Air pollution from container ships

Reductions possible with the use of diesel and effective exhaust gas technology – next to no impact on shipping and product prices


NABU/Damm

Consignments sent by container ship are considered to be environmentally friendly because the ships emit low levels of carbon dioxide (CO_2) per tonne-kilometre. This is only half the story, however, because the global shipping industry also emits huge amounts of air pollutants which cause major environmental damage and which accelerate climate change. What's more, in Europe alone, some 50,000 people die prematurely every year due to the impact of shipping emissions. The reason for this is that seagoing vessels run on heavy fuel oil, which is high in sulphur and heavy metals. The sulphur content of marine fuels is currently capped at a maximum of 3.5 per cent. This is 3,500 times more than is permitted in the diesel fuel used in HGVs. Efficient exhaust gas technology has been a legal requirement for land-based freight for some time, but is an absolute exception in the area of shipping. Similarly, the legal provisions and limits regarding emissions at sea lag far behind those stipulated on land. But the fact is that cleaner fuels and efficient exhaust gas technology are already available and are also cost-effective. The additional costs per transported product would be minimal were heavy fuel oil to be avoided and were exhaust gas technology introduced on all vessels.

Goods transportation using seagoing vessels – cleaner for just a few cents more

Seagoing vessels transport large quantities of containers over vast distances. Heavy fuel oil is cheap, and this, in addition to low manufacturing costs, is one of the reasons why many goods are produced overseas and are then shipped over to Europe. Transportation costs account for an average of two to three per cent of a product's total costs.

These days, a standard 20-foot container (TEU) can be shipped from Shanghai to Hamburg profitably for around 1,000 euros. Due to excess capacity recently, the freight rate, in other words the price paid by the customer for a container, has actually been even lower than this, at 895 euros. And the capacity of a container is considerable: there is space in a standard container for around 38,000 T-shirts or just under 3,500 shoeboxes. The shipping costs for the individual items are therefore low – around two cents and 30 cents respectively in these two cases.

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Tab. 1: Shipping costs for selected products and their respective additional costs if diesel fuel is used (50 ppm)

Product	Items per container	Shipment price per item, in euros	Additional price for shipment using diesel, in euros	Shipment price per item when shipped using diesel, in euros
T-shirt	38,000	2 cents	0.2 cents	< 2.2 cents
Digital camera	19,307	5 cents	< 1 cent	< 6 cents
Tablet PC	10,831	< 10 cents	1 cent	< 11 cents
Pair of shoes	3,456	< 30 cents	< 3 cents	< 33 cents
13“ notebook	2,160	< 50 cents	< 5 cents	< 55 cents
A4 printer	528	< 2 euros	< 20 cents	< 2.2 euros

Source: Own calculations

In comparison to heavy fuel oil, the additional costs for lower-sulphur fuel (0.005 per cent or 50 ppm) amounted to approximately 45 per cent in the second half of 2013. Fuel costs account for around 26 per cent of freight costs. This means the shipping costs only increase by twelve per cent if diesel fuel (50 ppm) is used instead of heavy fuel oil. These costs could be offset by means of “slow steaming”. This is when a vessel slows down to reduce its engine output and to save fuel. Emissions are then also reduced. Even if it were not possible to offset the higher purchase price of diesel fuel somewhere, the price of a tablet PC would still only increase by a cent because of that, while a T-shirt and a pair of shoes would cost just 0.2 cents and three cents more respectively.

For the air quality to be significantly improved, the shipping companies need to make the transition to lower-sulphur fuel and need to introduce efficient exhaust gas technology. A selective catalytic reduction (SCR) system and a diesel particulate filter (DPF) for a large container ship cost around 500,000 euros each. The building costs for a ship with a loading capacity of 10,000 to 12,000 standard containers are around 100 million euros. These would increase by a mere one per cent were efficient exhaust gas technology also incorporated. Even if the costs of incorporating a diesel particulate filter and an SCR system were passed on in their entirety to the customers, this would not have a significant impact on freight rates and would therefore not significantly affect the shipping companies’ profits.

Implementation of the three measures outlined above (a switch to lower-sulphur diesel fuel [50 ppm], fitting vessels out with particle filters and with SCR systems) would reduce black carbon (BC) emissions by 99 per cent, nitrogen oxide emissions by 97 per cent and the emissions of other toxic substances such as toxic metal oxides by more than 99 per cent.

