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Towards global SEEA Air Emission Accounts: Description and evaluation of the OECD methodology to estimate SEEA Air Emission Accounts for CO₂, CH₄ and N₂O in Annex-I countries to the UNFCCC

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The proposed methodology is assessed by comparing the estimates with the official emission accounts of countries that have already implemented this SEEA module. It has been endorsed by the OECD Working Party on Environmental Information (WPEI) in December 2017, and by the SEEA Technical Committee and the UNCEEA in June 2018.

This methodology can be applied to countries that do not yet compile AEAs, such as Iceland, Japan, Kazakhstan, New Zealand, the Russian Federation, Ukraine and the United States, thereby expanding the coverage of the OECD database on this topic. The resulting estimates will complement the already collected and disseminated official AEAs in a dedicated and clearly separated database.

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Towards global SEEA Air Emission Accounts

Description and evaluation of the OECD methodology to estimate SEEA Air Emission Accounts for CO₂, CH₄ and N₂O in Annex-I countries to the UNFCCC

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Abstract / Résumé

This paper describes and evaluates the OECD methodology to estimate Air Emission Accounts (AEAs) for carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), in line with the [System of Environmental Economic Accounting \(SEEA\)](#).

The proposed methodology is assessed by comparing the estimates with the official emission accounts of countries that have already implemented this SEEA module. It has been endorsed by the OECD Working Party on Environmental Information (WPEI) in December 2017, and by the SEEA Technical Committee and the UNCEEA in June 2018.²

This methodology can be applied to countries that do not yet compile AEAs, such as Iceland, Japan, Kazakhstan, New Zealand, the Russian Federation, Ukraine and the United States, thereby expanding the coverage of the OECD database on this topic. The resulting estimates will complement the already collected and disseminated official AEAs in a dedicated and clearly separated database.

Keywords: SEEA, Air Emission Accounts, Greenhouse Gases

Ce document décrit et évalue la méthode de l'OCDE pour estimer des comptes d'émissions atmosphériques pour le dioxyde de carbone (CO₂), le méthane (CH₄) et le protoxyde d'azote (N₂O), dans le cadre du [Système de Comptabilité Économique et Environnementale \(SCEE\)](#).

La méthode proposée est évaluée en comparant les estimations obtenues avec les comptes d'émissions officiels des pays qui ont déjà mis en œuvre ce module du SCEE. Elle a été adoptée en décembre 2017 par le Groupe de Travail de l'OCDE sur l'Information Environnementale, et en juin 2018 par le Comité Technique du SCEE et le Comité d'Experts des Nations Unies sur la Comptabilité Environnementale (UNCEEA).

Cette méthode peut être appliquée aux pays qui ne fournissent pas encore de comptes d'émissions atmosphériques, comme l'Islande, le Japon, le Kazakhstan, la Nouvelle-Zélande, la Fédération de Russie, l'Ukraine et les États-Unis, permettant ainsi d'étendre la couverture géographique de la base de données de l'OCDE sur ce sujet. Les estimations qui en découlent viendront compléter, dans une base de données dédiée, les comptes d'émissions officiels qui sont déjà collectés et publiés.

Mots clés : SCEE, Comptes d'émissions atmosphériques, Gaz à effet de serre

² https://seea.un.org/sites/seea.un.org/files/recommendation_of_the_seea-technical_committee_on_the_oecd_methodology_to_estimate_seea_air_emission_accounts_11_june_2018.pdf

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1. Towards global SEEA Air Emission Accounts

1. This paper summarises the current status of the work stream on estimating SEEA Air Emission Accounts (AEAs), undertaken by the OECD Statistics and Data Directorate. The objective is to develop a methodology that can be used (i) as a first point of reference for the implementation of this SEEA module by countries that do not yet compile AEAs, and (ii) to increase the number of countries, industries, years and types of emissions covered in the OECD database on AEAs.

