Nitrogen emissions to the air in the Baltic Sea area

HELCOM Baltic Sea Environment Fact Sheet (BSEFS), 2022

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Key Message

This year, the EMEP emission centre CEIP has provided nitrogen emission data for to the full 3-decade period from 1990 to 2020. The results are analysed by EMEP MSC-W with focus on the Baltic Sea region in this fact sheet.

For all HELCOM Contracting Parties, *oxidized* nitrogen emissions were lower in 2020 than in the reference period (1997 – 2003), with the largest reductions in Denmark (62%), followed by Finland (58%), Estonia (51%) and Germany (48%).

Concerning *reduced* nitrogen (ammonia), annual emissions were lower in 2020 than in in the reference period (1997 – 2003) in seven out of the nine HELCOM Contracting Parties, with the largest reductions in Denmark (27%), followed by Finland (17%), Germany (13%) and Sweden (12%). In Estonia, Lithuania, and Latvia ammonia emissions have increased since the reference period by 16%, 13% and 9%, respectively.

For all HELCOM Contracting Parties, *total* nitrogen emissions were lower in 2020 than in in the reference period (1997 – 2003), with the largest reductions having occurred in Finland (46%), followed by Denmark (43%), Germany (32%) and Sweden (31%).

(Using the period 1997 – 2003 as the 100% reference level was a decision taken by PLC-8 IG in order to use the same reference period as for the waterborne nutrient inputs under the Baltic Sea Action Plan.)

Results and Assessment

Relevance of the BSEFS for describing developments in the environment

This fact sheet presents the changes in annual emissions of nitrogen oxides (NO and NO_2) and ammonia (NH_3) from anthropogenic sources during the 1990 – 2020 period, which are the basis for the model calculations of the deposition on the Baltic Sea. The data include emissions from HELCOM Countries, Baltic and North Sea shipping and other sources outside the HELCOM area.

Policy relevance and policy references

The HELCOM Copenhagen Ministerial Declaration of 2013 on taking further action to implement the Baltic Sea Action Plan reconfirmed the need of reaching good environmental status for a healthy Baltic Sea. The declaration includes nutrient reduction targets, and thus also concerns airborne nitrogen input to the Baltic Sea. The Declaration sets targets on Maximum Allowed Inputs (MAI) covering both water- and airborne inputs. These targets are maintained in the updated Baltic Sea Action Plan of 2021.

The relevant policy to the control of emissions of nitrogen oxides and ammonia to the atmosphere on a global scale is set in the framework of the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). For EU member states the policy frame is set by the EU NEC and IED Directives. For the Russian Federation the corresponding policy frame is embraced by Federal Acts on Environment Protection and the Protection of Atmospheric Air. The Gothenburg Protocol (1999, and revised in 2012) requires that nitrogen oxides emissions in 2020 should be reduced by between 18% and 56% in 31 countries with respect to 2005 annual emissions, with the largest relative reductions in Denmark (56%), the United Kingdom (55%) and France (50%). Ammonia emissions should also be reduced, but by smaller percentages (1% to 24%). The largest

relative reductions of ammonia emissions should be in Denmark (24%), Finland (20%) and Sweden (15%). In the European Union, the revised Gothenburg Protocol is implemented by the EU NEC Directive 2016/2284/EU, which sets 2020 and 2030 emission reduction commitments for five main air pollutants, including nitrogen oxides and ammonia. It is worth noting that in the case of ammonia, the commitments set for 2030 are much stricter than the Gothenburg Protocol reductions that were set for 2020. The Gothenburg Protocol currently undergoes a review process that will most likely result in a new revision.

Assessment

In this fact sheet we present and discuss nitrogen emission data as used in the EMEP MSC-W model calculations performed for the 1990 – 2020 period. For all years, the gridded distributions of emissions have been provided by the EMEP Centre on Emission Inventories and Projections (CEIP) on 0.1° x 0.1° resolution. Details about the methods of gridding and gap-filling emission data done by CEIP can be found in the EMEP status report 1/2022 (EMEP, 2022, their section 3.5), which is publicly available on the web.

Time series of nitrogen oxides and ammonia annual emissions in the period 1990 – 2020, as used in the EMEP MSC-W model calculations, are shown for all HELCOM Contracting Parties in Figure 1. The figure also shows emissions from shipping in the North Sea and the Baltic Sea, as well as all other sources within the EMEP MSW-W model domain.

