Air pollution from ships

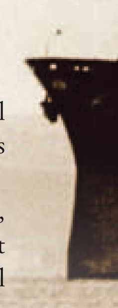
Seas At Risk
Bellona Foundation
North Sea Foundation
European Environmental Bureau
Swedish NGO Secretariat on Acid Rain
European Federation for Transport and Environment

Increasing emissions

Emissions from shipping contribute significantly to the concentrations and fallout of harmful air pollutants in Europe.

There are however technical means by which these pollutants could be cut by as much as 80–90 per cent, and very cost-effectively compared to achieving similar results by taking further measures for land-based sources.

Such reductions are needed to protect health and the environment, and to develop shipping as a more sustainable mode of transport.



While pollutant emissions from land-based sources are gradually coming down, those from shipping show a continuous increase.

The emissions from ships engaged in international trade in the seas surrounding Europe – the Baltic Sea, the North Sea, the north-eastern part of the Atlantic, the Mediterranean and the Black Sea – were estimated at 2.3 million tonnes of sulphur dioxide (SO_2), 3.3 million tonnes of nitrogen oxides (NOx), and 250,000 tonnes of fine particles (PM) a year in 2000.

Under current legislation, it is expected that shipping emissions of SO_2 and NOx will increase by 40–50 per cent up to 2020, as compared to 2000. In both cases, by 2020 the emissions from international shipping around Europe are expected to equal or even surpass the total from all land-based sources in the 27 EU member states combined (see Figures 1 and 2).

It should be noted that these figures, high as they are, refer only to ships in international trade. They do not include emissions from shipping in countries' internal waterways or from ships plying harbours in the same country, which are given in the domestic statistics of each country.

However, if the recent international agreement (see pp. 4–5) on new SO_2 and NOx emission standards is implemented, by 2020 emissions of SO_2 should come down significantly, while those of NOx would still increase, but not as much as was earlier anticipated.

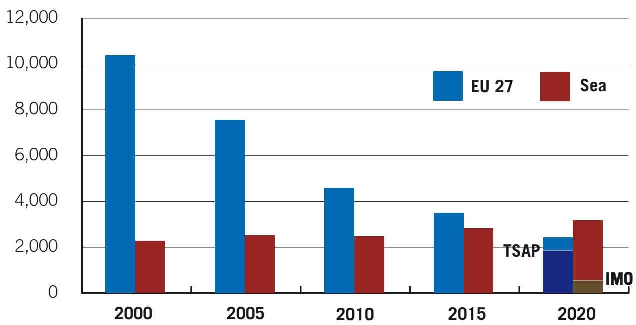


Figure 1: Emissions of SO_2 2000–2020 (ktonnes).

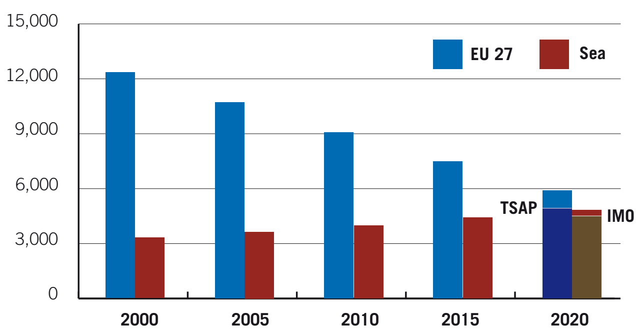


Figure 2: Emissions of NOx 2000–2020 (ktonnes).

Global emissions

With no change in international regulations, an Expert Group to the International Maritime Organization (IMO) predicted in autumn 2007 that today's total of 369 million tonnes of marine fuel consumption would rise to 486 million tonnes by 2020, of which 382 would be heavy fuel oil and 104 would be distillates.

Annual SO_2 emissions from ships were estimated at 16.2 million tonnes in 2006, rising to 22.7 million tonnes in 2020 under the "business-as-usual" scenario. Emissions of the greenhouse gas carbon dioxide (CO_2) from ships were estimated at 1,120 million tonnes per year, rising to 1,475 million tonnes in 2020.

EU27 = Emissions from land-based sources in all EU countries (incl. domestic shipping).
Sea = Emissions from international shipping in European sea areas.
TSAP = Target in line with the EU Thematic Strategy on Air Pollution from September 2005.
IMO = Expected outcome from implementing the preliminary IMO-agreement from April 2008.

Although most of the pollutants emitted by international shipping get deposited over the sea, it is the largest single source of acidifying and eutrophying fallout over many countries in Europe. It also contributes significantly to raising the levels of health-damaging fine particles and ozone.

