension. The economic dimension is representative for a commercial company's basic goals and capability to continue its existence and therefore has to be part of an assessment that is used by a commercial company.

In order to provide a proper assessment boundaries are drawn, distinguishing the system that is assessed from its environment. The flows crossing this boundary are assessed. In this research this boundary is drawn around the ship. Economic external effects are excluded while levels of ownership are combined. Achieving a real sustainable system is hard because a ship does not itself produce natural capital. In respect to time also boundaries had been drawn. The start of the assessment is set at the first impact and continues until the end of life. Impacts are assessed on a yearly basis and long-term impacts are to be expressed in a way their impact is expressed within the time frame.

Because in order to determine a ships level of sustainability with newly invested equipment the sustainability level before would have to be determined. It is recognised that this is complex and therefore is chosen to assess the changes of impacts due to the investment is done.

The indicators that will be used need to comply with the same requirement that were set for the measurement tool. These indicators have to assess the changes of flow to determine the impacts in one dimension. These impacts should be controlled by the company assessed, as well as be available and of sufficient quality. The impact measurement should be based on real measureable impacts. Since for the social dimension policies are such an important part, they are included. The number of indicators should not be too large. However they should provide a complete overview of the impacts of the sustainable investment. When unequal importance exists Analytic Hierarchy Process (AHP) can be used to adjust weightings. No distinction is made for aspects or indicators based on the motives of a company when voluntary installing equipment.

With the formulated requirements a number of measurements schemes were reviewed. The most abstract are the frameworks and indexes. This type of schemes provides reporting guidelines and standards and provides a qualitative representation or benchmarking.

SIA is a framework that assesses policies in three dimensions and allows both qualitative and quantitative methods. For the assessment of sustainability it was required not to use policies but to use impacts. The SNI method is a national framework, drawing boundaries based on countries borders. The income is discounted in order to calculate a sustainable income. This means combining the economic and environmental dimensions which contradicts with the formulated requirements. The reviewing of SEEA showed that this scheme did not assess sustainability based on three separated dimensions. Social dimension was not included other than the benefits from the environment. The economic and environmental dimensions were combined. SRF, developed by GRI, is mainly a reporting tool. Three dimensions are identified and assessed separately. Based on the industry assessed other aspects are added. Finally ESI was reviewed. As ESI is focussed on nations, boundaries were determined based on borders. The economic dimension is not included and social and environmental dimensions are partly combined.

The frameworks will need to be provided with data. A conversion method provides that data by translating indicators and provide one or a small number of values for the framework or index. Conversion methods can be based on Full Cost Accounting. When the complete life is reviewed this is also known as Life Cycle Assessment. SAM is a FCA method assessing the main controllable

activities within 4 separate dimensions. All impacts are monetized. The second FCA scheme reviewed is designed for the assessment of Higher Education Institutions. It is based on five types of capital that can be divided over the three dimensions. Impacts internally and externally are assessed separately and based on time; being either flow or capital. No system borders are defined nor is the allowance of trade-offs.

CO₂ equivalent scheme is used to determine the cost effectiveness of measures. It combines the economic and environmental dimension and prepares the trade-off of these. Two other conversion schemes addresses only environmental impacts based on footprints. The ecological footprint can assess either the maximum sustainable consumption or the ratio of consumption with respect to sustainable consumption. The CO₂ footprint does an assessment based on GHGs with help of their GWP. Emergy analysis uses again another unit; energy. Both economic and environmental dimension are converted to this unit. The scheme is based on a maximum of energy that can be used in the assessment. Finally the Fair Bank Guide is assessed. This tool is interesting since it is aimed at banks. It uses a qualitative rating based on a questionnaire.

The most concrete level of sustainability measurement are the indicators. Indicators provide the actual measured data of one aspect. This is data is usually provide in the unit it was collected in.

The first set reviewed was CSA. This is a questionnaire assessing three dimension but does not assess only real measurements of impacts. Another scheme, CSD, consists of many indicators of which the most appropriate should be used. Also CSD assesses three dimensions. ESI being a set aimed to assess nations, has clearly defined boundaries for its assessment of environmental and social impacts. Weightings are not used since all indicators are normalised. The final set of indicators, Azar's Socio-ecological indicators, focuses on the environmental and social dimension combined. A limited number of indicators was defined. The economic dimension was not included.

In this chapter was found that of the schemes that were assessed none comply with all requirements. A number of schemes combined dimensions or excluded one or two dimensions. Also not all schemes had clearly defined boundaries. However the assessment of the different schemes for frameworks, conversion methods and indicators will help when in the next chapters a measurement tool will be designed in order to assess sustainability of an investment in an innovation.

Based on the assessed schemes two more choices with respect to the measurement have to be made. For each dimension it has been determined whether to assess the internal and/or external aspects. To do so these dimensions were first be defined in more detail. Based on having the boundary around the ship external-economic impacts were not included in the assessment since they are outside the control of a company. The internal-environmental impacts were not included because the natural environment onboard a ship is very limited and strongly influenced by the external environment which will be assessed. The social dimension is assessed both internally, assessing the crews well-being, as well as externally, assessing other peoples well-being when impacted.

The second choice relates to the conversion unit. Since dimensions are split, one unit per dimension can be used. This way a more appropriate unit for each dimension is selected. Transforming these units to one unit for more dimensions is not ruled out and could be done using monetary units.

In the next chapter based on the requirements, reviewed measurement methods and choices that were made in this chapter a measurement method for the investment in sustainability on ships will be designed.

8 Designing a Measurement Method for the Assessment of Sustainable Investments in Shipping

In the chapter 7 sustainability was defined consisting of three dimensions. Requirements for measurements were formulated, existing measurement schemes were reviewed and additional choices with respect to the measurement were made. Following that in this chapter a measurement method for the change in sustainability, the sustainable development, of a ship due to an investment will be designed. The measurement method that will be developed will have to include indicators to measure, a conversion section to translate these different indicators to a presentation of impact per dimension and a framework used to report on the results. In the next chapter with this measurement method will be used to develop a tool for the assessment of investments in sustainability by ABN AMRO's clients.

Since one of the requirements in the previous chapter was to separate the different dimension the design of the measurement method is done for each dimension separately in the following three paragraphs. It was determined that reporting will be done in one specific unit per dimension. Each paragraph will start with a section on unit determination.

The next sections will determine, knowing the unit that will be used for each dimensions, indicators in order to measure impact for both locations within each dimension will have to be determined and secondly defined. For the indicator selection the requirements from section 7.1 are applied. A limited number of indicators is assumed to be appropriate and to be available in shipping and is used. Indicators have to be able to assess changes in impacts within the boundaries draws around the ship. For each dimension the standard time frame of one year is used. This means that the yearly changes in impacts are assessed.

After the indicators are selected the 'conversion' step has to be made. This means determining how the different indicator values will be transformed to come to a result in the unit for the associated dimension which has been determined earlier. The way the indicators are combined is discussed.

As has been discussed in chapter 7 the combination of impacts from different dimension is not required as part of the goal of this thesis. It has been chosen to report impact changes for each dimension separately and in a different unit for the economic, environmental and social dimension. In order to combine the impacts monetization could be used. Since money is a well understood unit it is recognized that the use of money could increase the understanding of impacts. In the last section of each paragraph the monetization of impacts is therefore discussed.

For each dimension the standard time frame of one year is used. This means that the yearly changes in impacts are assessed. Reoccurrence or duration are assessed separately for environmental and social impacts. The economic impacts are assessed on relevant time frame, which per impact may differ from monthly, quarterly to yearly. The cash flows are then made current with the use of a discount rate.

8.1 Measuring, Quantifying and Monetization of the Economic Sustainability Dimension

In this paragraph the measurability of the economic dimension of sustainability will be discussed. It was determined in section 7.3.1 that only the internal dimension was to be measured. First a unit which will be used to represent the economic dimension is determined. Followed by the indicators that are used to represent this dimension, the conversion of the data from the indicators to the unit for the dimension will jointly be discussed. The final section of this paragraph will address the monetization of the economic dimension of sustainability.

8.1.1 Unit

During the analysing of measurements schemes in the previous chapter, all schemes which assessed the economic dimension of sustainability have used monetary units (i.e. money) as the unit of measurement. Monetary units are well understood and easy to compare. The economic internal aspects that will be assessed are expressed in monetary values. There is no use to convert these aspects to any other unit and thus it is therefore rather obvious for the economic dimension to report in monetary units. It is thus chosen to report the economic dimension in monetary units.

8.1.2 Selecting Indicators of the Economic Sustainability Dimension

In this section will, with all restrictions and criteria in mind, determine proper indicators for the economic dimension of sustainability. Because external impacts are outside of the scope of influence of a normal commercial company these aspects were previously excluded from the assessment. It is assumed that a company has only influence on the internal aspects. Therefore only internal aspects are to be included.

8.1.2.1 Internal

The internal economic dimension refers to the change in financial performance with respect to the company, expressed in cash flows, because of the investment in an innovation or measure effecting sustainability. Simply put changes of the cash flows now and in the future. These changes in cash flows also reflect the change in shareholder's return since cash is required to provide these returns. Since boundaries are drawn around the ship the levels of ownership are combined and not assessed separately.

The cash flows that will have to be included in the assessment, are the cash flows that will be influenced by the implementation of sustainable measures or innovations. This includes the investment, financing, more specific the draw down, the interests and repayments, operational expense (opex), fuel costs (price and quantity), income (increased rates, better competitive position), risk (i.e. provisions and insurance premiums). These indicators will be defined in more detail in the following sections.

Investments

The most obvious cash flow is the investment in the sustainable equipment or measures. This expenditure or expenditures are paid to the supplier of the equipment or in case of measures to the ones implementing these. It may include wages of own staff or other internal costs made dedicated to the equipment or measure.

Within the investment category also the disinvestment is included. The disinvestment may be positive (i.e. sell for scrap or recycling) or negative (i.e. paying for removal) and is a cash flow occurring only once during the lifetime of an investment. Because of the character of the disinvestment; occurring only once and possibly be negative it is chosen to include it in the investment category.

To reduce the initial investment and promote sustainable innovation some governments have implemented subsidies. These subsidies can for example give a refund on investments. Because these subsidies have significant influence on the investment decision they will have to be included in the model.

Financing

In order to make the previous discussed investments possibly financing is necessary. This might be done by debt or by equity. Other options such as leasing are not specifically included in this assignment. Equity financing is not specifically included. However the return on this cash flow can be calculated with help of all other cash flows.

Most investments in shipping are mainly financed by debt. Financing by debt has as advantage that not all cash for the investment has to be available by the investor upfront. Returns to be paid on debt (interest) are usually lower than the required returns for equity.

For the NPV calculation certain parameters are important with respect to the financing by debt. First the amount borrowed and the moment of drawdown are essential. Also the type of repayment and the repayment frequency have significant influence. In combination with the interest rate the actual payments can be calculated.

Interest that has to be paid can either be fixed or floating. However when a floating interest is used the actual combined interest is uncertain. It is however possible to reduce this uncertainty by hedging. Floating interest is not included in this assignment but a hedge could be implemented by adding additional cash flows resulting from interest swaps.

Although many types and combinations of facilities can be designed for clients, most shipping finance facilities are either term loans or bullets. Term loans are based on a linear profile (the length until full repayment) and a tenor (the length of the facility). A facility with a 10 year profile and 5 year tenor has been repaid for 50% when it matures. Another 50% balloon has remained to be refinanced. A bullet facility is a facility where the principal is not repaid and only interest payments are made. At maturity the complete principal has to be repaid.

Companies that use debt financing will have to pay a fee or several fees to their bank for them to arrange the financing. These fees are included in the cash flow as well.

Another option is financing by a company's own capital, assuming cash is available, less cash would become available for return to shareholders and the investment is basically financed by equity. Because debt has priority over equity, risk for equity invested is higher. Therefore the (required) returns are higher.

In most cases investments are financed by a combination of both forms. Equity is important to reduce the debt risk, functioning as a buffer to the lender. Debt provides leverage on equity and may increase the equity returns. Equity financing is not part of the NPV assessment but is assumed to be the other origin (besides debt) of funding. Return on equity can be calculated by looking at the free cash flow.

Costs

Besides the initial investment it is likely that a number of reoccurring costs will be influenced. The measure or innovation invested in probably will need to be maintained, repaired and might require spare parts. In some cases equipment consumes certain products which will need to be replenished. Or software used for certain measures might need to be updated or license will need to be renewed. All these cost are in this thesis included in the operational expenses (opex). The opex changes due to the investment are to be part of the assignment.

Besides operational expenses the voyage related costs might be influenced. Some port charges are lower with certain certificates and/or measures installed as was seen in section 4.4. Fuel costs can also be influenced substantially. Changes in the choice of fuel could have significant effects on the fuel costs. The cost per litre but also the quantity of fuel used might be influenced. In some cases fuel consumption could be increased because the new equipment might have additional power requirements. The actual fuel cost change is part of the assessment.

The last specific cost group addressed in this thesis are the risk related costs. It is hard to actually express the financial risk in terms of cash flow. However risks can be represented by insurance premiums related to a particular risk. These premiums are actual cash expenses. To include risk related (future) expenditures provisions can be used. However it is required that they do actually express the expected costs. In conventional accounting provisions do not reduce the free cash flow. But the provisions will have to be included in the investment choice. The determination method for cost of risk with help of provisions would be more appropriate, and reliable when a larger fleet is assessed since then the combined provisions better resemble the actual expenditures.

Related to the costs the absolute change for each category will have to be known as well as the frequency of occurrence of each of the absolute costs change. In case of opex or voyage related costs, especially the fuel costs, an escalation may be applied indicating increasing costs because of aging.

Income

Besides changes on the cost side also a ship's income might change. Vessel's fuel efficiency is one of the parameters determining the charter rates and therefore determining the income of a vessel. It is likely that more efficient vessels receive better rates. Also vessels with similar age but higher efficiency and thus lower fuel cost would receive better charter rates. The absolute change of income should be part of the NPV assessment. Another way a company might benefit (i.e. increase their income) from investments in the economic dimension could be higher utilization. The vessel will have more work and thus fewer days without income.

The change of the charter rate and the additional income due to higher utilization are the main parameters for the income changes. Income change will be treated as a combination of the two. Since charter rates may fluctuate an escalation may be applied.

8.1.3 Conversion of the Economic Impact

The conversion section will discuss the combination and conversion of the different indicator values to the unit used to represent economic dimension of sustainability.

In economic calculations cash flows are often discounted to a Net Present Value (NPV) (Borucke, et al., 2012). This calculation discounts the 'value' of the investment and future cash flows to their current value. It uses a discount rate which can for instance be based on the cost of capital. By applying NPV future cash flows are valued lower and thus 'worth less' today compared to cash flows occurring today.

This calculation does also allow financing to be included in the calculation. Using the NPV derived from cash flows allows the expression of economic impacts over a certain period to be expressed in one single value. The economic dimension deviates therefore from the goal of expressing yearly impacts. The moment of the cash flow occurrence and the amount are required. A positive NPV indicates an investment project has a higher return than the discount rate and thus adds value to a company, suggesting investing would be a good decision. A negative value means investing in that project would reduce the company's value because the returns are lower than the discount.

A company might better chose (only based on this economic reasoning) not to invest in that project. The NPV method is used in this thesis.

Another way of using the NPV is by calculating at what cost of capital (CoC) the NPV is nil. The return is known as the Internal Rate of Return (IRR). If the CoC of a company is higher than the calculated CoC the return from the project are not sufficient. If the calculated CoC is higher the returns are higher than the cost and the company profits from this investment project. Instead of CoC one could use the Weighted Average Cost of Capital (WACC) which includes a required return for equity. This calculation is not used however since it does not allow to value the absolute impact.

8.1.4 Monetization of Economic

The final section of this paragraph focuses on the monetization. As been discussed before this is not required but could improve people's understanding of the impacts.

Since it has been decided that the economic dimension of sustainability will be measured by the financial impact investments will make based on cash flows and a NPV calculation of these investments, no conversion to monetary units is required. No adjustments are necessary to express the economic impact in monetary units.

8.1.4.1 Conclusion

The economic sustainable dimension will be expressed in monetary units. Only the internal aspects are assessed. This is done by assessing the changes in cash flows. These cash flows result from the investment and disinvestment, the financing including the draw down, interest payments and repayments, the change in costs including opex, voyages costs and risk related costs and finally the change in income. The NPV of these changes of cash flows is determined to be used as the unit of measuring.

This measurement method of the economic dimension that is now defined will be used in chapter 9 where the measurement tool will be designed. This tool will have to provide the means to include the cash flows as discussed in this section.

8.2 Measuring, Quantifying and Monetization of the Environmental Sustainability Dimension

Following the section on the economic dimension this paragraph will focus on determining the unit, selecting and defining indicators, design a conversion methods and finally discusses the monetization of the environmental sustainability dimension. The indicators will measure values in different units which will make the conversion method for environmental sustainability more complex than the economic dimension.

8.2.1 Unit

To evaluate the environmental sustainable dimension a unit of measurement is required. Within the reviewed schemes in section 7.2 different types of units for measuring environmental impacts have been used. A number of schemes transformed the environmental impacts into monetary units. For this transformation several methods were used and it was shown that results from these transformations may differ significant depending on the transformation method that is being used.

Non-monetary conversion schemes focus on environmental impacts like CO₂ equivalent heating which transforms impacts based on their global heating effects. The carbon footprint assesses the area needed to compensate CO₂ effects and could be combined to address all GHG emissions impacts. Ecological footprint addresses land space needed to carry environmental loads and compares this with the maximum environmental load per area. Emergy analysis assesses energy flows for products.

Since it is recognised that when transforming environmental impacts to monetary units the results depend heavily on the method that is used . Therefore it is chosen within this thesis to use a non-monetary unit. This should reduce the influence of the conversion method. The transforming into a non-monetary unit does not rule out a conversion into monetary units later.

The footprint methodology is well able to express long-term impacts and express different types of environmental impacts by assessing the flows occurring due to the investment in sustainable equipment. The footprint expresses the impact based on an area to compensate or absorb that impact. The severity of impacts can be clearly expressed by an increased area that is required, given that only a limited area is available. Impacts hard to reverse will need larger areas for compensation. For these reasons it is chosen to use a footprint to express the area that is needed to support, sustain and compensate operations based on changes in environmental emissions. Note that in cases of a (positive) sustainable development the change in footprint area will be negative, representing a decrease in footprint.

8.2.2 Selecting Indicators of the Environmental sustainability Dimension

Indicators that represent the impact in environmental sustainability dimension will have to be determined. This determination of indicators is done in this section. The selected indicators will have to comply with the requirements that were stated before and will need to be able to be used in the presentation of the environmental impacts in a footprint.

