Convention on Long-range Transboundary Air Pollution

emep

Co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe

TECHNICAL REPORT CEIP 3/2022

Methodologies applied to the technical review of emission data 2022

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EXECUTIVE SUMMARY

The main guidance documents for reporting air emission inventories are the *UNECE Reporting Guidelines* (UNECE, 2014b) and the *EMEP/EEA Inventory Guidebook* (EMEP/EEA, 2019).

Reporting requirements

Parties are formally only required to report on the substances and for the years set forth in the Convention and the protocols and their amendments that they have ratified and that have entered into force for them (UNECE, 2014b). Parties that have obligations to report emission inventories under protocols that they have ratified and that are in force shall annually report emission inventories (UNECE, 2014b). Annual reporting shall include national emissions and should include activity data for the sectors identified in annex I to these Guidelines for the years indicated (UNECE, 2014b). Parties are strongly encouraged to submit the IIR. The IIR should be submitted annually (UNECE, 2014b). Parties to the Gothenburg Protocol within the geographical scope of EMEP shall regularly update their projections and report every four years from 2015 onward theirupdated projections, for the years 2025 and 2030 and, where available, also for 2040 and 2050. Parties to the other protocols are encouraged to regularly update their projections and report every four years from 2015 (UNECE, 2014b). Every four years from 2017 onward, Parties shall report for the year x-2 updated aggregated sectoral (GNFR) gridded emissions and LPS emissions (UNECE, 2014b).

The review process

Each year the air pollutant emission inventories are checked in a technical review that is performed in accordance with the review guidelines (UNECE, 2018). The aim of the review is to improvine the quality of emission data and associated information reported to the LRTAP Convention. The present report documents the review methods. Details on the review results can be found in the annual CEIP Inventory Review reports[1].

The review process of the emission inventories is carried out in three stages. At each stage, national experts have the opportunity to clarify issues or provide additional information.

The stage 1 review (initial review) consists of automated tests which assess the timeliness, completeness and format of the submitted national inventories. Sectoral data as well as national total emissions are checked within these tests.

The stage 2 review (extended review) assesses the recalculations, time series consistency, key category analysis, inventory comparison and comparability of the submitted national inventories. Recalculations are checked to determine differences between national total emissions reported in the current and the previous submission. Key category analyses are made to assess the most important sources for each country, based on the latest submission. Inventories reported LRTAP and UNFCCC are compared. Instances of dips and jumps in trends in time series of sectoral data and national totals are highlighted.

The stage 3 review (in-depth review) is a centralised review of selected inventories checking if inventories are consistent with EMEP/EEA inventory guidebook, complete, consistent over time,

[1] https://www.ceip.at/review-of-emission-inventories/technical-review-reports

properly documented, comparable between the countries and accurate. Annually, approximately ten Parties are reviewed by expert review teams[2] set-up by CEIP based on nominations by countries[3]. Alternatively, an ad hoc review may be performed to focus on specific aspects of inventory data quality or science. (UNECE, 2018)

The review of gridded data and LPS information comprise a few standard tests. It is checked if sectoral gridded data or point sources for all pollutants/years are reported as requested by the UNECE Reporting Guidelines (UNECE, 2014b). Within the tests, the position of the cells/LPS is checked. The grid-sum data on sectoral level (GNFR) is compared with sectoral emissions (aggregated from NFR to GNFR sector level) reported in the NFR table.

The officially reported emission data, gap-filled and gridded emission data are made available via the CEIP database (https://www.ceip.at/webdab-emission-database).

Review findings are annually published at the CEIP website (https://www.ceip.at/) or in the Inventory Review reports.

[2] https://www.ceip.at/review-of-emission-inventories/in-depth-review-of-ae-inventories

[3] https://www.ceip.at/fileadmin/inhalte/ceip/3_review/0_roster_2021.pdf

1 INTRODUCTION

The review process of emission data has been developed on the basis of feedback from Parties and from the Task Force on Emission Inventories and Projections (TFEIP) and is seen by Parties as efficient tool for the improvement of their national emission inventories.

The technical review of national inventories checks and assesses Parties' data submissions in accordance with methods and procedures for the technical review of air pollutant emission inventories reported under the Convention and its protocols (UNECE, 2018)[4] with a view to improving the quality of emission data and associated information reported to the Convention. Over the last years the regular inventory reviews under CEIP have facilitated the identification of a number of inventory-related issues, and improvements have subsequently been implemented.

1.1 Reporting obligations - Scope

Parties are formally only required to report on the substances and for the years set forth in the Convention and the protocols and their amendments that they have ratified and that have entered into force for them (UNECE, 2014b). Parties that have obligations to report emission inventories under protocols that they have ratified and that are in force shall annually report emission inventories (UNECE, 2014b). Annual reporting shall include national emissions and should include activity data for the sectors identified in annex I to these Guidelines for the years indicated (UNECE, 2014b). Parties are strongly encouraged to submit the IIR. The IIR should be submitted annually (UNECE, 2014b). Parties to the Gothenburg Protocol within the geographical scope of EMEP shall regularly update their projections and report every four years from 2015 onward theirupdated projections, for the years 2025 and 2030 and, where available, also for 2040 and 2050. Parties to the other protocols are encouraged to regularly update their projections and report every four years from 2015 (UNECE, 2014b). Every four years from 2017 onward, Parties shall report for the year x-2 updated aggregated sectoral (GNFR) gridded emissions and LPS emissions (UNECE, 2014b).

A summary of the reporting obligations can be downloaded from the CEIP website[5]. The UNECE Reporting Guidelines (UNECE, 2014b) give detailed instructions on the reporting in section VI. Reporting.

1.1.1 Geographical coverage

According to the definition given in the Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP): "The geographical scope of EMEP means the area within which, coordinated by the international centres of EMEP, monitoring is carried out." (UNECE, 1984)[6] This definition has

[4] https://www.ceip.at/review-of-emission-inventories/review-process

[5] https://www.ceip.at/reporting-instructions

[6] See http://www.unece.org/env/lrtap/emep_h1.html

been referred to in all following protocols to the Convention. The EMEP domain covers the geographic area between 30°N-82°N latitude and 30°W-90°E longitude (Figure 1.1).

Figure 1.1: EMEP domain

1.1.2 International air and sea traffic[7]

International Shipping: includes emissions from fuels used by vessels of all flags that are engaged in international water-borne navigation. The international navigation may take place at sea, on inland lakes and waterways and in coastal waters. The definition includes emissions from journeys that depart in one country and arrive in a different country and excludes consumption by fishing vessels (EMEP/EEA, 2019).

