# Policy brief on sectoral airborne nitrogen inputs

## Agriculture and shipping related commitments crucial to be implemented without delay

HELCOM

Baltic Marine Environment Protection Commission



## Current situation and challenges

According to calculations made by EMEP (Co-operative programme for monitoring and evaluation for the long-range transmission of air pollutants in Europe), the total airborne nitrogen deposition to the Baltic Sea in 2021 amounted to 191 kt(N) (kilotonnes of nitrogen), thereby contributing with 24.2% of actual airborne inputs and 22.9% of the normalized inputs to the total nitrogen load. This deposition, together with the waterborne input, continues to lead to exceedances of maximum allowable nitrogen inputs in various parts of the Baltic Sea, causing eutrophication effects. The HELCOM Core indicator "Inputs of nutrients (nitrogen and phosphorus) to the sub-basins 1995-2021" describes the current exceedances of the maximum allowable inputs (MAI) of nitrogen to the sub-basins (Table 1).

Thus, a policy-relevant question is which countries and emission sectors have the largest contributions to nitrogen inputs. In a special contract with HELCOM, the EMEP Centre MSC-W has calculated the contributions from the nine HELCOM Contracting Parties, other countries within the EU, international shipping in the North Sea and Baltic Sea, and the other emitters ("Rest of the world"), to airborne nitrogen deposition to the Baltic Sea in 2021[1].

The contributions were further subdivided into five different emission sectors (or groups of sectors): Transport (Tra), Agriculture (Agr), Power Generation (Pow), Other Stationary Combustion (Osc), and the Sum of all other sectors (Oth). In total, these sectors make up all anthropogenic emissions.

For the shares of these emission sectors within the nine HELCOM countries (not including international shipping), as of 2021, the agricultural sector stands for 54% of total anthropogenic emissions from these countries. The second

**Table 1.** (Results table 1a from the 2021 MAI indicator) The trend-based estimate for normalized annual inputs of nitrogen during 2021. The table also contains data on statistical uncertainty, the remaining reduction needed to reach MAI and inputs in 2021 including statistical uncertainty in percentages of MAI. Classification of achieving MAI is given in colours: green=MAI fulfilled, yellow= fulfilment is not determined due to statistical uncertainty, and red=MAI not fulfilled. (Units in columns 2–5: tonnes per year).

| Baltic Sea Sub-basin | MAI* | N input 2021 | Statistical uncertainty 2021 | N input including statistical uncertainty 2021 | Exceedance of MAI in 2021 | Input 2021 including statistical uncertainty in % of MAI | Classification of achieved reduction |
|---|---|---|---|---|---|---|---|
| **Bothnian Bay (BOB)** | 57 622 | 52 084 | 1 623 | 53 707 | | 93 | green |
| **Bothnian Sea (BOS)** | 79 372 | 66 043 | 2 071 | 68 115 | | 86 | green |
| **Baltic Proper (BAP)** | 325 000 | 395 997 | 8 226 | 404 223 | 79 223 | 124 | red |
| **Gulf of Finland (GUF)** | 101 800 | 119 973 | 8 236 | 128 209 | 26 409 | 126 | red |
| **Gulf of Riga (GUR)** | 88 417 | 87 593 | 3 174 | 90 767 | 2 350 | 103 | yellow |
| **Danish Straits (DS)** | 65 998 | 57 224 | 1 816 | 59 040 | | 89 | green |
| **Kattegat (KAT)** | 74 000 | 65 476 | 2 676 | 68 152 | | 92 | green |
| **Baltic Sea (BAS)** | **792 209** | **861 434** | **21 571** | **883 004** | **90 795** | **111** | red |

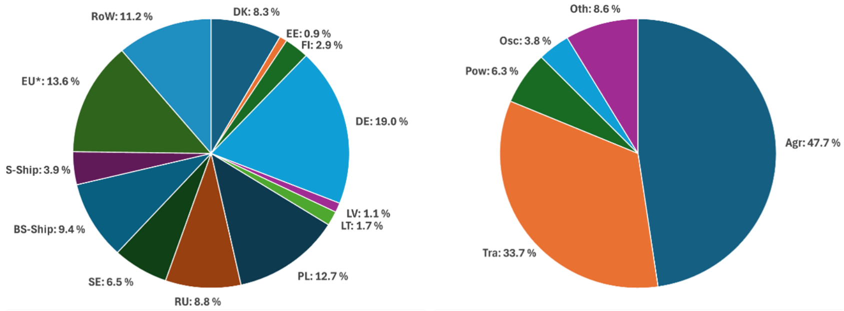



**Figure 1.** Contribution to airborne nitrogen deposition to the Baltic Sea in 2021 (%). Left: Country shares – from the nine HELCOM parties (DK, DE, etc.), EU countries which are not in HELCOM (EU*), international shipping in the Baltic Sea (BS-Ship) and the North Sea (NS-Ship), as well as all other countries (RoW). Right: Sector shares – from Agriculture (Agr), Transport (Tra, also including international shipping), Power generation (Pow), Other stationary combustion (Osc) and all other sectors (Oth).

largest contribution, 24%, is due to the transport sector (mainly road transport). Power generation accounts for 10% and other stationary combustion for 4%, with 8% remaining for all other sectors.