Time series of nitrogen oxides, ammonia and total nitrogen annual emissions, expressed as percentage of the 1997 – 2003 average, are shown in Figure 2. As usual, emissions from Russia are included only for the part of Russia that is covered by the EMEP MSW-W model domain.

The gridded emission data used in the EMEP MSC-W model calculations are available on CEIP's WebDab at: https://www.ceip.at/webdab-emission-database/emissions-as-used-in-emep-models. The emission data used this year are based on official data submissions received by CEIP as of June 2022.

A special case are emissions from international shipping: These are not reported by the Parties to the UN ECE LRTAP Convention but taken from the CAMS global ship emission dataset (Granier et al., 2019), which starts in the year 2000 and was developed by the Finnish Meteorological Institute (FMI). Ship emissions for years before 2000 are estimated using CAMS global shipping emissions for 2000, adjusted with trends for global shipping from EDGAR v.4.3.2 (JRC/PBL 2016). Emissions of *reduced* nitrogen from ships do not occur in any significant amount and are therefore not considered in the model or plotted in Figures 1 and 2.

In most HELCOM Contracting Parties, emissions of total nitrogen have been decreasing during the period 1990 – 2020. The reduction of emissions from the Baltic Sea region in the years 1990 – 2020 is more significant for nitrogen oxides than for ammonia: In all HELCOM Contracting Parties, oxidized nitrogen emissions were by 16 to 62% lower in 2020 than in the reference period (1997 – 2003), with the largest reductions in Denmark (62%), followed by Finland (58%), Estonia (51%) and Germany (48%). Reductions with respect to the reference period are also reported for all the other HELCOM Contracting parties: Sweden (46%), Poland (34%), Latvia (29%), Lithuania (21%), and Russia (16%).

For ammonia, the emissions from six out of nine HELCOM Contracting Parties were lower in 2020 than in the reference period (1997 – 2003), with the largest reductions in Denmark (27%), followed by Finland (17%), Germany (13%), and Sweden (12%). Reductions with respect to the reference period are also seen for Poland (9%) and Russia (1%), while Estonia, Lithuania, and Latvia have increased their ammonia emissions since the reference period (by 16%, 13%, and 9%, respectively).

Trends in emissions, if statistically significant at the 5% confidence level, are listed in Table 1 for the whole 31-year period but also for partial periods within it. Downward trends, if any, were larger in the 1990s than during the most recent decade. In some countries, emissions have even increased during the 2010 – 2020 period, especially in the case of reduced nitrogen from countries outside the EU and HELCOM areas.

