CEIP umweltbundesamt

Methodologies applied to the CEIP GNFR gap-filling 2018

Part III: Persistent organic pollutants

(Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total polycyclic aromatic hydrocarbons, Dioxin and Furan, Hexachlorobenzene, Polychlorinated biphenyls)

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1. Introduction

The EMEP Centre on Emission Inventories and Projections (CEIP) operates the UNECE/EMEP emission database (WebDab) which contains information on air pollutant emissions and projections from the Parties to the LRTAP Convention (UNECE 1979). Among these data sets, also emissions used in EMEP models (gap-filled emissions) and gridded emissions in Google maps are available from the CEIP website (www.ceip.at, CEIP 2018).

Data used by CEIP were reported by the Parties to the LRTAP Convention as sectoral emissions (NFR14) and National Total emissions according to the UNECE guidelines for reporting emissions and projections data under the Convention on long-range transboundary air pollution, Annex I (UNECE 2014). For the use by CEIP, the sector data were aggregated to 13 GNFR sectors. In several cases, no data were submitted by the countries, or the reporting is not complete or contains errors. Before these emission data can be used by modelers, missing or erroneous information have to be filled in. To gap-fill those missing data, CEIP typically applies different gap-filling methods. After the gap-filling, sector emissions are used for spatial emission mapping, i.e. the EMEP grid.

This documentation describes the gap-filling methods that have been used for the 2016 GNFR inventory (as reported in 2018) for Benzo(a)pyrene, Benzo(b)fluroanthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total PAHs, PCDD/Fs, HCB and PCBs. It illustrates reasons of replacements of reported data, discusses problems of the procedure and gives an overview on the data availability and gap-filling of each country or area.

2. Summary of the process

The first step is to collect the official submissions by the Parties to the LRTAP Convention. All submissions received up to 27th April 2018 were used as a basis for the gap-filled data set. Parties report their emission inventories to the LRTAP Convention as sectoral emissions (NFR14) and National Total emissions according to the UNECE guidelines for reporting emissions and projections data under the LRTAP Convention, Annex I (UNECE 2014).

The second step is to aggregate the sector data to 13 GNFR sectors. The third step is plausibility checks of all reported data. If plausibility was not given, reported data were replaced (see section 0). The checks comprise:

- Comparison of the reported data with previously reported data, gap-filled data from 2017, and expert data.
- Comparisons of the ratio of the reported data to population data and to GDP data with all other Parties.
- Comparison of the reported sectoral distribution among the Parties.
- Comparison of the reported sectoral distribution with previously reported data of the respective country and with the mean sector distribution from the 2017 gap-filled data set of all countries.
- Comparison of the sum of sectors with the National Total.
- Comparison of the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene with Total PAHs.

The next step is the gap-filling or change of the inventory. Gap-filling or replacement of data is applied if

(1) no data are submitted by a Party,
(2) the reporting is not complete,
(3) the data are erroneous,
(4) there is no reporting obligation for a certain area and thus no reported data are available.

After that step, the inventory is completed and will be used for the WebDab database (data as used in EMEP models) and for spatial emission mapping, i.e. the EMEP grid.

3. Gap-filling methods

2.1. Gap-filling of National Total data

If no submission is made, first data of previous submissions are checked for plausibility. If previous reported data are plausible and complete, extrapolation of these data is done. This can be done either by extrapolation of sector data and the National Total is then calculated by the sum of the sectors, or by extrapolation of the National Total, and the sector data are then splitted up using a distribution of another year or country.

If no previous reported data are available or the data are not plausible, different estimates were made. These estimates comprise extrapolation of (previous reported or expert) data by using population or GDP data ([1]) of the respective country. Further, (inter-, extrapolation or copy from previous years of) expert data were used.

Available data for comparison and gap-filling are:

- the Norwegian final report of the POPCYCLING-Baltic project (Pacyna et al. 1999), were emission data for HCB for the years 1990 and 1995 were given
- emission projections from the dutch institute TNO (Denier van der Gon et al. 2005) for dioxin, PAHs and HCB for the year 2000 and 2010
- a study on uncertainties in dioxin emission estimates for central Europe (Pulles et al. 2006) that contains dioxin data for the year 2000
- a study on the determination of dioxins, furans, PCB sources and anti-POPs campaign in Central Asia (Hodjamberdiev 2006) including dioxin data for 2006
- the global atmospheric emission inventory of PAHs with for the year 2004 (Zhang & Tao 2009)
- a primary estimate of global PCDD/F release (Wang et al. 2016) with several dioxin data for the years 2000 to 2007
- Data for Russia from Shen et al (2013)
- Data for Russia from Treger (2011)
- data given by Albania, the Kyrgyz Republic, Tajikistan, Turkey, the Ukraine (Albania 2017, Kyrgyz Republic 2006, Tajikistan 2006, Turkey 2010, Turkey 2014, Ukraine 2007) for the

