# Air pollution from ships

AirClim
Seas At Risk
Bellona Foundation
North Sea Foundation
Transport & Environment
European Environmental Bureau

# Increasing emissions

Shipping is a major cause of harmful air pollution in Europe and by 2020 shipping emissions of $SO_2$ and NOx could exceed the emissions of these pollutants from all other sources in the EU.

This pollution must be reduced dramatically to protect health and the environment and to make shipping a more sustainable form of transport.

Technical measures exist that could cut the level of pollution from ships by at least 80–90 per cent and doing so would be much cheaper than cutting the same amount of pollution from land-based sources.

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

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 particulate matter (PM) a year in 2000.

Under a business-as-usual scenario, it is expected that shipping emissions of $SO_2$ and NOx will increase by 40–50 per cent between the year 2000 and 2020. 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, and those of NOx will not increase as much as previously anticipated.

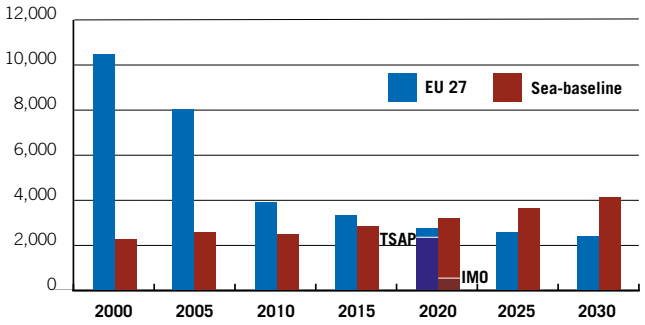



*Figure 1: Emissions of $SO_2$ 2000–2030 (ktonnes)*

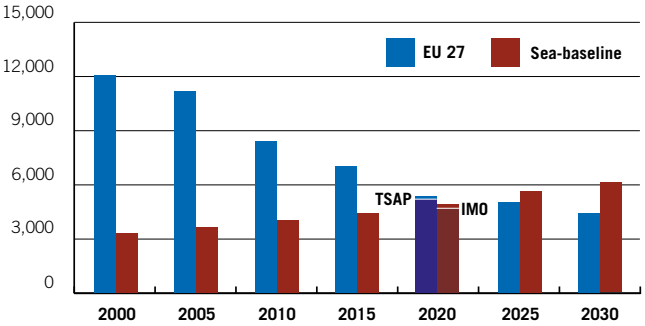



*Figure 2: Emissions of NOx 2000–2030 (ktonnes)*

**Greenhouse gas emissions**

Global annual emissions of the main greenhouse gas carbon dioxide ($CO_2$) from ships amounted to more than 1,000 million tonnes in 2007, corresponding to 3.3 per cent of total global manmade emissions. In the absence of mitigation policies, ship emissions could double or even triple by 2050.

Ships can improve efficiency and reduce emissions significantly by sailing at slower speeds. A 10 per cent reduction in speed will reduce fuel use by about 20 per cent per unit of distance, with a corresponding drop in $CO_2$ emissions. Moreover, emissions of air pollutants, such as $SO_2$ and PM, will also come down.

EU27 = Emissions from land-based sources (incl. domestic shipping)
Sea = Emissions from international shipping in European sea areas
TSAP = Target in line with the EU's Thematic Strategy on Air Pollution
IMO = Expected outcome from implementing the revised IMO MARPOL Annex VI

*Although much of the pollution emitted by international shipping gets deposited over the sea, it is the largest single source of acidifying and eutrophying fallout on land in many countries in Europe. It also contributes significantly to raised levels of health-damaging PM and ozone.*

## Health damage

Smokestack emissions from international shipping kill approximately 50,000 people a year in Europe, at an annual cost to society of more than €58 billion, according to a recent scientific study.

The researchers used data and projections of ships' emissions of $SO_2$, NOx and particulate matter (PM) for the years 2000–2020. Through chemical reactions in the air, $SO_2$ and NOx is converted into very small airborne 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.

Nearly half of Europe's population lives in areas where EU air quality targets are still not met, and in 2008, the EU's air quality standards for PM were exceeded in almost 300 zones in 21 member states (out of some 900 zones in total).

Implementing the stricter ship fuel sulphur standards agreed by the International Maritime Organisation in 2008 is estimated to save up to 26,000 lives per year in the EU in 2020.

## Acidification, eutrophication, ozone…

Since they cause acidification of soil and water, 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 (over-fertilisation), which negatively affects biodiversity both on land and in coastal waters.

*Acidification:* In 2000, deposits of sulphur and nitrogen exceeded the safe limits (critical loads) for acidifying substances over 280,000 square kilometres (22%) of sensitive forest ecosystems in the EU.

*Eutrophication:* In 2000, depositions of nitrogen in the EU exceeded the safe limits for eutrophication over more than 1.2 million square kilometres (73%) 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 safe level.