External-environmental aspects, i.e. the substances that are emitted to the environment, will be assessed. Internal environmental aspects are not included since there is not much natural environment onboard a vessel that can be influenced. The environmental aspects on board that do exist are strongly influenced by the external aspects.

8.2.2.1 External

Determining the indicators looking at external factors means that one will be looking at impacts having effect outside of the boundary as has been defined. The flows of impact across this

boundary, leaving the ship, are therefore assessed. These emissions can enter or leave the environment (i.e. cross the boundary) as an air, water or soil emission, through different systems on board and with different effects. The assessment of emissions means that consequences of for example climate change, biodiversity and resource usages are not directly assessed. These consequences will have to be included in the footprint based on emissions.

In chapter 4.1 the relevance of shipping in environmental impacts was discussed. These impacts can be reduced using innovations that were discussed in chapter 6. A number of these innovations might become required by regulations. An overview of the legislations on these emissions was given in chapter 5. The reaction of the shipping industry and other organisations was discussed in section 4.3.2 and section 4.4.

With respect to shipping a number of air emissions were most significant. These emissions, being CO₂, NO_x, SO_x, VOCs and refrigerants, will be included in the assessment. Particulate Matter (PM) emissions are not included in the environmental assessment because of two reasons. The first reason is that SO_x is responsible for a large part of the PM emissions. Separately assessing PM and SO_x would introduce double counting. The second reason not to include PM is that PM is defined as a range of material with a certain particle size. The actual chemical composition is not defined making it very difficult to estimate the effects on the natural environment of this emission.

The second category of emissions are the soil emissions. Soil emissions with respect to shipping are mainly been seen in waste processing. Since the assessment is based on changes the demolition of the ship is not specifically included. The occupation of areas caused by shipping is included in the 'soil emission'. Soil emissions are thus build-up by an area related to waste and the build-up lands.

With respect to the water emissions impacts like anti-fouling, spills and ballast water where observed. These three emissions are of a very different kind, anti-fouling (when applied) is an emission continuously and deliberately emitted. Ballast water is emitted on incidental basis and might, depending on location of discharging, present danger in the form of alien species that can be emitted. Spills are unintended and incidental emissions due to an accident. The inclusion of these impacts will be discussed.

8.2.3 [Conversion of the Environmental Footprint](#)

The indicators which were determined in the previous section will now be defined. It is required that indicators present the change in flows of substances that move over the system boundary and will eventually be presented in a footprint. The change in flow per year is to be assessed for these emissions. A footprint will presents a certain area needed to compromise or carry the yearly environmental loads based on a company's emissions or used land.

This section will define the indicators in more detail. First air emissions will be discussed followed by soil and water emissions. It will also discuss how to determine the footprint for each emission. The way the emissions are transformed to footprint will be discussed in this section.

8.2.3.1 *Definition of Air Emissions*

This section discusses the important emissions from a ship emitted in the form of gas into the atmosphere.

CO₂

The first gas to be assessed is CO₂. CO₂ is a greenhouse gas. Footprint based on climate change assesses CO₂ and all other Green House Gases (GHGs). To measure impact from different gasses in a footprint for GHGs usually Global Warming Potential (GWP) which uses CO₂ as a reference (GWP being 1) is being used (see section 7.2.3.3.2 for the explanation of GWP).

The area needed for compensating one ton of CO₂, which is considered to be its footprint is based on the absorption of CO₂ by forests. Based on data from Wada, the average global absorption of CO₂ by forests is 1,8 ton (metric) per hectare per year, 0,56 hectare per ton ((Wada, 1994) in (Wackernagel, 1994)). However a wide range varying from 1,2 to 35 tons CO₂ per hectare per year has been reported according to CE Delft (Boon, Schroten, & Kampman, 2006). The US Environmental Protection Agency reported 1,22 ton per acre for US forests (Agency, 2013), or 3,01 tons per hectare. In this thesis the 1,8 CO₂ per hectare as was reported by Wada is followed.

Refrigerants

Just like CO₂ refrigerants are a GHG and contribute to global warming. The relative high impact from refrigerants is represented in high GWPs. Refrigerants are often used on ships or in containers on board ships. For examples R-134a which is used by Carrier²⁸ in container refrigeration systems (Carrier, Refrigerants, 2013). This refrigerant has a GWP of 1.300.430 (United Nations, 2013). Based on the actual refrigerants used on a ship the assessment should be adjusted. For now the GWP as for R-134a will be suggested for use.

VOCs

VOCs are a group of gasses from organic origin which are damaging to the environment. They may have harmful effects in water, soil and the atmosphere. In the atmosphere VOCs may have ozone depleting properties and contribute to global warming. However a Global Warming Potential (GWP) will be rather hard to determine since VOCs are actually many different gases. VOCs are sometimes split in Methane (CH₄) and Non-Methane Volatile Organic Compounds (NMVOCs). According to Ødemark shipping was the cause of the emission of 21 kt of NMVOC and 0,43 kt of CH₄ in the arctic during 2004 (Ødemark, et al., 2012). In this thesis this split is assumed to be representative for shipping in general. Thus each ton of VOC is assumed to consist of about 0,02 ton consists of CH₄. This GHG has a GWP of 21 (United Nations, 2013) and thus its footprint based on CO₂ equivalent is 0,23 hectare per ton VOC.

The NMVOC impacts are less significant for the environment but do negatively affect vegetation and human health (Marintek, 2013). Since the actual composition of the VOC determines the effects and because the main effects are to be found on health related issues (i.e. within the social dimension) NMVOC are not taken further into account during this assessment.

SO₂ and NO_x

SO_x and NO_x are both non-green house gases. For the valuation of SO_x and NO_x the CO₂ equivalent method based on the heating potential of gasses is not suitable. And thus another way of determining the footprint area for carrying this environmental load will have to be used.

²⁸ Carrier is a wellknown supplier of air-conditioning and refrigeration solutions and is according to its own website the industry leader in this business (Carrier, Overview)

In the US significant reductions of the environmental impacts of these gases have been achieved by putting an emission trading scheme on these gases. These reductions have shown to stop further deterioration of ecosystems; “the emissions reductions and environmental improvements [...] have been substantial, but not sufficient to allow ecological recovery from the effects of acidification” (Burtraw & Szambelan, 2009). Although the reduction might not be enough to recover from acidification the emissions can be used to get an idea of the area that is needed to support a certain quantity of SO_x and NO_x emissions.

According to Burtraw and Szambelan a reduction of 40% of emitted SO₂ has been observed between 1980 and 2000 (Burtraw & Szambelan, 2009). And is projected to be reduced to only 48% of the 1980 emission by 2010.

To do so it is now assumed that the 2010 emission level of the US was sustainable for its land area. In 1980 the total emission of SO₂ in the US was;

$27 \cdot 10^6$ (short tons) $\cdot 0,90718$ ton/short ton = $24,5 \cdot 10^6$ ton (Gschwandtner, Gschwandtner, Eldridge, Mann, & Mobley, 1986).

This means an expected emission of SO₂ in 2010, 48% of the 1980 emission, of $11,7 \cdot 10^6$ ton.

According to the CIA ‘World Factbook’ the area of the US is 9.826.675 sq km (CIA, 2013). Dividing the tonnes by the area gives the area per ton which is 0,84 km² per ton SO₂ emitted.

The total emission of NO_x in the US was 16,1 ton in 2008. In 1980 this was still $22 \cdot 10^6$ short tonnes $\cdot 0,90718$ ton/short ton = $20 \cdot 10^6$ ton (van Atten, Saha, Liberman, & Reynolds, 2010). A year to year reduction of about 0,8% per year. Extrapolating this reduction to 2010 would lead to $15,7 \cdot 10^6$ ton. However this number is based on rather rough assumption and it is recommended to replace this data with more accurate actual data. In combination with the area provided by the CIA an area of 0,626 km²/per ton NO_x emitted is calculated.

In this calculation it is assumed that the reduction of each gas has contributed equally to the emission reduction and reduce in acidification. It would however be necessary to look in more detail to the effects for each emission, and the relative quantities of the different gasses that together are addressed as NO_x and SO_x with respect to acidification. This detailed assessment of the emissions is not included in this thesis.

8.2.3.2 *Definition of Soil Emissions*

The previous section has reviewed the air emissions. For air emissions the footprint or land area in order to compensate was calculated. For soil emissions this is done in a different way. First build-up land is assessed. Second for waste the area that is needed to produce products which end up as being waste and area needed to dispose the waste are included in the footprint.

Build-up land

The most obvious footprint is the actual build-up land. Land which is used for building, storing or other sorts of permanently occupation of a certain area of land. The footprint of shipping related to land use is limited. However the option to include build-up land is included in the model. Build-up land can be simply expressed in area, no conversions are needed.

Waste

Waste is special in the assessment since the emission of waste is not only assessed on the emission itself but also on the production of the goods which end up as waste. This means it assesses the phase before crossing the system boundary into the ship and the emission after crossing the system boundary and leaving the ship. Salequzzaman has developed a “sustainable tool for solid waste management” (Salequzzaman, Sultana, & Hoque, 2006). Based on the waste of inhabitants of the Bangladeshi city Khulna he found a footprint area with the help of the

methodology developed by M. Warckernagel et al²⁹. This method calculates the area needed to produce, process and dispose what has become waste.

The paper describes that the waste from inhabitants of Khulna consists of; 78% organic, 11,5% paper, 5% plastics, 4,7% glass and 2,8% metal. Because this adds up to 102% the percentage have been divided by 1,02 for the use in this thesis. The footprint area for this waste is determined per type based on a waste production of 0,5kg/day. But since the model looks at impacts on a time scale of 1 year the amount of waste has been multiplied by 365,25 days. Resulting in; 624,3m² for organic, 152,9m² for paper, 43,3m² for plastics, 19,3m² for glass and 46,7 m² for metal waste. These areas include area for supply of goods and/or energy and build-up lands.

With the percentages of the types of waste and with the footprint area per type of waste the footprint area per mass of each types can be determined. This footprint per type can also be used for waste with other compositions. In order to be able to include recycling the possibility to reduce the amount of waste by a certain percentage for each type of waste has been introduced.

With the waste composition in Khulna, 1 ton of waste has a total footprint of 0,485 ha. This area should provide enough resources to produce the materials and the means for the disposal of the waste in order to be able to support 1 ton of waste.

Hazardous waste

Since impacts from hazardous wastes may have a very different type of impacts an additional category for hazardous waste could be introduced. This is relevant for a measurement concerning ships since on ships hazardous wastes such as asbestos are to be expected. Since for hazardous waste no appropriate way of determining a footprint was found in the literature this additional category of waste is not applied in this thesis.

8.2.3.3 Definition of Water emissions

Previously it was determined that for a complete environmental footprint the water emission would have to be included. Water emissions that were selected are based on anti-fouling releases, (incidental) spills and ballast-water emissions. Water that is pumped from the vessel is to be filtered before released in sea. If this is not done properly it is considered to be spillage.

However the categories of water emissions were determined it has proven to be very difficult to acquire information in the literature on impacts from water emissions on the environment or information that could be used to determine an appropriate footprint of these water emissions. It is therefore very hard to estimate what footprint would be representative for water emissions. The qualification of a footprint for water emissions is therefore not included in this thesis. And will thus not be part of further analysis or be included in the case presented in this thesis. It is recommended that in further research an assessment of impact of these emissions is carried out in order to be able to provide a footprint.

8.2.3.4 Combining environmental impacts

The three types of emissions that have impact in the environmental dimension are to be combined to one footprint value for the environmental dimension. The assessment of these emissions is based on change in flow per year and the number of years that will be affected. This

²⁹ "Mathis Warckernagel, Ritik Dholakia, Diana Deumling and Dick Richardson, Redefining Progress v 2.0, March 2000" in (Salequzzaman, Sultana, & Hoque, 2006)

section will discuss the considerations that are at the basis of the footprint that is used in this thesis.

The emission of CO₂, refrigerants and methane to the air are assessed based on their GWP. This way emissions are assessed based on their effects relating to global warming. The impact from the different emissions can be combined this way. Another group of emissions consisting of NO_x and SO_x is assessed based on the area needed to absorb the acidification effects of these emissions.

It is however not unlikely that an area can both compensate for CO₂ emissions and absorb acidulous emissions at the same time. One option is to use the maximum negative impact of the two categories. However when only one of these emissions would be significantly reduced while the other would slightly increase the total impact expressed in footprint would still increase. This also conflicts in cases where two measures are assessed of which one focus on GHGs and one on acidification emissions. Results separately would not be positive while combined it would be an impact reduce in the environmental dimension.

In this thesis it is chosen to express both impacts independently and combine the results by taking their sum. The assessment using this method might give a distorted result because of this choice. The area gained or lost could be overestimated where both GHG and acidification emissions are reduced or increased.

The combination of footprint with respect to the soil emissions is less complicated. The used area and the footprint based on waste generation are combined and expressed as one footprint for soil emissions.

The combined footprint resulted from the soil emissions is added to the footprint of the air emissions and since the water emissions were not included this result in a total change in environmental footprint. The footprint is based on the carrying capacity of an area per year. The emissions were also assessed per year. This means that a footprint will not increase due to yearly reoccurrence of emissions. However the footprint is 'occupied' for a longer time.

One final issue to be solved is whether and how discounting should be applied for environmental impacts in terms of footprint. "Discounting is widely applied in economics"(Borucke, et al., 2012) and is used for economic impacts by applying the NPV. However it is claimed that "the benefit of the 'work of nature' will last in perpetuity when used in a sustainable manner"(Jansson, Hammer, Folke, & Costanza, 1994, p. 161) and "standard monetary analysis suffers from deficiency in promoting long-term ecological sustainability"(Borucke, et al., 2012). Applying discounting reduces the value of long-term impacts which conflicts with the goal of measurement of sustainability.

Also one will have to keep in mind that conversion based on an environmental footprint is based on the one year carrying capacity. Emitting the same emissions the following year does not increase the footprint but sustains it for a longer period of time. It is therefore chosen not to discount the environmental impacts when expressed in footprint.

8.2.4 [Monetization of Environmental](#)

In the previous section the transition from emissions to impact in term of a footprint has been made. This section will provide the means for this footprint to be converted into monetary units. It might be argued that environmental impact cannot be monetized and the actual monetization is therefore controversial. In this thesis the environmental impacts are being monetized as an alternative to presenting impacts in a unit per dimension.

It could be argued that monetization is not necessary since there are actual market prices for the most often addressed emissions. Within the EU an emission trade for greenhouse gases does exist

and in the US emission trade covers NO_x and SO₂ (European Commission, 2013) (Burtraw & Szambelan, 2009). However these schemes are not directly connected to the impact of the emissions. Such an emission scheme allows trading the rights to emitted a certain emission and might also cap that emission.

The CO₂ emission scheme is a market driven scheme where the price of CO₂ emission rights will increase with higher demand and reduce with a lower demand for the rights. However the market price may not reflect the 'real' environmental costs. Why would pollution be more 'costly' from environmental perspective with a higher demand for emitting these emissions. The scheme does not assess actual impacts but rather the demand and the moment in the economic cycle. Governments may include other, for example social, effects in the emission price.

Because trading schemes do not present a price or cost based on the impact of the emissions with respect to the environmental dimension, market prices are considered not to be a good monetization method of environmental impacts or costs.

Instead looking at organisation actually compensating emissions is more useful. Several CO₂ compensation schemes exist. These are schemes that allow individuals or companies to compensate their CO₂ emissions. This CO₂ compensation or 'offset' "negates or 'neutralizes' a ton of CO₂e [equivalent]" (Taiyab, 2013). The organisations that provide CO₂ compensation often do this compensation by reforestation. Below a table³⁰ can be found with a number of schemes and the cost for compensation per ton CO₂. The Atmosfair scheme and the MyClimate scheme are however are "offset providers committed to providing high quality energy-based offsets located in developing countries, with sustainable development benefits". Their projects do explicitly not invest in forests since the captured carbons might be released in the long term. Instead solar power projects and biomass or waste generation plants are invested in. This different approach causes these schemes to be significant more expensive. For conversion to dollar valuta.nl was used based on the exchange rate of 31 July 2013 (€ 1 = \$ 1,325 (Valuta.nl)).

| | |
|---|--------------------------------|
| Atmosfair (Atmosfair, 2013) | \$ 30,48 / t CO ₂ e |
| ClimateCare (ClimateCare, 2013) | \$ 11,40 / t CO ₂ e |
| Conservation International (Conservation International, 2013) | \$ 12,00 / t CO ₂ e |
| Greenfleet (Greenfleet, 2013) | \$ 12,64 / t CO ₂ e |
| GreenSeat (Greenseat, 2013) | \$ 13,25 / t CO ₂ e |
| MyClimate (MyClimate, 2013) | \$ 30,79 / t CO ₂ e |
| NativeEnergy (Native Energy, 2013) | \$ 14,00 / t CO ₂ e |

Table 8-1: CO₂ compensation scheme

Since Atmosfair and MyClimate are a special type of scheme and are thus excluded resulting in an average of \$ 12,66 per ton CO₂e is required as cost for the compensation of the impact. Since the impact in the previous section was transformed from tons CO₂e to land area the compensation costs will have to be transformed as well. The costs for CO₂ compensation are based on emissions emitted in one year and the land area is based on yearly capture capacity of CO₂ of an area. It was assumed that one hectare can compensate for 1,8 tons of CO₂ emitted per year. Therefore the cost per hectare will be;

³⁰ The Table is based on schemes described in the paper of (Taiyab, 2013) and (Boon, Schroten, & Kampman, 2006). However only schemes still existing with their current prices (in dollar based on the exchange rate of 31-7-2013) are presented.

$$Cost_{ha} = Cost_{ton} / CO_2 / year \cdot CO_2 / year / ha = \$ 12,66 \cdot 1,8 = \$ 22,79/ha$$

It is found that the cost of a hectare used to compensate CO₂ is \$ 22,79. This figure is based on yearly compensation. When emissions reoccurred yearly this compensation amount will have to be multiplied by the number of years an impacts is effective. When ones want to represent this in a proper financial way one should include a NPV calculation reducing (just) the monetary valuation of future impacts.

For other GHG emissions the footprint was based on the Global Warming Potential relative to CO₂. It is thus assumed that the same cost per area can be used because the area has been increased based on GWP. For other emissions from the acidification emissions type it is assumed that the cost of the use of area for CO₂ compensation is similar to the costs to compensate other emissions expressed with a footprint. And thus the costs of a footprint are assumed to be \$ 22,79 per year.