Health damage

Smokestack emissions from international shipping kill approximately 60,000 people a year, including 27,000 in Europe, at an annual cost to society of more than 200 billion euro, according to a recent scientific study.

The researchers used global inventories of ships' emissions of SO_2, NOx and PM for the year 2002. Through chemical reactions in the air, SO_2 and NOx is converted into fine particles, sulphate and nitrate aerosols.

Tiny airborne particles are linked to premature deaths. The particles get into the lungs and are small enough to pass through tissues and enter the blood. They can then trigger inflammations which eventually cause heart and lung failures. Ship emissions may also contain carcinogenic particles.

More than two-thirds of ship emissions occur within 400 kilometres of land. It was found that health impacts were concentrated in coastal regions along major trade routes. East Asia and South Asia were the most heavily impacted, each representing about one-quarter of the global impact. One-third of all shipping deaths occurred in Europe, and about one-tenth in North America.

Acidification, eutrophication, ozone...

Since they cause acidification of soil and water, the emissions of SO_2 and NOx continue to be a serious problem in large parts of Europe. NOx also contributes to the formation of ground-level ozone, which damages vegetation as well as human health, and contributes to global warming. Moreover, NOx lead to eutrophication, which negatively affects biodiversity both on land and in coastal waters.

Acidification: In 2000, the depositions of sulphur and nitrogen exceeded the critical loads for acidifying substances over 260,000 square kilometres (20%) of sensitive forest ecosystems in the EU.

Eutrophication: In 2000, the depositions of nitrogen in the EU exceeded the critical loads for eutrophication over more than 1 million square kilometres (70%) of sensitive terrestrial ecosystems.

Ozone: In 2000, approximately 800,000 square kilometres (60%) of the EU forest area were exposed to ozone concentrations exceeding the critical level.

Table 1. Examples of countries where the proportion of air pollutant depositions of sulphur and nitrogen oxides from shipping is most marked. Data for 2005.

	Sulphur	NOx-nitrogen
Denmark	45%	27%
Sweden	23%	22%
Netherlands	21%	18%
UK	19%	19%
Ireland	18%	20%
France	12%	14%
Finland	12%	14%
Belgium	12%	13%
Italy	11%	17%
Germany	10%	10%

Source: EMEP 2007

International action

Although some countries, such as Sweden and Norway, have taken steps to attack the problem of ships' emissions independently, on the whole little has been done about it.

IMO

Shipping being largely an international business, it would be logical to try and bring about global agreement for control of its emissions, and such attempts have been made in the Marine Environment Protection Committee (MEPC) of the UN International Maritime Organization (IMO).

After years of negotiation, agreement was reached in 1997 on an air-pollution annex to the IMO's MARPOL Convention – Annex VI, which came into force in 2005. It includes a global cap of 4.5% on the sulphur content of fuel oil, and contains provisions allowing for special emission control areas (ECAs) to be established with more stringent control on sulphur emissions.

In these areas, the sulphur content of fuel used onboard ships must not exceed 1.5%. Alternatively, ships must fit an exhaust gas cleaning system or use other methods to limit their SO_2 emissions. The Baltic Sea was the first to ECA to enter into force in 2006, followed by the North Sea in 2007. Annex VI also sets limits on the emissions of NOx from new ship engines, but these standards are so weak that in practice they do not have any appreciable effect.

During negotiations on the revision of Annex VI, a deal was reached by IMO's member states at an MEPC meeting in April 2008. According to this, the sulphur content of all marine fuels will be capped at 0.5% worldwide from 2020. In a first step, the global cap should be lowered to 3.5% as from 2012. The ECAs will face a stricter limit of 1.0% in 2010 and 0.1% in 2015.

There was also agreement on nitrogen oxide (NOx) emission standards for new ship engines in two steps. In the first step, emissions would be cut by 16–22% by 2011 relative to 2000, and in the second step by 80% by 2016. The latter (longer-term) limit would only apply in the specially designated ECAs, however. As regards existing engines, no significant reductions are expected

By fitting SCR to all its engines, the emissions of nitrogen oxides from Viking Line's MS Cinderella are cut by 97%, down to 0.4 g/kWh. MS Cinderella also uses low-sulphur (< 0.5%) fuel, and is in Stockholm connected to shore-side power.

The freighter MS Cellus emits 90 per equivalent standard ship. It is equipp low-sulphur fuel oil.

– it was agreed that some of the largest existing engines from the period 1990–1999 should be fitted with an emission-reducing "kit" that is expected to reduce NOx emissions by 10–20 per cent.