Figure 1 summarizes the results by country and sector. The largest country-wise contribution comes from Germany (19.0% or 36.2 kt(N)), followed by Poland (12.7% or 24.2 kt(N)). This is not only due to high emissions, but also caused by dominating westerly winds. The largest contribution by sector is made by Agriculture (47.7% or 91.1 kt(N)), followed by Transport (33.7% or 64.3 kt(N)) which also included international shipping on the Baltic Sea.

While in absolute terms, the contribution from Agriculture has decreased (due to nitrogen emission reductions of about 5% during the 2017 to 2021 period), the percentage contribution from Agriculture has increased slightly since 2017, which is in part due to the fact that some of the other sectors reduced their emissions to a larger extent.

## Contributing sectors

In Figure 2 the Top 10 contributing country-sector pairs are shown. In total, these 10 largest contributions account for more than 60% of the total airborne nitrogen deposition to the Baltic Sea. The agricultural sector is strongly represented among the Top 10 contributors. Baltic Sea shipping (part of the transport sector) makes the second largest contribution. These results show that the agricultural and transport sectors, especially Baltic Sea shipping, should be considered in future emission reduction schemes.

At the same time it is noted that none of the country-sector pairs clearly dominates (the single-largest contribution amounting to 11.3% only), and that the transport sector is expected to reduce its emissions of nitrogen oxide due to electrification of the road vehicle fleet (which will only partly be compensated by increases in the power generating sector).

The Gothenburg Protocol under the Convention of Long-Range Transboundary Air Pollution and the EU National Emission Ceilings Directive (NEC-Directive) provide the respective international and European frameworks for nitrogen emission reduction commitments. Under these regulatory regimes reduction targets were set for 2020 with respect to emissions in 2005 and compliance with these targets has recently been assessed (EMEP, 2023). Most HELCOM Contracting Parties have fulfilled their reduction commitments (table 2). Other countries that did not fulfil their Gothenburg Protocol commitment by 2021 are Romania (for $NO_x$), as well as Bulgaria, Luxembourg, Norway and Portugal (for $NH_3$).

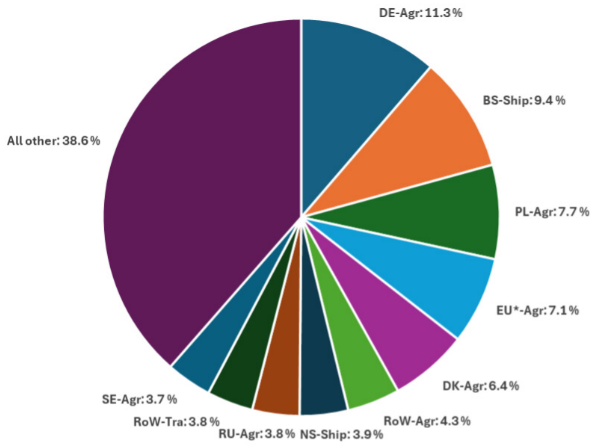



**Figure 2.** Top 10 contributions to airborne nitrogen deposition to the Baltic Sea in 2021. The largest contribution is made by Agriculture in Germany ('DE-Agr'), followed by International shipping in the Baltic Sea ('BS-Ship'). The tenth largest contribution is Agriculture in Sweden ('SE-Agr'), while all other percentage contributions are smaller than 3.7% and are combined in 'All other' in this plot.

**Table 2.** Reduction commitments and actual percentage change in emissions achieved by 2021 with respect to 2005 as required by the Gothenburg Protocol for oxidized nitrogen ($NO_x$) and ammonia ($NH_3$). 'Compliance' assesses the commitment has been fulfilled (Yes or No). Poland and Russia have not ratified the Gothenburg Protocol. For Poland, information is given in relation to the EU NEC Directive. For the Russian Federation (RU), the percentage change applies to the part of the country that is included in the EMEP model domain.