International Aviation: Emissions from flights that depart in one country and arrive in a different country. Include take-offs and landings for these flight stages. Emissions from international military aviation can be included provided that the same definitional distinction is applied (UNECE, 2014b).

1.1.3 Transparency and Informative Inventory Reports (IIRs)

Transparency means that Parties provide clear documentation (IIR) and report emissions and activity data at a level of disaggregation, which provides sufficient understanding of how the inventory was compiled, assuring it meets good practice requirements.

According to the UNECE Reporting Guidelines (UNECE, 2014b) Parties should submit annually Informative Inventory Report (IIR) along with their emission data. The IIRs shall be submitted in one of the working languages of the UNECE (English, French or Russian), and where relevant, Parties are encouraged to submit also an English translation of their reports (UNECE, 2014b). For the transparency of inventories, it is essential that information such as reasons for recalculations, new

[7] The below definitions are taken from chapters 3.5.1 and 3.6.1 of volume 2 of the IPCC Guidelines (IPCC, 2006).

(or closed) large emission sources, explanation of trends and the implementation of country-specific methods/data are provided in a transparent manner (see Annex II to the UNECE Reporting Guidelines "Informative Inventory Report").

The provision of an IIR is essential for an efficient stage 3 review (in depth review).

1.1.4 Reporting of adjusted inventories

Inventories shall be calculated without corrections or normalization relating, for example, to climate variations or trade patterns of electricity (UNECE, 2014a). Parties may apply to adjust their emission reduction commitments or inventory data in extraordinary circumstances, as defined in Executive Body decisions 2012/3 and 2012/4 (UNECE, 2012a, UNECE, 2012b) and amended in Executive Body decisions 2014/1 (UNECE, 2014a). Detailed instructions for reporting adjustemnts are given in the "Technical Guidance for Parties Making Adjustment Applications and for the Expert Review of Adjustment Applications (ECE/EB.Air/130)" and for emissions Inventory Adjustments under the Amended Gothenburg Protocol in the "Technical Guidance for Emissions Inventory Adjustments under the Amended Gothenburg Protocol: Inventory adjustments in the context of Emission Reduction Commitments" (TFEIP, 2022).

1.1.5 Fuel sold fuel used

Paragraph 22 of the UNECE Reporting Guidelines (UNECE, 2014b) specifies the basis for reporting emissions from transport: "*For emissions from transport, all Parties should calculate emissions consistent with national energy balances reported to Eurostat or the International Energy Agency. Emissions from road vehicle transport should therefore be calculated on the basis of the fuel sold in the Party concerned. In addition, Parties may voluntarily calculate emissions from road vehicles based on fuel used or kilometres driven in the geographic area of the Party and report in memo items. The method for the estimate(s) should be clearly specified in the IIR.*"

1.2 Quality parameters of the inventory

Parties shall as a minimum use the methodologies in the latest version of the EMEP/EEA Guidebook, as approved by the Executive Body to estimate emissions and projections for each source category. Parties can use, as an alternative to the EMEP/EEA Guidebook, national or international methodologies that they consider better able to reflect their national situation, provided that the methodologies produce more accurate estimates than the default methods, are scientifically based, are compatible with the EMEP/EEA Guidebook and are documented in their IIRs, as described in annex II to these Guidelines (UNECE, 2014a).

It is considered good practice to report inventories which are complete, consistent, comparable, and transparent and neither overestimated nor underestimated according to the best judgement.

The terms transparency, consistency, comparability, completeness and accuracy are defined in detail in the UNECE Reporting Guidelines (UNECE, 2014b).

2 REVIEW PROCESS

2.1 Technical review

2.1.1 Review under the LRTAP Convention

At the 38th session of Executive Body (EB) to EMEP (Geneva, December 2018) the document **'Updated methods and procedures for the review of emission inventories'** was adopted (Decision 2018/1). **The Appendix on Technical Revisions** provides guidance on the quantification of necessary technical corrections if the data are found to be inconsistent with recommended methodologies of the EMEP/EEA Guidebook or where the emission estimates are not provided for an NFR source category.

The technical review of national inventories checks and assesses Parties' data submissions with a view to improve the quality of emission data and associated information reported to the Convention. The technical review is carried out annually by EMEP. It is performed in accordance with the 'Updated methods and procedures for the review of emission inventories' ECE/EB.AIR/142/Add.1 (UNECE, 2018). The process of determining and calculating Technical Revisions is described in the Appendix of this document.

The process is carried out in three stages. The technical review of inventories is carried out in the following three stages:

- *initial review (stage 1):* An initial check of submissions for timeliness, completeness and formats;
- *extended review* (*stage 2):* A synthesis and assessment of all national submissions with respect to consistency , comparability, KCA, trends of data with recommendations for data quality improvement;
- in-depth reviews (*stage 3):* In-depth reviews of selected inventories, by pollutant, country or sector, as in the workplan approved by the EMEP Steering Body. Up to ten countries are checked annually by two review teams. Alternatively, an ad hoc review may be performed to focus on specific aspects of inventory data quality or science. (UNECE, 2018)

At each stage, national experts have the opportunity to clarify issues or provide additional information. They may also express their views at meetings of the Task Force on Emission Inventories and Projections. **Nominated CEIP contact points** are provided with passwords which allow them to access the review finings. Parties are requested to respond within four weeks after the notification.

2.2 Access to the data and review results

The review assesses emission data (including gridded data and LPS) reported under the CLRTAP to the UNECE Secretariat.

The information submitted by Parties during the reporting rounds can be accessed from the CEIP webpage.[8] In addition, the *officially reported emission data* are made available via the CEIP database[9]. *Gap-filled and gridded emission* data for modellers are also made available at the CEIP webiste[10].

Review findings of the stage 1 and stage 2 review under CLRTAP are published at the CEIP web-site.[11] Summaries of findings are annually published in the *Inventory review report* (CEIP, 2022)[12].

[8] https://www.ceip.at/status-of-reporting-and-review-results

[9] https://www.ceip.at/webdab-emission-database/reported-emissiondata

[10] https://www.ceip.at/the-emep-grid/gridded-emissions

[11] https://www.ceip.at/status-of-reporting-and-review-results/2022-submission

[12] https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2022/dp-169_inventoryreport_2022.pdf

3 INITIAL (STAGE I) REVIEW

The stage 1 review performed by CEIP consists of automated tests which assess the *timeliness, completeness and format* of the submitted national inventories. It presents results of these initial automated tests to countries and supports the subsequent stage 2 and stage 3 review process. Stage 1 tests are:

- Timeliness of reporting
- Format of submission
- Completeness per sector for emissions for 2020
- Completeness per pollutant for submitted time series (separately for, 1990-1999, and from 2000 to 2020).