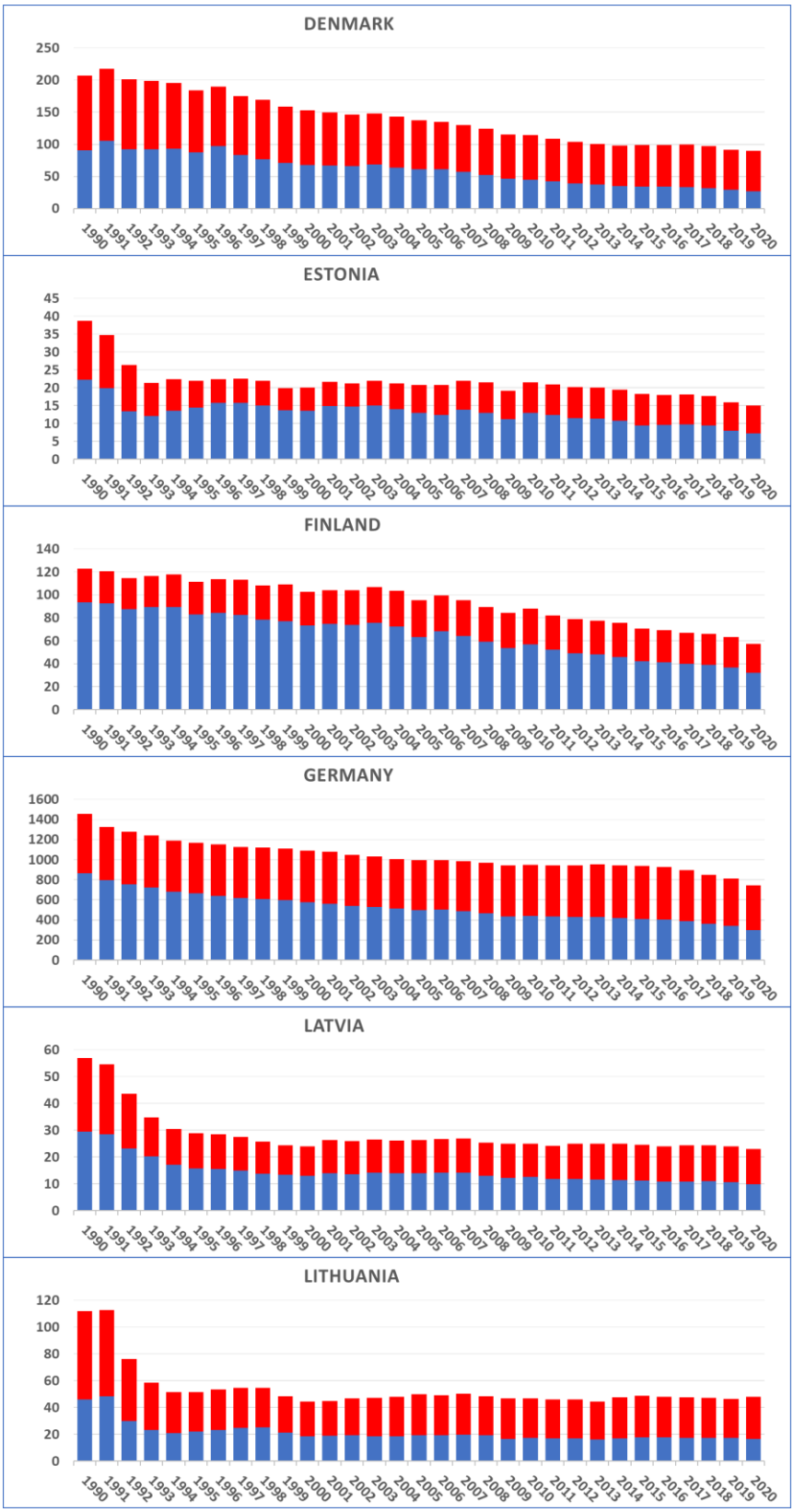

Figure 1. Annual atmospheric emissions of nitrogen oxides (NOx, blue) and ammonia (NH_3, red) from HELCOM Contracting Parties, international shipping (North Sea and Baltic Sea) and from other sources within the EMEP MSC-W model domain from 1990 to 2020. Unit: ktonnes(N)/year. The emission data are based on official submissions from EMEP countries as of June 2022. Trends, if significant at the 5% confidence level, are listed in Table 1. The Figure continues on the next page.