8.3 Measuring, Quantifying and Monetization of the Social Sustainability Dimension

The previous two paragraphs have focussed on measuring, quantifying and monetization of the economic and environmental dimension of sustainability. In the definition of sustainability used in this thesis an improvement in environmental sustainability can only be sustainable when the decrease of human's well-being is prevented. This paragraph will focus to measure and express the change in human well-being or social dimension of sustainability.

Like in the previous paragraphs the unit, indicators, a conversion method and the monetization of social dimension will be discussed. The measuring approach will be different due to the difficulties in measuring human's well-being; "social elements involve the least certain methods for estimating cost and benefit" (Brown & Frame, 2005). The solution to this problem will be explained.

8.3.1 Unit

In the schemes that were reviewed in section 7.2 only monetary units have been used to quantify social impacts. In order to do so shadow prices³¹ and contingent valuation³² methods are used (Brown & Frame, 2005). These valuation methods require social sustainability to value aspects of human well-being into monetary units.

Since the change of social impacts is assessed and made sure no reduction occurs a monetary unit or any 'unit' as such is not required. It is chosen to assess social impacts by determining a comparative rating of importance. Next the severity of a certain impact (degree of change; improvement or decrease) is determined and the number of people affected is assessed. Combining these values over all types of impacts assessed (i.e. all indicators) will provide a 'score' which can be considered to be the 'unit' used for sustainability. The total score is required not to be negative because this would indicate a negative development in human's well-being and thus an unsustainable development.

8.3.2 Selecting Indicators of the Environmental sustainability Dimension

In section 7.1 where the requirements for indicators were formulated it was decided that only real measureable impacts were assessed. However for the social dimension of sustainability policies are included since they compose an important part of the dimension.

Since the unit is determined and a requirement for the score or unit to be positive has been set the indicators for the social dimension will have to be determined. Since a company has significant social impact internally (on its crew, passengers ships are excluded) and externally (everyone involved or affected outside the company) both aspects will be assessed.

8.3.2.1 Internal

The internal aspect of social sustainability is about the well-being of crew and passengers on board a ship. Because ABN AMRO is almost not involved in passenger ships it is chosen in this thesis to exclude passengers and merely focus on crews interests. Indicators for internal social sustainability should focus on the circumstances of the crew (and passengers) during the time they live on board.

Living conditions on board and the development of employees presents are an important aspect

³¹ Prices derived from people's actual behaviour like salary premiums for risky jobs

³² Valuation based willingness to pay for reduced (mortality) risk with the help of questionnaires and/or surveys

relating well-being of the crew and thus of the indicators of social-internal sustainability. The facilities and services on board available for the crew are used as a measure of the shipowners involvement and the retention rate is used as an indicator for the indication of peoples contentment with their employer and job. The influence on health and safety onboard are part of the social sustainability and are assessed as well. As is the development of human capital (i.e. investing in people by providing training). Other labour related aspects are important aspects for crews well-being and therefore for internal-social sustainability. These labour related aspects include prohibited labour like forced labour and child labour but also fair labour practices like employee rights, equal treatment and prevention of discrimination.

8.3.2.2 External

Externally companies can contribute to the social sustainability aspect by adapting their behaviour influencing people's life. These adaptations in behaviour may not be part of a company's core business. However it has been determined that all efforts, either core business or philanthropy programs are included in the sustainability assessment within this thesis because it impossible to always know the true reason for a company's behaviour. As was discussed before the social dimension is an exception in the sense that policies will be included in the assessment. Transparency is an example of such an intangible aspect which will have to be assessed using a company's policy. The measurement of disclosed information, the quality and the undisclosed information is much more difficult if not impossible. Transparency is regarded being a subcategory of the ethical policy in combination with the policy on corruption and bribes and with the policy with respect to weapon and other unethical cargos.

Social indicators used in this thesis will focuses on behaviour of the company with respect to their influence in people's lives. Weather a company's threads its competitors and competes with them in a fair manner as well as the processing of complains are assessed. The last indicator included in the assessment indicating impact on people's life relates to the impact on humans health . Another important social aspect is the positioning of the company locally. This indicates the local involvement of a company and includes entering in local partnerships, local jobs or other contributions to society in general. Finally loss of life is included. Loss of life might be a real possible consequence. Another reason to include loss of life is to be able to use it as comparison and reference when expressing impact. Loss of life is a useful criterion since it is the most severe and concrete impact a company may have. For the use in assessments were one wants to express social values in monetary units including the value of life might will be useful since it has been attempted often to express the value of life.

8.3.3 Conversion of the Social Score

It is determined that the unit used for the social dimension of sustainability will be a score. This score is based on increase or decrease in human's well-being. However to come to a score the increase or decrease will have to be assessed in combination with the 'size' of the impact change and the relative importance.

The following section will explain how changes in impact will be transformed to impact based on severity, effected population, duration and relative importance.

8.3.3.1 Effected population, severity and time frame

The indicators that were determined are used to assess the social dimension of sustainability. They need to measure that human's well-being is not reduced due to innovations or measures implemented to increase sustainability. In order to compare the different social impacts this section will discuss a way to determine how much a certain impact is changed. This is done by

looking at the number of people affected, the severity of the change and the time frame of the change.

The first step in order to determine the real impact on human's well-being is an assessment determining the number of people involved. For this assessment the actual number of people involved can be used based on a one-year impact. It is assumed that an impact occurring a number of times a year will affect different persons each time. Long-time reoccurrence of the impact or long-term influence are corrected by adjustments in the time frame.

Using the real number of people is practical but might problems for ships when uncertainty exists about the future routing or operations. Therefore it is suggested to create certain categories which indicate that one person, a small group (like the crew), a large group (like crew and dockworkers), a town or coastal population are affected. In this thesis it is suggested to create these standard groups of effected people. The development of this groups and determination of sizes is not part of the thesis.

When determined what number of people are affected by a certain impact as appointed by the indicators also the change in severity of the impact will have to be assessed. Obviously a minor change should have less impact on the final score than a significant impact when reviewing the same indicator.

Because the change of the severity of a certain impact due to the implementation of measures or installation of equipment aimed to improve sustainability is hard to determine a scale is used having 7 levels of impact change. When no change is caused for a certain indicator one can use the no change level. However when severity will change three levels for each positive and negative change can be chosen from. The changes are assumed to be either minor (about 10%), medium (10-50%) or significant (>50%). In the calculations the upper bound of the percentage is used for the class.

Severity reflects the change in severity of a certain impact compared to its normal or medium impact. It has nothing to do with the seriousness of an impact or the relative importance of impacts.

Now that the number of people and the severity have been determined the final variable to determine how much an impact has is the time frame of a certain impact. The number of people that are impacted is based on a one year's impact. Impacts occurring a number of times a year are assumed to increase the number of people involved. However when impacts reoccur in the long term or last over several years the actual impact is increased. This should be part of the impact assessment as well. Therefore the time frame requires the number of years a certain impact will have effect. For the loss of life however this may give a distorted view. This is a one-time occurring event but has long lasting social impacts. The length of these impacts may differ from case to case. In this thesis the social impacts from the loss of life are assumed to impact for 30 years.

One remark that is to be made is that people have an increased aversion against larger consequences. The risk aversion is not linear. When the consequences become larger the perceived consequences does increase faster than the actual consequences (Kristiansen, 2005). This increased risk aversion is not taken into account in the impact assessment.

Based on the number of people that are affected, the severity of the impact and the long-term and reoccurring of the impact a combined impact will have to be made. This combined impact is made by multiplying each factor. The impact is now calculated by multiplying people affected, severity of impact change and duration. However the impacts per indicator cannot be simply summed because the relative importance of the indicators is unlikely to be equal. The next section will address this issue.

8.3.3.2 Weightings - Analytic Hierarchy Process (AHP)

In the previous section the impact for each indicator was determined by looking at the number of people affected, the change in severity and the duration or reoccurrence of impacts. However the seriousness or relative importance was not yet addressed. In this section a method will be used to determine the weighting of each indicator in order to make a final score.

To determine the relative weighting of the indicators Krajnc and Glavic's paper has been used as an example. They used the Analytic Hierarchy Process (AHP) method to determine weightings based on answers from 5 decision makers. In this thesis also the AHP will be used for the relative weighting of the different indicators within both types social dimension (Krajnc & Glavic, 2005). AHP is a decision method developed by T.L. Saaty in the 1970's (Wikipedia, 2013a). It defines a certain goal, criteria and sub-criteria in order to reach a goal and finally several alternatives. Different levels of criteria can be introduced and both qualitative and quantitative criteria can be compared (Haas & Meixner).

For implementation of AHP, on all levels and subsets of criteria as well as for all the alternatives, a relative weighting will have to be determined. Alternatives and criteria are pair-wise scaled with respect to their relative importance. The most important of the pair is indicated in either one of a 5 level scale; equal, moderate, strong, very strong or extremely and get respectively the rating 1, 3, 5, 7 and 9. Intermediate values can be used when compromised are to be made. A matrix is built with these values, a relative less importance is indicated with a score inverse of its opposite comparison. The normalised eigenvector of this matrix indicates the relative importance of these criteria or alternatives and is in effect the weighting. This process is repeated for each level of criteria's, sub-criteria's or alternatives.

After the matrix has been completed a Consistency Ratio (CR) can be used to check how consistent and accurate each survey used to provide the ratings is (Chou, 2010). To calculate the CR first the consistency index is determined. The eigenvalue of the weightings set (λ) is compared with the number of indicators (the dimensions of the $n \times n$ matrix (n)).

$CI = \frac{\lambda - n}{n - 1}$ and $CR = \frac{CI}{RI}$ where RI is a constant value depended on n . The value for RI can be found in Table 8-2

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| RI | 0,00 | 0,00 | 0,58 | 0,90 | 1,12 | 1,24 | 1,32 | 1,41 | 1,45 | 1,49 | 1,51 | 1,48 | 1,56 | 1,57 | 1,59 |

Table 8-2: RI per number of dimensions

A value of CR at 0 would mean perfect consistency. Higher values represent inconsistencies or random entries. Usually a CR of maximum 0,1 is allowed for the answers to be trustworthy. When a value higher than 0,1 is found it can be corrected by re-evaluating pairs in the pair-wise comparison that have the most influence on the consistency ratio.

Since $CR = \frac{\lambda - n}{n - 1}$ where RI, and n are constants based on the numbers of indicators. It is possible to, in order to see where inconstancy are originated from, for which entries a value change has the largest rate of change for the eigenvalue (λ). Saaty (Staay, 2003), who explained this procedure in more detail, shows the deduction of the formula for the partial derivative;

$$\frac{\partial \lambda}{\partial a_{ji}} = v_i w_j - a_{ji}^2 v_j w_i$$

Using this equation for the upper right part of the matrix the combination of indicators with the largest absolute value of partial derivative should be reconsidered. This procedure can be repeated while trying to bring the CR closer to the desired value.

Another way to look for values making an answer less consistent is “based on the fact that

$$n\lambda - n = \sum_{\substack{i,j=1 \\ i \neq j}}^n (\varepsilon_{ij} + \varepsilon_{ij}^{-1}).$$

This suggests that the judgement for which ε_{ij} is farthest from one is examined, that is, an entry a_{ij} for which $a_{ij}w_j/w_i$ is the largest.” Also this procedure and another variant are discussed in more detail by Saaty (Saaty, 2003). Using this method one selects the cell with the highest value and see if possible changes in the relative importance decrease the CR value.

For each set of pair-wise comparisons a separate matrix and consistency ration need to be calculated to arrive at the weightings resulting from that assessment. The weightings of criteria constructed of sub criteria will have to be multiplied with the weighting of each the sub-criteria and so onwards in order to arrive at the weighting of individual sub-criteria. These weightings can now be used in order to process performance per criteria.

When using AHP one should be aware of certain drawbacks. A scale from 1 to 9 has been used in the assessment but when another scale, for example 1 to 29, would have been used the end results may have changed. The maximum relative importance between two indicators is 9. However due to stepwise comparison the final relative difference in importance can be larger than the scale value (9 in this assessment) but nevertheless it limits the distance of indicators. This could cause problems when the relative importance of aspects lies very far apart.

The AHP method is usually not used for sets of more than 7 indicators (Coyle, 2004). However in the tool 13 categories will have to be rated. This larger number of indicators increases the risk of inconsistent answers.

8.3.3.2.1 Method of acquiring AHP scores

In this section the method of acquiring AHP scores is discussed. The result from this acquisition of weightings will be discussed in the next section. In this thesis AHP will only be used to determine the relative importance of indicators. However for acquisition of these weightings a pair-wise comparison between all indicators will have to be made. This has been done with the help of a questionnaire. The questionnaire that was used can be found in the Appendix B.

A set of 78 indicator-pairs will determine weightings of the 13 main categories. Two sets of 3 sub ratings were used. The sub-categories transparency, corruption & bribes paid and weapons or (other) unethical cargo were combined in the category Ethical policy. The category local position of the company was also divided in three sub-ratings being; local partnerships, contribution to society and local hiring of senior staff.

In order to get the most objective answers the order the questions on pair-wise comparison per set are asked in random order. Also which of the pair as to be related to which is random.

Relative importance is indicated by a scrollbar. This scrollbar is supposed to leave in the centred position in case of equal importance. When either one of the indicators is believed to be of a higher importance the scrollbar is scrolled towards that indicator while a figure indicates the importance. Surveyed may choose to indicate a moderate favour, a strong favour, a very strong favour or a highest possible or extreme favour indicated by respectively a value of 3, 5, 7, or 9. Intermediate values may be used when compromise is needed.

It was asked to rate the relative importance of an indicator based on a normal or medium severity and when applicable related to the impact on one person.

The questionnaire was completed by three persons within ABN AMRO. These persons were selected for being in a senior position capable of influencing ABN AMRO investment choices. The first person asked to complete the questionnaire was Gust Biesbroeck, Head of Transportation and thus involved in commercial choices of ABN AMRO within shipping. Second Karianne Tieleman, Head of Risk and Portfolio Management Energy & Transportation involved with risk and portfolio management was asked to complete the questionnaire. Maria Anne van Dijk, Senior Advisor ESE Risk & Policies representing the general perception of ABN AMRO on sustainability was the third asked to complete the questionnaire.

Feedback received from a participant revealed that they had trouble weighting the indicator pairs. It was felt like comparing ‘apples and oranges’³³.

8.3.3.2.2 Results and AHP scores

It was explained in the previous section how questionnaires were used to acquire ratings for the indicators. The anonymised results of each questionnaire will be discussed in this section. The results of each questionnaire can be found in Appendix C, Appendix D and Appendix E. The questionnaires are represented in random order and will only be referred to by a number in this thesis report for privacy reasons.

It was found that the consistency ratio for most rankings was too high to be at the normal acceptable level of 0,1. In Table 8-3 the consistency ratios for the criteria set and the two sub/criteria sets can be found.

| Questionnaire | 1 | 2 | 3 |
|---------------------------------------|--------|--------|--------|
| Consistency Ratio | 0,3256 | 0,2847 | 0,1495 |
| Consistency Ratio (Ethical policy) | 0,0000 | 0,3168 | 0,1169 |
| Consistency Ratio (Local Positioning) | 0,0079 | 0,3869 | 0,2754 |

Table 8-3: Consistency ratio's found

These high values of the consistency ratio's, indicating a high inconsistency may be because people are often unable to “estimate precisely measurement values even from a known scale and worse when they deal with intangibles” (Staay, 2003). Because these high consistency ratios one could correct the questionnaires by asking participants to review certain questions. This reviewing of questions was not done for the assessment in this thesis.

When reviewing the questionnaires in more detail they all show a similar result. Some ‘general inconsistency’ was observed for about 1 to 5 questions per questionnaire and on top of that high inconsistency was observed when loss of life was concerned. Loss of life was found to be the most important social indicator for each of the questionnaires. This could also be the reason for a relative high inconsistency there. When all are rated with the highest importance no distinction is made based on the other indicator of the pair.

However the consistency ratio of the AHP questionnaire is high (indicating relative high inconsistency) and the questionnaire has been experienced as being difficult to complete, the

³³ Expressed in Dutch (“appels en peren vergelijken”), Maria Anna van Dijk e-mail, 19-07-2013

answers of the three participants are rather well correlated. Correlations between the surveys that were found can be found in Table 8-4.

| 1-2 | 2-3 | 1-3 |
|------|------|------|
| 0,93 | 0,83 | 0,87 |

Table 8-4: Correlations between the 3 questionnaires

High correlation shows a consistent view amongst the surveyed decision makers within ABN AMRO of the relative importance of the different indicators that were selected in order to determine the social sustainability.

To give a clear representation of the scores and the relative importance Table 8-5 with colour scheme has been made. The relative high correlation is also reflected in this table.

| Questionnaire | 1 | 2 | 3 | avg |
|--|--------|--------|--------|--------|
| Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 0,0928 | 0,0352 | 0,0840 | 0,0707 |
| Prohibited labour (child/forced labour) | 0,1978 | 0,1312 | 0,1804 | 0,1698 |
| Health of employees | 0,0778 | 0,1197 | 0,0308 | 0,0761 |
| Safety of employees | 0,1148 | 0,1817 | 0,1397 | 0,1454 |
| Human Capital Development (training) | 0,0125 | 0,0264 | 0,1032 | 0,0474 |
| Facilities and services on-board for crew | 0,0257 | 0,0099 | 0,0479 | 0,0278 |
| Retention of crew (returning after leaves) | 0,0222 | 0,0455 | 0,0706 | 0,0461 |
| Ethical policy | 0,0260 | 0,0146 | 0,0372 | 0,0260 |
| <i>Transparency</i> | 0,0037 | 0,0010 | 0,0039 | 0,0029 |
| <i>Corruption policy & Bribes paid</i> | 0,0112 | 0,0105 | 0,0108 | 0,0108 |
| <i>Weapons or other unethical cargo</i> | 0,0112 | 0,0032 | 0,0225 | 0,0123 |
| Anti-competitive behaviour | 0,0133 | 0,0186 | 0,0159 | 0,0159 |
| Handling of complains (Influence in lives through ...) | 0,0163 | 0,0079 | 0,0244 | 0,0162 |
| Health (Influence in lives through ...) | 0,0506 | 0,0897 | 0,0506 | 0,0636 |
| Local Positioning | 0,0258 | 0,0167 | 0,0182 | 0,0203 |
| <i>Local partnerships</i> | 0,0118 | 0,0012 | 0,0112 | 0,0081 |
| <i>Contributions to society</i> | 0,0033 | 0,0117 | 0,0049 | 0,0066 |
| <i>Local hirements of senior staff</i> | 0,0108 | 0,0038 | 0,0021 | 0,0056 |
| Loss of (one) life (non-crew) | 0,3243 | 0,3029 | 0,1971 | 0,2748 |

Table 8-5: Scores found per impact using AHP

In order to come up with one relative importance value per indicator the average of the three questionnaires is used. This average is shown in the previous table in the most right column. The weightings presenting the relative importance that are now acquired can be used to determine the impact of a sustainability measure or innovation.