Sectoral data as well as national total emissions were checked within these tests.

The results of these initial automated tests are presented online, in the form of individual country *Stage 1 Status reports* annually in March. Parties were invited to provide comments or resubmissions, if applicable, within two weeks.

Data included in tests:

- Emissions reported under the Convention on LRTAP.

3.1 Timeliness

Example of feedback provided to country:
Date of submission of CLRTAP : 15.02.2022 , received within deadline 15.02.2022

3.2 Format

The submissions were checked against the **'NFR19' format** agreed by the EMEP Executive Body (EB) at its 27th session and amended taking into account changes to the POPs Protocol.

Parties were invited to submit entire time series in standard format to enable quality control of historical sector emissions, consistency of sectoral trends and a comparison of inventories between the Parties. It is highly recommended that Parties take advantage of consistency control (via RepDab) of their emission data upon submission (https://www.ceip.at/repdab) before the submission of their inventory to the UNECE secretariat, the EMEP Centre on Emission Inventories and Projections (CEIP) and/or the European Commission/European Environment Agency.

3.3 Completeness

The revised UNECE Reporting Guidelines (UNECE, 2014b) ask Parties to submit emissions for 1980 – latest year for Main Pollutants, 1990 – latest year for HMs and POPs, and for 2000 – latest year for PM. It has to be noted that the pollutant-specific CLRTAP Protocols formally request reporting only from Parties which have ratified the Protocol for the Protocol base year, for the year after the entry into force of that Protocol and for subsequent years.

Parties to the Gothenburg Protocol shall report their latest available projections at least every four years, and provide any updated projections annually by 15 February. Parties to the Convention that are not Parties to the Gotehnburg Protocol are encouraged to provide this information (UNECE, 2014b).

3.3.1 Example of completeness check results per sector for the current reporting year

"NE" in the figure below (Figure 3.1) shows for which sectors countries reported **'Not Estimated'** in the latest year emission data. Only priority pollutants are included in this analysis. The end of the table provides then number of notation key and the number of the notation key "NE" for each pollutant. statistics on how many sectors are listed and the number of reported 'NE' notation keys per pollutant.

Sector	NOx	NMVOC	SOx	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	DIOX	PAH	HCB	PCB
1A3ai(i)																			NE	NE	NE	NE
1A3aii(i)																			NE	NE	NE	NE
2B10a																				NE		
2B5					NE	NE	NE															
2C2										NE	NE	NE							NE	NE	NE	
2C3																				NE		
2C5												NE										
2C7a		NE							NE											NE		
2C7c					NE	NE	NE			NE	NE	NE							NE	NE	NE	
2D3i					NE	NE	NE															
2G																					NE	
5E	NE	NE	NE						NE											NE	NE	NE
1A3ai(ii)																			NE	NE	NE	NE
1A3aii(ii)																			NE	NE	NE	NE
14 of 135 Sectors listed																						
Count of overall notation keys	82	69	98	81	69	69	69	142	97	93	94	97	142	142	142	142	142	142	101	104	103	108
Count of 'NE' notation keys	1	2	1	0	3	3	3	0	2	2	2	3	0	0	0	0	0	0	6	10	8	5

Figure 3.1: Example of findings: CLRTAP emission (Completeness per sector for the current reporting year)

3.3.2 Example of completeness check results per pollutant

The completeness of the data in the WebDab database of priority pollutants (**Stage 1 review)** was evaluated on the basis of the criteria outlined in the UNECE Reporting Guidelines (UNECE,

2014b). Results show tables with all numbers as a percentage of the total number of reporting template cells per component and time series (examples see Figure 3.2). Flagging occurs

- when the number of cells containing a value or a notation key is less than 80 % of the total number of cells,
- if there are more than 10 % zeroes reported,
- if 'Not Estimated' is reported in cells and/or
- if the number of values reported is less than 10 %.

The completeness of CLRTAP NFR Sectors is divided in three sections:

- completeness of NFR Sectors from 2000 to 2020 without National Totals
- completeness of NFR Sectors from 1990 to 1999 without National Totals
- completeness of National Totals from 1990 to 2020 including NFR and SNAP

CLRTAP (Completeness of NFR Sectors from 2000 to 2020 without National Totals):

Component	% Value	% 0	% NO	% NE	% NA	% IE	% C	% NR	% All
NOx	43.0	0.0	20.0	1.0	29.0	7.0	0.0	0.0	100.0
NMVOC	52.3	0.0	20.0	2.0	17.7	8.0	0.0	0.0	100.0
SOx	30.0	0.0	20.0	1.0	40.0	9.0	0.0	0.0	100.0
NH3	43.0	0.0	20.2	0.0	29.0	7.0	0.0	0.0	100.0
PM2.5	51.0	0.0	20.0	2.0	21.0	5.0	0.0	0.0	100.0
PM10	51.0	0.0	20.0	2.0	21.0	5.0	0.0	0.0	100.0
TSP	51.0	0.0	20.0	2.0	21.0	5.0	0.0	0.0	100.0
BC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
CO	31.0	0.0	20.0	2.0	41.0	6.0	0.0	0.0	100.0
Pb	33.0	0.0	20.0	2.0	39.0	6.0	0.0	0.0	100.0
Cd	32.0	0.0	20.0	2.0	40.0	6.0	0.0	0.0	100.0
Hg	30.8	0.0	20.2	2.0	41.0	6.0	0.0	0.0	100.0
As	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Cr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Cu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Ni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Se	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Zn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
DIOX	29.0	0.0	20.0	3.0	42.0	6.0	0.0	0.0	100.0
PAH	26.0	0.0	20.0	6.0	42.0	6.0	0.0	0.0	100.0
HCB	28.1	0.0	20.0	5.0	41.8	6.0	0.0	0.0	100.0
PCB	24.0	0.0	20.0	2.0	49.0	6.0	0.0	0.0	100.0

"Value" – the cell contains a number > 0.005
"0" – the cell contains 0 or a number < 0.005
"NO", "NE", "NA", "IE", "C" and "NR" are notation keys as defined in Reporting Guidelines and NFR (Annex B)
In certain cases the total percentage value may not be exactly the sum of the other columns because of rounding differences

Figure 3.2: Example for the results of test, CLRTAP (completeness of NFR Sectors from 2000 to 2020 without National Totals)

4 STAGE 2 REVIEW

The stage 2 tests assess the recalculations, key category analysis, inventory comparison, trends and time series of the submitted national inventories. The following stage 2 tests were performed:

- Recalculations
- Key category analysis – CLRTAP
- Inventory comparisons
- Time series
- Trends

Data included in the stage 2 review are the emissions submitted under the CLRTAP and emissions reported under the UNFCCC and EEA before 1 May. The results of the tests are published annually in the form of individual synthesis and assessment reports on the CEIP website[13] by 10 March and 30 March (update). Nominated CEIP contact points are provided with passwords which allow them to access the review finings. Parties are requested to respond within four weeks after notification.