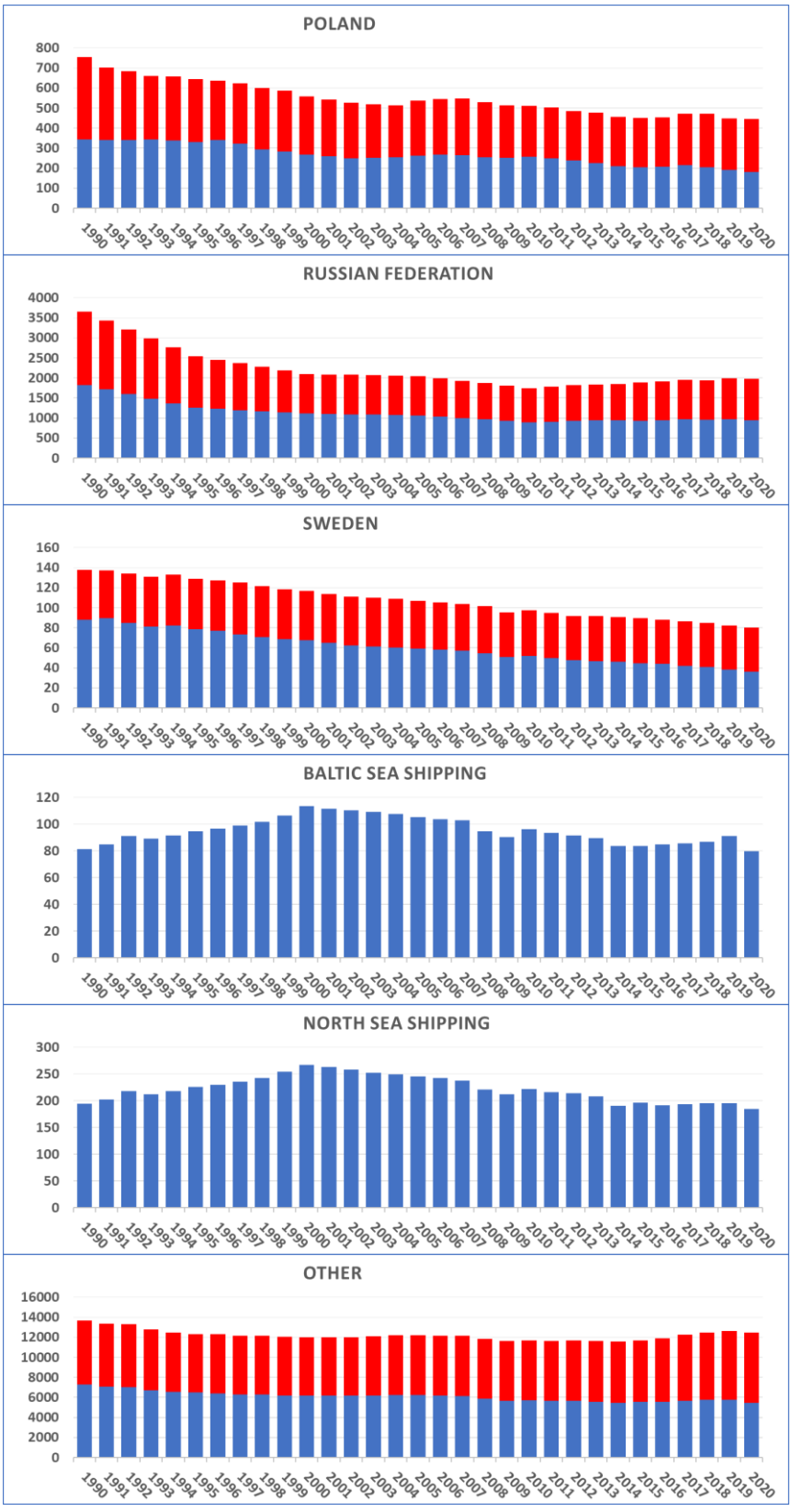

Figure 1. continued

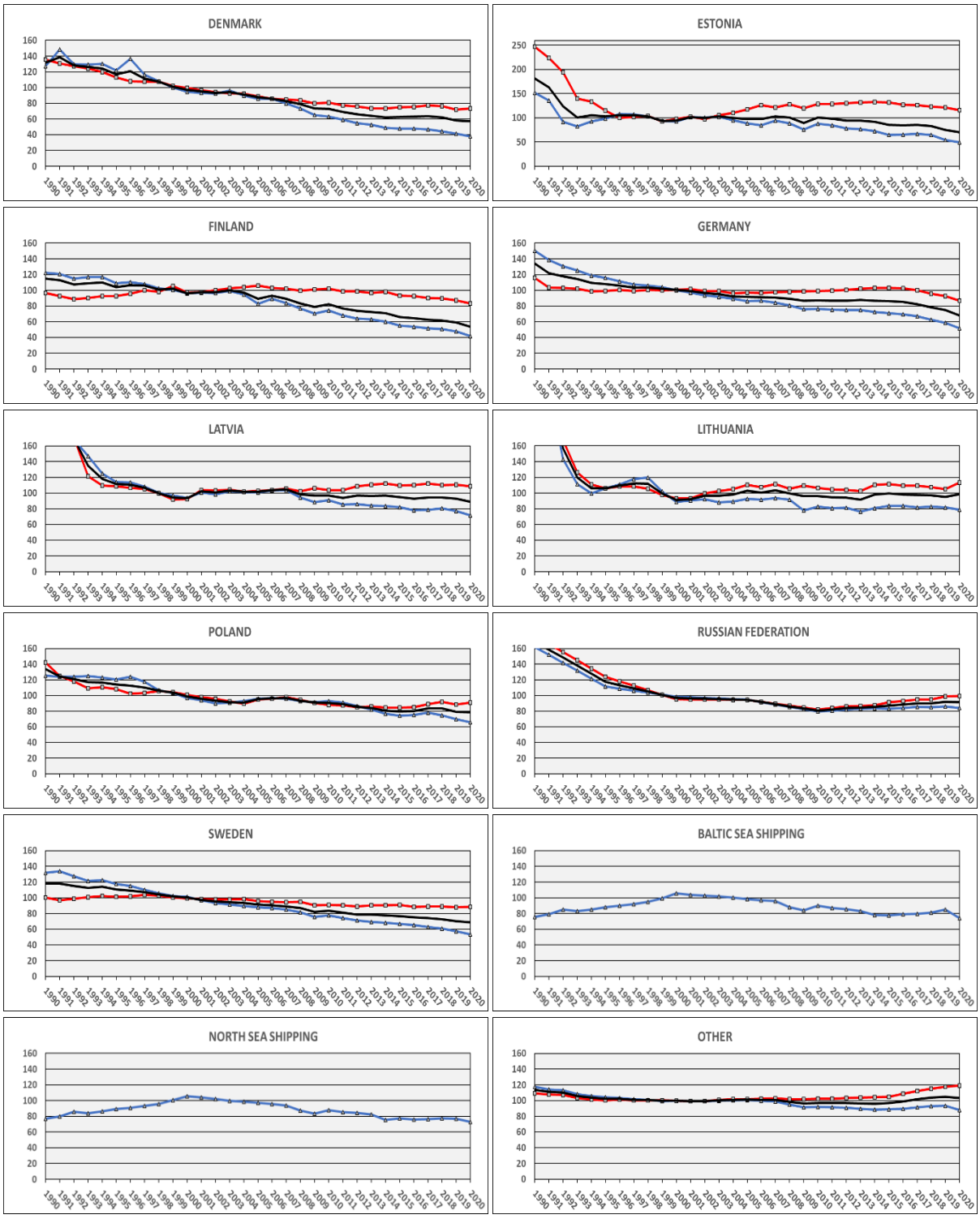

Figure 2. Changes in annual atmospheric emissions of nitrogen oxides (NOx, blue/triangles), ammonia (NH_3, red/squares) and total nitrogen (NOx+ NH_3, black solid) from HELCOM Contracting Parties, international shipping (North Sea and Baltic Sea) and from other sources within the EMEP MSC-W model domain from 1990 to 2020, plotted as percentage of the 1997-2003 average value. Unit: %. The emission data are based on official submissions from EMEP countries as of June 2022. Trends, if significant at the 5% confidence level, are listed in Table 1.

Table 1. Trends in emissions of oxidized, reduced, and total nitrogen from HELCOM Contracting Parties, international shipping (North Sea and Baltic Sea) and from other sources within the EMEP MSC-W model domain. The values correspond to the slopes of the linear regression line, given in units of ktonnes(N)/year, calculated for the whole 31-year period (1990 – 2020), for the 1990s and for the most recent decade. Missing values mean that there is no trend that is significant at the 5% confidence level (i.e. the Mann-Kendall test yields a p-value larger than 0.05). Positive trends are written in red font.