The results of the main criteria are expressed in percentages adding up to one. The relative weightings of sub-criteria are to be multiplied with the criteria they are part of to come to the real relative weighting of each sub-criteria as part of the full set.

8.3.3.2.3 Intermediate Conclusion with respect to AHP

AHP was used in this thesis for the determination of relative weightings of the social aspects of sustainability. Obtaining weightings for the social dimension of sustainability by the use of AHP was suggested by Krajnc and Glavic(Krajnc & Glavic, 2005).

A problem which arose was the inconsistency. The consistency of the questionnaires was below the minimum requirements usually used to accept the results. It was found when checked for the causes of inconsistency that the inconsistency was partly caused because a scale with a maximum deviation of 9 was used and because one aspect was considered to be far more important. This aspect was (almost) always rated with 9 which caused inconsistency between the other aspects which had different relative rating amongst each other. Responses received on the survey also indicated people had trouble with determining the ratings.

The questionnaire consisted of a comparison of 78 pairs for the main criteria and another 6 for two sets of sub criteria. This large number of questions might have contributed to the inconsistency and the experienced trouble with ratings. Using more sub-criteria could reduce the number of pair-wise comparisons and thus reduces the number of ratings.

In Krajnc's paper 'AHP model for the container port choice in the multiple-ports region' Chou used a survey under 5 top decision makers to apply the AHP method on the choice for a container port by a shipping company. In this thesis only 3 decision makers within the transportation and sustainability department were surveyed. However since the correlation between the three different surveys is high the opinion of the importance of aspects within the social dimension is rather consistent between ABN AMRO's decision makers and thus the answers the results from the survey are used later in the case study.

8.3.4 [Monetization of Social](#)

The measurement of the social dimension is being done rather different than the method that was used for the economic and environmental dimension. The definition of sustainability only requires the prevention a reduce in human's well-being.

The unit used for social is a score based on impact and relative importance that was determined. Determining the impact was done by assessing the number of people affected, the severity of the impact and by assessing the time frame. Peoples increased risk aversion for larger consequences was not included. Next the relative importance of the different indicators was determined. This relativity was determined comparing an impact to the loss of one life impact.

Since no real unit was used and the measurement in this thesis only requires determining that human well-being is not reduced no monetization is applied for the social dimension. The relative importance that was assessed based on AHP is regarded not be a good reference for monetization. If this is would have been the case however one could use the valuation of one of the impacts and uses the relative importance for the monetization of all impacts. One impact that is been expressed in money is the value of life.

8.4 Chapter Conclusion

In this chapter a measurement scheme for sustainable investments onboard ships was designed. This was done with the help of the requirements, choices and information from chapter 7.

Per dimension units were defined. It was determined that the internal economic dimension would be assessed based on the NPV. In order to determine the NPV the change in the different cash flows due to the investment will have to be assessed. The changed cash flows that were identified are investment and disinvestment, cash flows relating to the financing, changes of flows with respect to costs like opex, risk related costs, fuel and port charges and finally the changes in income. Using the cash flows and the moment of occurring an NPV can be calculated. This NPV is used to express the economic impact in a single value. The NPV does not need to be monetized since it is already expressed in monetary units.

For the environmental dimension also a unit was determined. Chosen was to use a footprint for the representation of the external environmental impacts. The footprint will be used to assess the changes of air, soil and water emissions per year. The assessment of air emissions consists of CO₂, refrigerants, VOCs, NO_x and SO_x. The footprints for these emissions was determined at 0,556 hectare, 722,222 hectare, 0,234 hectare 0,626 hectare and 0,840 hectare per ton respectively. The footprint for soil emissions is based on wastes and includes the material consumption to produce the waste and area usage. Using the standard split for the materials of waste a footprint of 0,485 hectare per ton was found. Hazardous waste is not assessed separately in this thesis. Water emissions were intended to be included in the assessment but due to insufficient information to determine a footprint of water emissions water emissions are not included in the assessment. To monetize these impacts a cost of \$ 22,79 per hectare was found for each year the impact reoccurs.

The third dimension, the social dimension is expressed in score which acts as unit. This score expresses the impact in human well-being and needs to be positive in order to show that no deteriorating is caused by the investment in sustainability. To do so a number of indicators are used to express the internal and external dimension of the social sustainability dimension. Internally the well-being of the crew is assessed based on facilities and services on board, retention rate of crew and the protection of the health and safety of the crew. Related to the labour conditions the fair labour practises and the use of prohibited labour are assessed. Where the internal aspects focus on the crew externally the focus is on other people that are affected. The transparency is assessed. This is an example of an indicator based on policy. Other indicators are the corruption policy and bribery and the transportation of weapons or (other) unethical cargo. The influences a company may have in peoples life is assessed by the assessment of anti-competitive behaviour, the way complains are handled and the influence a company has on people's health. A companies local positioning is accessed via the assessment of local partnerships, contributions to society and local hiring of senior staff. Finally the loss of life resulting from a company's behaviour is included as being an external indicator. For each indicator the number of people effected, the severity and time frame are assessed. For loss of life impact duration of thirty years was assumed. Also the relative importance was determined by the use of AHP to express the relative impacts. Monetization is not done for the social dimension since only the decline of well-being was to be assessed. This can be done without monetization.

In the next chapter with the information provide in chapter 8 a tool will be developed that can be used to assess the sustainable development as a result of investments in sustainable equipment or measures by clients of ABN AMRO.

9 Tool

In this thesis an assessment of sustainable development in shipping due to the investment in sustainable equipment or measures has been done. For this assessment in chapter 2 sustainability was defined and in chapter 7 requirements were formulated and existing measurement schemes were reviewed. Based on the information in chapter 7 and in chapter 8 a measurement scheme was designed. That measurement scheme is used in this chapter to develop a tool that can be used to assess the impacts of a sustainable investment for ABN AMRO's clients based.

The tool needs to be provided with the actual impacts change (for economic, environmental and social impacts). The acquisition of the data of the indicators is not included in this thesis. The impacts are not calculated based on the ship type or the innovation invested in. It therefore is not required to provide operation profile, loadings, savings or particulars of a ship or innovation. Changes of these properties should have been reflected in the change in emissions as a result from the measure or innovation. Further research could help to extend the tool such that with data based on ship type, operational profile and specified savings per innovation or measure an estimation of impact per dimension could be given.

A simple example to demonstrate this multidimensional impact is given here. When looking at the implementation of LNG onboard a vessel the economic dimension would be impacted because of the investment and change in fuel costs. Also such a choice would reduced environmental impacts and thus change the environmental footprint. Finally the social impact could change due to a reduced emission of harmful substances or due increased risk resulting from a more dangerous fuel on board.

The first paragraph of this chapter will discuss a number of basic parameters. The three paragraphs following will discuss the implementation of the emissions for each dimension in the tool. Next the results and the presentation of results will be discussed. In section 9.6 a case study will be used to test the tool and to show the way the tool works and presents its results. This paragraph is followed by the chapter conclusions.

9.1 **Basic parameters**

In the tool a number of basic parameters are required for a correct assessment of the impacts. Financial impacts can in this tool be expressed in euros or dollars. When an impact is expressed in euros it will be converted to dollars by one exchange rate. This rate is to be defined by the user.

Secondly the monetization parameter for the footprint in the environmental dimension is to be defined. In section 8.2.4 the value of \$ 22,79 per year was found. This amount is provided as standard but can be adjusted.

The third and final basic parameter that is to be assessed is the discount rate. The discount rate is important for the determination of the NPV. It determines the discount for future cash flows. A high discount rate will make that future cash flows are discounted more, resulting in lower valuation of these future cash flows. The start of the project or first impact may differ from the month were discounting should start the basic month can be specified.

Figure 9-1 shows the form to provide these variables.

Basic values

Investments

| | Amount |
|--------------------------|------------|
| Exchange rate 1 euro | 1,3 (\$) |
| Cost per hectare (/year) | 22,79 (\$) |

Discount rate

| | |
|---------------|-------|
| Discount rate | 8 (%) |
| Basis month | 0 |

Next

Figure 9-1: Tool - Form Basic values

9.2 Economic impact assessment

The measurement of the economic dimension is based on the change in company'; cash flows resulting from the choice to invest in a sustainable measure or innovation. In this section the assessment of the economic dimension by the tool will be discussed.

9.2.1 Economic input for the tool

The elements that are to be included in the tool are all changes in cash flows. The indicators that are to be included are: investments, financing, costs and income. The indicators that are used were discussed in more detail in section 8.1.2. The indicators are assessed in the tool on a detailed level. Since in this thesis the result is expressed in the form of a NPV it is important that all cash flows are provided in combination with the moment of occurrence. As an example one of the forms used to assess indicators for the economic dimension is shown by Figure 9-2.

| Investments | Amount | \$/€ | Effective month |
|-------------------------|--------|------|-----------------|
| Pre-payment | 0 | \$ | 0 |
| Investment | 0 | \$ | 0 |
| First renewal | 0 | \$ | 0 |
| Second renewal | 0 | \$ | 0 |
| Subsidies | 0 | \$ | 0 |
| Disinvestment / removal | 0 | \$ | 0 |

Figure 9-2: Tool - Form Economic Impacts (1/3)

The economic impact is expressed with the use of an NPV calculation. To be able to perform an NPV calculation the moment of occurrence is required. It is chosen to work with monthly intervals. And thus every time interval will have to be transformed to a monthly interval. For simplicity all cash flows are expected to take place at the first day of the month. Note that for interest this means an interest payment in (for example) April is the interest over previous month(s) (e.g. January – March) outstanding. The tool works by constructing a time-line including all cash flows at the moment of occurrence in order to help valuating all cash flows. The timeline is then used for NPV calculations.

Because the tool should be able to spend a complete lifetime of a ship the span of the time frame of the tool is chosen at 31 years. This length has been chosen to represent the entire life of the vessel. It ranges from -12 months to month 359. Allowing impacts occurring for the start of the project to be included up to one year in advance. This could be extended if necessary. It is intended to use month 0 as the start of operation and prepayments can be used in the months before.

9.3 Environmental impact assessment

The assessment of environmental impacts is done based on a split per emission type. Air, soil and water emissions have been split for qualification of impacts and are treated separately in the tool as well. The indicators that are used to express the different impacts are expressed in emission change per tons. The footprint areas per ton of emission that has been determined in section 8.2.3 is used in the tool. In Figure 9-3 the form used to enter environmental impacts is shown.

Environmental Impacts

Water emissions

Anti-fouling (tons)

Oil spills (tons)

Ballast water impact (tons)

Air emissions

CO₂ (tons)

Refrigerants (tons)

VOC (tons)

NO_x (tons)

SO₂ (tons)

Soil emissions

Build-up area (tons)

Hazardous or toxic waste (tons)

Waste generation (non hazardous) (tons)

Use standard split for waste? ☒

Waste split

| | |
|--------------|---|
| Organic | <input type="text" value="76.47"/> (%) |
| Paper | <input type="text" value="11.27"/> (%) |
| Plastic | <input type="text" value="4.90"/> (%) |
| Glass | <input type="text" value="4.61"/> (%) |
| Metal | <input type="text" value="2.75"/> (%) |
| Total | <input type="text" value="100"/> (%) |

Previous Next

Figure 9-3: Tool - Form Environmental Impacts

9.3.1 Air emissions' input for the tool

For air emissions the tool will need information on emitted tonnes for CO₂, Refrigerants, VOCs, NO_x and SO_x. In the tool a split has been made between emissions which are Green House Gases (GHGs) and emissions which have environmental impacts due to acidification.

The GHG emissions consist of CO₂, refrigerants, VOCs (excluding Non-Methane VOCs). The change in emission is multiplied with the Global Warming Potential and the base area which is needed to compensate for 1 ton of CO₂. GHG compensation is based on area to compensate for the global warming effect and was determined in section 8.2.3.1. The results are expressed as an area that is required for the compensation of global warming effects of GHGs.

For NO_x and SO_x the calculation is similar. The tons of gases related to acidification that are emitted are transformed to footprints based on the data from section 8.2.3.1. The footprint for acidification gases is based on the area needed to absorb these acids.

9.3.2 [Soil emissions' input for the tool](#)

The soil emissions are made up by build-up area, waste and hazardous or toxic wastes generated. The change in these emissions is to be provided in tons. Since no appropriate method for determining hazardous or toxic wastes' footprint was found hazardous or toxic waste emissions cannot be entered and are not assessed in the tool.

In the assessment of the footprint of wastes the energy and land needed to produce the original product are included. A detailed split is per material is used. A standard split is suggested but can be adapted for specific cases. Additionally a recycled percentage may be entered reducing the footprint area. The footprint and split data that are used were provided in section 8.2.3.2. Build-up area includes all area which is used for buildings or is otherwise permanently occupied excluding the area's needed for the production of supplies or processing of waste.

9.3.3 [Water emissions' input for the tool](#)

Water emissions were excluded from this research because not enough data for the determination of a footprint was available. In the tool the fields used for entering water emissions have been disabled as can be seen in Figure 9-3.

9.3.4 [Total environmental](#)

The separate footprints for air, soil and water emissions are summed up to one total footprint in hectare for the change in environmental impact. It thus assumed that no combined areal use exists.

The total impact change in the environmental dimension has now been determined. However additionally an impact expressed in monetary units can be used to provide better understanding and the ability to compare. In section 8.2.4 a monetization method for the environmental dimension has been developed resulting in a cost of \$ 22,79 per hectare. Since this amount is based on one year costs every year a measure or innovation is active these costs are to be included.

Environmental impacts were not previously discounted. However for environmental impacts expressed in monetary units it would be useful to express these 'costs' per year with discounted figures. Therefore the reoccurring environmental impacts expressed in monetary units are discounted.

9.4 Social impact assessment

In this paragraph the assessment of third and final dimension of sustainability by the tool is discussed. Social impacts are presented in the form of a score. The calculation of the score is performed by the tool based on the indicators.

9.4.1 Social input for the tool

Social sustainability is assessed by thirteen indicators. These thirteen indicators, or criteria, are composed of main 11 criteria and 2 other criteria which are composed of 3 sub criteria each are included in the tool. The relative importance for each indicator is normalised such that loss of life has become the base value (one). Together with the effected population, the increase or decrease of the severity of an impact (relative to a 'normal' or 'medium' impact of that sort) and the reoccurrence or time (in years) the impact per indicator is determined. This is done by calculating the product of these aspects per indicator. The form assessing these impacts is shown below.

Since the indicator impact is determined, a total social impact can be calculated. Because all scores include the relative importance the changes in total social impact can now be calculated by adding all partial scores to one total.

The summated score shows the impact of a measure and can be used to compare several measures. In order for a measure or innovation to be sustainable according to the definition used in this thesis the impact in social dimension may not be negative. Since the impact is only assessed to prevent decline of human's well-being no monetization for the social dimension is applied.

| Internal Social aspects | Number of people affected (per year) | Duration of impact | Positive Developments | | | Change in severity | | | Negative Developments | | |
|--|--------------------------------------|--------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | Significant (>50%) | Medium (10-50%) | Minor (<10%) | Minor (<10%) | No Change | Minor (<10%) | Medium (10-50%) | Significant (>50%) | |
| Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 0 (#) | 0 (years) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Prohibited labour (child/forced labour) | 0 (#) | 0 (years) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Health of employees | 0 (#) | 0 (years) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Safety of employees | 0 (#) | 0 (years) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Human Capital Development (training) | 0 (#) | 0 (years) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Facilities and services on-board for crew | 0 (#) | 0 (years) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Retention of crew (returning after leaves) | 0 (#) | 0 (years) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Figure 9-4: Tool - Form Social impact (1/2)

9.5 Results

The results are presented for each dimension separately by the tool. The economic dimension is expressed in the NPV of the investment, the impact in the environmental dimension is expressed in a footprint required for compensation and absorption of the environmental emissions and the impact in human well-being is expressed by the use of a social score. The results are presented in the unit for which each dimension was assessed. Besides this numerical result the impact can also graphically presented by the use of a bar diagram. Again this is expressed in the selected unit per dimension. Social impact is either positive and in accordance to the definition or negative showing the investment is not sustainable according to the used definition.

Figure 9-5 shows an example of the way results are presented when an assessment is completed both the impact in specific unit per dimension is presented. There is no trade-off of any kind between dimensions. To determine the relative scaling of the impacts in the different units it was chosen to use the scaling based on the monetized impacts. The social impact is always sized 0,5 or -0,5 times the maximum impact when social impact is positive or negative respectively. In case of a neutral impact the bar is sized 0 and thus not visible.

The figure below shows that the NPV of the project is negative. The returns of the investments are not profitable with the used discount rate. A positive impact on the footprint area was found which means the footprint is reduced. The social impact is positive which is in accordance to the definition of sustainability.

Based on a result as the one presented below ABN AMRO should determine if its client can bare the reduce in the economic dimension and whether the capital that is needed for this investment reduces the impact in the environmental dimension sufficiently. This decision is not part of this thesis and will have to be made on a case by case basis depending on both sustainability goals, requirements for profitability, available capital and other business opportunities.

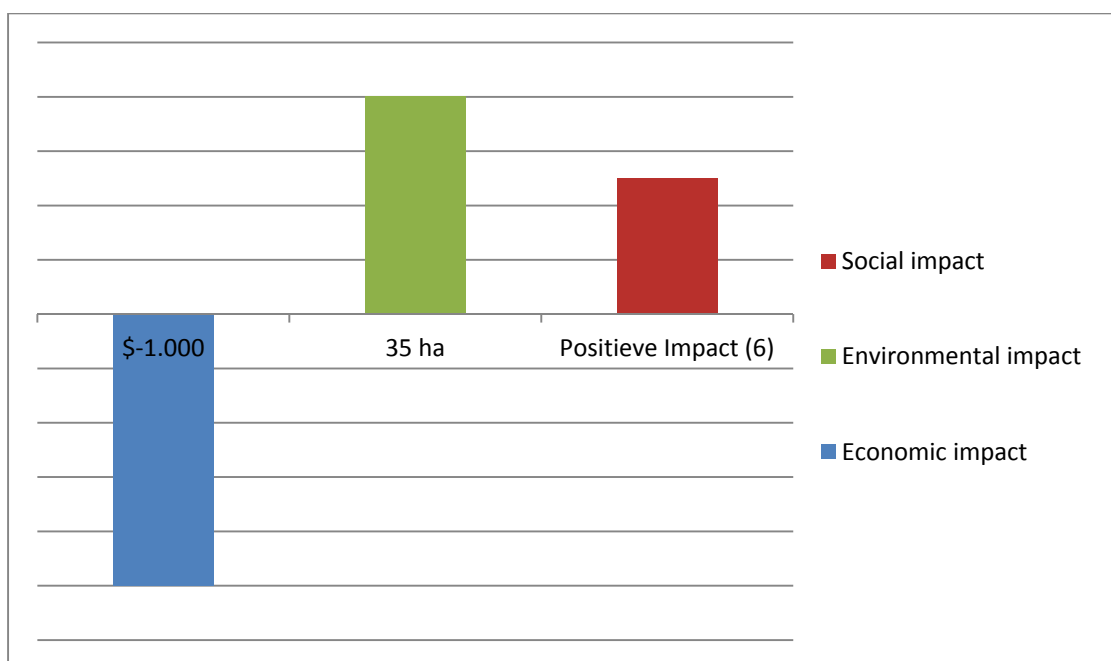


Figure 9-5: Tool - Example result, unit per dimension

The results above were presented in a different unit per dimension. However impacts could also be expressed in one unit. In that case monetary units are used. The monetized results are being heavily influenced by the assumptions used for the monetizing of the results. Also the discount rate has a significant influence on the discounted results expressed in monetary units. This influence is most strong for long term projects. The same example results are presented in monetized units in Figure 9-6.