4.1 Recalculations

Recalculations should be made if there are changes in methodologies or changes in the manner in which emission factors and activity data are obtained or used, or if estimates are provided for sources which have existed since the reference year but which were not previously accounted for in previous submissions. Parties should apply any recalculations to every relevant year in the full time series to ensure consistency across years (UNECE, 2014b). The aim of this test is to identify differences between national totals submitted by Parties in the present year and the latest available national totals submitted in previous reporting years.

It is important and necessary to identify inventory recalculations and to understand their origin in order to correctly evaluate the officially reported emission data.

In this test, *differences between national total emissions* reported by Parties to the CLRTAP in the last and the last but one year are determined and variances larger than ± 10 % are flagged[14]. A minus value indicates that the latest available emission submitted in previous years is higher. Blank cells mean that data or notation keys in the present reporting year or in the previous reporting years are missing. 0 % is given when data (value or notation key) in the present reporting year and in the latest available previous reporting year are equal. If there is a number and a notation key reported, the difference is the number. An example for this test is given in Figure 4.1.

[13] https://www.ceip.at/status-of-reporting-and-review-results

[14] The formula used to calculate the magnitude of recalculations is $100*[(X_{present\ year} - X_{previous\ year})/X_{previous\ year}]$, where $X_{present\ year}$ is emissions reported in the present year and $X_{previous\ year}$ represents emission reported in the previous year.

Year	NOx	NMVOC	SOx	NH3	PM2.5	PM10	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	DIOX	PAH	HCB	PCB
1990	0.76%	-0.31%	0.00%	12.01%	0.11%	0.66%	0.76%		0.03%	0.00%	0.00%	15.82%							-0.02%	-0.02%	-0.03%	-20.76%
1991	0.71%	-0.29%	0.00%	12.06%					-0.01%	0.00%	0.00%	16.97%							-0.02%	-0.02%	-0.04%	-27.15%
1992	0.67%	-0.26%	0.00%	10.70%					-0.03%	0.00%	0.00%	19.58%							-0.03%	-0.01%	-0.03%	-31.11%
1993	0.65%	-0.04%	0.00%	9.21%					-0.06%	0.00%	0.00%	23.12%							-0.03%	-0.01%	-0.03%	-32.05%
1994	0.65%	-0.04%	0.00%	8.89%					-0.07%	0.00%	1.05%	29.88%							-0.02%	0.02%	-0.03%	-36.86%
1995	0.59%	-0.11%	0.00%	7.34%	-0.04%	0.55%	0.65%		-0.10%	27.88%	5.61%	29.50%							-0.01%	0.03%	-0.02%	-38.91%
1996	0.52%	-0.14%	0.00%	6.96%					-0.12%	24.56%	4.45%	27.11%							-0.01%	0.04%	-0.02%	-38.22%
1997	0.51%	-0.19%	0.00%	6.28%					-0.12%	30.66%	5.98%	35.32%							-0.01%	0.06%	-0.02%	-39.39%
1998	0.47%	-0.10%	0.00%	6.42%					-0.12%	34.29%	7.06%	46.21%							0.00%	0.08%	-0.02%	-39.74%
1999	0.45%	-0.14%	0.00%	5.97%					-0.15%	30.84%	5.27%	44.15%							-0.02%	0.08%	-0.04%	-41.05%
2000	0.41%	-0.38%	0.00%	5.69%	-0.05%	0.56%	0.66%		-0.13%	35.14%	6.15%	52.44%							-0.02%	0.10%	-0.06%	-42.94%
2001	0.34%	-0.50%	0.01%	5.31%	0.03%	0.97%	1.12%		-0.19%	36.25%	6.01%	49.76%							-0.03%	-0.05%	-0.05%	-43.62%
2002	0.27%	-0.52%	0.00%	4.93%	-0.10%	0.97%	1.14%		-0.25%	36.86%	6.63%	54.71%							-0.09%	-0.14%	-0.09%	-44.87%
2003	0.23%	-0.50%	0.01%	5.08%	-0.04%	1.02%	1.18%		-0.26%	36.40%	6.42%	52.55%							-0.08%	-0.12%	-0.14%	-45.00%
2004	0.21%	-0.54%	0.03%	4.80%	-0.04%	1.03%	1.19%		-0.30%	37.98%	6.77%	56.60%							0.14%	0.75%	-0.23%	-45.33%
2005	0.19%	-0.56%	0.02%	4.95%	-0.04%	1.05%	1.21%		-0.23%	41.86%	7.62%	60.89%							0.22%	0.92%	-0.20%	-45.86%
2006	0.18%	-0.56%	0.01%	4.70%	-0.02%	1.10%	1.26%		-0.21%	41.04%	7.52%	4.75%							0.34%	1.33%	-0.13%	-46.02%
2007	0.20%	-0.50%	0.01%	4.67%	-0.08%	1.08%	1.25%		-0.15%	-27.33%	-16.28%	4.99%							0.24%	0.94%	-0.06%	-47.09%
2008	0.17%	-0.49%	0.01%	4.22%	-0.08%	1.08%	1.24%		-0.10%	-27.21%	-15.99%	4.89%							0.09%	0.37%	-0.02%	-47.20%
2009	0.16%	-0.43%	0.00%	4.13%	-0.02%	1.07%	1.21%		-0.08%	-22.96%	-12.56%	4.13%							0.08%	0.30%	0.03%	-46.08%
2010	0.15%	-0.31%	-0.01%	4.19%	-0.03%	0.95%	1.08%		-0.08%	-25.90%	-14.53%	4.78%							0.08%	0.27%	0.04%	-47.55%
2011	0.20%	-0.30%	-0.01%	4.20%	-0.12%	0.89%	1.02%		0.02%	-26.37%	-15.33%	4.96%							-0.03%	-0.20%	0.12%	-48.06%
2012	0.18%	-0.34%	0.01%	4.13%	-0.01%	0.89%	0.99%		0.08%	-26.21%	-14.95%	4.83%							-0.07%	-0.30%	0.08%	-48.42%
2013	0.14%	-0.29%	-0.04%	3.96%	-0.06%	0.85%	0.95%		0.13%	-27.22%	-15.84%	4.92%							-0.19%	-0.73%	0.03%	-48.99%
2014	0.16%	-0.32%	-0.03%	3.85%	0.05%	1.00%	1.07%		0.13%	-27.98%	-16.44%	5.06%							-0.28%	-1.07%	0.02%	-48.96%
2015	0.09%	-0.22%	-0.07%	3.78%	-0.07%	0.94%	1.04%		0.04%	-27.91%	-15.65%	5.90%							0.21%	0.95%	0.29%	-49.11%
2016	0.19%	-0.36%	-0.03%	3.96%	-0.24%	0.88%	1.00%		-0.07%	-26.66%	-15.44%	5.42%							-0.77%	-1.21%	-0.26%	-48.65%
2017	0.10%	-0.24%	-0.09%	3.71%	-0.27%	0.89%	1.01%		-0.10%	-28.55%	-16.48%	0.06%							-0.89%	-1.10%	-0.31%	-48.44%
2018	0.24%	-0.19%	-0.21%	3.34%	-0.34%	0.95%	1.08%		-0.12%	-25.24%	-14.16%	4.10%							-0.65%	0.51%	-0.23%	-48.42%
2019	0.24%	-0.08%	2.07%	3.35%	-0.39%	0.93%	1.08%		-0.30%	-31.31%	-17.24%	2.99%							0.19%	2.05%	-0.41%	-49.51%