Source	Oxidized Nitrogen			Reduced Nitrogen			Total Nitrogen		
	1990-2020	1990-2000	2010-2020	1990-2020	1990-2000	2010-2020	1990-2020	1990-2000	2010-2020
DK	-2.5	-3.2	-1.6	-1.7	-3.1	-	-4.3	-6.0	-2.0
EE	-0.3	-	-0.6	-	-1.0	-0.1	-0.2	-0.9	-0.6
FI	-2.0	-1.9	-2.1	-	0.4	-0.5	-2.1	-1.6	-2.7
DE	-14.2	-24.6	-11.4	-0.8	-	-	-15.4	-26.8	-15.0
LV	-0.3	-1.4	-0.2	-	-1.2	-	-0.2	-2.5	-0.1
LT	-0.3	-1.6	-	-	-2.6	-	-0.3	-4.0	-
PL	-5.3	-6.6	-6.7	-3.2	-7.4	-	-8.9	-14.8	-5.4
RU	-18.8	-71.4	6.0	-16.8	-84.3	18.5	-36	-155.6	25.5
SE	-1.7	-2.3	-1.4	-0.3	-	-0.1	-2.0	-2.1	-1.5
HELCOM	-43.4	-113.9	-17.3	-21.3	-100.3	15.0	-64.9	-214.1	-
BAS	-	2.5	-	-	-	-	-	2.5	-
NOS	-1.7	6.0	-3.4	-	-	-	-1.7	6.0	-3.4
Other	-47.9	-107.0	-	13.6	-52.5	109.2	-32.9	-155	99.4

References

EMEP, 2021: EMEP Status Report 1/2021. "Transboundary particulate matter, photo-oxidants, acidifying and eutrophying components" Joint MSC-W & CCC & CEIP Report. Link for direct download: https://emep.int/publ/reports/2021/EMEP_Status_Report_1_2021.pdf

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JRC/PBL: Emission Database for Global Atmospheric Research (EDGAR), Global Emissions EDGAR v4.3.1, European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL), URL http://edgar.jrc.ec.europa.eu, 2016.