2. The OECD methodology takes the emission data from the national greenhouse gas (GHG) inventories submitted under the [UNFCCC](#) as a starting point. After careful evaluation and testing, UNFCCC inventories are preferred to alternative data sources such as the estimates of carbon dioxide (CO₂) emissions from fuel combustion compiled by the [International Energy Agency \(IEA 2018\)](#), because inventories cover all types of CO₂ emissions as well as additional gases. Moreover, restricting the analysis to CO₂ emissions from fuel combustion, results are very similar when UNFCCC inventories or IEA estimates are used as a starting point. For Annex-I countries to the UNFCCC, relying exclusively on inventories has the advantage of simplicity and completeness. Admittedly, this strategy may need to be reviewed for non-Annex-I countries, for which the IEA provides much more information than the inventories.³

3. In order to assess the accuracy of the estimation methodology for Annex-I countries, officially reported AEAs are used as benchmarks. Compared to a preliminary study carried out in 2016, the OECD methodology has been improved in the following ways:

- It is now applied to additional countries, years and types of emissions.
- It is systematically assessed using measures of dispersion between the reported and estimated AEAs.
- The resulting estimates are available at a greater level of granularity across industries and households.

4. As compared to UNFCCC inventories, AEAs allocate air emissions to industries and households using the same concepts and classifications as national accounts. For example, road transport emissions are allocated to all economic activities and households in AEAs, whereas they are grouped into a single item in UNFCCC inventories. It is only when transport is the principal activity of a firm that the corresponding emissions are allocated to the transport industry. Similarly, it is only when transport is the principal activity of a firm that this firm is allocated to the transport industry in national accounts.

5. All estimated AEAs for CO₂, CH₄ and N₂O are available on OECD.Stat using the following link: <http://stats.oecd.org/Index.aspx?DataSetCode=OECD-AEA>.

6. Ultimately, this work supports the compilation of a global database on AEAs in line with the [System of Environmental-Economic Accounting \(SEEA\) – Central Framework](#). Going forward, such a database would significantly improve the information basis to

³ The OECD Statistics and Data Directorate is currently investigating the possibility to estimate AEAs for non-Annex-I countries as well. The corresponding results will be presented in a future paper.

analyse industry-specific emission intensities and decoupling trends from economic growth, allow in-depth investigations across policy domains by directly comparing AEA data with those from the System of National Accounts (SNA), compile demand-based emissions of GHGs and air pollutants (see Wiebe and Yamano [2016]), and monitor the relevant Sustainable Development Goal (SDG) Indicator.⁴

7. The structure of this paper is as follows. Section 2 describes the OECD methodology, Section 3 compares the estimated AEA with benchmark official AEA, and Section 4 concludes. Detailed results for individual countries are available in Annex B-D.

⁴ [SDG Indicator 9.4.1](#) is about CO₂ emissions per unit of value added.

2. Description of the OECD methodology to estimate SEEA Air Emission Accounts for CO₂, CH₄ and N₂O in Annex-I countries to the UNFCCC

8. This Section describes the OECD methodology in detail. Its overall objective is to estimate reliable AEAs on a territory basis.⁵ As currently predominantly European countries compile AEAs (Table 1), the OECD methodology aims to provide estimates for those (OECD and non-OECD) countries that do not yet report them. In order to assess the suitability of the proposed methodology, the resulting estimates are compared to official AEAs for countries that currently compile them. This benchmarking exercise, including a systematic assessment using conventional measures of dispersion, allows drawing conclusions on the reliability of the proposed methodology.

9. The emission data from the national GHG inventories submitted under the [UNFCCC](#) constitute the starting point. The following considerations led to opting for these data compared to alternative data sources, in particular the IEA estimates of CO₂ emissions from fuel combustion:

- The results for CO₂ emissions from fuel combustion are very similar when UNFCCC inventories or IEA estimates are used as a starting point (Figure A A.1 in Annex A), which is explained by the fact that both rely on the same underlying energy statistics based on the [International Recommendations for Energy Statistics \(IRES\)](#).⁶ Hence, for CO₂ emissions from fuel combustion, the two data sources can be considered as equivalent for the estimation of AEAs.⁷
- By definition, the IEA estimates of CO₂ emissions from fuel combustion do not cover CO₂ emissions from other sources (e.g. industrial processes). This would limit the estimated AEAs to one source of emissions.