| | DK | EE | FI | DE | LV | LT | PL | RU* | SE |
|---|---|---|---|---|---|---|---|---|---|
| **Commitment $NO_x$** | -56 | -18 | -35 | -39 | -32 | -48 | (-30) | - | -36 |
| **Actual $NO_x$** | -60 | -51 | -52 | -42 | -33 | -24 | (-31) | (-10) | -44 |
| **Compliance $NO_x$** | Y | Y | Y | Y | Y | N | (Y) | - | Y |
| **Commitment $NH_3$** | -24 | -1 | -20 | -5 | -1 | -10 | (-1) | - | -15 |
| **Actual $NH_3$** | -23.9 | -2 | -22 | -16 | +4 | -2 | (-11) | (-0) | -11 |
| **Compliance $NH_3$** | N | Y | Y | Y | N | N | (Y) | - | N |

## Key messages

**The 2021 Baltic Sea Action Plan contains effective actions to further reduce nitrogen emissions from all relevant sectors. These require swift implementation**

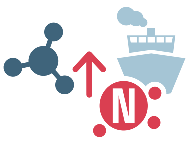
The 2021 Baltic Sea Action Plan includes 15 actions on agriculture and 7 for nutrient recycling, the latter being mostly related to agricultural practices (under the segment Eutrophication) as well as 16 actions on pollution from shipping (under the segment Sea-based activities). The HELCOM nutrient reduction scheme includes NICs also for shipping. Some of the related key activities are described below. There are specific 2021 BSAP actions that are relevant for the findings on airborne nitrogen deposition and address the most important sectoral sources.

**Ammonia emissions from agriculture need to be substantially reduced in the next years**

In 2024 HELCOM adopted Recommendation 42-43/5 on Mitigation of Ammonia Emissions from Agriculture thus implementing BSAP action E20. As agriculture is a large contributor to the ammonia emissions in the Baltic Sea region, swift national implementation of the Recommendation is essential to reduce emissions and to report the actions taken to HELCOM in 2027 as defined in the Recommendation. The reporting will include, e.g., how ammonia emissions from agriculture have developed in the country during the reporting period, which measures have been implemented and which have been the most efficient measures, and whether the country has been able to meet the ammonia emission reduction targets set by the EU National Emission Ceilings (NEC) Directive or other international commitments including the Gothenburg Protocol.

**The enforcement of the compliance with the NECA regulations has to be ensured**

In 2023 HELCOM has developed a Roadmap to strengthen the implementation and enforcement of the Baltic Sea NOx Emission Control Area (NECA) thus implementing BSAP action S23. According to the Roadmap, verifying possible violations and non-compliance as well as sanctioning them has been a challenge for the HELCOM Contracting Parties as enforcement is currently limited to documentation inspections. Also, according to scenarios developed by the SCIPPER project and other studies referred to in the Roadmap, non-compliance and the share of not properly working Selective Catalytic Reduction (SCR) equipment can be high, especially in coastal regions where ships sail at low speeds. Thus, relative nitrogen emission from shipping might even increase by 2040. The Roadmap proposes 7 indirect steps to support the needed policy change and regulatory amendments at IMO level. Furthermore, it supports remote and on-board measurements of NOx emissions and to create incentives for NOx reductions for existing ships, if technically and/or economically feasible. However, the actual enhanced enforcement of the NECA is very important to reach the planned nitrogen emission reduction targets for Baltic Sea shipping.



**Ammonia as a future shipping fuel could increase nitrogen emissions and implications need to be investigated**

One future alternative fuel for shipping in the Baltic Sea is ammonia. The scenarios by the SCIPPER project demonstrated that a wide future application of ammonia as a shipping fuel will cause significant particle formation, unless emissions are regulated. In addition, nitrogen emissions may increase when using ammonia as a ship fuel, but this will depend on technology, which in turn will depend on regulation. A dedicated EMEP modelling study is planned to further investigate the consequences, but finances have not yet been secured.

**Swiftly implementing the Gothenburg Protocol/NEC Directive is vital for reaching the targets**

In the BSAP the HELCOM Contracting Parties committed to continue to reduce the deposition of atmospheric nitrogen on the Baltic Sea through the implementation of the national nitrogen reduction commitments foreseen by the Gothenburg Protocol and the EU NEC-Directive 2016/2284. They also committed to ensure that measures taken in transportation, combustion and agriculture be tailored to contribute to the reduction of the nitrogen deposition on the Baltic Sea (BSAP action E21). Meeting these commitments is vital for reaching the HELCOM nutrient reduction targets.

## Baltic Proper as an example for effective emission reductions

The Baltic Proper is the largest Baltic Sea sub-basin and due to its large surface area atmospheric deposition contributes to 29.9% of the actual and 27.0% of the normalized total nitrogen inputs . Figure 3, taken from the 2021 MAI core indicator shows the waterborne and airborne nitrogen inputs to the Baltic Proper. Evaluation of MAI fulfilment takes into account the uncertainty on inputs.

Figure 4 shows the airborne part of the nitrogen inputs to the Baltic Proper.