Background

Ship-based air pollution – out of sight, out of mind

90 per cent of global trade is handled by around 45,000 freight vessels. The world's biggest container shipping company is the Danish company Maersk, followed by the Swiss Mediterranean Shipping Company (MSC) and CMA CGM in France. The largest container shipping company in Germany is Hapag-Lloyd. Germany has the third-largest commercial fleet in the world, with 3,750 cargo vessels.

Container ships are getting bigger and bigger. The largest vessels around are currently in the Triple E class, with a capacity of up to 18,000 TEUs. Chinese shipping companies are already planning to build vessels with a loading capacity of 20,000 TEU. The emissions caused by commercial shipping have increased considerably in recent years, among other things because of increased trade with the Far East. Although container shipping has been in a crisis for a number of years relating to surplus capacities caused by the building of new large vessels, analysts are still forecasting a steady increase in shipping in the years to come. Ongoing economic globalisation, population growth and low shipping costs will continue to increase the volume of goods shipments around the world – and therefore also of emissions.

Black carbon deposits in the Arctic. Photo: Olaf Otto Becker

Air pollutants in ship exhaust gases

In 2012, the World Health Organization (WHO) categorised the emissions of diesel engines, in particular black carbon particles, as carcinogenic and put them on a par with asbestos in terms of their hazard potential.

Sulphur oxides (SO_x). These are partially responsible for acid rain and do damage to vegetation. They irritate our airways and, together with other air pollutants, cause numerous premature deaths, in particular in coastal regions.

Nitrogen oxides (NO_x) acidify the ground and water. They also over fertilise lakes, soil and coast areas (estuaries). High nitrogen dioxide immissions reduce lung functionality and increase the risk of cardiovascular disease. Nitrogen oxides are also a precursor to ground-level ozone (O_3). Shipping is responsible for up to 22 per cent of global NO_x emissions.

Ground-level ozone (O_3) is harmful to human health and to vegetation, and plays a significant part in climate change.

Particulate matter (PM) and **black carbon** (BC) can trigger heart and lung diseases, chronic bronchitis and asthma complaints. In addition, black carbon emissions are the second biggest driver of climate change, second only to carbon dioxide. In particular, black carbon has a major climatic impact on the Arctic regions and on glaciers: the black particles are deposited on white ice and snow surfaces, creating darker patches that absorb a great deal more heat than white ice. This lowers the sun's reflection coefficient (albedo), resulting in an acceleration in the melting of Arctic ice. If this leads to an increase in the proportion of dark sea surfaces, the Arctic warms up even further – the result being a self-amplifying melting process. Approximately 50 per cent of Arctic warming is attributed to black carbon. Vessels operating in these regions therefore constitute an especially high ecological risk.

The danger posed by ship emissions is underestimated – who in, for example, Berlin or Munich spares a thought for ship exhaust gases? Who thinks about black carbon particles and sulphur dioxide when they buy an electronic device or a pair of trainers? Out of sight, out of mind – it's an understandable attitude, but one which is misguided, because the majority of exhaust gases are produced in close proximity to the coast, but can be transported inland over great distances. Around the world, 80 per cent of all ship emissions are emitted within just 400 kilometres of the coast. In the North Sea, up to 90 per cent of ship emissions are even emitted within just 90 kilometres of the coast. This makes them especially dangerous to people and nature.

Germany's contribution

As 85 per cent of all ship emissions are generated in the northern hemisphere, there is an urgent need for shipping companies, port operators and politicians in Europe and, with its large commercial fleet, in Germany to act.

Technical measures to reduce emissions

Ship emissions can be reduced in the short and medium term by a whole host of technical measures. The simplest, quickest and best solution for reducing sulphur emissions is to use fuel with a very low sulphur content. The lower the sulphur content, the lower the proportion of heavy metals and polycyclic aromatic hydrocarbons (PAH). A reduction in sulphur also leads to a tangible reduction in particulate mass. However, the dangerous black carbon emissions are not reduced accordingly. The vessels therefore also need to be fitted with catalytic converters and black carbon particle filters (↓). Such filters only work in conjunction with fuels of less than 0.5 per cent sulphur – and are therefore another argument in favour of eliminating heavy fuel oil. The use of lower-sulphur fuels needs to be backed politically, ideally in the form of a ban on heavy fuel oil. However, the shipping companies can and should implement these changes voluntarily in advance of any such legal stipulations.