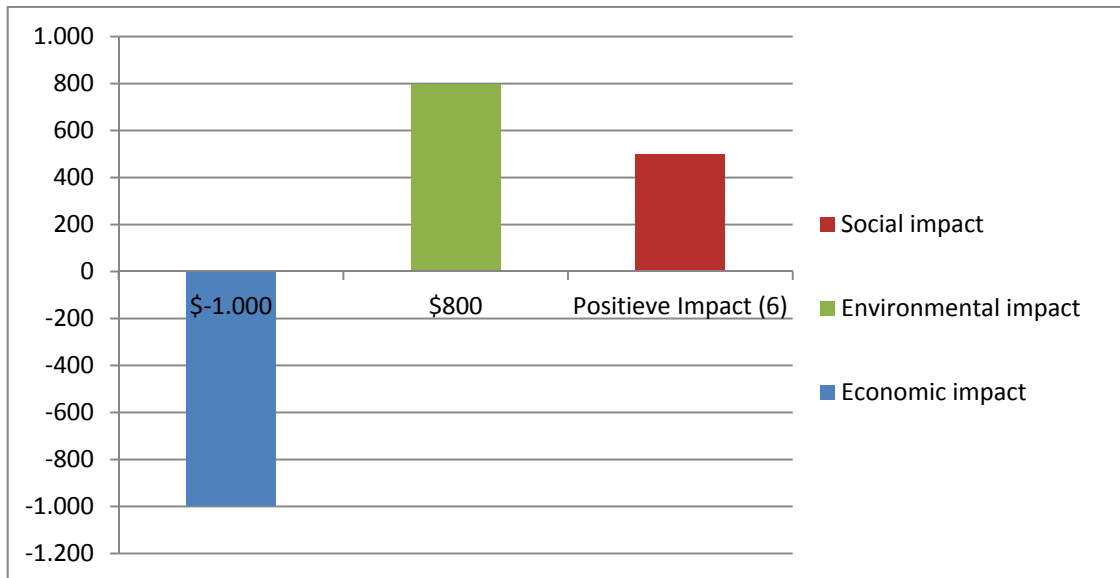


Figure 9-6: Tool - Example monetized result

When expressed in monetary units the unit on the axis does change but since the bars were already based on the monetary impact their size is unaffected.

9.6 Case study of the impact of a Scrubber

In this paragraph a fictional case study will be used to test the tool and show how it works. This example is also used to show a possible result of the tool. In the paragraph following the tool will be reviewed based on the results found in this case study.

The case study is based on a container ship on which a scrubber is installed. It is assumed enough space on board the ship is available and that the scrubber will be a seawater scrubber. The case is fictional but is tried to present the case as realistic as possible.

The scrubber is an innovation aiming to reduce SO_x emissions. It was discussed in section 6.11 and properties and data were provided in that chapter are used. The ship that is used was part of an assignment in the report 'Green Ship of the Future' which conducted a study to the possibilities of reducing exhaust gas emissions (Nielsen, 2009).

9.6.1 Ship particulars

The installation of a scrubber on a container ship will be used as example. For this containership a so called A-Class container ship as been operated by Maersk Line is taken as example. This ship has also been used as an example in the Green Ship of the Future report (Nielsen, 2009). It is not the objective here to present the real and accurate data but the example is used to show possible outcomes.

The main particulars for this ship are found in Table 9-1.

| | | |
|----------|----------|-----|
| Loa | 352,25 | m |
| Breath | 42,80 | m |
| Depth | 24,10 | m |
| Draught | 15,00 | m |
| DWT | 109.000 | ton |
| Speed | 26,50 | kn |
| Capacity | ± 8500 | TEU |
| ME | 63000 | kW |
| PTI | 6000 | kW |
| AE | 1 x 2590 | kW |
| | 3 x 3455 | kW |

Table 9-1: Ship's particulars

To sail at the design speed the ship will require its main engine to operate at 56000kW, additionally the Power Take In (PTI) delivers 6000kW which due to losses require a diesel generator to deliver 6771kW. Based on 2960 kW of average electrical load and similar losses the total power requirements are 56000kW from the ME and about 10000kW from the auxiliary engines.

In Figure 9-7 the typical load profile of a post-Panamax container ship is presented. CSR = 90% MCR. In the report the profile is assumed to be valid for 75% of the time. It is assumed that this load profile is representative for every journey.

The fuel consumption can be estimated based on the cruising speed and an electrical load at sea of 2960kW. A specific fuel consumption of 165,3g/kWh for the ME and 191g/kWh for the AE is used. In the report this calculation is done resulting in 268 ton of diesel or 283 tons of HFO per 24 hours.

While sailing at cruising speed and using HFO with a sulphur content of 3% emissions are estimated to be 878 tons of CO_2 , 26 tons NO_x , 17 tons SO_2 per 24 hours.

The remaining 25% of time is regarded to be port time with no ME load. The electrical load is estimated to be 2020kW during port time.

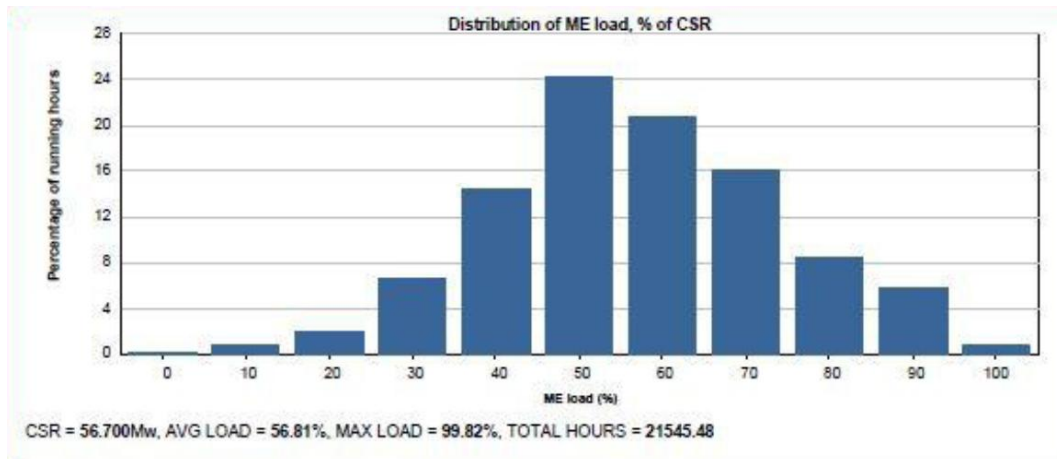


Figure 9-7: Typical load profile of a post-Panamax container ship (Nielsen, 2009)

9.6.2 The Scrubber

Scrubber details were discussed before in section 6.11. The power demand to operate the scrubber is expected to be about 367kW or 2%. The scrubber will have a certain power demand itself. The scrubber power demand is estimated by Wärtsilä to be 0,4 – 0,6%. With a maximum of 1% at top ship speed. 0,6% power demand will be used (Wärtsilä, 2012). The scrubber will discharge 3110m³/h of used water (Nielsen, 2009).

9.6.3 Price difference HFO-MGO per kWh

A scrubber helps a company to comply with regulations. In order to calculate the cost or saving of installing a scrubber it should be compared with other methods to comply. Another way to easily comply is switching to low sulphur fuel. In order to do so the additional costs for fuel switching will also have to be calculated. In the Entec report on SO₂ abatement a premium of €₂₀₀₀ 64 (€₂₀₁₃ 84,6 (Centraal Bureau voor de Statistiek, 2013)) is assumed between Low-Sulphur HFO and 'normal' HFO (Ritchie, Jonge, Hugi, & Cooper, 2005).

In this report it is assumed LSHFO and HFO have the same specific fuel consumption and that the vessel will use either LSHFO or normal HFO for the fuelling of both its ME and AEs.

9.6.4 Input

In this section the values that are used to assess the scrubber's impacts are discussed. These indicator values are the input for the tool. This section is divided in 4 parts discussing basic values, economic input, environmental input and the social input.

9.6.4.1 Basis values input

In order to use the tool a number of inputs will be given. The first set are basic values used for calculation with respect to exchange rate and conversion for monetization and NPV calculations. In this example the exchange rate is assumed to be \$ 1,30/€ 1,00. The cost per hectare per year is used as it was determined in section 8.2.4. This results in a cost per hectare of \$ 22,79 per year. The discount rate is assumed to be 8% with month 0 as basis meaning that cash flows after this month will be discounted and before will be increased with a mark-up.

9.6.4.2 *Economic input*

On the next three forms following the basic inputs the economic inputs are to be indicated. Remember that the change in impacts is assessed. The first of the three forms concerns the investment. In this case it is assumed that no prepayment or renewals are to be paid and that no subsidies or removal costs are part of the project. This leaves only one investment of the purchase and installation of the scrubber.

The investment cost of the scrubber is based on the data that was discussed in section 6.11 using the information provided by Wärtsilä. Wärtsilä estimated a start cost of € 1,6M and additionally € 70/kW. Installation costs would add another 50-75%, 62,2% is used (van der Klip, 2013).

Based on the previous calculations calculating the total power demand the scrubber should be able to handle 66000kW. A scrubber for this size would costs based on Wärtsilä's data:

$$€ 1,6M + 66.000 * € 70 = € 6,2M$$

When the installation costs are included:

$$€ 6,2M * 1,622 = € 10,1M$$

This figure is included in this case being the investment.

An estimation of the scrubber cost based on the Entec data provided in the same section would estimate the cost at € 11,1M. Both prices are in the same range.

The second of the three economic forms allows entering financing details. It is assumed that \$ 8,5M is financed. That is about 65% financing. A fee of \$ 100k is assumed and the loan is assumed to have a profile and term of 36 months. Interest on this loan will be assumed to be 6%. And down payments and interest payments will be done every three months and all finance related amounts are assumed to take place or be effective in month 0. No second debt facility is assumed to be in place.

The figures used for the financing of this fictional case are assumptions since the financial position of the company, the other debt facilities on the assessed and the employment are not known.

The last form concerning economic impacts lets the user adjust for costs and income. In section 6.11 the operational costs of a scrubber estimated by Entec were reported to be between 1 and 3% of the new price (Ritchie, Jonge, Hugi, & Cooper, 2005). Since the scrubber will be in the large category 1% is assumed at € 1M/year or € 83,3K/month. These costs will be escalated for 15 years at 3% including inflation and increasing cost of older equipment.

The fuel costs will be lower for the time the vessel is either in port or in (S)ECAs. At other moments the ship is expected to have used HFO anyway. The 'Green Ship of the Future' report expected time in port to account for about 25% of total, additionally 10% of the time is assumed to be in ECAs (Nielsen, 2009). While sailing the ship uses either 268 tons of diesel or 283 tons of HFO per 24 hours. Because the ship is 10% of time in ECAs 36,5 days it would have to use diesel instead of HFO. This comes down to 9782 tons of diesel that now is replaced with 10330 tons of HFO.

The 25% of the time the vessel is in port its power requirements is much lower. Based on the electrical load of 2020kW the power requirements for the auxiliary engines are about 2130kW with 95% efficiency as was used in the 'Green Ship of the Future' report. Also with the specific fuel consumption from the report; 191 g/kWh the consumption in port is calculated to be 9,75 tons per day. Since the vessel is 25% of time in port this will be 92,25 days times 9,75 tons 890 tons of diesel or 940 tons of HFO.

Assuming the vessel will keep using HFO but switched to low sulphur during these periods yearly 11270 tons of HFO are to be replaced with low-sulphur HFO. Applying a premium of € 86,4 as was

estimated in the Entec report and corrected for inflation a saving in fuel of € 973k/year or € 81,1k/month can be realised by applying scrubbers. Savings are also escalated with 3%. This escalation represents the inflation and increasing cap between HFO and Low-Sulphur HFO. The application of a scrubber will influence the power demand. The total fuel consumption is expected to rise with 0,6%. Assuming a HFO price of \$ 600/ton this result in an additional cost of \$ 282K/year or 23,5k/month.

The changes in fuel consumption and costs are presented in Table 9-2;

| Mode | Time | <u>Basis (no scrubber)</u> | | <u>Scrubber</u> | |
|--------------|---------------|----------------------------|--------------|-----------------|-------------|
| | | HFO (ton) | LSHFO (ton) | HFO (ton) | LSHFO (ton) |
| Operating | (65%) | 67145 | 0 | 67548 | 0 |
| ECA | (10%) | 0 | 10330 | 10392 | 0 |
| Port | (25%) | 0 | 940 | 946 | 0 |
| Total | (100%) | 67145 | 11270 | 78885 | 0 |

| | | | |
|----------------|-----------|-------------|------------------|
| Premium LSHFO | 11270 ton | -86,4 €/ton | € -973.728 /year |
| Additional HFO | 470 ton | 600 \$/ton | \$ 282.294 /year |

Table 9-2: Changes in fuel consumption (HFO and LSHFO)

Port charges or risk related costs are in this case assumed not to change. Also no income changes were included in this assessment.

9.6.4.3 Environmental input

This section will discuss the inputs related to the environmental changes. No water emissions are included in the tool for now so the changes in water emissions are not assessed.

SO_x

The changes in air emission are to be based on the difference between operation using HFO with an average of 2,7% sulphur (see section 6.13.1) and Low Sulphur HFO with a maximum of 1% sulphur *and* the operation of only using HFO but with the appliance of a scrubber.

The SO_x emissions are listed in the table below split for the base case and the scrubber the SO_x production is calculated. Next the effects of the scrubber are applied. For these effect data discussed in section 6.11 is used. It is assumed that a scrubber reduces the SO_x emission with 95%. The total SO_x emission and the change in SO_x due to the scrubber is indicated. This change of SO_x is used in the tool.

| | <u>Basis (no scrubber)</u> | | <u>Scrubber</u> | |
|--|----------------------------|-------------|-----------------|---------------------|
| | HFO (ton) | LSHFO (ton) | HFO (ton) | LSHFO (ton) |
| Fuel | 67145 | 11270 | 78885 | 0 |
| SO _x (based on fuel) | 1813 | 113 | 2130 | 0 |
| Scrubber (-95%) | 0 | 0 | -2023 | 0 |
| Total SO _x after scrubber | | 1926 | | 106 |
| <u>Change of SO_x (ton)</u> | | | | <u>-1819</u> |

Table 9-3: Changes in Sulphur emissions (HFO and LSHFO)

CO₂

The 'green ship of the future' report estimates a CO₂ emission of 878 tons per 283 tons of HFO (Nielsen, 2009). Since it was calculated that the scrubber would consume an additional 470 tonnes of HFO an additional CO₂ emission of 1458 tons is expected. This is used in the tool.

Soil emissions

There is no change in soil emissions for the installation of the scrubber assumed. Since the scrubber which is applied is a sea-water scrubber it does not use additional consumables. Other waste generation is assumed to be not significant and thus not included.

9.6.4.4 *Social input*

The most difficult impacts to assess are social impacts. It is rather hard to define and determine the change in severity, the number of people that are affected and the duration of impact. This section will determine the inputs for the internal and external impacts.

First the internal social aspects are assessed. The effects of the installation of a scrubber are being assessed. Internally the scrubber installation is expected only to affect the indicator assessing the human capital development. The operation of the scrubber will require crew to be trained additionally. This could make crew less depend on the company. This is expected to affect only the crew, about 20 people, for the complete duration (i.e. 15 years).

Externally other indicators are used. The scrubber effects people's health due to the reduction of harmful substances, like SO_x, in the air people breath. Since this effect is small for a single ship the positive development is rated as minor. However the number of people that are affected may be large. Because the actual number is very difficult to estimate an assumption will have to be made. It is assumed about 50.000 people will be affected with minor changes during port time. When not in port no one will be affected is assumed. Since the vessel is only 25% of time in port this 50.000 will be multiplied with 25% resulting in an affected population of 12.500.

9.6.5 *Results*

In the previous section the different indicators that are used to express the impact in each of the three dimensions as well as for basic values were discussed. In this section the results of this assessment by the tool are presented. The results will be presented in the units that were selected per dimension as well as in monetary units.

9.6.5.1 *Presentation of results per unit*

The results provided by the tool are separated for each dimension. The results are thus presented for economic, environmental and social dimension separately. The separation assures that the different dimensions are not (unconsciously) combined. The first result presents the results in the unit per dimension. In order to scale the monetary conversion was used for environmental and economic dimension. Social is scaled 0,5 times the maximum impact. The results are presented graphically in Figure 9-8.