Figure 4.1: Results for recalculation check, Example (CLRTAP)

The recalculation of whole time series usually indicates a revision of inventory methods and/or improvement of activity data. Recalculation of part of the time series or single historical years might indicate the corrections of inconsistent time series or only partial recalculation which might lead to an inconsistent time serie.

4.2 Time series consistency

The time series is a central element of an air pollutant inventory because it provides information on historical emission trends and tracks the effects of strategies to reduce emissions at the national level. Emission trends should be neither over- nor underestimated. All emission estimates in a time series should be estimated consistently, which means that, as far as possible, the time series should be calculated using the same method and data sources for all years. Using different methods and data in a time series could introduce bias because the estimated emission trend will reflect not only real changes in emissions but also the pattern of methodological refinements (EMEP/EEA, 2019).

The aim of these tests is to highlight instances of dips and jumps in trends in time series of sectoral data and national totals reported by Parties. Sudden changes in subsequent years often indicate an inconsistency of methods and/or of emissions factors and/or of activity data used in national inventories.

Color Key

Indicates a dip in the time series data

Indicates a jump in the time series data

Indicates time series data with large sigma

MAIN (Unit = Mg)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NOx	3Da1	5599	5581	5497	5208	5046	5095	5066	5142	5186	4940	4822
NMVOC	2D3e	13262	12245	11228	10211	9194	8176	8160	8144	8127	8111	6514
SOx	1A2d	4300	4912	2600	2246	2208	1971	1955	2022	1706	1295	1216
SOx	1B2b	2000	1300	2000	2100	1280	1530	1200	67	42	42	43
SOx	NATIONALTOTAL	73703	70728	54200	52822	47191	46806	43941	40406	35638	33746	31580
SOx	NTCOMPLIANCE	73703	70728	54200	52822	47191	46806	43941	40406	35638	33746	31580
NH3	3B3	9968	10059	9792	9498	9262	9213	8996	8986	9295	8354	8070

Figure 4.2: Results from the time series check, Example (CLRTAP)

Time Series:

Only data in NFR02, NFR09, NFR14 and NFR19 reporting format were analyzed and data for which at least three years were reported. All years where only NFR02 or NFR09 sectors are available were converted to NFR14/NFR19. Only the converted sectors are shown in the time series analysis.Reported time series data were log 10-transformed prior to analysis to reduce intra-series variability and improve general time series linearity. A linear regression was subsequently applied to the log-transformed values for each time series. An individual value within the time series was identified as a dip/jump if the respective residual value (regression forecast value - reported value) was greater than 2 standard deviations from the mean of all residuals within the time series. Only time series where the flagged data value contributed a significant fraction (>3%) of the national total for the given year are included in this dataset for expert review.

Time series where sigma grows largely (i.e. larger than 20% of the time series mean value) because of extreme variation in the emission data are also flagged. Zero values indicate small numbers rounded to zero.

Trends:

The trend figures of national total emissions, are part of the stage 2 findings and include all submitted data irrespective of the chosen format of reporting (e.g. SNAP sectors and NFR sectors as well). Parties receive trend figures for all reported pollutants. Dips, jumps and not reported pollutants can be easily identified (see examples in Figure 4.3).

