# NOx controls for shipping in EU seas

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## Summary

Nitrogen oxide (NOx) emissions from shipping are a major concern for public health and environmental protection in Europe, particularly in coastal regions. NOx from EU shipping remains largely unregulated and, if left unabated, is set to overtake land-based NOx emissions by 2020.

A study, commissioned by T&E and conducted by IVL Swedish Environmental Research Institute and CE Delft, identifies for the first time the policy options available at the EU level to regulate ship NOx emissions in the EU seas and compares them with measures to be taken under the International Maritime Organisation (IMO). The study compares NOx abatement options and their associated costs for the shipping sector with EU level measures implemented either on their own or in addition to the designation of Nitrogen Emissions Control Areas (NECAs) under the IMO in the Baltic Sea, North Sea and the English Channel.

T&E considers that in addition to implementing NECAs, the EU option of a NOx levy and fund, the revenues of which will be used to finance the uptake of NOx abatement technologies, is the best way forward. It promises 70% annual NOx reduction compared to business as usual and about 60% in 2025 and about 30% in 2040 if the NECAs are also established.

## 1. Context

Emissions from shipping are known to contribute significantly to environmental and health risks, primarily in coastal regions. The emissions contain health affecting particles and gases, acidifying and eutrophying substances, as well as greenhouse gases. Nitrogen oxides (NOx) contribute to particle and ozone formation and also potentially cause acidification and eutrophication upon deposition on land, lakes and seas. It is moved long distances by air and is, therefore, often considered a 'regional' pollutant.

Global NOx regulation at the IMO MARPOL treaty involves three progressively more stringent tiers. Europe is now at the Tier II level, requiring from all ships built after 2011 a reduction of NOx emissions of about 20%. Tier III delivers a NOx reduction of 80% and only applies in NECAs and only to new ships built after the implementation date of the relevant NECAs. The US and Canadian NECAs around the North American coast applies to all ships built after 2016 and sailing within the N American NECA zone. Countries around the Baltic Sea, North Sea and the English Channel have been considering a similar NECA in these seas for many years and final agreement to submit a NECA application was eventually reached by all Baltic coastal states in March 2016. Applications to the IMO for the Baltic, North Sea and English Channel NECAs are currently under preparation for consideration by the IMO later this year. Implementation date is expected to be 2021.

As these NECAs will only apply to ships built after 2021, and sailing in the NECAs, it leaves NOx emissions from all existing ships and the new ships outside NECAs under-regulated. This warrants extra EU-level policy measure to cover existing ships and all EU seas which will not be covered by NECAs.

This briefing summarises the key outcomes of a study commissioned by Transport & Environment to examine ship NOx abatement policies and their associated costs for the shipping sector with EU level measures implemented either on their own or in addition to the designation of NECAs under the IMO. The study was carried out by the consultancies IVL and CE Delft.

# 2. NOx emissions in EU seas and the effectiveness of the EU-level policy instruments

## 2.1. Feasibility, potential and estimated cost of abatement technologies

The study provides a review of the available technologies to reach the NECA NOx emission limits and concludes that that three abatement technologies fulfil the requirements:

- Selective Catalytic Reduction (SCR), a mature after-treatment technology tested on over 500 ships and with efficient NOx reduction at high exhaust gas temperatures;
- Exhaust Gas Recirculation (EGR), a technology less tested than SCR in marine applications, but confirmed by engine manufacturers to reach the Tier III level. EGR operations are most efficient at high engine loads, similar to SCR;
- Liquefied Natural Gas (LNG), an alternative fuel that has been proven for maritime use over the last decade. NOx emission levels from LNG are very low without the need for any abatement technologies. A prerequisite for a more widespread use of LNG as a marine fuel is the adequate supply of costly fueling infrastructure and the need for purpose-built and LNG powered ships or expensive retrofitting.