⁵ The reason for focusing on estimates on a territory basis (in contrast to a residence basis) is that no suitable approach to estimate the country-specific bridging items between the two concepts is available so far. However, there is an on-going collaboration between the OECD Statistics and Data Directorate and Eurostat exploring the possibility to estimate these bridging items. Based on the bridging items reported in the official AEAs, the average discrepancy between territory-based and residence-based emissions is around 5% of total CO₂ emissions, and lower than 1% for CH₄ and N₂O emissions.

⁶ These Recommendations also include a discussion of the differences between energy statistics and energy balances on the one hand, and SEEA energy accounts on the other hand (see pp. 135-138). The main conceptual difference between the two relates to the use of the territory principle for the energy statistics and balances, and the residence principle for the SEEA energy accounts. Moreover, while all energy uses for transport purposes are aggregated into a single category in the energy balances, they are broken down into ISIC industries corresponding to the principal activity of the energy users in the SEEA accounts. These differences translate into similar ones between UNFCCC inventories and SEEA air emission accounts.

⁷ Notwithstanding the broad alignment between the UNFCCC inventories and the IEA estimates for CO₂ emissions from fuel combustion, there are a number of methodological differences, which are documented by the IEA (2018).

Table 1. Data availability of [air emission accounts](#) and [output data](#) on OECD.Stat, [UNSD output data](#) for non-OECD countries, [Eurostat output data](#) for EU countries

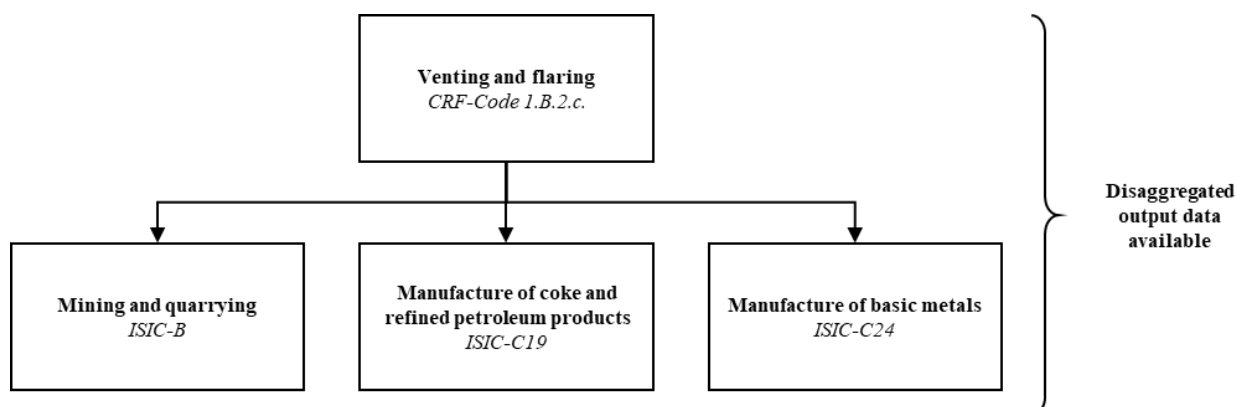
Country	AEA availability	Aggregated output data availability	Disaggregated output data availability	UNFCCC inventory availability	OECD methodology applicable at an aggregated level (8 industries)	OECD methodology applicable at a disaggregated level (14 industries)	Detailed information
Australia							<i>industry disaggregation for GHG aggregate only; no output data</i>
Austria							
Belgium							
Canada							<i>detailed industry disaggregation for GHG aggregate only</i>
Chile							
Czech Republic							
Denmark							
Estonia							
Finland							
France							
Germany							
Greece							
Hungary							
Iceland							
Ireland							
Israel							<i>no output data</i>
Italy							
Japan							
Korea							
Latvia							
Luxembourg							
Mexico							
Netherlands							
New Zealand							
Norway							
Poland							
Portugal							
Slovakia							
Slovenia							
Spain							
Sweden							
Switzerland							
Turkey							<i>output data for 2012 only</i>
United Kingdom							
United States							
Bulgaria							
Croatia							
Cyprus							
Lithuania							
Malta							
Ukraine							
European Union							
Russian Federation							
Romania							
Belarus							<i>no output data</i>
Liechtenstein							<i>no output data</i>
Monaco							<i>no output data</i>
Kazakhstan							