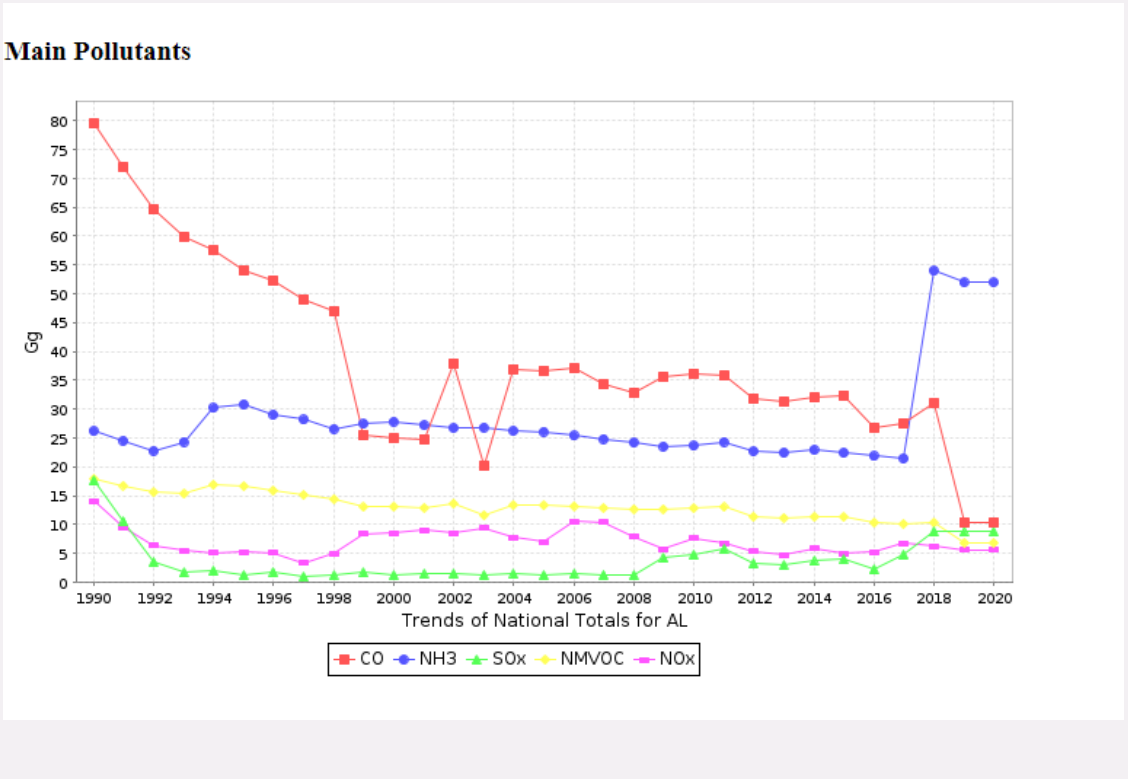

Figure 4.3: Example of a trend graph with dips and jumps highlighted in time series consistency tests.

4.3 Key category analysis (KCA)

"Key categories" for a given substance means a source category of emissions that has a significant influence on a Party's total emissions in terms of the

- absolute level of emissions of that substance
- the trend in emissions over a given time period
- and/or, for a Tier 2 key category analysis, the uncertainty in the estimates for that Party.
-
- The concept of key categories is an important aspect in inventory development in that it helps to identify priorities for resource allocation in data collection and compilation, quality assurance/quality control and reporting (UNECE, 2014b).
- Following the revised EMEP/EEA Air Pollutant Emission Inventory Guidebook (EMEP/EEA, 2019), the Key categories are those which, when summed up in descending order of magnitude, cumulatively add up to 80 % of the total level (EMEP/EEA, 2019).

Key category analysis – Level assessment is carried out for all Parties that submit relevant information. The KCA is performed at the level of NFR categories as provided in the reporting template (Table 1). Each air pollutant emitted from each category is considered separately.

The contribution of each source category to the total national inventory level is calculated according to

Key category level assessment = |source category estimate| / total contribution

$$L_{x,t} = E_{x,t} \; / \; \Sigma \, E_t$$

Where:

$L_{x,t}$ = level assessment for source x in latest inventory year (year t)
$E_{x,t}$ = value of emission estimate of source category x in year t
ΣE_t = total contribution, which is the sum of the emissions in year t, calculated using the aggregation level chosen by the country for the key category analysis

Key categories according to this equation are those, that – when summed together in descending order of magnitude – add up to 80 % of the sum of all $L_{x,t}$.

An example of the results of test "Key category analysis" is shown in Figure 4.4. The key sources for the 2020, 2010 and 2005 emissions, including the corresponding percentages, are available.

Component	Year	Key categories (Sorted from high to low from left to right)											Total
NOx	2020	1A3bi (31.7%)	1A3biii (9.2%)	1A4bi (8.2%)	1A1a (6.6%)	1A3bii (5.4%)	1A4cii (4.9%)	1A2f (4.6%)	3Da2a (4.2%)	1A2gvii (3.9%)	1A2d (3.4%)		82.2%
NMVOC	2020	1A4bi (20.6%)	2D3a (19.0%)	3B1b (11.3%)	3B1a (9.8%)	2D3d (7.9%)	3Da2a (7.6%)	2D3e (2.5%)	2H2 (2.4%)				80.9%
SOx	2020	1A2a (41.4%)	1A4bi (12.1%)	1A2gviii (11.0%)	1A2f (6.7%)	1A1a (6.6%)	1A2d (6.0%)						83.9%
NH3	2020	3Da2a (38.3%)	3B1b (16.5%)	3B1a (12.3%)	3B3 (9.2%)	3Da1 (6.5%)							82.7%
PM2.5	2020	1A4bi (44.0%)	1A1a (6.2%)	1A3bvi (5.2%)	2A5a (4.0%)	1A3bi (3.9%)	1A4cii (3.3%)	2G (3.0%)	1A3bvii (2.9%)	1A4ci (2.8%)	1A4ai (2.4%)	5E (1.8%)	1A2gviii (1.6%)	81.1%
PM10	2020	1A4bi (24.4%)	2A5a (18.0%)	3Dc (12.9%)	2A5b (5.6%)	1A3bvi (5.0%)	1A1a (3.9%)	1A3bvii (2.8%)	1A3c (2.2%)	1A3bi (2.0%)	2I (1.8%)	2G (1.7%)		80.3%
TSP	2020	2A5a (26.3%)	1A4bi (17.8%)	3Dc (8.8%)	2A5b (7.6%)	1A3bvi (4.5%)	1A3c (4.3%)	1A3bvii (3.8%)	2I (3.1%)	1A1a (3.0%)	2C1 (1.5%)			80.7%
CO	2020	1A4bi (44.1%)	1A2a (30.7%)	1A3bi (7.0%)										81.8%
Pb	2020	1A3bvi (33.2%)	1A1a (15.6%)	1A4bi (14.7%)	1A2d (7.7%)	2C5 (4.7%)	2G (4.4%)							80.2%
Cd	2020	1A4bi (24.8%)	1A2d (15.2%)	1A1b (15.1%)	1A1a (14.4%)	2G (7.9%)	1A2gviii (4.9%)							82.3%
Hg	2020	2C1 (36.6%)	1A2f (17.5%)	1A4bi (14.5%)	1A1a (12.0%)									80.6%
DIOX	2020	1A4bi (48.1%)	2C3 (9.5%)	2C1 (7.5%)	5E (7.1%)	1A2gviii (4.9%)	1A1a (4.3%)							81.4%
PAH	2020	1A4bi (75.9%)	1A4ci (9.4%)											85.3%
HCB	2020	1A4bi (46.4%)	2C1 (24.3%)	2C3 (10.9%)										81.6%
PCB	2020	2C1 (92.0%)												92.0%

Figure 4.4 : Example of results for Key category analysis

5 CHECKS AS PART OF THE REVIEW REPORT

As part of the review report (CEIP 2022) a few additional checks are performed. The results and methodological details of these checks are included in the review report and its Annexes[15].