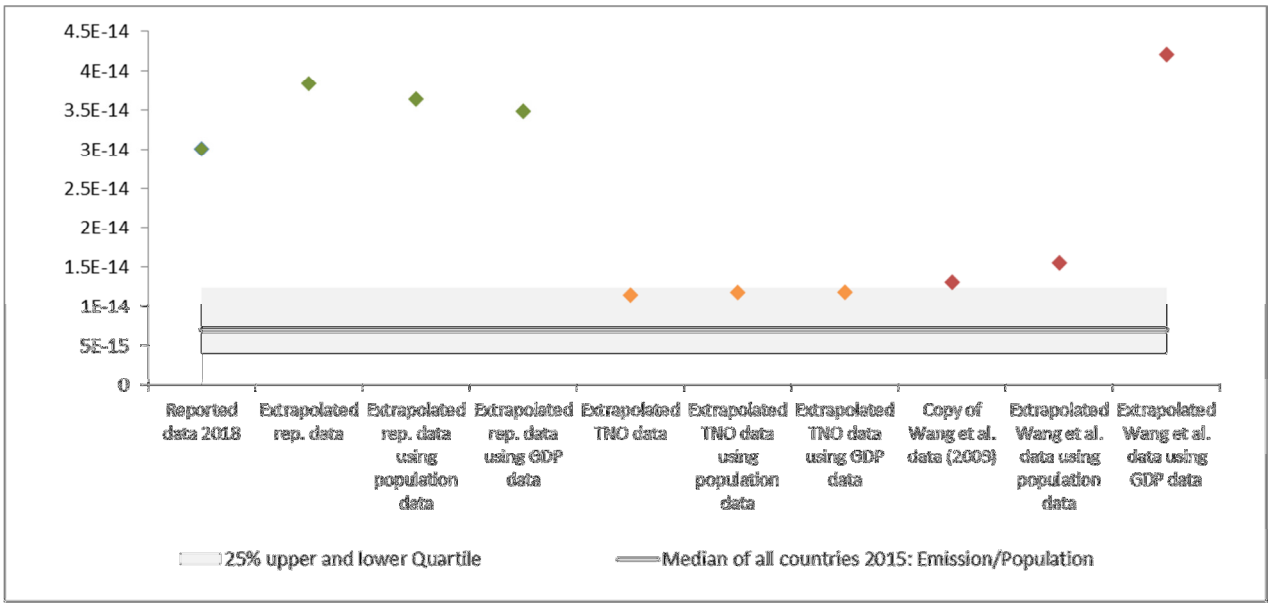
([1]) Population data from database: Population estimates and projections (Last Updated: 12/18/2017). Indicator: Population, total. Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.
GDP data from database: World Development Indicators (Last Updated: 03/01/2018). Indicator: GDP, PPP (constant 2011 international $).

National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants.

Further, a common imputation method – only for the PAHs – was the split of reported Total PAH data into Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. This method was used when no data for PAHs were given, but information on Total PAH was available. Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries ([2]) by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

In several cases, not only one estimate is given for a country. To facilitate the choice of the estimate for the gap-filling, ratios for each pollutant between emissions and population data and GDP were calculated by using data of the gap-filled inventory from 2017 (separate for EMEP West and EMEP East countries, for the country grouping see Table 8.1) for the year 2015. The distance of the different estimates to this ratio shows how similar the estimates are to the mean. An example for PCDD/Fs estimates of Azerbaijan (AZ) is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Figure 3.1 Example for different PCDD/Fs estimates for Azerbaijan



2.2. Gap-filling of sectoral data

There were no expert estimates on the sectoral distribution of the emissions available, only sector distributions from previous reported submissions and a mean sector distribution from the 2017 gap-filled data set of all countries.

The most common imputation method to gap-fill sector data was to use the distribution ratio of sector emissions from similar countries. To identify which countries are similar to each other, gap-filled National Totals for all countries were used to generate a distance matrix (Euclidean distances)

([2]) These countries are: AZ, BE, BG, BY, CH, CY, CZ, DK, EE, FR, GB, GE, HR, HU, IE, IS, LT, LU, LV, MT, NL, NO, PL, SI.

using GDP data ([3]) and gap-filled or reported National Total emissions Total PAH, PCDD/F and HCB as variables (z-transformed).

For the Russian Federation in the extended EMEP domain (RUE) a similar sector distribution as for the Russian Federation (RU) was assumed.

Further, a common imputation method – only for the PAHs – was the split of reported Total PAH data into Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. This method was used when no data for PAHs were given, but information on Total PAH was available. Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data were calculated using a ratio to split Total PAH emissions. This sector splitting ratio was derived using data from other countries by calculating the mean share of the reported PAH data on the Total PAH emissions. Data were only used from countries where the sum of the PAHs equals the reported Total PAH data.