The study estimates that EGR and the SCR are comparable in costs per kg/NOx avoided. The costs for LNG are largely depending on whether an existing engine is rebuilt for LNG or whether the LNG engine is installed on a new ship. The latter is considerably cheaper than the former. Fluctuations in LNG price also affect the potential return on investment to the ship owner (Table 1).

**Table 1. Costs for $NO_X$ emission reduction technologies for MGO driven vessels. Effects of fuel costs included in total costs**

| $NO_X$ reduction alternatives | Total costs, $€_{2010}$/t reduced $NO_X$ | |
|---|---|---|
| | Company perspective | |
| | min | max |
| **SCR** | 151 | 2 025 |
| **EGR** | 210 | 1 194 |
| **LNG*** | -2 242 | 17 406 |

*Negative cost indicate gains. LNG is expected to be less costly than MGO, which is why the cost in €/MWh is negative; the costs for MGO are used as baseline.

## 2.2. NOx emissions in the Baltic Sea, North Sea and the English Channel

The study set up a model for calculating NOx emissions for the time period 2005 to 2040, containing the crucial input parameters for estimating total NOx emissions from different ship categories. NOx emissions are calculated from data on fuel consumption of different ship categories, which are taken from Kalli et al. (2013).[i]

The study estimates the evolution of ship NOx emissions in the Baltic Sea, North Sea and the English Channel until 2040 due to the designation of these seas as NECAs under the IMO. Historical analysis reveals only small changes in the total amount of fuel consumed by shipping in Northern Europe for the projected period. Increases in traffic are more or less evened out by gradual efficiency improvements. In a scenario with no NECAs in the seas of Northern Europe, a gradual decrease in emissions until around year 2035 is projected. If NECAs are designated in the Northern Seas the projections indicate higher reductions of NOx after 2020, as NECAs are expected to be effective from 2021 (Table 2). However, without additional measures to cover existing ships (and new ships operating outside NECAs), the rate of reduction of ship NOx emissions will be only gradual towards 2040. In order to speed up the NOx reduction rate and cover all EU seas and not only those to be covered by NECAs under the IMO, additional policy measures are warranted at the EU level. This study analyses the effectiveness of these additional policy measures in a case study covering the Baltic Sea, North Sea and the English Channel.

**Table 2. Overview of projected NOx emissions (ktonnes) 2010 to 2040.**

| | *Projected total emissions in the Baltic Sea, the North Sea and the English Channel if no NECA is established* | | | | | | | *Projected total emissions in the Baltic Sea, the North Sea and the English Channel if a NECA becomes effective in 2021* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *2010* | *2015* | *2020* | *2025* | *2030* | *2035* | *2040* | *2010* | *2015* | *2020* | *2025* | *2030* | *2035* | *2040* |
| Total Ships | **906** | **830** | **798** | **768** | **741** | **716** | **715** | **906** | **830** | **798** | **644** | **524** | **404** | **306** |

## 2.3. Analysis of additional/alternative EU level NOx policy instruments

The study has shortlisted the following three additional/alternative EU level policy instruments for NOx reduction:

1. Regulated slow steaming with a NOx levy as alternative compliance option, where the revenues are used to fund the uptake of NOx abatement measures.
2. A stand-alone NOx levy whose revenues are not earmarked.
3. A NOx levy whose revenues are used to fund the uptake of NOx abatement measures.

For the three shortlisted NOx reduction instruments, the emission reductions and the associated costs for the shipping sector have been calculated on the NECA-fleet level and for two scenarios, i.e. for a 'No-NECA scenario' in which the shortlisted reduction instruments are alternative instruments to North and Baltic Sea NECA requirements and for a 'NECA scenario' in which the shortlisted reduction instruments are implemented for non-Tier III ships in the North Sea, Baltic Sea NECAs.[ii]

### 2.3.1. Regulated slow steaming

Regulated slow steaming leads indirectly, i.e. via a reduction of the fuel consumption of ships, to a reduction of NOx emissions. It is assumed that ferries, which sail at a certain speed in order to meet a daily schedule, and 10% of the other ship types will continue to sail at the baseline speed and will not take NOx reduction measures and pay the NOx levy instead. The costs for the shipping sector for regulated slow steaming, which are related to the fact that the annual transport work of a ship is reduced at slower speeds, are based on CE Delft (2012a).[iii] The net direct costs, i.e. the costs net of the fuel expenditure savings, used in the calculation amounts to approximately € 800/tonne NOx reduced.