[15] https://www.ceip.at/review-of-emission-inventories/technical-review-reports/inventory-review-2022-dataviewer

6 REVIEW OF GRIDDED DATA AND LPS

Every four years from 2017 onward, Parties shall report for the year x-2 updated aggregated sectoral (GNFR) gridded emissions in a grid of 0.1 x 0.1 degrees and LPS emissions.

6.1 Gridded data

It has to be noted that gridded emissions are used in models only on sectoral level (13 GNFRs 2018 onwords) and therefore only submitted gridded sectoral emissions can be used.

During the annual review process CEIP performs a few standard tests:

- check if sectoral gridded data for all pollutants/years are reported as requested by the revised UNECE Reporting Guidelines (UNECE, 2014b)
- compare sectoral grid-sum data with emissions reported in NFR table (aggregated to GNFR)
- check if all reported cells are inside the country (position of the cells)

6.2 Large Point Sources (LPS)

Large point sources (LPS) are defined as facilities[16] whose combined emissions, within the limited identifiable area of the site premises exceed the pollutant emission thresholds identified below which have been extracted from the full list of pollutants in the E-PRTR Regulation (EC, 2006, Annex II) and listed in Table 6.1 below (UNECE, 2014b).

Table 6.1: List of pollutants to be reported for a LPS if the applicable threshold value is exceeded based on thresholds specified in E-PRTR Regulation (annex II)

Pollutants/Substances	Thresholds in kg/year
SO_2	150 000
NO_x	100 000
CO	500 000
NMVOCs	100 000
NH_3	10 000
$PM_{2.5}$	50 000
PM_{10}	50 000
Pb	200
Cd	10
Hg	10
PAHs	50

[16] As defined in Article 2 (4) and (5) of the E-PRTR Regulation, "(4) 'Facility' means one or more installations on the same site that are operated by the same natural or legal person; (5) 'Site' means the geographical location of the facility;" (EC, 2006).

Pollutants/Substances	Thresholds in kg/year
PCDD/F	0.0001
HCB	10

Parties that do not report combustion process emissions under any other international or EU wide protocols or decisions may limit their criteria for Combustion Process LPS selection to > 300 mw thermal capacity.

Table 6.2: The stack height classes (physical height of stack) in the reporting templates

	Height class
1.	Height class 1 < 45 metres;
2.	45 metres ≤ Height class 2 < 100 metres;
3.	100 metres ≤ Height class 3 < 150 metres;
4.	150 metres ≤ Height class 4 < 200 metres;
5.	Height class 5 < 200 metres.

During the annual review process CEIP is performing a few standard tests:

- check if point sources for all pollutants/years are reported as requested by the revised UNECE Reporting Guidelines (UNECE, 2014b)
- check if all reported point sources are inside the country (position of the LPS)
- comparison with E-PRTR facilities (planned for the future)

7 CENTRALISED IN-DEPTH REVIEW (STAGE 3)

The stage 3 review (in-depth review) is a centralised review of selected inventories checking if submitted inventories are complete, consistent through the time, properly documented, comparable between the countries and accurate. It is a centralized review of quantitative and qualitative information of selected inventories by pollutant, country or sector, as in the work plan agreed by the EMEP Executive Body. The plan is to check in detail the inventories of each Party at least once every five years. Annually, up to ten Parties are reviewed. The annual in-depth review aims to be consistent across Parties and the process should ensure that the same approach is performed each year. Alternatively, an *ad hoc* review may be performed to focus on specific aspects of inventory data quality or science. (UNECE, 2018)

The review is performed by the experts nominated by Parties[17]. The expert review teams (ERTs) are set up by CEIP at the beginning of each review round. Two expert review teams (ERTs) check NFR tables and IIRs submitted by Parties under CLRTAP. The lead reviewers (LRs) are coordinating the work of ERTs and communicate questions to the Parties.

CEIP prepares data, tools and templates for reviewers to ensure an consistent approach across the teams and years. An introduction to the review process, including the timeschedule and templates, is provided at a password protected 'clever workspace' website https://workplace.umweltbundesamt.at/.

Initial checks

CEIP experts prepare initial checks in May and provide the results to the review teams.

The basic principles of the review are to see if the provided data are easy to understand (transparent), are in line with the EMEP/EEA Guidebook, consistent across the time series and pollutants and as accurate as possible.

One of the key additions to the revised 'Emission Review Guidelines' document is the inclusion of 'Technical Corrections'. These allow the Expert Review Teams (ERT) to work together with Parties during the review process to develop revised emission estimates where reported data is found to be inconsistent with the recommended methodologies of the EMEP/EEA Guidebook or where emission estimates are not provided for an NFR source category. The objective of the Technical Revisions process is to establish improvements in completeness, consistency, comparability and accuracy of the reported emissions data from Parties (UNECE, 2018).

During an emissions inventory review the ERT highlights an observation and issues questions to the Party. The ERT specifies in their question whether this could relate to a 'significant' over or under estimate, and hence a possible Technical Revision.
The Party responds with clarifications and/or answers. The Party can provide a justification for their existing estimate, or propose a Revised Estimate that addresses the issue raised by the ERT. The Revised Estimate may span several sources, several pollutants, and be relevant for multiple years.

[17] https://www.ceip.at/review-of-emission-inventories/review-process , go to 'Roster of review experts'

If the ERT agrees with the Party's response (i.e. a valid justification or Revised Estimate calculated and provided by the Party) the issue is considered closed and a recommendation is made in the Party's review report i.e. that the updated estimate should be included in the Party's next annual inventory submission. However, should the ERT not be able to reach agreement with the Party, then the ERT will calculate a Technical Correction which is sent to the Party for commenting.
After the centralised review week, a Party can respond to indicate that they agree with the proposed Technical Correction. The issue is then dealt with as for a Revised Estimate. Alternatively, a Party can respond that they disagree with the Technical Correction proposed by the ERT, and provide a justification for their position.
If the ERT does not agree with the information provided by the Party (or no response is provided), they inform the Party, and include the Technical Correction in the draft review report that is sent to the Party (UNECE, 2018).

The findings are compiled in individual country reports. All countries have 4 weeks for commenting. After consideration of comments, reports are published. The final country review reports can be downloaded as PDF documents from the CEIP website.The individual country reports are published (i.e., posted at the CEIP website) before the next annual EMEP Executive Body meeting.