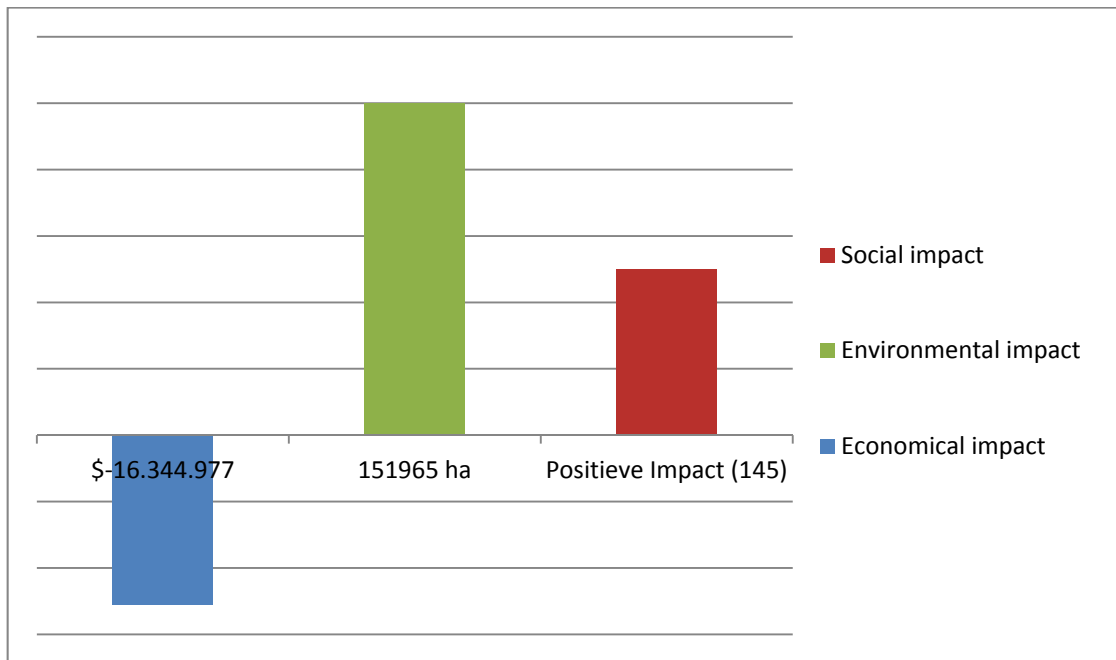


Figure 9-8: Tool - Scrubber case-study - result, unit per dimension

It was found that the installation of a scrubber will contribute to human's well-being since a positive value is shown for the social dimension. Both internally (additional training) and externally (reduced impact on people's health) the impact is positive.

For the economic impact a negative NPV was found of \$ -16,3M. The investment will reduce the value of the company based on the parameters that were used. Since the investment is about \$ 13M and the combined costs increase and savings increase the total monthly costs this figure seem reasonable.

The environmental footprint includes positive impact from SO_x reduction and negative impact from additional CO_2 emissions. It has positive value of 151965 ha. To put this in perspective this is 1/98009 of the total earth service (CIA, 2013a). Or about 0,001%. Given that at the beginning of 2012 104.305 ships were in service (UNCTAD, 2012), ships emitted in 2007 'only' about 8% of global SO_x emissions and other emissions besides SO_x are emitted indicates that the actual footprint is overestimated (Lauer, Eyring, Hendricks, Jöckel, & Lohmann, 2007).

9.6.5.2 *Presentation of results in monetary units*

The second way of presentation of results is in monetary units. Only economic and environmental impacts are transformed to monetary units. The impacts in each dimension are still presented separately but on the vertical axis now monetary impact are presented. Since the social dimension is not monetized and is used as a minimal requirement it is not presented in monetary units. It still is scaled with half the maximum impact, either positive or negative except in neutral impact when it is scaled 0. The presentation of environmental and economic dimension in monetary units risks that the bars are simply compared based on financial representation which is fact is a cross dimensional trade-off. The monetized results from the case study can be found in Figure 9-9.

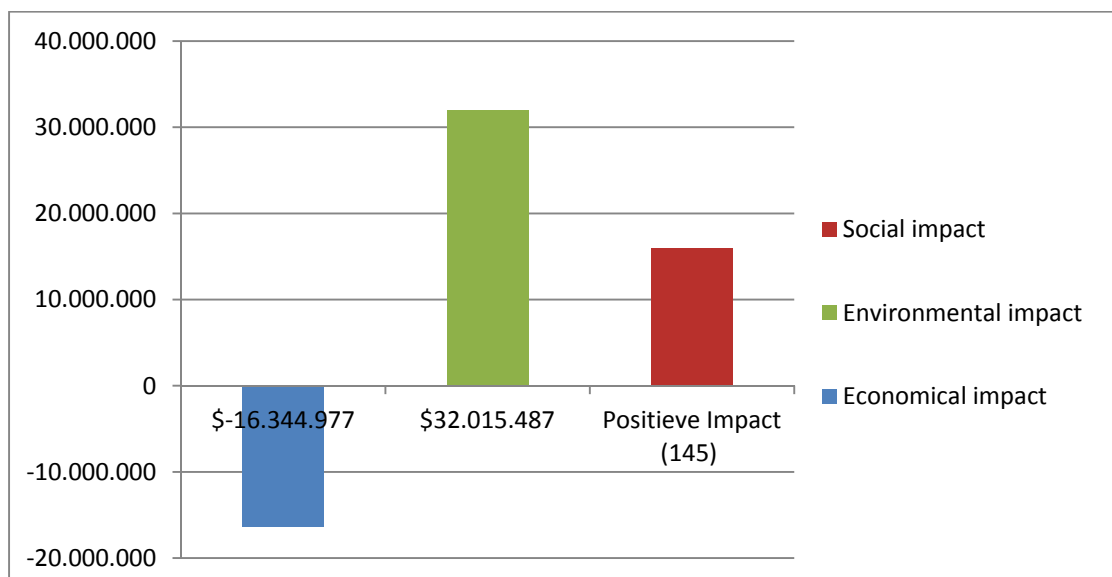


Figure 9-9: Tool - Scrubber case-study - monetized result

Other than the unit of representation the actual representation is not changed. In the social dimension still a positive impact was found. The impact in the economic and environmental dimension are still both negative.

9.6.6 Intermediate Conclusion

This section the in this thesis developed tool was used for the assessment of a scrubber. This case study showed the way this tool works and at the same tested the usage of the tool.

The example used was based on an 8500 TEU, 109000 DWT container ship with a total power demand in cruising conditions of about 66.000 kW. For the scrubber data was used that was provided in section 6.11. The scrubber is estimated to cost about € 10,1M and to require operational costs of 1% of the original price per year. It is expected to increase power demand by 0,6% and will save due to a price difference between LSHFO and HFO of € 84,6.

In this chapter the indicators that were used were discussed for the basic input consisting of exchange rate, cost per hectare and discount data. This was followed by the economic input including investment, financing, costs and income. The environmental input was limited to air emissions, no water or soil emissions were included. Finally social input consisting of human capital development internally and influence in human's health externally.

The assessment resulted a NPV of \$ -16.344.977, a footprint reduction of 151965 and a positive social impact. When environmental impact is also expressed in monetary units its impact is \$ 32.015.487. These results are represented in bar diagrams that were shown in this chapter.

The assessment returned an environmental impact reduction of the ships expressed in a 151965 hectare footprint reduction. Reviewing this figure indicates an overestimation of the environmental footprint impact of the ship.

The results that were found showed that the investment could be sustainable both the environmental and social dimensions profit from this investment. Whether the economic impact can be borne cannot be determined without more information on the company. The information acquired can be used by ABN AMRO to choose the investments it wants to support and wants to make capital available for.

9.7 Chapter Conclusions – Reviewing the tool

In this chapter the development of the tool has been discussed. The tool was based on the measurement method that had been developed in chapter 8 and aimed to assess the impact change due to the investment in sustainability by a client of ABN AMRO.

The tool is provided with indicator values. The indicators which were determined in chapter 8 express the change in a certain dimension. They are either part of the basic values, the economic input, environmental input or the social input. The basic values that are used have significant impact on especially for long term financially expressed results. Based on the investment assessed all or a number of indicators may be assessed.

The results from the assessment are presented per dimension. Dimensions are not combined. The representation of the economic dimension is done by the transformation of provided cash flows into a NPV of the investment, the economic dimension is expressed in hectares presenting the impact change and for the social dimension it is indicated whether the impact is positive, neutral or negative. The results are presented in a bar diagram where, because of different units, the scaling in monetary units is used. For social scaling is done based on the largest absolute impact and expressed with half that size. Alternatively also a representation expressed in monetary units can be done. The scaling does not change but the environmental impact is now also expressed in monetary units. The social dimension on not monetized and thus not represented in monetary units.

In the final section of this chapter a case study was used to show the way the tool works and present results as well as to test the tool. The installation of a scrubber onboard an 8500 TEU container vessel was used as case. This case showed results in separate units per dimension as well as monetized units for environmental and economic.

It was found that the economic impact caused a negative impact of \$ -16,3M. This is explained by the investment and increased costs. The environmental impact was found to be 151965 hectares or expressed in monetary units about \$ 32,0M. The social impact was found to be positive in accordance to the definition. Most of the results from the tool seem reasonable. However the impact change in the environmental dimension expressed in footprint is overestimated based on the impact reduction with respect to the total emissions from all ships, total industry and complete set of emissions.

The results showed that the investment could be sustainable since both environmental and social impacts are reduced. The negative financial impact will have to be assessed in relation with the company on a case by case base to determine whether those costs can be regarded sustainable. However ABN AMRO can use these results to determine whether it wants to support this investment and make capital available to do so.

10 Conclusions & Recommendations

In this final chapter the conclusions from this research are presented. These conclusions are divided over three sections. The conclusion is followed by recommendations. These recommendations appoint a number of issues that require additional research.

10.1 Conclusions

The conclusions are presented in three sections. The first section presents the results of the research of the definition of sustainability and the current policy of ABN AMRO regarding sustainability. In the second section the findings of the assessment of the shipping industry with respect to sustainability are presented. The final section presents the results from the assessment of a measurement method for sustainability and the tool that was developed.

10.1.1 ABN AMRO and Sustainability

The objective of this research is to help the Transportation department of ABN AMRO with the implementation of the sustainability strategy of the department Energy, Commodities & Transportation (ECT). A definition of sustainability that could be used in ABN AMRO's operations is formulated to be; *'a state which maintains the combined amount of natural capital and assures maintaining human's well-being.'* To describe a system that is not yet sustainable but is moving closer to a sustainable state the term *'sustainable development'* is used.

ABN AMRO's Sustainability was assessed. This assessment showed that the strategy is based on two pillars; 'A Better Bank' and 'A Better World'. This thesis focuses on the second pillar. The current sustainability assessment of shipping investments is based on the client's location of business and the answers given on a questionnaire regarding a clients policies relating to sustainability.

10.1.2 Assessment of the shipping industry with respect to sustainability

The assessment of the shipping industry showed that shipping is very important in global trade, but that it is also a significant contributor of emissions such as CO₂, SO_x, NO_x, VOC and PM. Also impacts due to ballast water, garbage and ship recycling are significant. Socially many people including crew and inhabitants of coastal areas are affected. ABN AMRO is one of a limited number of banks financing the shipping industry, which was depressed since 2008, resulting in low vessel values and returns. A number of other trends put pressure on companies; such as the increase in fuel prices and the decreased capital availability due to Basel III requirements on banks. Slow steaming was observed to be implemented often partly stimulated by low Libor rate. Movements in the sector are taking place, proven by key stakeholders expecting companies to become more transparent and by large companies and NGOs that are initiating sustainable initiatives.

Pressure on companies has also been increased by regulators who made regulations on sustainability more stringent, especially for the environmental dimension. Operational difference like location of sailing or ports visited may stringent the requirements further.

A number of innovations, mostly aimed to reduce the ship's environmental impact, were discussed. Some of these innovations are aimed to increase efficiency for ships that do not

operate in their design condition (anymore) for example because they started slow steaming. Other innovations reduce the power demand or provide power by other means or fuels. Innovations may also be stimulated by regulations like a ballast water treatment system or an after-treatment systems of exhaust gases like a scrubber or selective catalytic reduction.

10.1.3 [Method and Tool for the assessment of Sustainability](#)

In order to make sustainability a 'workable' concept in a commercial organization the environmental and social dimension of sustainability are complemented with an economic dimension. The impact change due to the investment in a sustainable innovation in three dimensions will be assessed separately within the boundaries of the system. The assessment will start at the first impact and will include the rest of the investment's or ship's life. The impact changes, are represented by indicators which will comply with the dimensional split, boundaries and time scope. They will measure real measureable yearly impact changes that can be influenced by a company. Policies are only included for the social dimension since these are very important in this dimension. A limited number of indicators which are available and of sufficient quality, regardless of the company's motives, are to be used to present a complete overview of sustainability. When it is needed to adjustments weightings the Analytic Hierarchy Process (AHP) can be used.

A review of existing measure methods showed that these are constructed on three levels; the framework or index reporting results, the conversion method translating the indicator values and the indicators as the initial input. No scheme complied with all requirements. Two additional choices had to be made. First it was chosen to only assess the internal economic, the external environmental and both internal and external social dimensional aspects. Secondly the unit for reporting was chosen to be selected per dimension.

Based on the requirements and choices formulated, a measurement scheme was developed. The internal economic change in impacts including investments, financing, costs and income in the form of cash flows are converted to a Net Present Value (NPV). Externally, the environmental dimension is assessed with a footprint based on a conversion of the yearly impact change from the air emissions, CO₂, NO_x, SO_x, VOCs and refrigerants, and soil emissions from garbage and area usage. Water emissions are excluded due to insufficient information to determine a footprint. In addition the footprint is converted based on a cost of \$ 22,79 per hectare per year to a NPV for an evaluation in monetary units. The social impact change is assessed based on a score build-up from facilities on board, retention rate of crew, protection of health and safety, fair labour practises and prohibited labour internally. Externally companies transparency, corruption and bribery policy, transportation of weapons or (other) unethical cargo, anti-competitive behaviour, complain handling, influence in people's health, local partnerships, contributions to society, hiring or local staff and loss of life is used in the assessment. The number of people affected, the severity and duration or reoccurrence of the impact and relative importance based on the AHP assessment are assessed to create a score to determine whether the social impact is positive, negative or neutral. No monetization is done since only the direction of development in the social dimension is assessed.

The measurement scheme is implemented in a tool for the assessment of sustainable investments. The tool requires input on the different indicators and expresses the result based on the dimensional unit or in monetary units. Social impacts are presented as either positive, neutral or negative.

The tool is used for the assessment of a fictional case study of the investment in a scrubber on an 8500 TEU container ship. economic, environmental and social impacts are estimated and assessed

with the tool, resulting in an economic impact of \$ -16,3 M, an environmental impact of 152 thousand hectares or \$ 32,0M and a positive social impact. Because social and environmental impacts are positive ABN AMRO can use these results to determine if this project is a good sustainable investment. It was concluded however that the measurement scheme overestimates the footprint.

10.2 Recommendations

Following the assessment of the shipping industry and the development of a measurement method and tool for investments in sustainability onboard ships, a number of recommendations is proposed for further research.

The assessment of the impacts was done assuming the ship as being the system drawing the boundaries around that ship. However within these boundaries a number of levels of ownership exist. These levels were discussed in section 4.2.2 but no distinction was made during the assessment. The levels could cause problems with the actual investments in sustainability since they may cause costs and benefits of a sustainable development to be located at different entities. It is recommended to perform more research into these foreseen problems.

The impacts that are assessed are based on changes in impacts which can be influenced by companies, assuming a constant demand, in order to exclude changes in economic developments. Due to this assumption, also competitive advantages and the change of modal choice by (potential) customers are excluded. It is recommended to conduct further research on the impacts of investments on demand and income and to research a way to include economic developments in the assessment.

The conversion of environmental footprints is based on limited data. Additional research on the evaluation of footprints of acidification emissions and their relative impacts, hazardous wastes, and PM emissions is recommended as well as is the assessment of combination of emissions. Research on the footprint of water emissions is recommended in order to add these impacts to the assessment.

The social dimension uses the Analytic Hierarchy Process (AHP) method to determine relative weightings for impacts. It is recommended that the use of this method is reviewed. The relative high inconsistency indicated that large differences between importance may not be presented correctly due to limited spread in ratings in the pair-wise comparison. The high number of pairs that is used should be reconsidered. It is recommended that for use of the measurement method in other organisations a new assessment of social indicators will be done to present a representative reflection of the view of that organisation.

The social impact is expressed as a direction of development since maintaining human's well-being is a requirement based on the definition of sustainability used. Additional research is recommended of the quantification, duration and monetization of the social impact.

The tool is based on an assessment method assessing impacts. To improve the practicality of the tool an assessment could be developed that could calculate impacts based on ship particulars, operational profile and innovations properties. Such add-on for the tool would require additional detailed research on impacts of innovations. For the use within ABN AMRO the development of such a tool is recommended.