Particle filters can almost completely eliminate black carbon emissions in vessels running on a fuel with a sulphur content of a maximum of 0.5 per cent. Such filters

are already mandatory in new passenger cars and heavy goods vehicles (HGVs) due the strict emission limits applicable on land. But to date, not one commercial seagoing vessel uses a particulate filter, even though the technology is already available. This is because there are currently no legal requirements for a significant reduction in black carbon emissions at sea.

Selective catalytic reduction systems (SCR systems) can eliminate more than 90 per cent of NO_x emissions. This established technology is already in use in some 500 vessels around the world.

Another technical measure implemented in order to reduce sulphur oxide emissions is what's known as "scrubbing". This entails using water or a dry substance to clean a ship's exhaust gases in a **scrubber system**. Depending on the system and the fuel used, sulphur emissions can be reduced in the range of 70 to 95 per cent. However, a major drawback of this process is that it generates waste water/waste materials that then have to be disposed of on land. Not all ports offer the necessary disposal facilities and there is no way of preventing ships from simply dumping the waste straight into the sea. Scrubber systems also work with heavy fuel oil and can be activated and deactivated while a ship is in operation. Installing a scrubber system is therefore not just an incentive to continue to use heavy fuel oil – it is also possible to only use the scrubber system where this is required by law and where compliance checks are performed, while continuing to pollute the air and water when elsewhere. What's more, using a scrubber system increases fuel consumption by between one and three per cent. NABU is not in favour of scrubber systems being installed, due to the many disadvantages for the environment.

As it is not possible to finance the retrofitting of a ship whenever necessary and as a lack of space can then also be an issue, installing a diesel particulate filter and an SCR system is the only economically prudent and environmentally clean solution, especially in view of the fact that a limit on the sulphur content of diesel fuel of 0.5 per cent will apply globally as of 2020[1]. The minimum operating temperature of an SCR system very much depends on the sulphur content of fuel: the lower the sulphur content, the lower the operating temperature. The sulphur content of marine fuel should therefore be as low as possible. In 2013, the difference in the price of marine diesel oil (MDO) with 0.1 per cent sulphur content and diesel fuel with 0.005 per cent sulphur content was just 11 US dollars a tonne in Rotterdam. The use of diesel fuel is therefore justifiable. In addition, using appropriate diesel fuel would further reduce a ship's sulphur dioxide emissions by a factor of 20.

Source: NABU/ Matthias Boerschke

Political measures to reduce emissions

The international framework for the regulation of emission reductions in shipping on the high seas is established by the International Maritime Organization (IMO) of the United Nations (UN), to which Germany belongs. Annex VI of the **IMO's International Convention for the Prevention of Pollution from Ships (MARPOL Convention)** sets limits for sulphur dioxide and nitrogen oxide emissions, and prohibits the deliberate emission of ozone-depleting substances. It also allows for the designation of emission control areas (ECAs) in which stricter limits are set for specific harmful substances. To date, the IMO has defined and designated **sulphur emission control areas (SECAs)** and **NO_x emission control areas (NECAs)**: there is a combined NECA/SECA area in North America, while in Europe, the North Sea, the Baltic Sea and the English Channel are all

[1] In the EU as of 2020. In the non-SECAs as of 2020 or 2025, subject to a review in 2018.

designated as SECAs. The countries on the Baltic Sea and the North Sea are currently preparing to apply for NECA status. The sulphur limits in the SECAs will already become significantly stricter in 2015 (0.1 per cent), and will be reduced to 0.5 per cent in all other areas from 2020 at the earliest. The nitrogen oxide levels applicable in the NECAs will be reduced in stages. Vessels built as of 1 January 2016 are likely to require a so-called Tier III engine within a NECA. Tier III stands for an exhaust gas standard much like the standards applicable to passenger cars and HGVs in the EU, and stipulates the maximum permissible levels of air pollutants that may be emitted by a vehicle in the harmful substance category in question. This standard does not apply to existing vessels, and as ships tend to have a long lifespan, any reductions in NO_x are expected to materialise only with a significant delay. There is an ongoing debate within the IMO as to whether nitrogen oxide limits should apply as of 2016 or alternatively not until 2021.
The EU has broadly incorporated the IMO's sulphur limits into EU law, and Germany has already implemented them within its national laws on the basis of its legislation to tackle MARPOL contravention (MARPOL-ZuwV).