### 2.3.2. NOx levy (and fund)

A NOx levy can, depending on the rate of the levy, lead to a direct NOx emission reduction: Ships weigh the levy payment against the costs of NOx abatement measures. The costs of the abatement measures are considered from the company perspective, differentiating between the costs for new builds and retrofits, and assuming that ships use distillates in the baseline.

## 2.4. Results: Emission reductions and company costs

The study compares the ship NOx emissions reduction potential of the EU level instruments in two scenarios: if a NECA is established in the Baltic Sea, North Sea and the English Channel and the other scenario without a NECA (Figure 1).

### 2.4.1. Results for the 'No-NECA scenario'

If no NECA was established, the relative emission reduction associated with each of the three alternative instruments increases over time. This increase is explained by the gradual phase out of old (Tier O) ships which are, because of their age, assumed, with the exception of slow steaming, not to take any NOx abatement measures but to pay a levy instead.

**Stand-alone levy**: with a €2/kg NOx levy, existing Tier I and II ships reduce NOx emissions by means of SCR, while new builds by means of EGR. A significantly higher NOx reduction (approximately 65%) can thus be achieved compared to the lower levy rate. The total costs for the sector range from €1,060 million per year in 2025 to €950 million in 2040.

**Levy and fund**: with a €2/kg NOx levy existing Tier I and II ships would use SCR even if not funded and therefore receive no funds. Tier II new builds are subsidised (difference between EGR and SCR compliance costs) to take up SCR instead of EGR. Total costs are significantly lower compared to the stand-alone levy, especially for the higher (€2/kg and above) levy rates.

**Regulated slow steaming/levy and fund**: The line of reasoning for those ships that do not slow down (ferries and 10% of others) is similar to that for a levy and fund (see above). The NOx reduction effect is thus also the same for all three levy rate cases. In contrast to the other two instruments, Tier O ships reduce their NOx emissions (also by slowing down). Total costs are significantly lower compared to the other instruments - less than half the costs under a levy and fund.

### 2.4.2. Results for the 'NECA scenario'

If European NECAs are established, the relative emissions reduction associated with all three additional EU NOx reduction instruments decreases over time and would eventually converge to zero. This decrease can be explained by a gradually decreasing share of the ships that have to comply with the additional instruments which are the non-Tier III ships.

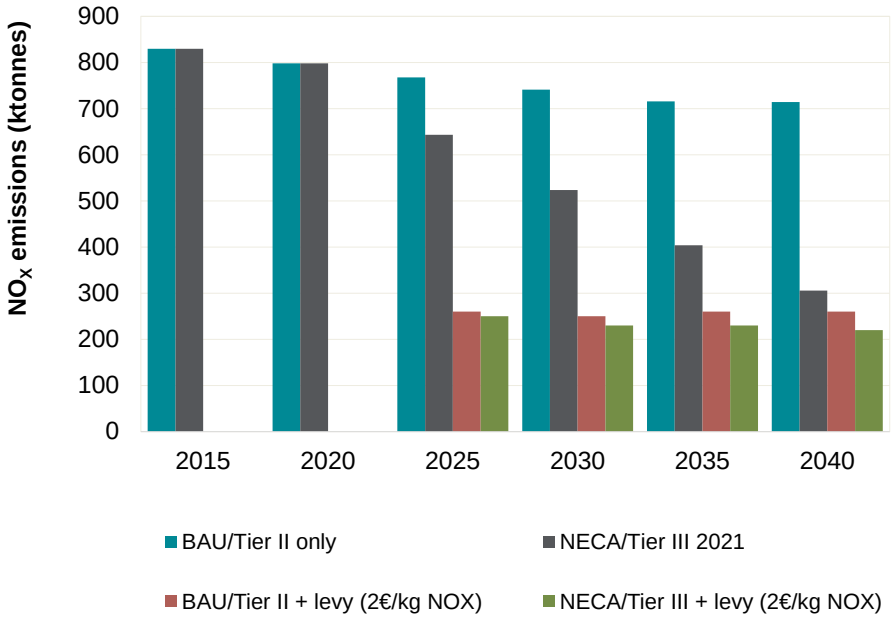
**Stand-alone €2/kg NOx levy**: Due to the levy, existing ships are incentivised to use SCR resulting in significantly lower NOx emissions (-60% in 2025 and -30% in 2040). Total costs per year range from €830 million in 2025 to € 170 million in 2040.