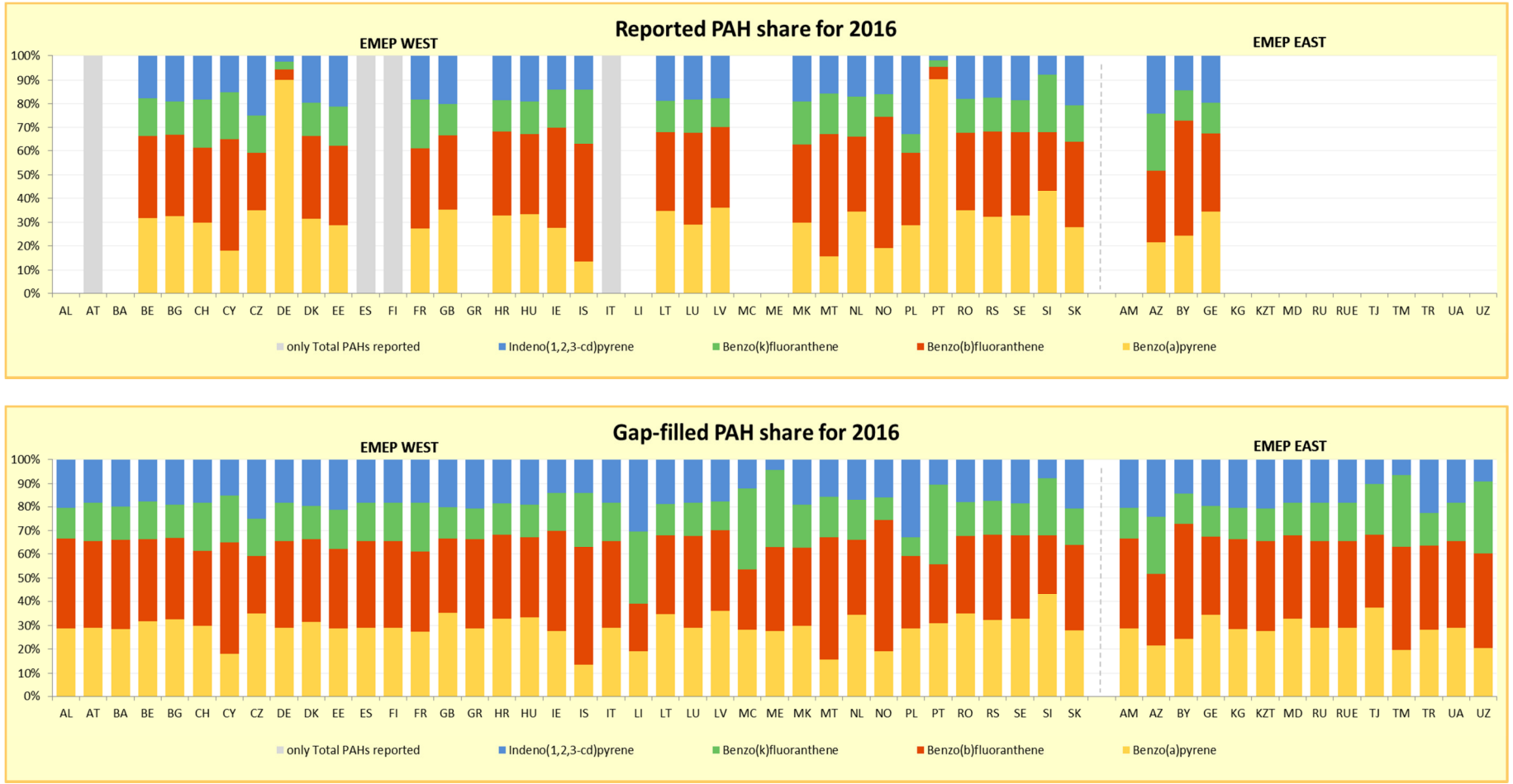
([3]) Data from database: World Development Indicators. Indicator name: GDP, PPP (constant 2011 international $), indicator code: NY.GDP.MKTP.PP.KD. Values for 2016 are taken. For MC and LI, GDP per capita (current US$) data for the years 2011 (MC) and 2014 are taken, as no other data were available.

2.3. Gap-filling effects

Figure 3.2 shows the sectoral distribution as reported and after gap-filling of PCDD/Fs emissions in the year 2016 for all countries, as an example on the effects of the gap-filling. Figure 3.3 shows the share of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene on Total PAHs before and after the gap-filling.

