Summary: Toward sustainable sea and inland waterway shipping by 2050

Operational measures and the application of existing technologies can drastically reduce the CO_2, SO_2, NO_x and PM_{10} emitted by sea and inland waterway shipping between 2010 and 2050. The CO_2 emissions from sea shipping can be reduced by 45% during this period, especially by sailing slowly. A great degree of associated uncertainty exists, however. The CO_2 emissions of inland waterway shipping can be reduced by 65% by 2050, particularly through the use of fuel-saving technologies and Liquefied Natural Gas (LNG), for which a lesser degree of uncertainty exists than for sea shipping. For both sea and inland waterway shipping, the treatment of emitted gases ('end-of- pipe-solutions') can reduce SO_2, NO_X and PM_{10} emissions by 80-100%.

Reduction options are not automatically implemented, however. In many cases the market is responsible for eliminating such obstacles. If government intervention is required, the government - in its regulatory role - can deploy various instruments, such as emission taxes, emissions trading (including an emission ceiling), fiscal measures, subsidies and standardisation. The latter virtually always occur on the international level. The government - in its communicative role - can provide reliable information that is disseminated among the relevant parties.

Emissions-determining factors

Freight transport via water – by both sea and inland waterways – is expected to increase over the next 40 years, particularly for container transport. This increase in freight transport contributes to both economic growth and prevailing negative effects, such as air pollution (SO_2, NO_x and PM_{10} emissions), as well as greenhouse gas emissions gases (particularly CO_2). The main research question posed in this paper is: To arrive at sustainable sea and inland waterway shipping by 2050, what are the reduction and policy options for CO_2, SO_2, NO_x and PM_{10} emissions?

As with the emissions for other modalities, those for sea and inland waterway shipping are the result of three or four factors. The emission of CO_2 is a product of three factors: volume (number of kilometres sailed), ship efficiency (amount of energy per transport unit or MJ/km), and the fuel's CO_2 intensity (CO_2/MJ). A fourth factor applies to the emissions of air-polluting particles: the so-called end-of-pipe solutions, the filtering out of exhaust gases.

The volume factor seemingly has little reduction potential for sea and inland waterway shipping. Although the melting of the polar ice caps is creating shorter northern shipping routes between Asia and Europe, this effect is difficult to quantify. Moreover, because not all transport can occur via land, there are few viable alternatives to sea and inland waterway shipping. The loading rates for sea and inland waterway shipping could be higher, and initiatives aimed at facilitating this are emerging from the Top Sector Logistics, yet in recent years the loading rates were more likely to decrease than increase.

There is then no certainty that loading rates will increase and, as a consequence of this, the number of kilometres sailed will decrease. The number of kilometres sailed factor is therefore beyond the scope of this paper.

In Figure S1, the emissions of CO_2 and $SO_2/NO_x/PM_{10}$ respectively are represented schematically.

An increase in emissions

The Business-as-Usual (BAU) scenario derives from a development that occurs without the implementation of additional policy measures, but does take into account autonomous developments. In this scenario, the CO_2 emissions from sea shipping will increase by 26% until 2050, as compared to 2010 levels. This is an increase of 0.6% per year. NO_x and PM_{10} emissions will increase by 40% and 82% respectively until 2050. Under the existing policy, SO_2 emissions (on the Dutch Continental Shelf) will decrease by 70%. The increase in sea shipping emissions is primarily due to increased container transport.
Without the implementation of additional policy measures, and with autonomous developments taken into account, the CO_2 emissions of inland waterway shipping will increase by 110% by 2050, as compared to 2010 levels. This is an annual increase of 1.9%. This is a larger increase than for sea shipping, because inland waterway shipping will experience a greater increase in container transport than sea shipping. Inland waterway shipping also claims a larger share of the hinterland transport market. The emissions of NO_x and PM_{10} will increase by 110% until 2050, as compared to 2010 levels. Due to existing policy, SO_2 emissions have already decreased to such an extent that further reductions seem unlikely. We therefore do not address the SO_2 emissions of inland waterway shipping in this paper.