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List of Abbreviations

| | |
|-----------------|---|
| AMP | Alternative Marine Power |
| BDI | Baltic Dry Index |
| CO | Carbon monoxide |
| CoA | Contract of Affreightment |
| CoC | Cost of Capital |
| CO ₂ | Carbon dioxide |
| CPP | Controllable Pitch Propeller |
| DWT | Deadweight tonnage |
| DME | Di-methyl Ether |
| ECA | Emission Control Area |
| ECT | Energy, Commodities & Transportation |
| EEDI | Energy Efficiency Design Index |
| EVDI | Existing Vessel Design Index (™) |
| FCA | Full Cost Accounting |
| FRC | Foul Release Coating |
| FPP | Fixed Pitch Propeller |
| GHG | Green House Gas |
| GDP | Global Domestic Product |
| GWP | Global Warming Potential |
| HFO | Heavy Fuel Oil |
| IMO | International Maritime Organisation |
| IPO | Initial Public Offering |
| LCA | Life Cycle Analysis |
| LNG | Liquefied Natural Gas |
| LPG | Liquefied Petroleum Gas |
| LWT | Light Weight Tonnage |
| MALS | Mitsubishi Air Lubrication System |
| MEPC | Marine Environment Protection Committee |
| MCR | Maximum Continuous Rate |
| MFO | Marine Fuel Oil |
| MGO | Maritime Gas Oil |
| NGO | Non-Governmental Organisations |
| NM VOC | Non-Methane Volatile Organic Compound |
| NO _x | Mono-Nitrogen Oxides |
| NPV | Net Present value |
| PM | Particulate Matter |
| PTI | Power Take In |
| PTO | Power Take Off |
| SECA | Sulphur Emission Control Areas |
| SEEMP | Ship EE Management Plan |
| SPV | Special Purpose Vehicle |
| SO _x | Sulphur Oxide |
| TCE | Time Charter Equivalent |
| TEU | Twenty-foot Equivalent unit |
| UN | United Nations |
| USD | United States Dollar, \$ |
| VOC | Volatile Organic Compounds |

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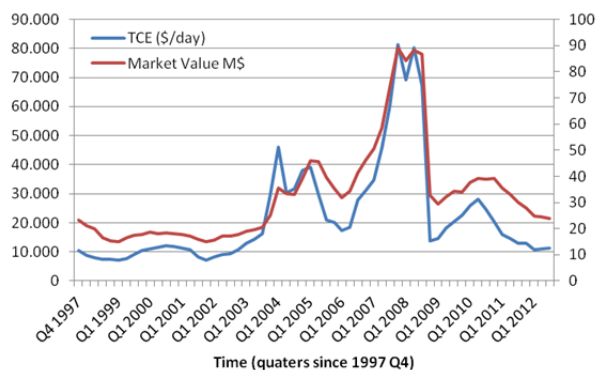
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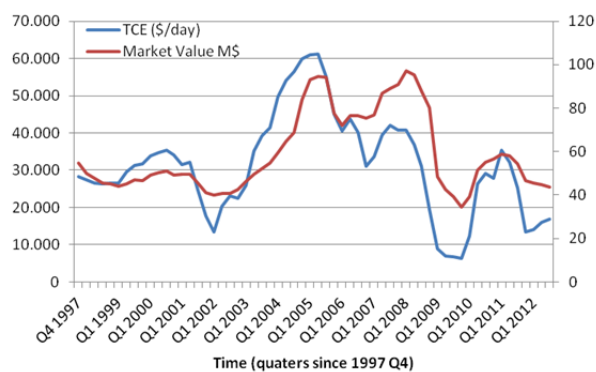
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Appendix A – TCE and vessel values of several ship types

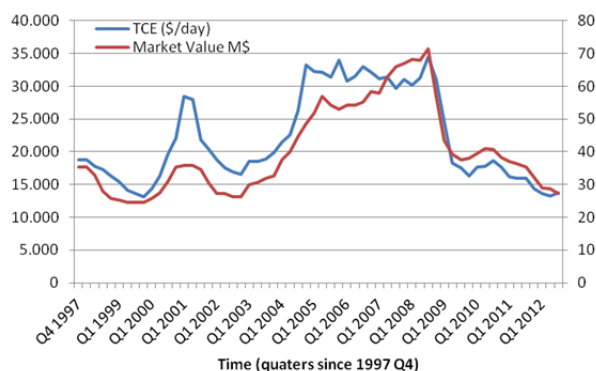
Bulk Carrier (80000 DWT, 5 year)



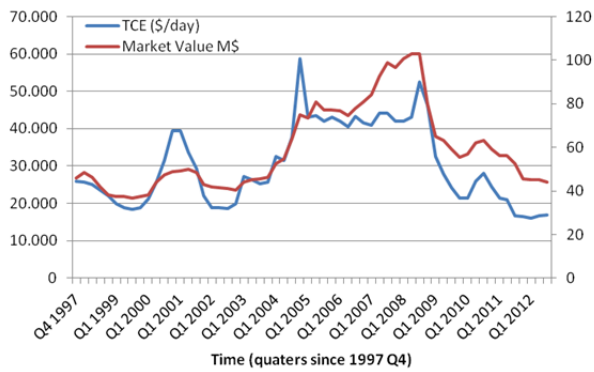
Container Carrier (5800 TEU, 5 year)



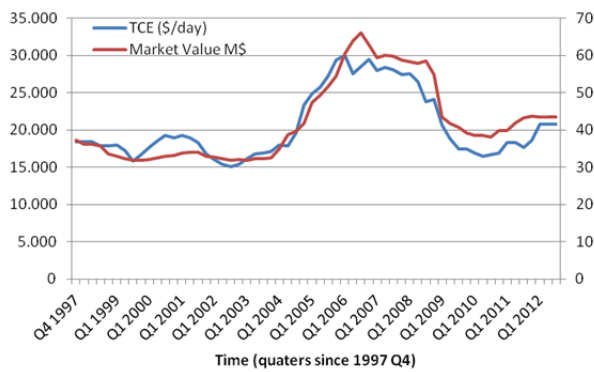
Product Tanker (75000 DWT, 5 year)



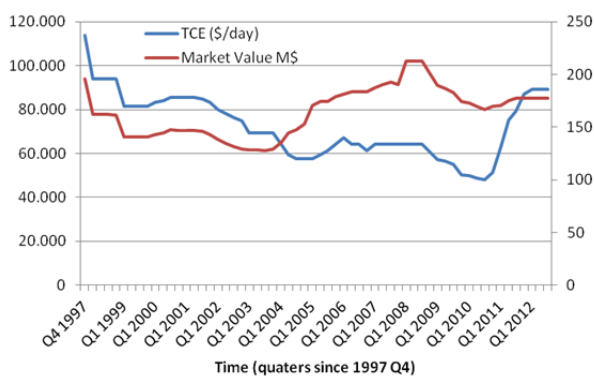
Crude Tanker (155000 DWT, 5 year)



LPG Carrier (20500 CBM, 5 year)



LNG Carrier (72000 CBM, 5 year)



Appendix B – Questionnaires

Move the scroll bar to the aspect which considered more important.
When equally important leave the scroll bar centred
Number on the left or right side indicate relative importance

1: Equal importance
3: Somewhat more important (moderate favour for an aspect)
5: Much more important (strong favour for an aspect)
7: Very much more important (very strong favour for an aspect)
9: Absolutely more important (highest possible /extreme favour for an aspect)
(values 2,4,6,8 can be used when compromise is needed)

In this questionnaire a group of 13 indicators will be assessed. Therefore 78 pairwise comparisons will need to be made.
The group concerns internal and external indicators which all will be briefly introduced below.
Internal indicators address impacts within a company, external address impacts outside the company scope.

Internal (impacts within company boundaries)

- 1) The first indicator concentrates on Fair labour practises (for example Labour rights, Gender equality, Discriminations)
- 2) The second indicator focuses on Prohibited labour (for example child labour or forced labour)
- 3) The third indicator focuses on health, since this is a internal indicator only Employees Health is assessed with this indicator
- 4) Working and other conditions related to Safety of employees is assessed with this fourth indicator
- 5) The fifth indicator focuses' on Human Capital Development in effect training of crew
- 6) The sixth indicator focuses' on Facilities and services on-board for crew
- 7) The Retention of crew (the returning after leaves) is used as the seventh indicator

External (impacts outside company boundaries)

- 8) Ethical policy indicator relates to several policies combined
Ethical policy includes the policies on Transparency, Corruption and Bribery and Weapons or other unethical cargo.
- 9) The ninth indicator focuses' on Anti-competitive behaviour of a company in order to get better returns
- 10) The way companies influence lives of stakeholders by the Handling of complains is assessed with the 10th indicator
- 11) Also external Health is an indicator for social sustainability. It assesses the influence of a company on health in the external location
- 12) Local Positioning of a company includes arrangement in local partnerships, contributions to society and the local hirement of local staff.
- 13) Loss of life is used as an indicator. This assesses the possible loss of life of one (1) human outside the direct company (externally)

When answering you are asked to answer based of impact of medium or normal severity when applicable.
This medium impact is to be rated to have impact on one person or crew-member

| | | | |
|---|---|--|--|
| 1 Human Capital Development (training) | 1 | | 1 Prohibited labour (child/forced labour) |
| 2 Facilities and services on-board for crew | 1 | | 1 Retention of crew (returning after leaves) |
| 3 Loss of (one) life (non-crew) | 1 | | 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) |
| 4 Safety of employees | 1 | | 1 Health of employees |
| 5 Prohibited labour (child/forced labour) | 1 | | 1 Ethical policy |
| 6 Health of employees | 1 | | 1 Human Capital Development (training) |
| 7 Retention of crew (returning after leaves) | 1 | | 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) |
| 8 Facilities and services on-board for crew | 1 | | 1 Prohibited labour (child/forced labour) |
| 9 Anti-competitive behaviour | 1 | | 1 Human Capital Development (training) |
| 10 Retention of crew (returning after leaves) | 1 | | 1 Anti-competitive behaviour |
| 11 Health (Influence in lives through ...) | 1 | | 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) |
| 12 Safety of employees | 1 | | 1 Ethical policy |
| 13 Anti-competitive behaviour | 1 | | 1 Health (Influence in lives through ...) |
| 14 Facilities and services on-board for crew | 1 | | 1 Human Capital Development (training) |
| 15 Safety of employees | 1 | | 1 Human Capital Development (training) |
| 16 Prohibited labour (child/forced labour) | 1 | | 1 Safety of employees |
| 17 Loss of (one) life (non-crew) | 1 | | 1 Ethical policy |
| 18 Anti-competitive behaviour | 1 | | 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) |
| 19 Local Positioning | 1 | | 1 Human Capital Development (training) |
| 20 Loss of (one) life (non-crew) | 1 | | 1 Handling of complains (Influence in lives through ...) |
| 21 Handling of complains (Influence in lives through ...) | 1 | | 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) |
| 22 Ethical policy | 1 | | 1 Local Positioning |
| 23 Ethical policy | 1 | | 1 Handling of complains (Influence in lives through ...) |
| 24 Human Capital Development (training) | 1 | | 1 Loss of (one) life (non-crew) |
| 25 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 1 | | 1 Ethical policy |
| 26 Safety of employees | 1 | | 1 Anti-competitive behaviour |
| 27 Loss of (one) life (non-crew) | 1 | | 1 Prohibited labour (child/forced labour) |
| 28 Facilities and services on-board for crew | 1 | | 1 Handling of complains (Influence in lives through ...) |
| 29 Human Capital Development (training) | 1 | | 1 Handling of complains (Influence in lives through ...) |
| 30 Prohibited labour (child/forced labour) | 1 | | 1 Health (Influence in lives through ...) |

| | | | | |
|---|---|--|--|--|
| 31 Local Positioning | 1 | | | 1 Facilities and services on-board for crew |
| 32 Loss of (one) life (non-crew) | 1 | | | 1 Local Positioning |
| 33 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 1 | | | 1 Health of employees |
| 34 Retention of crew (returning after leaves) | 1 | | | 1 Health of employees |
| 35 Anti-competitive behaviour | 1 | | | 1 Ethical policy |
| 36 Prohibited labour (child/forced labour) | 1 | | | 1 Handling of complains (Influence in lives through ...) |
| 37 Ethical policy | 1 | | | 1 Facilities and services on-board for crew |
| 38 Retention of crew (returning after leaves) | 1 | | | 1 Health (Influence in lives through ...) |
| 39 Handling of complains (Influence in lives through ...) | 1 | | | 1 Anti-competitive behaviour |
| 40 Facilities and services on-board for crew | 1 | | | 1 Anti-competitive behaviour |
| 41 Health (Influence in lives through ...) | 1 | | | 1 Loss of (one) life (non-crew) |
| 42 Local Positioning | 1 | | | 1 Health of employees |
| 43 Health (Influence in lives through ...) | 1 | | | 1 Ethical policy |
| 44 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 1 | | | 1 Safety of employees |
| 45 Health of employees | 1 | | | 1 Health (Influence in lives through ...) |
| 46 Retention of crew (returning after leaves) | 1 | | | 1 Safety of employees |
| 47 Retention of crew (returning after leaves) | 1 | | | 1 Local Positioning |
| 48 Facilities and services on-board for crew | 1 | | | 1 Safety of employees |
| 49 Anti-competitive behaviour | 1 | | | 1 Local Positioning |
| 50 Local Positioning | 1 | | | 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) |
| 51 Prohibited labour (child/forced labour) | 1 | | | 1 Health of employees |
| 52 Handling of complains (Influence in lives through ...) | 1 | | | 1 Safety of employees |
| 53 Retention of crew (returning after leaves) | 1 | | | 1 Human Capital Development (training) |
| 54 Safety of employees | 1 | | | 1 Loss of (one) life (non-crew) |
| 55 Health of employees | 1 | | | 1 Facilities and services on-board for crew |
| 56 Retention of crew (returning after leaves) | 1 | | | 1 Handling of complains (Influence in lives through ...) |
| 57 Facilities and services on-board for crew | 1 | | | 1 Health (Influence in lives through ...) |
| 58 Ethical policy | 1 | | | 1 Human Capital Development (training) |
| 59 Local Positioning | 1 | | | 1 Prohibited labour (child/forced labour) |
| 60 Anti-competitive behaviour | 1 | | | 1 Health of employees |
| 61 Health (Influence in lives through ...) | 1 | | | 1 Safety of employees |
| 62 Anti-competitive behaviour | 1 | | | 1 Loss of (one) life (non-crew) |
| 63 Ethical policy | 1 | | | 1 Retention of crew (returning after leaves) |
| 64 Prohibited labour (child/forced labour) | 1 | | | 1 Anti-competitive behaviour |
| 65 Prohibited labour (child/forced labour) | 1 | | | 1 Retention of crew (returning after leaves) |
| 66 Local Positioning | 1 | | | 1 Health (Influence in lives through ...) |
| 67 Retention of crew (returning after leaves) | 1 | | | 1 Loss of (one) life (non-crew) |
| 68 Facilities and services on-board for crew | 1 | | | 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) |
| 69 Health of employees | 1 | | | 1 Handling of complains (Influence in lives through ...) |
| 70 Loss of (one) life (non-crew) | 1 | | | 1 Facilities and services on-board for crew |
| 71 Local Positioning | 1 | | | 1 Handling of complains (Influence in lives through ...) |
| 72 Health of employees | 1 | | | 1 Ethical policy |
| 73 Human Capital Development (training) | 1 | | | 1 Health (Influence in lives through ...) |
| 74 Health of employees | 1 | | | 1 Loss of (one) life (non-crew) |
| 75 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 1 | | | 1 Prohibited labour (child/forced labour) |
| 76 Local Positioning | 1 | | | 1 Safety of employees |
| 77 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 1 | | | 1 Human Capital Development (training) |
| 78 Health (Influence in lives through ...) | 1 | | | 1 Handling of complains (Influence in lives through ...) |
| Ethical policy | | | | |
| 79 Transparency | 1 | | | 1 Weapons or other unethical cargo |
| 80 Corruption policy & Bribes paid | 1 | | | 1 Transparency |
| 81 Weapons or other unethical cargo | 1 | | | 1 Corruption policy & Bribes paid |
| Local Positioning | | | | |
| 82 Local hirements of senior staff | 1 | | | 1 Contributions to society |
| 83 Contributions to society | 1 | | | 1 Local partnerships |
| 84 Local partnerships | 1 | | | 1 Local hirements of senior staff |

Appendix C – Questionnaires Results & Consistency Q1

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|---|-----|-----|-----|-----|
| 1 | 1 | 1/9 | 1/3 | 5 | 7 | 4 | 7 | 7 | 1 | 6 | 5 | 5 | 1/9 |
| 2 | 9 | 1 | 7 | 9 | 7 | 9 | 8 | 5 | 8 | 7 | 5 | 1 | 1/9 |
| 3 | 3 | 1/7 | 1 | 1/7 | 8 | 8 | 5 | 6 | 8 | 7 | 3 | 4 | 1/9 |
| 4 | 1/5 | 1/9 | 7 | 1 | 9 | 9 | 7 | 4 | 9 | 9 | 8 | 7 | 1/9 |
| 5 | 1/7 | 1/7 | 1/8 | 1/9 | 1 | 1/5 | 1/3 | 1/4 | 5 | 1/2 | 1/7 | 1 | 1/9 |
| 6 | 1/4 | 1/9 | 1/8 | 1/9 | 5 | 1 | 4 | 1/5 | 5 | 6 | 1/5 | 1 | 1/8 |
| 7 | 1/7 | 1/8 | 1/5 | 1/7 | 3 | 1/4 | 1 | 1/3 | 5 | 4 | 1/6 | 4 | 1/9 |
| 8 | 1/7 | 1/5 | 1/6 | 1/4 | 4 | 5 | 3 | 1 | 4 | 1/4 | 1/4 | 1 | 1/9 |
| 9 | 1 | 1/8 | 1/8 | 1/9 | 1/5 | 1/5 | 1/5 | 1/4 | 1 | 1/3 | 1/5 | 1 | 1/8 |
| 10 | 1/6 | 1/7 | 1/7 | 1/9 | 2 | 1/6 | 1/4 | 4 | 3 | 1 | 1/7 | 1/5 | 1/9 |
| 11 | 1/5 | 1/5 | 1/3 | 1/8 | 7 | 5 | 6 | 4 | 5 | 7 | 1 | 5 | 1/6 |
| 12 | 1/5 | 1 | 1/4 | 1/7 | 1 | 1 | 1/4 | 1 | 1 | 5 | 1/5 | 1 | 1/8 |
| 13 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 8 | 9 | 6 | 8 | 1 |

Q8

| | 1 | 2 | 3 |
|---|---|-----|-----|
| 1 | 1 | 1/3 | 1/3 |
| 2 | 3 | 1 | 1 |
| 3 | 3 | 1 | 1 |

Q12

| | 1 | 2 | 3 |
|---|-----|---|-----|
| 1 | 1 | 4 | 1 |
| 2 | 1/4 | 1 | 1/3 |
| 3 | 1 | 3 | 1 |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|---|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | | -0,108 | -0,021 | 0,004 | 0,000 | 0,000 | 0,001 | 0,001 | -0,017 | 0,000 | 0,002 | 0,001 | -0,038 |
| 2 | | | 0,001 | 0,002 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | -0,018 | -0,099 |
| 3 | | | | -0,098 | 0,000 | 0,001 | 0,000 | 0,001 | 0,000 | 0,000 | 0,001 | 0,000 | -0,032 |
| 4 | | | | | 0,000 | 0,001 | 0,000 | 0,000 | 0,000 | 0,000 | 0,001 | 0,000 | -0,052 |
| 5 | | | | | | -0,025 | -0,008 | -0,014 | 0,002 | -0,005 | -0,017 | 0,003 | 0,041 |
| 6 | | | | | | | 0,002 | -0,055 | 0,001 | 0,001 | -0,021 | 0,000 | 0,019 |
| 7 | | | | | | | | -0,015 | 0,001 | 0,001 | -0,027 | 0,002 | 0,020 |
| 8 | | | | | | | | | 0,001 | -0,059 | -0,012 | 0,000 | 0,015 |
| 9 | | | | | | | | | | -0,014 | -0,004 | 0,004 | 0,056 |
| 10 | | | | | | | | | | | -0,025 | -0,034 | 0,039 |
| 11 | | | | | | | | | | | | 0,001 | 0,001 |
| 12 | | | | | | | | | | | | | 0,019 |
| 13 | | | | | | | | | | | | | |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | 1,0000 | 0,2367 | 0,2794 | 6,1817 | 0,9445 | 1,1068 | 1,6745 | 1,9636 | 0,1432 | 1,0536 | 2,7244 | 1,3916 | 0,3881 |
| 2 | 4,2254 | 1,0000 | 2,7543 | 5,2241 | 0,4434 | 1,1692 | 0,8985 | 0,6585 | 0,5380 | 0,5771 | 1,2791 | 0,1307 | 0,1822 |
| 3 | 3,5796 | 0,3631 | 1,0000 | 0,2107 | 1,2879 | 2,6413 | 1,4271 | 2,0082 | 1,3674 | 1,4666 | 1,9504 | 1,3283 | 0,4631 |
| 4 | 0,1618 | 0,1914 | 4,7451 | 1,0000 | 0,9822 | 2,0143 | 1,3544 | 0,9076 | 1,0428 | 1,2782 | 3,5257 | 1,5758 | 0,3139 |
| 5 | 1,0588 | 2,2552 | 0,7764 | 1,0181 | 1,0000 | 0,4102 | 0,5910 | 0,5198 | 5,3083 | 0,6507 | 0,5769 | 2,0627 | 2,8765 |
| 6 | 0,9035 | 0,8553 | 0,3786 | 0,4965 | 2,4381 | 1,0000 | 3,4580 | 0,2028 | 2,5884 | 3,8076 | 0,3938 | 1,0058 | 1,5780 |
| 7 | 0,5972 | 1,1130 | 0,7007 | 0,7384 | 1,6921 | 0,2892 | 1,0000 | 0,3909 | 2,9941 | 2,9362 | 0,3796 | 4,6539 | 1,6225 |
| 8 | 0,5093 | 1,5186 | 0,4980 | 1,1019 | 1,9240 | 4,9321 | 2,5583 | 1,0000 | 2,0426 | 0,1565 | 0,4856 | 0,9922 | 1,3836 |
| 9 | 6,9810 | 1,8587 | 0,7313 | 0,9590 | 0,1884 | 0,3863 | 0,3340 | 0,4896 | 1,0000 | 0,4086 | 0,7608 | 1,9429 | 3,0481 |
| 10 | 0,9492 | 1,7329 | 0,6818 | 0,7823 | 1,5368 | 0,2626 | 0,3406 | 6,3900 | 2,4473 | 1,0000 | 0,4433 | 0,3170 | 2,2103 |
| 11 | 0,3671 | 0,7818 | 0,5127 | 0,2836 | 1,7334 | 2,5391 | 2,6341 | 2,0593 | 1,3145 | 2,2558 | 1,0000 | 2,5539 | 1,0684 |
| 12 | 0,7186 | 7,6531 | 0,7528 | 0,6346 | 0,4848 | 0,9942 | 0,2149 | 1,0079 | 0,5147 | 3,1546 | 0,3916 | 1,0000 | 1,5688 |
| 13 | 2,5766 | 5,4880 | 2,1594 | 3,1855 | 0,3476 | 0,6337 | 0,6163 | 0,7228 | 0,3281 | 0,4524 | 0,9360 | 0,6374 | 1,0000 |