Data

Table 2. National total emissions of nitrogen oxides from HELCOM Contracting Parties, international shipping (NOS: North Sea, and BAS: Baltic Sea), and from other sources within the EMEP MSC-W model domain in the period 1990 – 2020, as used in the EMEP MSC-W model calculations of nitrogen deposition. The bottom row ('Ref') shows the average for the 1997 – 2003 reference period. Unit: ktonnes(N)/year.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	Sum HELCOM	Shipping		Other
											BAS	NOS	
1990	90.5	22.3	93.3	863	29.5	45.9	343	1822	88.0	3397	81.4	194	7292
1991	106.	19.9	92.4	796	28.4	48.4	340	1708	89.3	3227	84.8	202	7068
1992	92.4	13.4	87.7	751	23.1	29.9	340	1594	85.0	3017	91.2	218	7012
1993	92.0	12.1	89.3	721	20.2	23.2	342	1480	81.1	2861	89.0	212	6713
1994	92.7	13.6	89.5	682	17.1	20.8	338	1367	82.0	2702	91.4	218	6546
1995	87.0	14.4	83.1	665	15.7	22.1	331	1253	78.5	2549	94.5	225	6462
1996	97.2	15.8	84.4	640	15.6	23.1	340	1224	77.0	2517	96.4	230	6391
1997	83.0	15.7	82.6	617	14.8	24.6	322	1195	73.5	2428	98.7	235	6289
1998	76.9	15.0	78.3	609	13.7	25.1	293	1166	70.6	2347	101.5	242	6256
1999	71.3	13.7	76.9	599	13.3	21.4	284	1137	68.5	2284	106.6	254	6149
2000	67.4	13.6	73.4	575	12.9	18.5	266	1107	67.6	2202	113.5	267	6175
2001	66.5	14.9	74.4	558	13.8	19.0	258	1099	64.6	2169	111.4	263	6163
2002	65.7	14.7	73.7	540	13.5	19.3	247	1091	62.3	2127	110.3	258	6148
2003	68.5	15.0	75.7	526	14.0	18.4	250	1082	61.1	2111	109.0	253	6181
2004	63.8	13.9	72.2	512	13.9	18.6	254	1074	60.0	2082	107.4	249	6215
2005	61.3	13.0	63.4	497	13.8	19.4	262	1065	58.9	2054	105.3	245	6249
2006	61.3	12.4	68.1	500	14.2	19.1	266	1031	58.3	2030	103.7	242	6166
2007	57.1	13.8	64.2	484	14.2	19.5	264	997	56.9	1970	102.9	237	6131
2008	52.2	13.0	58.9	465	12.9	19.1	255	963	54.4	1893	94.4	221	5876
2009	46.5	11.1	53.7	436	12.1	16.3	250	928	50.6	1805	90.1	212	5663
2010	45.0	12.9	57.0	440	12.5	17.3	255	894	51.9	1786	96.3	222	5700
2011	42.2	12.4	52.1	432	11.7	16.9	249	908	49.8	1774	93.3	216	5652
2012	39.0	11.5	49.1	430	11.8	17.0	238	926	47.6	1769	91.7	214	5629
2013	37.5	11.3	48.2	430	11.6	16.0	226	935	46.5	1762	89.3	208	5552
2014	34.6	10.7	45.9	416	11.4	16.9	210	938	45.8	1730	83.6	191	5466
2015	34.2	9.4	42.3	409	11.2	17.5	204	932	44.5	1705	83.5	196	5523
2016	34.2	9.6	41.0	401	10.7	17.5	206	947	43.7	1710	84.7	192	5537
2017	33.4	9.8	39.7	386	10.8	17.1	214	963	42.1	1715	85.4	193	5665
2018	31.7	9.5	38.7	360	11.1	17.3	205	956	40.9	1670	86.8	195	5754
2019	29.4	7.9	36.5	337	10.6	17.1	191	965	38.4	1634	91.1	195	5772
2020	27.1	7.2	32.1	298	9.8	16.4	181	946	35.9	1553	79.8	185	5463
Ref	**71.3**	**14.7**	**76.5**	**575**	**13.7**	**20.9**	**274**	**1125**	**66.9**	**2238**	**107**	**253**	**6194**