Quelle: NABU/Philip Scholl

Tab. 2: Global comparison of sulphur limits for marine fuel

	Global (IMO)			EU			North America	
	Current (2013)	2015	2020	Current (2013)	2015	2020	Current (2013)	2015
Non-SECAs	3.5%	3.5%	0.5%*	3.5%	3.5%	0.5%	3.5%	0.5%
SECAs	1.0%	0.1%	0.1%	1.5%	0.1%	0.1%	1.0%	0.1%

* Subject to a review in 2018, with possible postponement of implementation until 2025.

The EU member states must use and promote ECAs as an instrument in order to further reduce the shipping sector's air pollutant emissions. The introduction of NECAs and SECAs in all EU waters and economic zones at sea (EU 27) would result in emission reductions of 160,000 tonnes of SO_2 and 970,000 tonnes of NO_x. A key factor in relation to any limits is that compliance with them be closely monitored and that heavy sanctions be put in place in the event of infringements of the limits. This is not currently the case. What's more, the IMO and the EU need to develop effective strategies for reducing emissions of particulate matter and black carbon in the shipping sector. As yet, there are no black carbon emission limits applicable to seagoing vessels. The political measures implemented so far to reduce air pollution are both important and right. However, the introduction of even stricter limits is, in a number of cases, scheduled very late and is also at risk of being postponed. And no limits have even been set yet for hazardous air pollutants such as PM and black carbon.

The aims and demands of NABU

Within the "Soot-Free for the Climate" campaign, NABU – together with BUND (Friends of the Earth Germany), VCD (German Association for Sustainable Mobility) and DUH (German Environmental Aid) – aims to reduce the dangerous soot emissions and nitrogen oxide emissions from diesel engines. These air pollutants are very harmful for human health and moreover, soot is a strong climate forcer. The campaign therefore demands that within the EU all diesel soot emissions shall be eliminated until the year 2020. In view of ever-increasing global trade, NABU and its partners are calling for fast and effective measures to be implemented by politicians and the world of business, in order to reduce the emissions caused by commercial shipping in line with the reductions achieved in the area of land-based transport.

NABU is calling upon the following measures to be implemented as quickly as possible:

- Commercial vessels must make the transition from heavy fuel oil to low-sulphur diesel (50 ppm) or to a similarly clean fuel such as liquefied natural gas (LNG).
- Commercial vessels must be fitted with efficient exhaust gas after-treatment systems. Only diesel particulate filters and SCR systems are viable options – scrubber systems are not a solution.

Extra costs caused by these measures can only partially be compensated through other measures such as more efficient engines or slow steaming. But, as outlined before, the extra costs per product are so small that customers can pay them without causing significant losses in revenue for ship owners and forwarders.

NABU therefore is calling upon companies that ship their goods using seagoing vessels:

- To demand cleaner transports from their ship owners and logistics companies and to order cleaner transports as soon as they are available (ships with cleaner fuels and effective emission abatement techniques).
- To include black carbon and NO_x levels in their sustainability reports and carbon footprints.

Besides the world of business, also politicians are urgently demanded to act for a drastic reduction of emissions on the high seas.
That is why NABU is calling

...upon the German government:

- To introduce and promote funding programmes for the further development, testing and installation of effective exhaust gas technology such as diesel particulate filters.
- To only operate state-owned vessels using higher-grade fuel with a maximum sulphur content of 50 ppm or a similarly clean fuel, to look into fitting such vessels with a diesel particulate filter and an SCR system, and to make this technology a prerequisite for all newly built ships.
- To rigorously monitor compliance with the limits as set out in the sulphur regulations and to impose serious penalties in the event that these limits are infringed.

...upon the EU:

- To strictly monitor compliance with the EU's sulphur limits (Directive 2012/32/EU) and to impose heavy sanctions in the event of infringements.
- To introduce strict exhaust gas regulations for SO_2, NO_x, PM and black carbon in all of the EU's coastal regions and ports.
- To incorporate PM and black carbon emission limits into all EU treaties and directives relating to the reduction of harmful substances in shipping.
- To include shipping in its national emission ceilings (NEC) directive (2001/81/EC).

... upon the IMO:

- To designate all coastal regions and ports around the world as SECAs and NECAs.
- To incorporate black carbon emission limits into all IMO treaties and directives relating to the reduction of harmful substances in shipping.
- To immediately and comprehensively check particulate matter and black carbon emissions in the global shipping sector.
- To introduce stricter limits for the NO_x emissions of newly built ships and to stipulate more stringent NO_x limits for existing vessels.
- To back the speedy introduction of NECAs.
- To implement a global ban on heavy fuel oil in shipping as of 2020.

For more information, go to: www.NABU.de/ships

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