**Levy and fund (€2/kg)**: existing ships would use SCR even without a subsidy. Since no funds are used in the case of a €2/kg NOx levy, the NOx reduction is the same as for the stand-alone levy case (60% in 2025 and 30% in 2040). Total costs are significantly lower compared to the stand-alone levy, especially for the higher levy rates.

**Regulated slow steaming/levy and fund**: The reasoning for those ships that do not slow down (ferries and 10% of others) is the same as for levy and fund (see above). The NOx reduction effect is thus also the

same for all three levy rate cases. In contrast to the other two instruments, Tier 0 ships reduce their NOx emissions (by also slowing down). Compared to the other two instruments, the NOx reduction of the instrument (approximately 35% in 2025 and 15% in 2040) is about half of the reduction that could be achieved with the levy and fund which means that, if compared with the stand-alone levy, the instrument gives higher NOx emissions only for the €1/kg NOx levy case. Total costs are significantly lower compared to the other instruments, less than half of the costs under a levy and fund.

**Figure 1. Projected NOx emissions to 2040 in scenarios with a levy of 2 €/kg NOx in scenarios with and without the NECA. NOx emissions in reference scenarios without any economic incentive are also shown.**




## 3. Conclusions

A levy and fund can lead to relatively high annual NOx emission reductions in both scenarios, such as if used as alternative instruments to a Baltic and North Sea NECA (annual NOx reductions of around 70%) and if used as additional instruments to a Baltic and North Sea NECA for non-Tier III ships (annual NOx reduction in the range of 60-30% below NECA reference line).

Compared to a stand-alone levy, costs for the sector are significantly lower for both a levy and fund and regulated slow steaming combined with a levy and fund, at least if the revenue is not only used to subsidise uptake of NOx reduction measures, but if remaining revenue is also recycled back to the sector.

Costs for the sector are the lowest if regulated slow steaming (15% below baseline speed) combined with a levy and fund is implemented. Costs for the sector under this option are less than half of the costs under a levy and fund option.

In terms of NOx reduction and costs for the sector, two of the three instruments thus stand out as potential additional/alternative instruments for a Baltic and North Sea NECA, such as a levy and fund and regulated slow steaming combined with a levy and fund. With the levy and fund relatively high NOx reductions can be achieved – roughly twice the reduction achieved with regulated slow steaming combined with a levy and fund – at least if the baseline speed is reduced by 15%. However, costs for the sector of a levy and fund are also roughly twice the costs of regulated slow steaming combined with a levy and fund.

## Further information

Name: Faig Abbasov
Aviation and Shipping Officer
Transport & Environment
faig.abbasov@transportenvironment.org
Tel: +32(0)2 851 0211

## Endnotes

[i] Kalli, J., et al. (2013). "Atmospheric emissions of European SECA shipping: long-term projections." WMU Journal of Maritime Affairs 2013(12): 129-145.

[ii] The study considers three levy rates €1/kg, €2/kg NOx, €3/kg NOx in the calculations for all three instruments, although this brief will consider only €2/kg NOx for space considerations.

[iii] CE Delft, 2012a. Regulated Slow Steaming in Maritime Transport. An assessment of options, costs and benefits. Delft, February 2012.