Table 3. National total emissions of ammonia from HELCOM Contracting Parties and from other sources within the EMEP MSC-W model domain in the period 1990 – 2020, as used in the EMEP MSC-W model calculations of nitrogen deposition. The bottom row ('Ref') shows the average for the 1997 – 2003 reference period. Unit: ktonnes(N)/year.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	Sum HELCOM	Other
1990	116	16.4	29.3	591	27.4	65.9	412	1831	49.7	3140	6383
1991	112	14.8	28.0	528	26.1	64.2	362	1722	48.1	2906	6297
1992	109	12.9	26.9	527	20.6	46.4	343	1613	48.9	2747	6267
1993	106	9.29	27.3	521	14.6	35.1	317	1504	50.0	2585	6041
1994	103	8.83	28.1	505	13.2	30.8	320	1395	50.8	2454	5935
1995	96.7	7.61	28.1	505	13.1	29.4	314	1285	50.3	2330	5863
1996	92.8	6.61	29.0	513	12.9	30.1	297	1226	50.4	2257	5921
1997	92.0	6.78	30.3	507	12.7	30.1	299	1167	51.5	2196	5875
1998	92.1	6.88	29.7	514	12.0	29.3	307	1108	51.0	2149	5885
1999	87.6	6.12	31.9	512	11.1	27.1	303	1048	49.8	2076	5877
2000	85.5	6.48	29.4	514	11.2	25.9	293	989	49.2	2003	5832
2001	82.9	6.76	29.6	517	12.5	25.9	283	987	48.8	1994	5808
2002	80.8	6.44	30.3	507	12.5	27.6	279	985	48.6	1977	5827
2003	79.6	6.97	31.1	505	12.6	28.5	267	983	48.6	1963	5891
2004	79.1	7.30	31.5	491	12.3	29.1	259	982	48.8	1940	5954
2005	76.2	7.81	32.1	497	12.4	30.6	274	980	47.6	1958	5964
2006	73.4	8.38	31.3	492	12.5	29.8	278	954	47.0	1927	5995
2007	72.7	8.04	30.9	499	12.7	30.9	283	928	46.8	1912	6010
2008	72.0	8.46	30.2	501	12.3	29.3	273	902	47.1	1876	5948
2009	68.6	7.95	30.6	504	12.8	30.4	263	877	44.8	1839	5954
2010	69.3	8.52	30.9	506	12.5	29.5	255	851	45.2	1808	5983
2011	66.5	8.52	29.9	509	12.5	29.1	254	870	44.9	1824	5990
2012	65.1	8.64	29.8	514	13.1	28.9	246	893	44.1	1843	6051
2013	63.1	8.74	29.3	520	13.3	28.5	250	896	45.0	1854	6076
2014	63.2	8.80	29.7	527	13.5	30.7	246	910	44.9	1874	6106
2015	64.3	8.76	28.3	526	13.2	31.0	245	948	45.0	1910	6130
2016	64.7	8.41	28.0	523	13.3	30.3	246	962	44.0	1920	6353
2017	66.4	8.35	27.3	510	13.5	30.3	258	984	44.2	1942	6573
2018	65.5	8.14	27.1	489	13.3	29.9	267	985	44.1	1929	6724
2019	61.9	8.04	26.5	474	13.3	29.1	256	1026	43.7	1939	6866
2020	62.8	7.70	25.3	442	13.1	31.5	264	1031	43.9	1922	6973
Ref	**85.8**	**6.63**	**30.3**	**511**	**12.1**	**27.8**	**290**	**1038**	**49.6**	**2051**	**5857**

Table 4. National total emissions of total nitrogen from HELCOM Contracting Parties, international shipping (NOS: North Sea, and BAS: Baltic Sea), and from other sources within the EMEP MSC-W model domain in the period 1990 – 2020, as used in the EMEP MSC-W model calculations of nitrogen deposition. The bottom row ('Ref') shows the average for the 1997 – 2003 reference period. Units: ktonnes(N)/year.