CR 0,33

| | |
|--|-------|
| 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 0,093 |
| 2 Prohibited labour (child/forced labour) | 0,198 |
| 3 Health of employees | 0,078 |
| 4 Safety of employees | 0,115 |
| 5 Human Capital Development (training) | 0,013 |
| 6 Facilities and services on-board for crew | 0,026 |
| 7 Retention of crew (returning after leaves) | 0,022 |
| 8 Ethical policy | 0,026 |
| 9 Anti-competitive behaviour | 0,013 |
| 10 Handling of complains (Influence in lives through ...) | 0,016 |
| 11 Health (Influence in lives through ...) | 0,051 |
| 12 Local Positioning | 0,026 |
| 13 Loss of (one) life (non-crew) | 0,324 |

Appendix D – Questionnaires Results & Consistency Q2

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|
| 1 | 1 | 1/5 | 1/9 | 1/9 | 5 | 5 | 1/9 | 6 | 5 | 5 | 1/9 | 6 | 1/9 |
| 2 | 5 | 1 | 3 | 1/5 | 9 | 9 | 7 | 9 | 7 | 9 | 6 | 9 | 1/9 |
| 3 | 9 | 1/3 | 1 | 1/5 | 9 | 9 | 9 | 9 | 9 | 9 | 4 | 9 | 1/5 |
| 4 | 9 | 5 | 5 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 9 | 1/6 |
| 5 | 1/5 | 1/9 | 1/9 | 1/9 | 1 | 5 | 1/3 | 5 | 4 | 8 | 1/9 | 5 | 1/9 |
| 6 | 1/5 | 1/9 | 1/9 | 1/9 | 1/5 | 1 | 1/9 | 1/6 | 1/4 | 6 | 1/6 | 1/6 | 1/9 |
| 7 | 9 | 1/7 | 1/9 | 1/9 | 3 | 9 | 1 | 1 | 4 | 6 | 1/6 | 4 | 1/9 |
| 8 | 1/6 | 1/9 | 1/9 | 1/9 | 1/5 | 6 | 1 | 1 | 1/6 | 5 | 1/9 | 1/5 | 1/9 |
| 9 | 1/5 | 1/7 | 1/9 | 1/9 | 1/9 | 1/4 | 4 | 1/4 | 6 | 1 | 1/9 | 4 | 1/9 |
| 10 | 1/5 | 1/9 | 1/9 | 1/9 | 1/8 | 1/6 | 1/6 | 1/5 | 1 | 1 | 1/9 | 1/5 | 1/9 |
| 11 | 9 | 1/6 | 1/4 | 1/3 | 9 | 6 | 6 | 9 | 9 | 9 | 1 | 9 | 1/9 |
| 12 | 1/6 | 1/9 | 1/9 | 1/9 | 1/5 | 6 | 1/4 | 5 | 1/4 | 5 | 1/9 | 1 | 1/9 |
| 13 | 9 | 9 | 5 | 6 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 1 |

Q8

| | 1 | 2 | 3 |
|---|---|-----|-----|
| 1 | 1 | 1/6 | 1/6 |
| 2 | 6 | 1 | 6 |
| 3 | 6 | 1/6 | 1 |

Q12

| | 1 | 2 | 3 |
|---|---|-----|-----|
| 1 | 1 | 1/5 | 1/6 |
| 2 | 5 | 1 | 6 |
| 3 | 6 | 1/6 | 1 |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|---|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|--------|--------|
| 1 | | -0,007 | -0,037 | -0,021 | 0,001 | 0,000 | 0,000 | 0,000 | 0,001 | 0,000 | -0,059 | 0,001 | -0,008 |
| 2 | | | 0,001 | -0,028 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,001 | 0,000 | -0,067 |
| 3 | | | | -0,025 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,001 | 0,000 | -0,016 |
| 4 | | | | | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 | -0,041 |
| 5 | | | | | | 0,000 | -0,010 | 0,001 | 0,001 | 0,000 | -0,039 | 0,001 | 0,005 |
| 6 | | | | | | | -0,033 | -0,049 | -0,011 | 0,002 | 0,011 | -0,036 | 0,056 |
| 7 | | | | | | | | -0,004 | 0,001 | 0,000 | -0,018 | 0,001 | -0,002 |
| 8 | | | | | | | | | -0,045 | 0,001 | -0,011 | -0,037 | 0,036 |
| 9 | | | | | | | | | | -0,004 | -0,023 | 0,001 | 0,018 |
| 10 | | | | | | | | | | | 0,009 | -0,018 | 0,071 |
| 11 | | | | | | | | | | | | 0,000 | -0,043 |
| 12 | | | | | | | | | | | | | 0,024 |
| 13 | | | | | | | | | | | | | |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | 1,0000 | 0,6810 | 0,3422 | 0,5253 | 3,5484 | 1,3258 | 0,8048 | 2,2475 | 2,4877 | 1,0452 | 0,2600 | 2,6818 | 0,8861 |
| 2 | 1,4685 | 1,0000 | 2,7135 | 0,2777 | 1,8759 | 0,7009 | 1,6545 | 0,9901 | 1,0229 | 0,5525 | 4,1227 | 1,1815 | 0,2602 |
| 3 | 2,9224 | 0,3685 | 1,0000 | 0,3070 | 2,0740 | 0,7749 | 2,3519 | 1,0947 | 1,4540 | 0,6109 | 3,0387 | 1,3062 | 0,5179 |
| 4 | 1,9038 | 3,6012 | 3,2573 | 1,0000 | 1,3511 | 0,5048 | 1,5321 | 0,7131 | 0,9472 | 0,3980 | 1,4847 | 0,8509 | 0,2812 |
| 5 | 0,2818 | 0,5331 | 0,4822 | 0,7402 | 1,0000 | 1,8681 | 0,3780 | 2,6391 | 2,8043 | 2,3564 | 0,3663 | 3,1491 | 1,2486 |
| 6 | 0,7543 | 1,4268 | 1,2905 | 1,9810 | 0,5353 | 1,0000 | 0,3372 | 0,2354 | 0,4691 | 4,7300 | 1,4705 | 0,2809 | 3,3418 |
| 7 | 1,2426 | 0,6044 | 0,4252 | 0,6527 | 2,6455 | 2,9653 | 1,0000 | 0,4654 | 2,4730 | 1,5584 | 0,4845 | 2,2216 | 1,1010 |
| 8 | 0,4449 | 1,0100 | 0,9135 | 1,4023 | 0,3789 | 4,2472 | 2,1485 | 1,0000 | 0,2214 | 2,7902 | 0,6940 | 0,2386 | 2,3656 |
| 9 | 0,4020 | 0,9776 | 0,6877 | 1,0557 | 0,3566 | 2,1317 | 0,4044 | 4,5172 | 1,0000 | 0,4201 | 0,5225 | 3,5934 | 1,7809 |
| 10 | 0,9568 | 1,8099 | 1,6370 | 2,5129 | 0,4244 | 0,2114 | 0,6417 | 0,3584 | 2,3802 | 1,0000 | 1,2436 | 0,4277 | 4,2391 |
| 11 | 3,8469 | 0,2426 | 0,3291 | 0,6736 | 2,7301 | 0,6800 | 2,0639 | 1,4410 | 1,9140 | 0,8041 | 1,0000 | 1,7194 | 0,3787 |
| 12 | 0,3729 | 0,8464 | 0,7656 | 1,1752 | 0,3176 | 3,5594 | 0,4501 | 4,1903 | 0,2783 | 2,3383 | 0,5816 | 1,0000 | 1,9825 |
| 13 | 1,1285 | 3,8425 | 1,9309 | 3,5567 | 0,8009 | 0,2992 | 0,9082 | 0,4227 | 0,5615 | 0,2359 | 2,6403 | 0,5044 | 1,0000 |

CR 0,26

| | |
|--|-------|
| 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 0,039 |
| 2 Prohibited labour (child/forced labour) | 0,132 |
| 3 Health of employees | 0,119 |
| 4 Safety of employees | 0,183 |
| 5 Human Capital Development (training) | 0,027 |
| 6 Facilities and services on-board for crew | 0,010 |
| 7 Retention of crew (returning after leaves) | 0,031 |
| 8 Ethical policy | 0,014 |
| 9 Anti-competitive behaviour | 0,019 |
| 10 Handling of complains (Influence in lives through ...) | 0,008 |
| 11 Health (Influence in lives through ...) | 0,091 |
| 12 Local Positioning | 0,017 |
| 13 Loss of (one) life (non-crew) | 0,309 |

Appendix E – Questionnaires Results & Consistency Q3

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|---|-----|-----|----|-----|
| 1 | 1 | 1/4 | 4 | 1/4 | 1/4 | 3 | 4 | 4 | 4 | 4 | 4 | 2 | 1/5 |
| 2 | 4 | 1 | 4 | 4 | 4 | 4 | 3 | 4 | 5 | 4 | 4 | 6 | 1 |
| 3 | 1/4 | 1/4 | 1 | 1/4 | 1/4 | 1/4 | 1/4 | 1/3 | 2 | 3 | 1 | 5 | 1/5 |
| 4 | 4 | 1/4 | 4 | 1 | 4 | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 1/4 |
| 5 | 4 | 1/4 | 4 | 1/4 | 1 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 1/4 |
| 6 | 1/3 | 1/4 | 4 | 1/4 | 1/4 | 1 | 1/4 | 4 | 4 | 4 | 1/4 | 4 | 1/5 |
| 7 | 1/4 | 1/3 | 4 | 1/4 | 1/3 | 4 | 1 | 3 | 4 | 4 | 4 | 3 | 1/4 |
| 8 | 1/4 | 1/4 | 3 | 1/4 | 1/4 | 1/4 | 1/3 | 1 | 4 | 4 | 1/4 | 4 | 1/4 |
| 9 | 1/4 | 1/5 | 1/2 | 1/5 | 1/4 | 1/4 | 1/4 | 1/4 | 1 | 1/4 | 1/4 | 1 | 1/6 |
| 10 | 1/4 | 1/4 | 1/3 | 1/5 | 1/4 | 1/4 | 1/4 | 1/4 | 4 | 1 | 1/2 | 3 | 1/4 |
| 11 | 1/4 | 1/4 | 1 | 1/4 | 1/3 | 4 | 1/4 | 4 | 4 | 2 | 1 | 4 | 1/5 |
| 12 | 1/2 | 1/6 | 1/5 | 1/4 | 1/4 | 1/4 | 1/3 | 1/4 | 1 | 1/3 | 1/4 | 1 | 1/4 |
| 13 | 5 | 1 | 5 | 4 | 4 | 5 | 4 | 4 | 6 | 4 | 5 | 4 | 1 |

Q8

| | 1 | 2 | 3 |
|---|---|-----|-----|
| 1 | 1 | 1/4 | 1/4 |
| 2 | 4 | 1 | 1/3 |
| 3 | 4 | 3 | 1 |

Q12

| | 1 | 2 | 3 |
|---|-----|-----|---|
| 1 | 1 | 4 | 3 |
| 2 | 1/4 | 1 | 4 |
| 3 | 1/3 | 1/4 | 1 |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|---|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | | -0,014 | 0,001 | -0,026 | -0,037 | 0,001 | 0,003 | 0,001 | 0,000 | 0,000 | 0,002 | -0,003 | -0,024 |
| 2 | | | -0,001 | 0,002 | 0,001 | 0,000 | 0,000 | 0,000 | -0,001 | -0,001 | 0,000 | -0,001 | 0,000 |
| 3 | | | | 0,003 | -0,005 | -0,032 | -0,016 | -0,022 | 0,000 | 0,002 | 0,003 | 0,002 | 0,008 |
| 4 | | | | | 0,002 | 0,000 | 0,001 | 0,000 | -0,001 | 0,000 | 0,001 | -0,001 | -0,030 |
| 5 | | | | | | 0,001 | 0,002 | 0,001 | -0,001 | 0,000 | 0,001 | -0,001 | -0,019 |
| 6 | | | | | | | -0,031 | 0,003 | 0,001 | 0,001 | -0,047 | 0,001 | -0,004 |
| 7 | | | | | | | | 0,001 | 0,000 | 0,001 | 0,002 | -0,001 | -0,008 |
| 8 | | | | | | | | | 0,001 | 0,002 | -0,035 | 0,001 | 0,009 |
| 9 | | | | | | | | | | -0,029 | -0,008 | 0,000 | 0,026 |
| 10 | | | | | | | | | | | 0,000 | 0,002 | 0,020 |
| 11 | | | | | | | | | | | | 0,001 | -0,006 |
| 12 | | | | | | | | | | | | | 0,031 |
| 13 | | | | | | | | | | | | | |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1 | 1,0000 | 0,5366 | 1,4637 | 0,4155 | 0,3070 | 1,7114 | 3,3598 | 1,7710 | 0,7558 | 1,1636 | 2,4094 | 0,4338 | 0,4690 |
| 2 | 1,8635 | 1,0000 | 0,6819 | 3,0968 | 2,2883 | 1,0631 | 1,1739 | 0,8251 | 0,4401 | 0,5421 | 1,1225 | 0,6063 | 1,0925 |
| 3 | 0,6832 | 1,4665 | 1,0000 | 1,1354 | 0,8389 | 0,3897 | 0,5739 | 0,4033 | 1,0327 | 2,3849 | 1,6461 | 2,9637 | 1,2817 |
| 4 | 2,4070 | 0,3229 | 0,8808 | 1,0000 | 2,9557 | 1,3731 | 2,0218 | 1,0657 | 0,5685 | 0,8752 | 1,4499 | 0,5221 | 0,3528 |
| 5 | 3,2574 | 0,4370 | 1,1920 | 0,3383 | 1,0000 | 1,8583 | 2,0521 | 1,4422 | 0,6155 | 0,9476 | 1,4716 | 0,7065 | 0,4774 |
| 6 | 0,5843 | 0,9407 | 2,5658 | 0,7283 | 0,5381 | 1,0000 | 0,3681 | 3,1044 | 1,3248 | 2,0397 | 0,2640 | 1,5208 | 0,8221 |
| 7 | 0,2976 | 0,8518 | 1,7426 | 0,4946 | 0,4873 | 2,7167 | 1,0000 | 1,5813 | 0,8998 | 1,3853 | 2,8685 | 0,7747 | 0,6979 |
| 8 | 0,5646 | 1,2120 | 2,4794 | 0,9383 | 0,6934 | 0,3221 | 0,6324 | 1,0000 | 1,7070 | 2,6281 | 0,3401 | 1,9595 | 1,3241 |
| 9 | 1,3231 | 2,2721 | 0,9683 | 1,7591 | 1,6248 | 0,7548 | 1,1114 | 0,5858 | 1,0000 | 0,3849 | 0,7970 | 1,1479 | 2,0685 |
| 10 | 0,8594 | 1,8447 | 0,4193 | 1,1426 | 1,0553 | 0,4903 | 0,7219 | 0,3805 | 2,5981 | 1,0000 | 1,0353 | 2,2368 | 2,0153 |
| 11 | 0,4150 | 0,8909 | 0,6075 | 0,6897 | 0,6795 | 3,7883 | 0,3486 | 2,9401 | 1,2547 | 0,9659 | 1,0000 | 1,4403 | 0,7786 |
| 12 | 2,3052 | 1,6494 | 0,3374 | 1,9155 | 1,4154 | 0,6575 | 1,2909 | 0,5103 | 0,8711 | 0,4471 | 0,6943 | 1,0000 | 2,7028 |
| 13 | 2,1322 | 0,9154 | 0,7802 | 2,8347 | 2,0946 | 1,2164 | 1,4328 | 0,7552 | 0,4834 | 0,4962 | 1,2844 | 0,3700 | 1,0000 |

CR 0,15

| | |
|--|-------|
| 1 Fair labour practises (exp. Labour rights, Gender equality, Discriminations) | 0,084 |
| 2 Prohibited labour (child/forced labour) | 0,180 |
| 3 Health of employees | 0,031 |
| 4 Safety of employees | 0,140 |
| 5 Human Capital Development (training) | 0,103 |
| 6 Facilities and services on-board for crew | 0,048 |
| 7 Retention of crew (returning after leaves) | 0,071 |
| 8 Ethical policy | 0,037 |
| 9 Anti-competitive behaviour | 0,016 |
| 10 Handling of complains (Influence in lives through ...) | 0,024 |
| 11 Health (Influence in lives through ...) | 0,051 |
| 12 Local Positioning | 0,018 |
| 13 Loss of (one) life (non-crew) | 0,197 |

Appendix F – Tool