ENVIRONMENTAL CHALLENGES IN MARITIME TRANSPORT

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Abstract: *Maritime transport is by definition the most environmentally friendly mode of transport per ton of cargo transported, but in recent years, its negative impacts are being emphasized more often, although the International Convention for the Prevention of Pollution from Ships (MARPOL) convention exists since 1973.*

Negative impacts of maritime transport occur mainly during ship's sailing, but also those arising during operations in ports should not be neglected, mainly due to the proximity of ports to residential areas.

In this paper, the authors provide an overview of the environmental challenges in shipping industry that have to be tackled by ship-owners, ship-operators and ports in order to achieve greener maritime transport. Also, the examples of best practice resolving specific issues are mentioned and the estimates of costs in achieving greener shipping are provided.

Keywords*: Maritime transport, green maritime transport, air pollution, sea pollution*

1. INTRODUCTION

Shipping is the most cost-effective mode of transport for majority of commodities. In some cases it is the only possible mode of transport, so it is not surprising that around 80 (UNCTAD, 2014) to 90 percent (ICS, 2015) of all commodities in international trade are at some point transferred to the sea. Shipping is also the most environmentally friendly mode of cargo transport. In fact, only around 37% of all transport generated carbon dioxide (CO_2) emissions in international trade were attributable to maritime transport in 2010 (OECD/ITF, 2015a). According to the estimates presented in the Third IMO GHG Study from 2014, international shipping emitted 796 million tonnes of CO_2 in 2012, which accounted for no more than about 2.2% of the total CO_2 emissions for that year (IMO, 2015).

However, although most often emphasized, the environmental concerns regarding maritime transport are not limited to engine air emission alone, or even just to CO_2 emissions. Besides air emissions, also water damage and noise pollution from maritime transport occur on regular or random basis.

The aim of this review paper is to present the main environmental challenges in maritime transport, both during ships' sailing and ships' staying in ports and to provide the state-of-the-art estimation of the environmental impacts of maritime transport.

2. CURRENT ENVIRONMENTAL FOOTPRINT OF MARITIME TRANSPORT

Shipping is the most energy-efficient way to move large volumes of cargo, in fact in 2010 ships produced a total of 60,053 billion tonne-kilometres and are projected to produce 256,433 billion tonne-kilometres in 2050 (OECD/ITF, 2015a). In 2015 seaborne trade surpassed 10 billion tonnes (UNCTAD, 2016); however maritime transport is producing, as said before, certain environmental damages, which can be grouped into air pollution, sea pollution and noise pollution. In this paper, the authors are focused on air and sea pollution originating directly from the provision of maritime services.

2.1 Air pollution from maritime transport

Ships burn heavy and low quality fuel, which can have a sulphur content of up to 2,000 times higher than fuel used by road vehicles. As a result from 2007 to 2012, average annual totals of nitrogen oxides (NO_x) and sulfur oxides (SO_x) reached 20.9 million and 11.3 million tonnes from all shipping activities respectively, and as such represent about 15% and 13% of global NO_x and SO_x from man-made (anthropogenic) sources respectively (IMO, 2015). In addition, 2.7 % of CO_2 emissions can be attributed to international shipping.

Ships emit also carbon monoxide (CO), methane (CH_4) and particulate matters (PM) both during sailing and in-port operations; however, the in-port emissions represent barely around 2% of total international shipping emissions (OECD/ITF, 2015b).

Nevertheless, these emissions, together with the emissions produced by sailing in coastal areas (according to IMO (2009), 70% of maritime traffic occurs within 200 nautical miles from shore, even more fascinating 44% and 36% occur within 50 and 25 nautical miles respectively) can have significant impact on human health, besides damaging the environment; they can cause respiratory problems and bronchitis symptoms. In fact, Corbett and others (2007) have determined that PM from shipping activities are responsable for approximatelly 60,000 cardiopulmonary and lung cancer deaths wordlwide annually. As a matter of fact, a single large container ship can emit cancer and asthma-causing pollutants equivalent to that of 50 million cars (Winkler, 2008) or with other words, 16 super-ships can emit as much sulphur as the world fleet of cars (Varsami et al., 2011). Maritime flows and consequentially majority of in-port and open seas emissions from maritime transport are expected to increase, so also the number of deaths related to maritime transport is predicted to increase; the prediction for 2012 was 87,000 (Corbett, et al., 2007). If the emissions of SO_X and NO_X from ships continue to grow at the current rate, shipping will become the biggest single emitter of these pollutants in Europe, surpassing all land-based sources combined, by 2020 (Rahm, 2015), while in 2050 ships are prejected to emit 2,630 million tonnes of CO_2 in comparisson to 779 million tons in 2010 (OECD/ITF, 2015a).