The agreement must be finally approved at the MEPC's plenary body meeting in October 2008. It will then go into effect by March 2010.

EU

Although it has long been held within the European Union that shipping is a matter for the IMO, the Commission has recently been investigating the economic, legal, environmental, and practical implications of co-ordinated EU action for reducing the emissions of air pollutants from ships. This initiative was partly spurred by the EU directive on national emission ceilings requiring the Commission to present a programme of action for reducing emissions from international maritime traffic.

A directive regulating the sulphur content of marine fuels was adopted in 2005, largely confirming the global Annex VI standards, but also setting a 1.5% limit for all passenger ferries in the EU, and a 0.1% limit for vessels at berth. The directive is to be reviewed in 2008. There are no EU standards for NOx or PM emissions from sea-going ships.

Cost-effective measures

The costs of typical measures for reducing the emissions of SO_2 from ships range from 0.3 to 2.5 €/kg and of NOx from 0.01 to 0.6 €/kg. The measures required to further reduce emissions of the same pollutants from sources on land would generally cost more, and in some cases much more.

One reason for costs at sea being lower is that the easiest and least expensive measures have already been taken ashore, but not yet at sea.

The cost-effectiveness of abatements at sea has been studied by IIASA, the International Institute for Applied Systems Analysis, both with regard to the EU directive on national emission ceilings and the thematic strategy on air pollution.

Their analyses clearly show that by combining measures for shipping and land-based sources, the health and environmental targets could be attained at a considerably reduced cost. Alternatively, significantly improved health and environmental protection could be achieved at the same cost.

cent less NOx and 80 per cent less sulphur dioxide than an
ed with an SCR flue gas emission control system and uses

Benefits outweigh costs

Many benefits of reduced emissions cannot be quantified in monetary terms. However, using figures from the US Environmental Protection Agency for the value of a statistical life, the annual cost to society of the 60,000 or so annual deaths caused by shipping in 2002 is over 200 billion euro per year.

Clearly the cost to society of taking no action to reduce air pollutant emissions from ships is much higher than the cost of implementing control measures (e.g. a global 0.5% sulphur distillate fuel requirement) and the benefits of reduced emissions greatly exceed the costs.

Of course, there are other likely health impacts from shipping emissions that are not accounted for by looking only at premature mortality, such as non-fatal heart attacks, lung disease, asthma, hospital visits and lost work days, as well as a wide variety of environmental impacts.

The means are available

The technology already exists for cost-effective reduction of the emissions of SO_2, NOx and PM from ships.

Sulphur dioxide

Low-sulphur fuel. Sea-going ships burn extremely dirty fuels that contain on average 2.5–3% sulphur – almost 3,000 times the sulphur content of road diesel fuel in Europe. Emissions are directly proportional to the sulphur content of the fuel, and the simplest way of reducing them is to use fuel oil with a low sulphur content.

Because of its higher quality, low-sulphur distillate fuel has the advantage of making for smoother engine running, with less risk of operating problems and less maintenance costs. It also significantly reduces emissions of PM and several other harmful substances.

Scrubbers. A possible alternative option is to install flue gas cleaning, or scrubbers. This is a relatively new technology, and trials are ongoing. There are still some questions regarding e.g. abatement efficiency, use in harbour areas, and waste production and handling.

Nitrogen oxides

Internal Engine Modifications (IEM), Exhaust Gas Recirculation (EGR) and water injection are different techniques for preventing the formation of NOx during combustion. The potential for emission reduction is around 30–50%, the highest for water injection.

HAM, Humid Air Motor, prevents NOx-formation during combustion by adding water vapour to the combustion air. The method is able to reduce NOx by 70–85%.

Selective Catalytic Reduction, SCR, is a system for after-treatment of exhaust gases. It can reduce emissions of NOx by more than 90%, and operates better with low-sulphur fuel oil. There are now around 100 ships fitted with SCR – many of them are frequent callers at Swedish ports.

Gas engines

Ship engines can also operate on natural gas (LNG) and in this way reduce SO_2 emissions to almost zero since there is no sulphur in LNG. Emissions of NOx and PM are also significantly reduced, by 80% or more.