Figure 3.2 Reported and gap-filled sectoral distributions of PCDD/Fs emissions in the year 2016

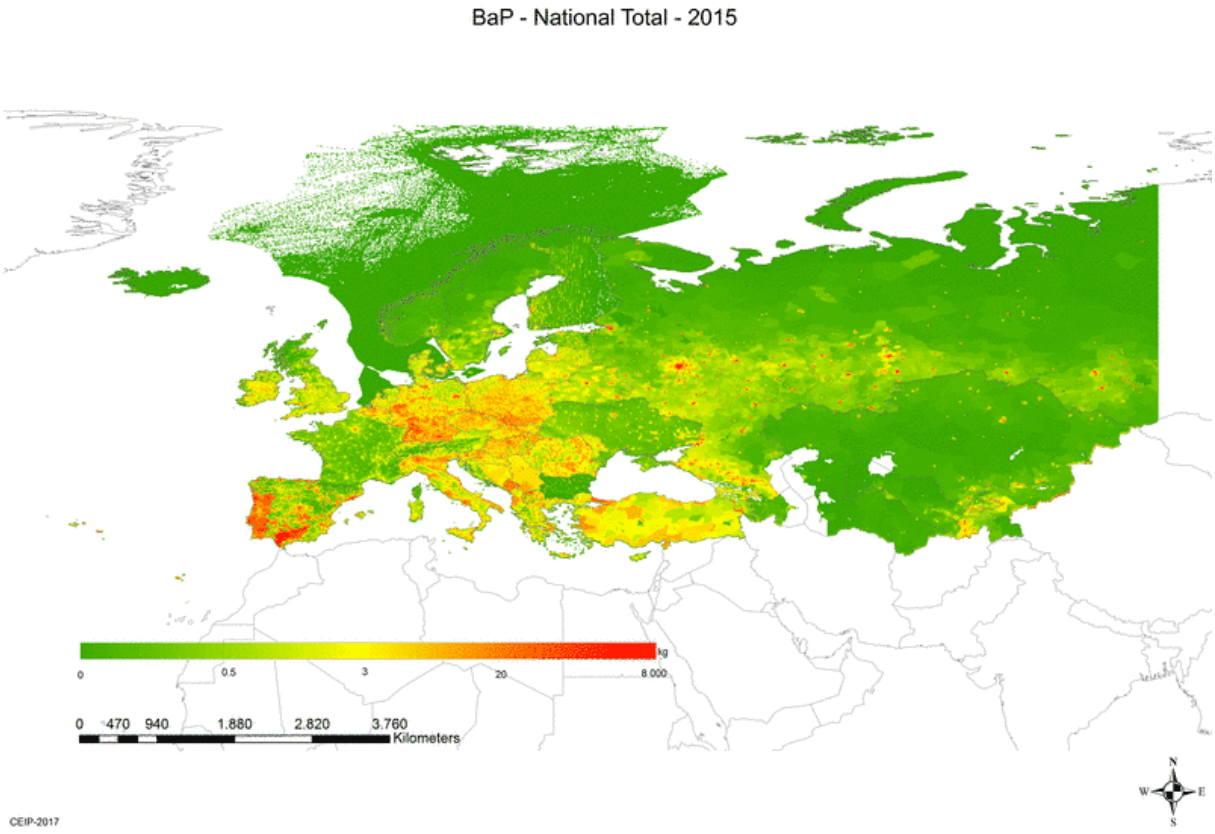
Figure 3.3 Reported and gap-filled share of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene on Total PAHs in the year 2016



4. Reasons for replacement of reported data

In cases, where data are in all probability erroneous, these data are replaced. If data in such cases will not be replaced, it is likely to get a wrong picture in gridded maps. As example, Figure 4.1 shows not Benzo(a)pyrene data in gridded maps of the year 2015. In that case, for example the reported National Total was too low for the Ukraine (compared with expert estimates and with the data of other countries).

Figure 4.1 Example for too low National Total emissions and of the Ukraine, showing a peculiar picture in gridded maps: Benzo(a)pyrene emissions of the year 2015



In 2018, data of eleven countries were (partly) replaced. **Table 4.1** provides an overview of all replaced data of the gap-filled inventory 2018, including a short rationale. For more information see section 6**Fehler! Verweisquelle konnte nicht gefunden werden.**, information of the respective country.

Table 4.1 Overview of and reasons for replaced data

Country	Pollutant	NT, Sectors,…	Reason
AM	PCDD/Fs	National Total, Sectors A, B, C	Reported data are much too low compared with expert estimates. Only a few sectors reported.