Furthermore, shipping emissions cause considerable external costs; conservative estimation suggest that emissions of NO_X, SO_X and PM caused almost 12 billion EUR of external costs in the 50 largest ports in the Organization for Economic Cooperation and Development (OECD) (Merk, 2014). External costs of airborne emissions from shipping in European waters are estimated to 19.6 billion EUR per year (Sieber and Kummer, 2008).

To diminish the negative effect of heavy oil burning, International Maritime Organization (IMO) has declared four emissions controlled areas, namely Baltic Sea, the North Sea, the US Caribbean and the coastal waters of Canada and the United States. In these areas, cleaner fuel has to be used, that is a fuel with 0.1% of sulphur content since 1st of January 2015 (global limit is still 3.5%), or ships must be adequately equipped to produce cleaner emissions. For example, instead of using marine diesel, cleaner and more expensive marine fuel, shipping operators can choose to substitute fuel power by renewable or more sustainable energies (eg. solar power, LNG or heat recovery systems) or to cut their sulphur emissions by fitting engines with scrubbers or other exhaust gas cleaning technologies.

In addition, China has voluntarily established a marine sulphur limit of 0.50% applicable to fuel used while at berth in specific ports in the Pearl River Delta Area, the Yangtze River Delta Area, and the Bohai Sea Area. They will extend the application of this regulation firstly (in 2018) to all ports in these three areas and later to ships transiting these Sea areas (in 2019).

The following measures are proposed to reduce shipping emissions (OECD/ITF, 2015b):

- Alternative fuels or power sources;
- Operational measures that cover the operation of ship itself (hull condition, propeller condition, trim/draft optimization) and routing measures, such as voyage execution and weather routing (avoiding navigation in areas with bad weather conditions);
- Technical measures that cover machinery and measures under water (propeller and hull);
- Structural changes including port efficiency, vessel speed reduction (through fleet increase) and cold ironing (using power while at berth).

2.2 Sea pollution from maritime transport

Maritime transport is damaging sea with accidental or deliberate:

- spills of liquids, like ballast water, bilge water, bunker fuel, tank washing water or oil;
- dumping of solids like dunnage or garbage or
- dumping of mixed waste like sewage or cargo residuals.

Closer to the shore these activities occur, the larger the damage is.

In 2014, 3,025 marine casualties were reported, among which, 251 cases of pollution; in 216 the sea was affected, while the remaining 35 were air pollution. In the majority of cases (165), sea pollution was caused by the release of the ship's bunker and other pollutants (EMSA, 2015). In 2014, there were 126 reported cases of pollution; 108 were sea pollution and 18 were air pollution (EMSA, 2014). These numbers suggest the deterioration, but the truth is, that the reporting system is improving, so the casualties causing pollution are being more often reported.

The biggest threat for marine environment is the oil spill from tanker ships; however, since 1970s the number of oil spills (oil spill of more than 700 tonnes) has been declining continuously. For example, in the period from 1970 to 1979 in average 24.5 oil spills happened per year, while in the period from 2010 to 2014 in average only 1.8 yearly oil spills occurred. This can be related to strickter legislation for tankers which resulted from several devastating oil spills. The most important changes include the requirement for tankers of 5,000 dwt and more ordered after 6th of July 1993 to fitted with double hulls, and the neccessity to convert or take out from service the tanker built before that date when it reaches a maximum of 30 years.

Another issue directly arising from maritime transport is the introduction of invasive species following the ballast water exchange. Ballast water is indispensable for safe operation of ships, but the transfer of harmful organisms can create ecological and health problems. An estimated 10,000 marine species are transported around the world in ballast water every day (NOAA). Currently, more than 30 treatment systems to combat this potentially huge environmental hazard are under development. In addition, all ships in international will need to manage their ballast water to an agreed standard and according to approved ship-specific ballast water management plan. Ships will aslo need to carry a ballast water record book and have a valid international ballast water management certificate after 8th of September 2017 when International Convention for the Control and Management of Ships' Ballast Water and Sediments will enter into force.

In addition, ships are submerged into sea, and anti-fouling paints are used to coat the bottoms of ships to prevent sea-life organisms from attaching to the hull, and consequently slowing down the ship and increasing its consumption. These paints include chemicals and metallic compounds, which are persistent in the water, thus provoking lasting damage to the marine environment.