The key outcomes of the review are the:

- Record of questions and answers which contain all questions submitted to the countries plus detailed responses from the countries
- Review report which contains the public findings and recommendations (sector tables in the template are updated with NFR14 - but in the text references to NFR09 might appear)
- Excel file with technical corrections

History of stage 3 in depth reviews of air emission inventories 2008-2020

The EMEP Steering Body approved the first schedule (2008-2013) for the centralised in-depth reviews at the 33rd session in September 2009 (see Table 7.1). The list was updated in the following years at the Steering Body meetings. The updated list is shown below (Table 7.1)

Table 7.1: History[18] of stage 3 in depth reviews of inventories 2008-2021

	Year	Countries
3rd review round 2018-2021	**2021**	Kazakhstan, Liechtenstein, Monaco, Montenegro *Bosnia and Herzegovina did not provide any emission data to EMEP/CEIP yet.*
	2020	European Union, North Macedonia, Iceland, Kyrgyzstan, Switzerland. *Kazakhstan, Liechtenstein and Monaco did not submit data on time, review postponed to 2021.*
	2019	Albania, Georgia, Norway, Russian Federation, Serbia, Turkey
	2018	Moldova, Armenia, Finland, Belarus, Ukraine, Azerbaijan
2nd review round 2013-2017	**2017**	Albania**, Armenia*, Austria, Malta*, EU, Kazakhstan, Kyrgyzstan*, Liechtenstein*, Monaco*
	2016	Estonia, Georgia, Iceland, Luxembourg, FYR of Macedonia, Russian Federation, Serbia, Switzerland, Turkey, United Kingdom
	2015	Azerbaijan, Belarus, Czech Rep., Ireland, Rep. of Moldova, The Netherlands, Slovakia, Slovenia and Ukraine
	2014	Belgium, Greece, Cyprus, Croatia, Denmark, Germany, Hungary, and Spain
	2013	Bulgaria, France, Italy, Latvia, Lithuania, Norway, Poland, Portugal, Romania and Sweden
1st review round 2008-2012	**2012**	Albania*, Georgia*, European Community, Liechtenstein*, Malta*, Monaco*, Republic of Moldova*, Montenegro*, Serbia* and Turkey**
	2011	Czech Republic, Belarus, Croatia, Estonia*, Greece*, Iceland, Luxembourg, The former Yugoslav Republic of Macedonia, Slovenia and Ukraine*
	2010	Austria, Cyprus, Germany, Italy, Netherlands, Romania, Russian Federation*, Slovakia, Switzerland and United Kingdom
	2009	Belgium, Bulgaria, Denmark, Finland, Hungary, Ireland, Latvia, Lithuania, Poland and Spain
	2008	France, Norway, Portugal and Sweden (voluntary)

Note:
** Party did not submit a complete emission inventory in standard format or did not submit an IIR for the last three reporting rounds*
*** Party did not submit neither inventory data nor an IIR for the last three reporting rounds*

[18] The EMEP Steering Body approved the schedule (2008-2013) for centralised in-depth reviews at its 33rd session in September 2009.

In 2022 an ad-hoc review was performed. $PM_{2.5}$ emissions from residential heating and road transport, with a special focus on the topic of 'condensable particulate matter' were reviewed in depth for all Parties that had submitted an IIR before the start of the desk review (40 Parties in total[19]). In addition a follow-up review assessing the implementation of recommendations given as part of the review carried out in 2021 was performed for Kazakhstan, Liechtenstein, Monaco and Montenegro.

[19] Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazachstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, the Netherlands, Turkey, Ukraine, United Kingdom

8 UNITS AND ABBREVIATIONS

kg ..... 1 kilogram = 10^3 g (gram)
t ..... 1 tonne (metric) = 1 megagram (Mg) = 10^6 g
Mg ..... 1 megagram = 10^6 g = 1 tonne (t)
TJ ..... 1 terajoule
kPa ..... 1 kilopascal
K ..... 1 Kelvin
µm ..... 1 micrometre
Cd ..... cadmium
CDR ..... central data repository of EEA's Eionet Reportnet
CEIP ..... EMEP Centre on Emission Inventories and Projections
CLRTAP ..... Convention on Long Range Transboundary Air Pollution
CO ..... carbon monoxide
CRF ..... common reporting format (UNFCCC for greenhouse gases)
EEA ..... European Environment Agency
Eionet ..... European environmental information and observation network
EMEP ..... Co-operative Programme for Monitoring and Evaluation of the Long-range Transmissions of Air Pollutants in Europe
E-PRTR ..... European Pollutant Release and Transfer Register
EU ..... European Union
GNFR ..... nomenclature for reporting of gridded data amd LPS
H_2S ..... hydrogen sulphide
H_2SO_4 ..... sulphuric acid
HCB ..... hexachlorobenzene
Hg ..... mercury
HMs ..... heavy metals
IIASA ..... International Institute for Applied Systems Analysis
IIR ..... informative inventory report
KC ..... key category
KCA ..... key category analysis
LRTAP Convention ..... UNECE Convention on Long-range Transboundary Air Pollution
LPS ..... large point source
Main pollutants ..... NO_x, NMVOCs, SO_x, NH_3 and CO
Main HMs ..... Cd, Hg and Pb
NECD ..... National Emission Reduction Commitment Directive (EC, 2016)
NFR ..... UNECE nomenclature for reporting of air pollutants
NH_3 ..... ammonia
NMVOCs ..... non-methane volatile organic compounds
NO_2 ..... nitrogen dioxide
NO_x ..... nitrogen oxides

PAHs ..... polycyclic aromatic hydrocarbons
Pb..... lead
PCDD/PCDF..... dioxines and furanes
PM ..... particulate matter
PM_{10}..... particulate matter, with a 50 per cent efficiency cut-off at 10 µm aerodynamic diameter or less
$PM_{2.5}$ ..... particulate matter, with a 50 per cent efficiency cut-off at 2.5 µm aerodynamic diameter or less
PM_{coarse} ..... particulate matter, the difference between PM_{10} and $PM_{2.5}$
BC ..... black carbon
POPs ..... persistent organic pollutants
SNAP ..... selected nomenclature for air pollution
SO_x ..... sulphur oxides
SO_2 ..... sulphur dioxide
SO_3 ..... sulphur trioxide
TFEIP ..... UNECE Task Force on Emission Inventories and Projections
TSP ..... total suspended particles
UNECE..... United Nations Economic Commission for Europe
UNFCCC ..... United Nations Framework Convention on Climate Change

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