AZ	PCDD/Fs	National Total, Sectors A, B, C, D, J	Reported data are much too high compared with expert estimates. Only a few sectors reported.
FI	Benzo(a)pyrene, Benzo(b)fluoranthene	Sectors B-F, I, J, L	Sum of individual PAHs do not equal Total PAHs.
FI	Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene	Sectors B, D-F, J, L	Sum of individual PAHs do not equal Total PAHs.
KZT	Benzo(a)pyrene	National Total, Sectors B, F, I	Reported data are much too low compared with expert estimates. Only a few sectors reported. Sum of individual PAHs do not equal Total PAHs. Sum of sectors do not equal to National Total.
KZT	Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene	National Total, Sectors B, F	Reported data are much too low compared with expert estimates. Only a few sectors reported. Sum of individual PAHs do not equal Total PAHs.
KZT	Total PAHs	National Total, Sectors B, J	Reported data are much too low compared with expert estimates. Only a few sectors reported. Sum of individual PAHs do not equal Total PAHs.
KZT	PCDD/Fs	National Total, Sectors B, G, I, J	Reported data are much too low compared with expert estimates. Only a few sectors reported.
KZT	HCB	National Total, Sectors B, G, J	Only a few sectors reported. Sum of sectors do not equal to National Total.
KZT	PCBs	National Total, Sectors B, G, J	Reported data are much too low compared with expert estimates. Only a few sectors reported. Sum of sectors do not equal to National Total.
MK	Total PAHs	National Total, Sectors A, B, C, E, I, J	Sum of individual PAHs do not equal Total PAHs.
PT	Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene	National Total, Sectors A, B, D, E, F, J, L	Reported data are much too high compared with expert estimates. Sum of individual PAHs do not equal Total PAHs.
RO	Benzo(a)pyrene, Benzo(b)fluoranthene	National Total, Sector A, B, C, E, F, I, J, L	Sum of individual PAHs do not equal Total PAHs.
RO	Benzo(k)fluoranthene	National Total, Sector A, B, C, E, F, J, L	Sum of individual PAHs do not equal Total PAHs.
RO	Indeno(1,2,3-cd)pyrene	National Total, Sector A, B, C, E, F, L	Sum of individual PAHs do not equal Total PAHs.
RO	PCBs	Sectors A, B, C, G	Sum of sectors do not equal to National Total
RS	Benzo(a)pyrene, Benzo(b)fluoranthene	National Total, Sectors A-F, I, J	Sum of individual PAHs do not equal Total PAHs.
RS	Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene	National Total, Sectors A-F, J	Sum of individual PAHs do not equal Total PAHs.

SE	Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene	National Total, Sectors A-G, I, J	Sum of individual PAHs do not equal Total PAHs.
SK	Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene	National Total, Sectors A-D, F, G, I, J	Sum of individual PAHs do not equal Total PAHs.

5. Improvements of the gap-filling procedure

Most countries submitted data that seem to be complete and plausible. Problems occur especially where no data at all are available or when submitted data are not plausible.

In autumn 2017, a new tool was developed that simplify comparisons of emission data with other countries, expert data and previously reported and gap-filled data. Comparisons comprise National Totals, sector data, and data in relation to population and GDP data. This new tool was used for the gap-filling 2018.

6. Data availability and gap-filling method per country

6.1. Albania (AL)

In 2018, no submission was made. Reported data from previous years are available up to the year 2009.

The best method to calculate 2016 National Total data was extrapolation of 2000 and 2010 TNO data for PAHs. For HCB, extrapolation of reported data for 2008 using GDP data was done. Albania reported for the year 2009 extraordinary high HCB emissions, therefore data reported for the year 2008 were used for the extrapolation. For PCDD/Fs and PCBs, extrapolation of reported data for 2009 using population data was done.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Latvia. Therefore the GNFR sector distribution from Latvia was used to split the National Totals of the POPs into GNFR sectors.

6.2. Armenia (AM)

In 2018, only data for PCDD/Fs were reported. These data seem to be far too low compared with expert estimates. Reported data for the other pollutants are available from previous submissions for the years 2007 and 2014.

The best method to calculate 2016 National Total data was the extrapolation of 2000 and 2010 TNO data using population data for PAHs, and extrapolation of data from Wang et. al (2016) using population data for PCDD/Fs. For HCB, linear extrapolation of expert data from Pacyna et al. (1999) was used. For PCBs, linear extrapolation of reported data (2007-2014) was done.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was the Former Yugoslav Republic of Macedonia. Therefore the GNFR sector distribution from the Former Yugoslav Republic of Macedonia was used to split the National Totals of the POPs into GNFR sectors.

6.3. Austria (AT)

The data of Austria reported for the year 2016 seemed to be complete and plausible. Data for Total PAHs were available, but not for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. Data of these pollutants were thus calculated using a ratio to split Total PAH emissions (see section 2.2).

6.4. Azerbaijan (AZ)

Azerbaijan reported data for the year 2016, but the data for PCDD/Fs seemed to be too high compared with expert data. Thus PCDD/Fs data were replaced by extrapolated 2000 and 2010 TNO data. The sector distribution of HCB is rather unusual, with a large contribution of the sector “J - Waste”. Further review is recommended here.

To split the National Total emission data of PCDD/Fs into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Slovakia. Therefore the GNFR sector distribution from Slovakia was used to split the National Totals of PCDD/Fs into GNFR sectors.