*Examples of countries with a high proportion of air pollutant deposits of sulphur and oxidised nitrogen from shipping. Data for 2008.*

| | Sulphur | NOx-nitrogen |
|---|---|---|
| Denmark | 39% | 28% |
| Netherlands | 31% | 21% |
| Sweden | 25% | 25% |
| Norway | 25% | 23% |
| UK | 18% | 20% |
| France | 18% | 15% |
| Italy | 15% | 15% |
| Belgium | 13% | 16% |
| Finland | 12% | 17% |
| Germany | 10% | 10% |

Source: EMEP 2010

# 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.

## International Maritime Organisation

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 marine pollution "MARPOL" Convention – Annex VI, which came into force in 2005. It set a global cap of 4.5 per cent on the sulphur content of marine fuel oil, and established provisions allowing for the designation of special sulphur emission control areas (SECAs) with more stringent control on sulphur emissions.

For these areas, a limit to the sulphur content of fuel used onboard ships was set at 1.5 per cent. Alternatively, ships could fit an exhaust gas cleaning system (e.g. scrubber) or use other methods to limit their $SO_2$ emissions. The Baltic Sea was the first SECA to enter into force in 2006, followed by the North Sea in 2007. Annex VI also set limits on the emissions of NOx from new ship engines, but these first NOx standards were so weak that in practice they did not have any appreciable effect.

In October 2008, after three years of negotiating a revision of Annex VI, IMO member states unanimously agreed to strengthen the emission standards. It was decided that the sulphur content of all marine fuels would be capped at 0.5 per cent worldwide from 2020 (subject


*By fitting SCR to all its engines, the emissions of NOx from Viking Line's MS Cinderella are cut by 97 per cent, down to 0.5 g/kWh. It also uses low-sulphur (<0.5%) fuel, and is in Stockholm connected to shore-side power. In early 2013, Viking Line will introduce a new ship serving the Turku-Åland-Stockholm line and operating on liquefied natural gas (LNG).*

to a review in 2018). In a first step, the global cap was lowered to 3.5 per cent as from 2012. The SECAs faced stricter limits of 1.0 per cent from July 2011 and 0.1 per cent from January 2015.

NOx emission standards for new ship engines were also strengthened. In a first step, emissions would be cut by 16–22 per cent by 2011 relative to the 2000 standards, and in a second step by 80 per cent by 2016. The latter limit applies only in specially designated NOx-ECAs, however.

In March 2009, the United States and Canada applied to the IMO to have their coastline out to 200 nautical miles (370 kilometres) designated as a combined sulphur and NOx emission control area. The North American ECA entered into force in August 2011.

## European Union

Although it has long been held within the EU that shipping is a matter for the IMO, the European Commission has 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 2001 EU directive on national emission ceilings requiring the Commission to present a programme of action for reducing emissions from international maritime traffic.

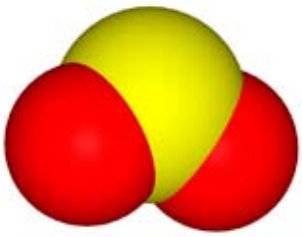
A directive regulating the sulphur content of marine fuels was adopted in 2005, largely confirming the then global Annex VI standards, but also setting a 1.5 per cent limit for all passenger ferries in the EU, and a 0.1 per cent limit for vessels at berth which took effect in January 2010.

In July 2011, the Commission tabled a proposal to further revise the directive by incorporating the new sulphur standards adopted by the IMO in 2008. Incorporation of these provisions into EU law would ensure their proper and harmonised enforcement by all EU member states. Placing the monitoring and enforcement under the EU regime would also improve the effectiveness of the IMO standards.

By extending the stricter 0.1 per cent sulphur standard to passenger ships outside of SECAs from 2020, the EU proposal goes beyond what is required by the IMO.

Extending the SECA coverage to more European sea areas is likely to offer net benefits and address competitiveness concerns, according to the Commission. However, it cannot propose this to the IMO – any such proposals must come from member states bordering the sea area in question. The same applies to the designation of NOx-ECAs.

There are currently no EU standards for NOx or PM emissions from sea-going ships, but the Commission has said that this could be considered in the forthcoming review of EU air quality policy, to be finalised in 2013.



## Cost-effective measures

The costs of typical measures for reducing the emissions of $SO_2$ from ships range from 0.5 to 4 €/kg and of NOx from 0.01 to 0.6 €/kg. Measures required to further reduce emissions of the same pollutants from sources on land beyond the substantial reductions already achieved over the past 30 years would generally cost more, and in some cases much more.

By taking action to reduce emissions from international shipping, the EU's health and environmental objectives could be attained at a considerably reduced cost, compared to taking additional measures only on land.

### Benefits outweigh costs

A study for the European Commission examined the costs and benefits of implementing the IMO's 2008 marine fuel standards in European sea areas.

The expected cost to the shipping industry is between €2.6 billion and 11 billion per year in 2020. The lower bound of costs is based on ships fitting exhaust cleaning techniques, while the upper bound assumes a fuel switch to more expensive lower-sulphur distillate fuels. The costs are likely to be overestimated, since they do not account for innovations in technology development or for measures to improve ship fuel efficiency, such as slow steaming.