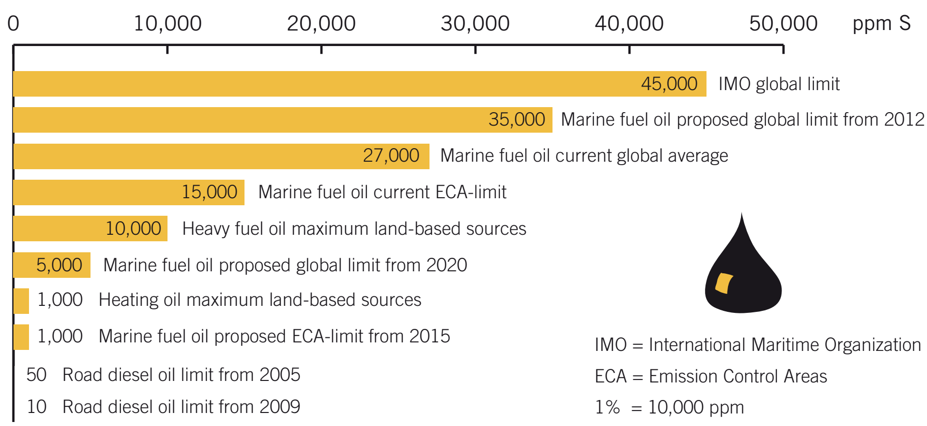
Shore-side electricity

While docked at the port, ships shut off their propulsion engines, but use their auxiliary engines to power refrigeration, lights, pumps and other equipment. If ships connect to a shore-side power supply instead, emissions of SO_2, NOx and PM can be cut by 90% or more.

Alternative energy sources

The use of fossil fuel must come down. Experiments with wind power (SkySails) and fuel cells are ongoing. Small craft operate on solar power and scaling this technology up is a challenge for the shipping industry.

In the EU, the maximum allowed sulphur content in light fuel oil is 0.1%, and in heavy fuel oil it is 1%. Any new large combustion plants (i.e. with a thermal capacity of more than 50 megawatts) built after 2003 must keep their SO_2 emissions below levels equivalent to maximum sulphur contents in fuel oil of between 0.1 and 0.5%. The bigger the plant, the stricter the emission limit value.



Six environmental organizations – the European Environmental Bureau, European Federation for Transport and Environment, Seas At Risk, North Sea Foundation, Bellona Foundation, and the Swedish NGO Secretariat on Acid Rain – have jointly worked out a series of recommendations for action to be taken.

What the EU and its member states should do

As regards global action under the International Maritime Organization, the EU and its member states should:

- Ensure the adoption and implementation of a revised MARPOL Annex VI in line with the agreement reached by MEPC in April 2008.
- Make every effort to markedly strengthen the weak emission standards for NOx in Annex VI, both for existing and new ships.

To speed up the introduction of low-sulphur fuel and cleaner ships, regulation should be complemented by market-based instruments that apply fair and efficient Community pricing principles to the marine sector. The EU and its member states should:

- Expand the Emission Control Areas (ECAs) to include all European sea areas. Currently only the Baltic Sea and the North Sea have ECA status. There is an urgent need for the north-eastern Atlantic, the Mediterranean, and the Black Sea to also become ECAs.
- Ensure reductions of SO_2 and PM by revising directive 2005/33 on the sulphur content of fuels. The maximum permitted sulphur content for marine fuels used by ships in the Exclusive Economic Zones (or at least in territorial waters) should initially be set at 0.5%, and should be applied in all Community sea areas. In a second stage the sulphur limit should be lowered to 0.1%.
- Cut emissions of NOx by establishing mandatory NOx emission standards for ships entering EU ports.
- Adopt an EU directive to regulate the quality of marine fuels.

Since the EU legislative process is likely to take some years, and will probably only tackle parts of the problem, charges should be imposed that are differentiated for environmental effect and apply impartially to all vessels.

- Adopt an EU directive that makes all member states introduce charges that are related to the amounts of pollutants emitted, and set so as to make it financially worthwhile – at least for ships that regularly frequent the area – to use cleaner fuels or to invest in techniques needed to ensure a distinct reduction in emissions.

Substantial PM reductions are also needed, and here the co-benefits of NOx and SO_2 reductions should be considered. After reviewing available control measures to reduce PM emissions, specific PM standards should be developed and introduced.

Any measure needs to be accompanied with monitoring of compliance, not only for sea-going vessels, but also marine fuel trading barges and at onshore selling points.

It is important to note that measures such as lowering of the sulphur content of fuels will bring immediate emission reductions, as will the retrofitting of SCR or HAM. On the other hand, measures that will apply only to new vessels, such as stricter NOx emission standards exclusively for new ship engines, will only gradually reduce emissions over a longer time period (depending on the fleet turn-over rate).

To get more information

More information on ships and air pollution is available at the websites of the organizations listed below. Further copies of this pamphlet can be obtained free of charge on request to The Swedish NGO Secretariat on Acid Rain, address below. It can also be downloaded in pdf format from the secretariat's website at www.acidrain.org.

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