6.5. Bosnia and Herzegovina (BA)

In 2018, no submission was made. No previous reported data were available. The best method to calculate 2016 National Total data was the extrapolation of 2000 and 2010 TNO data for PAHs and for PCDD/Fs. For HCB, extrapolation of expert data from Pacyna et al. (1999) using population data was used. No data for PCB are available.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Latvia. Therefore the GNFR sector distribution from Latvia was used to split the National Totals of the POPs into GNFR sectors.

6.6. Belgium (BE)

The data of Belgium reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.7. Bulgaria (BG)

The data of Bulgaria reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.8. Belarus (BY)

The data of Belarus reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.9. Switzerland (CH)

The data of Switzerland reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed. No data for PCB are available.

6.10. Cyprus (CY)

The data of Cyprus reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.11. The Czech Republic (CZ)

The data of the Czech Republic reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.12. Germany (DE)

The data of Germany reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.13. Denmark (DK)

The data of Denmark reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.14. Estonia (EE)

The data of Estonia reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.15. Spain (ES)

The data of Spain reported for the year 2016 seemed to be complete and plausible. Data for Total PAHs were available, but not for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. Data of these pollutants were thus calculated using a ratio to split Total PAH emissions (see section 2.2).

6.16. Finland (FI)

The data of Finland reported for the year 2016 seemed to be plausible. Data for Total PAHs were available, and for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene data for some sectors were reported. The sum of these data did not equal to the Total PAHs. Data for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene were thus calculated using a ratio to split Total PAH emissions (see section 2.2), and thereby the reported data of the sectors replaced. The HCB data are rather high for 2016, further review is recommended here. No data for PCB are available.

6.17. France (FR)

The data of France reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.18. The United Kingdom (GB)

The data of the United Kingdom reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.19. Georgia (GE)

The data of Georgia reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed. No data for PCB are available.

6.20. Greece (GR)

In 2018, no submission was made by Greece. The best method to calculate 2016 National Total data was the extrapolation of 2000 and 2010 TNO data using population data for PAHs, and extrapolation of 2000 and 2010 TNO data for HCB. For PCDD/F extrapolation of reported data (-2015) was used. PCB was calculated by the extrapolation of previous reported (2000-2015) data.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Belarus. Therefore the GNFR sector distribution from Belarus was used to split the National Totals of the POPs into GNFR sectors.

6.21. Croatia (HR)

The data of Croatia reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.22. Hungary (HU)

The data of Hungary reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.23. Ireland (IE)

The data of Ireland reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.24. Iceland (IS)

The data of Iceland reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.25. Italy (IT)

The data of Italy reported for the year 2016 seemed to be complete and plausible. Data for Total PAHs were available, but not for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene. Data of these pollutants were thus calculated using a ratio to split Total PAH emissions (see section 2.2).

6.26. Kyrgyzstan (KG)

In 2018, no submission was made. From previous submissions, only National Total data of Benzo(a)pyrene for the years 2010-2012 were available. The best mehod to calculate 2016 National

Total data was the extrapolation of 2000 and 2010 TNO data using population data for PAHs, and extrapolation of 2000 and 2010 TNO data for HCB. For PCDD/F copy of data for 2003 from the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (Kyrgyz Republic 2006) was used. No data for PCB are available.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was the Former Yugoslav Republic of Macedonia. Therefore the GNFR sector distribution from the Former Yugoslav Republic of Macedonia was used to split the National Totals of the POPs into GNFR sectors.

6.27. Kazakhstan (KZT)

In 2018, Kazakhstan provided emission data for POPs, but only of a few sectors. Further, the sum of the sectors for Benzo(a)pyrene, HCB and PCBs did not equal to the National Total. The reported data of all pollutants but HCB differ strongly to expert estimates and to the mean sector distribution from the 2017 gap-filled data set of all countries. Thus, reported data were replaced, except National Total data for HCB and PCBs. For PCBs, no expert data are available, thus National Total data were not replaced. But as the sector distributions of HCB and PCBs are rather unusual and the sum of sectors did not equal to the National Total, sectors of HCB and PCBs were replaced as well.

PAH data were replaced by extrapolated TNO data (2000 to 2010) using population data, and Total PAHs as the sum of the four individual PAHs. For PCDD/Fs, extrapolation of 2000 to 2010 TNO data was used.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Romania. Therefore the GNFR sector distribution from Romania was used to split the National Totals of the POPs into GNFR sectors.

6.28. Liechtenstein (LI)

In 2018, no submission was made by Liechtenstein. Reported data from previous years are available up to the year 2015, except for PCBs. These data seemed to be complete and plausible. Therefore, sector data were extrapolated (years 2000-2015). Sector data for total PAHs were calculated by the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene . The National Totals for all of the POPs were then calculated by the sum of the sectors.