3. ECONOMIC IMPACT OF SELECTED MEASURES

In order to achieve economically efficient transport, shipping companies have been ordering ever bigger ships. However, the increase in size in usually linked to the necessity to install more powerful engines, which have bigger fuel consumption, and finally the emissions increase. This was happening until the environmental performance of the engines was not a subject of international regulations. But, studies show that substituting a string of ships with a string of bigger ships of same number, going at a slower speed so that total throughput remains the same, will reduce total fuel bill, hence total emissions (Psaraftis, 2009).

In October 2008 IMO member states agreed that the sulphur content of all marine fuels will be capped at 0.5% worldwide from 2020. Also, the NO_X emission standards for new ship engines were strengthened; in 2016 they needed to be reduced by 80% in comparison to the year 2000. Both will affect capital expenses of shipping companies, while sulphur requirements can pose also significant burden to the operating costs as well (in regards to method of emission abatement selected). In fact, the decrease of sulphur content from 3.5% to 0.5% is estimated by the OECD to cost between 5 and 30 billion US$ in additional fuel costs for the world container fleet alone, beginning in 2020 (WSC, 2017).

Table 1. Overview of environmental regulations and their impact on costs of shipping companies; Source: (Rahm, 2015)

What?	When?	Where?	Impact on OpEx	Impact on CapEx
SO_X	2015, 2020	Regional, global	High	High
NO_X	2016	Regional	Limited	High
CO_2	2018	Regional	High	High
Ballast water	Uncertain	Global	Limited	High

Note: OpEx – Operating expenses, CapEx – Capital expenses

In general, the costs for reducing pollutant emissions from shipping are estimated within a range between 0.5 and 4 EUR per kg of SO_2 and from 0.01 to 0.6 per kg of NO_X (CSC, 2011). Cleaner ships' exhaust is estimated to save 26,000 people a year in EU, resulting in up to 34 billion EUR saved in health costs each year if the IMO fuel standards were transposed into the EU legislation (T&E, 2017). EU recognizes the benefits of decreased emissions and thus supports the initiatives to achieve cleaner maritime transport also with tangible projects; for example the EU's TEN-T Programme has supported with almost 4 million EUR the pilot construction of the UK's first LNG bunker and the liquefied natural gas (LNG) propulsion system of two new ships (EC, 2014) and invested almost 600,000 EUR in a study for the promotion of LNG use in Greek maritime transport (EC, 2015).

In addition, World Ports Climate Initiative (WPCI), which includes majority of major worldwide ports, is aiming to stimulate the improvement of ships' emissions. One of their main goals is to develop an Environmental Ship Index (ESI), which can be used by the ship owners and by the ports as a label of good performance, and as a way to calculate discounts on port dues. The formula combines the ships' performance in terms of SO_X, NO_X and CO_2 emissions as well as the availability of on board connection for Onshore Power Supply (OPS). The index is intended to be used by ports to reward ships when they participate in the ESI and will promote clean ships, but can also be used by shippers and ship owners as their own promotional instrument (ESPO, 2012).

In accordance to new rules, ballast water exchange requires huge capital investment due to the installation of adequate treatment systems. The physical exchange will pose some extra running costs as well, namely pumping costs comprising the use of additional fuel, energy and labor as well as machine maintenance costs associated with running ballast water pumps as well as the delay costs including the deviation or the necessity to slow down ship (Challinor et al., 2014).

4. CONCLUSIONS

Shipping is by far the most energy efficient mode of freight transport. Nevertheless, recently it is more often criticized for its environmental performance, so efforts to find ways to improve efficiency of shipping operations and shipping design must continue. At the moment one tonne of marine bunker in average produces: 3.17 tonnes of CO_2 (independently of fuel type or engine type), 0.02×S tonnes of SO_2, where S is the percentage of sulphur content in fuel, and 0.057-0.087 tonnes of NO_X depending on engine (Psaraftis, 2008). Total emissions from maritime transport are predicted to increase, although there currently exist many approaches and technologies to reduce environmental footprint, especially air emissions. However, for most of them, both certain advantages as well as certain disadvantages exist and the trade-offs between cost and efficiency or efficiency and complexity of installation or implementation must be done. In any case, the final cost of maritime transport will increase and final consumers will consequently pay more for the products they buy.

In addition, shipping is not (yet) included in the Kyoto global emissions reduction target for CO_2 and other greenhouse gas emissions. This could change as EU Parliament wants to include vessels in its Emissions Trading System (ETS), although there are several countries, led by China, India and Brazil that together with the shipping companies furiously oppose to this idea. But when there's smoke, there's fire, and another environmentally triggered impact on shipping costs is to be expected in forthcoming decades.

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