Options for emissions reduction

A major share of CO_2 reduction in sea shipping can be achieved through operational measures; that is, measures that pertain to sailing. A 24% reduction by 2016 is possible, with slower sailing being the most important operational measure required to achieve this. There is however great uncertainty surrounding this potential reduction. Applying energy-saving measures, such as improvements to engines, hulls and propellers, and alternative energy sources, such as Liquefied Natural Gas (LNG), will result in an additional 33% reduction in CO_2 by 2050. This means that the total CO_2 reduction in sea shipping could reach 45% by 2050, as compared to 2010 levels. Sea shipping emissions of NO_x, SO_2 and PM_{10} are partly related to the energy saving measures that lead to CO_2 reduction; namely, 32% for NO_x, 28% for SO_2, and 30% for PM10. However, the largest emission reductions derive from end-of-pipe technologies, such as water injection and chemical reduction technologies. It is possible to reduce NO_x emissions by 99%, SO_2 by 90%, and PM_{10} by 94%. The degree of uncertainty pertaining to the reduction potential of these technologies is much lower than those for CO_2 reduction.

A 65% reduction of CO_2 by 2050 is possible for inland waterway shipping. Unlike sea shipping, slower sailing plays less of a role in inland waterway shipping. Fuel saving technologies and the use of LNG as a fuel source have greater and more secure potential for inland waterway shipping than for sea shipping. A condition of using LNG is that the amount of released methane slip is reduced; otherwise, the CO_2 reduction is minimal. As with sea shipping, the use of end-of-pipe technologies substantially reduces inland waterway shipping's NO_x and PM_{19} emissions: 84% and 100%, respectively.

When we compare the maximum reduction potential to internationally formulated objectives, the targets set for SO_2, NO_x and PM_{10} are achievable, especially through the application of end-of-pipe technologies. Greater uncertainty exists pertaining to the objectives set for CO_2 emissions.

Implementation of emission reduction options

It is in principle the responsibility of the sea and inland waterway shipping firms to implement the technologies and measures required to render the sector more sustainable, including a higher level of organisation or improved logistics efficiency. This does not always occur, however. Various obstacles can prevent successful implementation from occurring. We can divide these obstacles into market imperfections, technical and legal barriers, and other obstacles.

In some cases, the government can reduce or remove these obstacles. For this, the government has various policy options at its disposal: opportunities and associated instruments that the Dutch government can deploy in order to render sea and inland waterway shipping more sustainable. But the Netherlands is extremely limited in implementing these policy options independently. Given the international character of the sector and the desire to create an equal playing field, the majority of decisions pertaining to sea and inland waterway shipping must be taken internationally.

Obstacles and opportunities for the government

The policy options for removing obstacles are divided into options that promote the dissemination of emission reduction technologies and options that promote innovation. The impression is that the dispersion of emission-reducing technologies poses the greatest challenge for sea and inland waterway shipping, and not innovation. We therefore restrict ourselves to policy options that remove obstacles to emissions reduction.

The key market imperfection that applies to all factors in Figure S1 is ‘environmental externality’: a price is not applied to emissions. Governmental instruments, such as emission taxes, emission trading, standards and agreements, can remove this obstacle. In addition, the ‘information asymmetry’ obstacle can be removed through information dissemination. The risk-aversion and restraint displayed by shipowners, shipbuilders and shipping companies also plays a role. Finally, a ‘split incentive’ is also a factor: the benefits of investing do not accrue to the same party as the costs. Financial measures, such as including fuel costs in rates, can result in a fairer division of benefits and hence serve as a solution.

Technical obstacles primarily play a role in as far as they reduce the loading space. Legal obstacles derive from international regulations. Adapting to international conventions can offer a solution, and this also applies to adherence with international safety standards, as the lack thereof impedes the construction of infrastructure for LNG fuel, for example. Conversely, there are perhaps good other reasons than improving sustainability for not changing international regulations.

Various aspects fall under the ‘other obstacles’ category, including a lack of incentives (the sector derives no immediate benefit from implementing end-of-pipe technologies, for instance), high net costs, the lack of investment space, the impact of the economic crisis, uncertain fuel prices, the long life-spans of ships, reduced availability and high costs of alternative energy sources, such as wind and solar energy, and alternative fuel sources, such as LNG and biofuels.

An additional issue for inland waterway shipping is the very nature of the inland waterway shipping market, which is comprised of many small, conservative companies that, owing to competition, focus on short-term returns.

The government can help remove the identified obstacles by implementing financial measures, such as promoting end-of-pipe technologies, and reaching agreements aimed at promoting greater collaboration within the inland waterway shipping sector.