6.29. Lithuania (LT)

The data of Lithuania reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.30. Luxembourg (LU)

The data of Luxembourg reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.31. Latvia (LV)

The data of Latvia reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.32. Monaco (MC)

In 2018, no submission was made by Monaco. Reported data from previous years are available up to the year 2015. National Total data of PCDD/Fs, HCB and PCB were extrapolated (years 2000-2015) from this previous data set. The best method to calculate 2016 National Total data for Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene was the extrapolation of estimates from Zhang & Tao (2009) using population data. The National Total of Total PAHs was calculated by the sum of the National Totals of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene . Sector data were replaced, as data were reported only for very few sectors.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Iceland. Therefore the GNFR sector distribution from Iceland was used to split the National Totals of the POPs into GNFR sectors.

6.33. Republic of Moldova (MD)

In 2018, no submission was made by the Republic of Moldova. Reported data from previous years are available up to the year 2015. These data seemed to be complete and plausible. Therefore, sector data were extrapolated (years 2000-2015). Sector data for total PAHs were calculated by the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene . The National Totals for all of the POPs were then calculated by the sum of the sectors.

6.34. Montenegro (ME)

In 2018, no submission was made by Montenegro. Reported data from previous years are available up to the year 2011. These data seemed to be complete and plausible. Therefore, sector data were extrapolated or copied from previous years (e.g. if extrapolation would have resulted in negative values). Sector data for total PAHs were calculated by the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene . The National Totals for all of the POPs were then calculated by the sum of the sectors.

6.35. The Former Yugoslav Republic of Macedonia (MK)

The data of the Former Yugoslav Republic of Macedonia reported in 2018 seemed to be complete and plausible, except that the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene do not equal to the Total PAHs. Therefore, sector data and National Totals of Total PAHs were replaced by the sum of the individual PAHs.

6.36. Malta (MT)

The data of Malta reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.37. The Netherlands (NL)

The data of the Netherlands reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed. No data for PCB are available.

6.38. Norway (NO)

The data of Norway reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.39. Poland (PL)

The data of Poland reported in 2017 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.40. Portugal (PT)

For Portugal, only the data of PCDD/Fs, HCB and PCBs reported for the year 2016 seemed to be complete and plausible. The data for the PAHs seemed to be far too high. For that reason, data were replaced by extrapolations of estimates from Zhang & Tao (2009) using population data. Total PAHs were calculated by the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene.

To split the National Total emission data of the PAHs into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was the Czech Republic. Therefore the GNFR sector distribution from the Czech Republic was used to split the National Totals of the POPs into GNFR sectors.

6.41. Romania (RO)

The data of Romania reported in 2018 seemed to be complete and plausible, except for PAHs and PCBs. For PAHs, the sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene did not equal to Total PAHs, whereas Total PAHs were higher. Therefore, the individual PAHs were replaced by splitting up the Total PAHs according to the reported distribution. For PCBs, the National Total was much higher than the sum of the sectors. Therefore, the reported sector distribution was used to split up the PCB data into the sectors.

6.42. Serbia (RS)

The data of Serbia reported in 2018 seemed to be complete and plausible, except for PAHs. The sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene did not equal to Total PAHs, whereas Total PAHs were higher. Therefore, the individual PAHs were replaced by splitting up the Total PAHs according to the reported distribution.

6.43. Russian Federation in the former official EMEP domain (RU)

In 2018, no submission was made. Only very few previous reported data were available.

The best method to calculate PAH National Total data was the copy of expert estimates for the year 2007 from Shen et al. (2013) for Benzo(a)pyrene, and the calculation of the other PAHs using the PAH split factor. For HCB, extrapolation of 2010 TNO data using GDP data were used, and for PCDD/Fs copy of expert estimates from Treger (2011) were used. No data for PCB are available.

All expert data were modified by multiplying emissions of whole Russia with the factor 0.79, and for HCB by multiplying emissions of whole Russia with the factor 0.75, to get data only for the part of the Russian Federation in the former official EMEP domain.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Germany. Therefore the GNFR sector distribution from Italy was used to split the National Totals of the POPs into GNFR sectors.

6.44. Russian Federation in the extended EMEP domain (RUE)

As the Russian Federation in the extended EMEP domain does not follow common borders, no reported data are available.

The part of the Russian Federation in the extended EMEP domain were calculated for PCDD/F and PAHs by multiplying emissions of whole Russia with the factor 0.21, and for HCB by multiplying emissions of whole Russia with the factor 0.25. Using these factors, emissions were calculated from emission data of the Russian Federation in the former official EMEP domain. The best method to calculate PAH National Total data was the copy of expert estimates for the year 2007 from Shen et al. (2013) for Benzo(a)pyrene, and the calculation of the other PAHs using the PAH split factor. For HCB, extrapolation of 2010 TNO data using GDP data were used, and for PCDD/Fs copy of expert estimates from Treger (2011) were used. No data for PCB are available.