Year	DK	EE	FI	DE	LV	LT	PL	RU	SE	Sum HELCOM	Shipping		Other
											BAS	NOS	
1990	207	38.7	123.	1454	56.9	112.	755	3653	138	6537	81.4	194	13675
1991	218	34.7	120.	1324	54.5	113.	702	3430	137	6133	84.8	202	13366
1992	201	26.3	115.	1278	43.7	76.3	683	3207	134	5764	91.2	218	13280
1993	198	21.4	117.	1242	34.8	58.3	659	2984	131	5446	89.0	212	12755
1994	195	22.4	118.	1187	30.4	51.6	658	2761	133	5156	91.4	218	12480
1995	184	22.0	111.	1170	28.8	51.5	645	2538	129	4879	94.5	225	12325
1996	190	22.4	113.	1152	28.5	53.2	637	2450	127	4774	96.4	230	12312
1997	175	22.5	113.	1124	27.5	54.6	622	2362	125	4625	98.7	235	12164
1998	169	21.9	108.	1122	25.7	54.4	600	2273	122	4496	102.	242	12141
1999	159	19.8	109.	1110	24.3	48.4	586	2185	118	4360	107.	254	12026
2000	153	20.1	103.	1090	24.0	44.4	558	2097	117	4206	114.	267	12007
2001	149	21.7	104.	1076	26.3	44.9	541	2086	113	4163	111.	263	11971
2002	146	21.2	104.	1047	26.0	46.9	526	2076	111	4104	110.	258	11975
2003	148	22.0	107.	1031	26.6	46.9	517	2066	110	4073	109.	253	12072
2004	143	21.2	104.	1002	26.2	47.7	514	2055	109	4022	107.	249	12169
2005	138	20.8	95.4	993	26.2	50.0	537	2045	107	4012	105.	245	12213
2006	135	20.8	99.4	992	26.7	48.9	544	1985	105	3957	104.	242	12161
2007	130	21.9	95.1	983	26.9	50.4	547	1925	104	3883	103.	237	12141
2008	124	21.4	89.1	966	25.3	48.4	528	1865	102	3770	94.4	221	11824
2009	115	19.1	84.3	940	24.9	46.7	513	1805	95	3643	90.1	212	11617
2010	114	21.4	87.9	946	25.0	46.8	510	1745	97	3594	96.3	222	11683
2011	109	20.9	82.1	941	24.2	46.0	503	1778	95	3598	93.3	216	11642
2012	104	20.1	79.0	944	24.9	45.9	483	1819	92	3613	91.7	214	11681
2013	101	20.0	77.5	950	24.9	44.5	475	1832	91	3616	89.3	208	11628
2014	98	19.5	75.6	943	25.0	47.6	456	1848	91	3604	83.6	191	11572
2015	99	18.2	70.6	935	24.5	48.5	449	1880	90	3614	83.5	196	11653
2016	99	18.0	69.0	924	24.0	47.8	452	1909	88	3629	84.7	192	11890
2017	100	18.1	67.0	896	24.3	47.4	472	1947	86	3657	85.4	193	12238
2018	97	17.6	65.8	849	24.3	47.1	472	1941	85	3599	86.8	195	12478
2019	91	16.0	63.0	811	23.9	46.2	448	1992	82	3573	91.1	195	12638
2020	90	14.9	57.3	740	22.9	47.9	445	1977	80	3475	79.8	185	12436
Ref	**157**	**21.3**	**107**	**1086**	**25.8**	**48.6**	**564**	**2163**	**117**	**4290**	**107**	**253**	**12051**

Metadata

Technical information

1. Source: EMEP Centre on Emission Inventories and Projections (CEIP).
2. Description of data: The gridded distributions of emissions have been provided by the EMEP Centre on Emission Inventories and Projections (CEIP). The emissions for the 1990-2000 period are derived from official data submissions to UNECE CLRTAP as of June 2022.
3. Geographical coverage: EMEP domain covering Europe, parts of Asia and a part of the Atlantic Ocean.
4. Temporal coverage: Data on emissions of nitrogen oxides and ammonia are presented here for the period 1990 - 2020.
5. Methodology and frequency of data collection: National data on emissions are regularly submitted by the Parties to the CLRTAP Convention to the UN ECE Secretariat. Oftentimes, emissions are updated also for years far back in time (i.e. not only for the most recent year), so that model results for the past (e.g. the reference period) can change. Emission data inventorying is based on a combination of emission measurements and emission estimates, based on activity data and emission factors. Submitted data undergo a QA/QC procedure and are stored in the WebDab database of the EMEP Centre for Emission inventories and Projections (CEIP) in Vienna, Austria.

Quality information

6. Strengths and weaknesses: Strength: data on emissions are annually submitted, checked and stored in the CEIP database; Weaknesses: there are gaps in time series of national emissions, which have to be corrected by experts. Delays occur in updating historical emission data submitted by the EMEP Contracting Parties.
7. Uncertainty. No official information about the uncertainty of provided nitrogen emission data is available from CEIP.
8. Further work required: Further work on emission uncertainty is required.