The estimated costs are however far outweighed by public health savings of up to €34 billion/year. In addition, there are significant benefits related to environmental improvements, such as reduced acidification damage to ecosystems.

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 and the benefits of reduced emissions greatly exceed the costs.

# The means are available

The technology already exists for cost-effective reduction of emissions of air pollutants from ships

## Sulphur dioxide

*Low-sulphur fuel.* Sea-going ships burn extremely dirty fuels that contain on average 2.5–3 per cent sulphur – almost 3,000 times the sulphur content of road fuel in Europe. The simplest way of reducing $SO_2$ emissions is to switch to fuel oil with a low sulphur content.

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

*Scrubbers.* A possible alternative option to low sulphur fuel is to install exhaust gas cleaning (scrubbers), which can reduce $SO_2$ emissions by up to 99 per cent, and also markedly cut PM emissions. There are still some concerns however, including the abatement efficiency of various technologies, 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 per cent, 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 per cent.

*Selective Catalytic Reduction, SCR,* is a system for after-treatment of exhaust gases. It can reduce emissions of NOx by more than 90 per cent, and operates better with low-sulphur fuel oil. Worldwide there are already around 500 ships fitted with SCR.

## Gas engines

Ship engines can also operate on liquefied 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 per cent or more. LNG is more an option for new ships although conversions have been done.

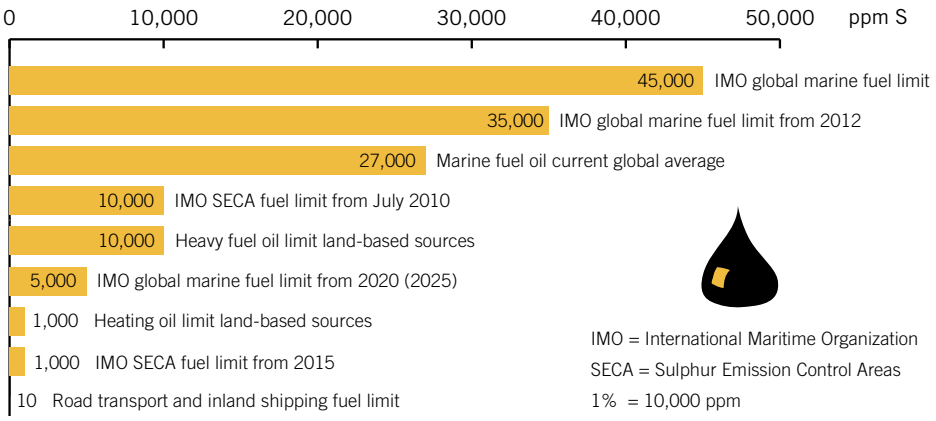
## Shore-side electricity

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 per cent or more.

## Alternative energy sources

The use of fossil fuel must come down. Experiments with wind power (SkySails), biofuels 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 per cent, and in heavy fuel oil 1 per cent. Any large new 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 a maximum sulphur content in fuel oil of between 0.1 and 0.5 per cent. The bigger the plant, the stricter the emission limit value.*



Six environmental organisations – the European Environmental Bureau, Transport & Environment, Seas At Risk, North Sea Foundation, Bellona Foundation, and AirClim – have jointly worked out a series of recommendations for needed action.

# What the EU and its member states should do

As regards global action under the IMO, the EU and its member states should:

- Ensure the implementation of the revised MARPOL Annex VI.
- Make every effort to strengthen significantly the weak emission standards for NOx in Annex VI, both for existing and new ships.

As regards regional and national action, the EU and its member states should:

- Expand the Emission Control Areas (ECAs) to include all European sea areas and to become combined sulphur and NOx-ECAs. Currently only the Baltic Sea and the North Sea have SECA status, and there are no NOx-ECAs. There is an urgent need for the north-eastern Atlantic (including the Irish Sea), the Mediterranean, and the Black Sea to also become ECAs.
- Ensure reductions of $SO_2$ and PM by revising EU legislation 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 0.1 per cent, and should be applied in all Community sea areas. In a second stage the sulphur limit should be further lowered.
- Cut emissions of NOx by establishing mandatory NOx emission standards for all ships entering EU ports.
- Adopt an EU directive to regulate the quality of marine fuels.

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

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 requires all member states to introduce charges that are related to the amount of pollutants emitted, and that are set so as to make it financially worthwhile to use cleaner fuels or to invest in techniques that 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 by strict 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 switching to cleaner fuels will bring immediate emission reductions, as will the retrofitting of exhaust gas cleaning (e.g. SCR or scrubber). On the other hand, measures that will apply only to new vessels, such as NOx emission standards exclusively for new ship engines, will only gradually reduce emissions over a longer time period (depending on the fleet turnover rate).

## To get more information

More information on ships and air pollution is available at the websites of the organisations listed below. Further copies of this pamphlet can be obtained free of charge on request to AirClim, address below. It can also be downloaded in full (in pdf format) from AirClim's website at www.airclim.org.

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