For the Russian Federation in the extended EMEP domain a similar sector distribution as for the Russian Federation (in the former official EMEP domain) is assumed. Therefore, the sector distribution of RU is used to split the National Total emissions of RUE into the GNFR sectors.

6.45. Sweden (SE)

The data of Sweden reported in 2018 seemed to be complete and plausible, except for PAHs. The sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene did not equal to Total PAHs, whereas Total PAHs were higher. Therefore, the individual PAHs were replaced by splitting up the Total PAHs according to the reported distribution.

6.46. Slovenia (SI)

The data of Slovenia reported for the year 2016 seemed to be complete and plausible. Therefore no gap-filling was performed.

6.47. Slovakia (SK)

The data of Slovakia reported in 2018 seemed to be complete and plausible, except for PAHs. The sum of Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene did not equal to Total PAHs, whereas Total PAHs were higher. Therefore, the individual PAHs were replaced by splitting up the Total PAHs according to the reported distribution.

6.48. Tajikistan (TJ)

No reported data were available. The best method to calculate 2016 National Total data was the extrapolation of estimates from Zhang & Tao (2009) using population data for PAHs, and the extrapolation of data from Hodjamberdiev (2006) using population data for PCDD/F. For HCB, data

from the gap-filling made in 2015 were copied (i.e. expert estimates on the basis of GDP), as no other data were available.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Bulgaria. Therefore the GNFR sector distribution from Bulgaria was used to split the National Totals of the POPs into GNFR sectors.

6.49. Turkmenistan (TM)

No reported data were available. The best method to calculate 2016 National Total data was the extrapolation of estimates from Zhang & Tao (2009) using GDP data for PAHs, and the extrapolation of data from Hodjamberdiev (2006) using population data for PCDD/F. For HCB, data from the gap-filling made in 2015 were copied (i.e. expert estimates on the basis of GDP), as no other data were available.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Croatia. Therefore the GNFR sector distribution from Croatia was used to split the National Totals of the POPs into GNFR sectors.

6.50. Turkey (TR)

No reported data were available. The best method to calculate 2016 National Total data was the extrapolation of 2000 and 2010 TNO data using population data for PAHs, extrapolation of TNO data using GDP data for HCB, and extrapolation of expert estimates for the year 2000 from Pulles et al. (2006) using population data for PCDD/F.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Italy. Therefore the GNFR sector distribution from Italy was used to split the National Totals of the POPs into GNFR sectors.

6.51. Ukraine (UA)

In 2018, no submission was made. Only very few previous reported data were available. Reported data for PAHs and HCB (National Totals and some sectors) were available only for the years 2010 to 2013.

To calculate data for the PAHs, the copy of data from the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (Ukraine 2007) was used. For PCDD/Fs, the extrapolation of data for the years 1990 and 2002 reported within the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants was taken.. For, HCB the extrapolation of data from the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (Ukraine 2007) using population data was used.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Spain. Therefore the GNFR sector distribution from Spain was used to split the National Totals of the POPs into GNFR sectors.

6.52. Uzbekistan (UZ)

No reported data were available. The best method to calculate 2016 National Total data was the extrapolation of estimates from Zhang & Tao (2009) using GDP data for PAHs, and the copy of data from Hodjamberdiev (2006) for PCDD/F. For HCB, data from the gap-filling made in 2015 were copied (i.e. expert estimates on the basis of GDP), as no other data were available.

To split the National Total emission data into GNFR sectoral emissions, the sector distribution of a similar country was used. The country that turned out as most similar, and that also had a proper sector distribution, was Slovakia. Therefore the GNFR sector distribution from Slovakia was used to split the National Totals of the POPs into GNFR sectors.

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8. EMEP Country Codes

AL	Albania
AM	Armenia
AST	Asian areas in the extended EMEP domain
AT	Austria
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
BY	Belarus
CH	Switzerland
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
EU	European Union
FI	Finland
FR	France
GB	United Kingdom
GE	Georgia
GR	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IS	Iceland
IT	Italy
KG	Kyrgyzstan
KZT	Kazakhstan
LI	Liechtenstein
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
ME	Montenegro
MK	FYR of Macedonia
MT	Malta
NL	Netherlands
NO	Norway
NOA	North Africa
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
RU	Russian Federation in the former official EMEP domain
RUE	Russian Federation in the extended EMEP domain
SE	Sweden
SI	Slovenia
SK	Slovakia
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
UA	Ukraine
UZ	Uzbekistan

Table 8.1 Countries of the EMEP West and EMEP East region

EMEP West countries	AL, AT, BA, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LI, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK
EMEP East countries (9 EECCA countries + TR)	AM, AZ, BY, GE, KG, KZT, MD, RU, TR, UA
Non-EMEP EECCA countries (CLRTAP not ratified)	TJ, TM, UZ

Note: EECCA = Eastern Europe, Caucasus and Central Asia