Only significant changes and trends are mentioned. Estimated total inputs of TN in 2021 to Baltic Proper were 124% of the respective MAI, although being 9.5% lower than in the reference period (1997-2003) (MAI 2021 chapter 4.3). Reduction in airborne TN inputs accounts for all the total reduction in TN inputs since the reference period. There is a 24% reduction in total TN inputs since 1995. Since 2009 there is no trend in total nitrogen inputs. Waterborne TN inputs have even increased since 2009 (18%).

The success of nitrogen reductions over the last decades has been attributable to the decrease of airborne inputs. Agriculture and traffic remain the biggest sectors contributing to the nitrogen deposition on Baltic Proper. It is thus vital for the Baltic Proper and the other Baltic Sea sub-basins that the key policy messages are considered to achieve further reductions in nitrogen emissions.

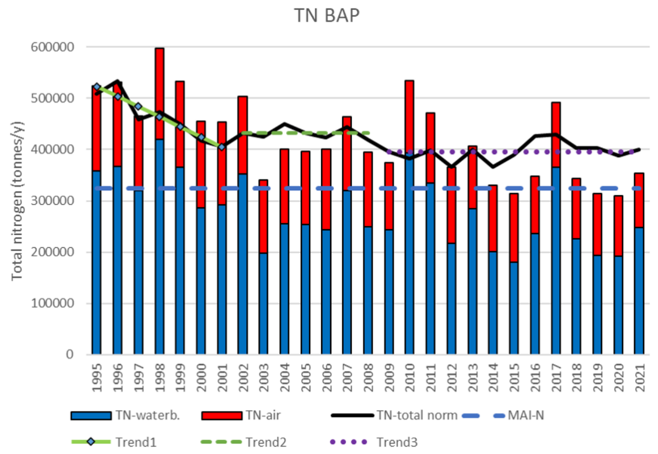



**Figure 3.** (From MAI 2021 Results figure 2a.) Actual total air- and waterborne annual input of nitrogen (TN) to the Baltic Proper from 1995 to 2021 (tonnes/y). The normalized total annual inputs of nitrogen are given as a black line. The trend line for normalized total nitrogen is given as a green line with markers. In cases when a break point divides the trend into two parts, the second part (called trend 2) is shown by a green line without marker. In cases with two breaks points the third part (called trend 3) is indicated as a green line. (Solid trend line shows statistically significant trend and dotted line no statistically significant trend). The MAI is shown as the bold dotted blue line.

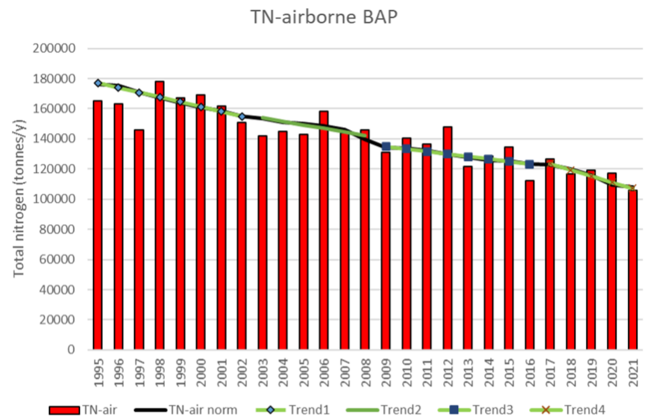



**Figure 4.** (From MAI 2021 Results figure 2c.) Actual annual airborne deposition of nitrogen (TN) to the Baltic Proper from 1995 to 2021 (tonnes/y). The normalized annual airborne deposition inputs of nitrogen are given as a black line. The trend line for normalized total nitrogen deposition is given as a green line with markers. In cases when a break point divides the trend into two parts, the second part (called trend 2) is shown by a green line without marker. In case with two or three break points divide the trend into three or four parts, respectively, the third and fourth part is shown as a green line with (different) markers. Solid trend line shows statistically significant trend and dotted line no statistically significant trend.

## References

Contributions of emissions from different countries and sectors to atmospheric nitrogen input to the Baltic Sea. Michael Gauss, Ágnes Nyíri and Heiko Klein (EMEP MSC-W), HELCOM Report 2024

EMEP status report - Transboundary particulate matter, photo-oxidants, acidifying and eutrophying components (2023)

HELCOM Recommendation 42-43/5 on Mitigation of Ammonia Emissions from Agriculture

Roadmap to strengthen the implementation and enforcement of the Baltic Sea NOx Emission Control Area (NECA)

https://www.scipper-project.eu/library/

1 The year 2021 was chosen because, at the time of the model calculations (2023), this was the most recent year for which quality-assured observations and emission data were available. The emission data are based on official reports from the EMEP countries to the EMEP Centre CEIP. 2021 is also the periodic reporting year for waterborne nutrient inputs in the PLC-8 project.