- Even though choosing the UNFCCC inventories has the drawback of limiting the country coverage to [Annex-I countries](#),⁸ these data cover all types of CO₂ emissions as well as additional gases. Moreover, this choice does not prevent using IEA data to estimate AEAs for CO₂ emissions from fuel combustion in non-Annex-I countries.

10. One of the main features of AEAs (and SEEA accounts more generally) is their systematic breakdown by industries and households, thus making the data directly comparable to (socio-) economic data in the SNA. Therefore, the emission data reported in the [inventories](#) need to be allocated to [ISIC rev. 4](#) industries and households. To this end, the allocations suggested by the [correspondence table developed by Eurostat](#) are used.

11. Given that Eurostat's correspondence table sometimes requires the allocation of an inventory item to more than one industry, a method is required to allocate the corresponding emissions across industries. This method should be applicable across countries, time and types of emissions. Given the correlation between air emissions and output⁹ in a given industry, the allocation from one inventory item to more than one industry is made according to the output share of each industry involved in the split. Figure 1 illustrates this approach, using the inventory item *venting and flaring* as an example. The emissions recorded under this inventory item are split between three ISIC industries according to the output share of each of them.

Figure 1: Mapping between the classification used in the UNFCCC inventories and the ISIC rev. 4 classification - Example



12. There are two exceptions to this general method. The first exception concerns the allocation of road transport emissions. This allocation poses a specific challenge because the relevant emissions are aggregated into a single item in the UNFCCC inventories. In national accounts as well as AEAs, it is only when the transport of passengers and freight is the principal activity of a firm that the corresponding activity and emissions are allocated to the transport industry. If transport is a secondary or an ancillary activity of a firm, the

⁸ In addition to the 42 Annex-I *countries*, the European Union is part of the 43 Annex-I *Parties* to the UNFCCC. Even though Kazakhstan is only considered an Annex-I country for the purposes of the [Protocol](#), it provides similar air emission inventories as Annex-I countries.

⁹ In this paper, output means production of goods and services (SNA code P.1). Even though, in economic terms, only part of output corresponds to value added, because some intermediate products are transformed into final products in the production process, the level of air emissions is related to the level of output, not to value added.

corresponding output and emissions are allocated to the industry corresponding to the firm's principal activity.¹⁰ Finally, even though the own-account use of transport vehicles by households is outside the scope of the SNA, the related emissions are allocated to households in AEAs.

13. In practice, the OECD methodology allocates road transport emissions across industries and households, using road transport allocation keys from Denmark, France and Sweden (Figure 2).¹¹ It is assumed that taking industry averages for these three countries provides a sufficiently reliable initial allocation key for road transport emissions in developed countries. This approach is further supported by the fact that Denmark, France and Sweden rely on more refined methods than other European countries.¹² Countries willing to use the OECD estimates as a first step to compile their own AEAs are then strongly encouraged to rely on national allocation keys to refine the allocation of road transport emissions.

14. The second exception to the general method relates to the inventory item *solid waste disposal* for methane (CH₄) emissions. Eurostat's correspondence table recommends allocating the corresponding CH₄ emissions to the waste management industry (ISIC-E37-39), households and the manufacturing industry as a whole (ISIC-C). While the former two seem reasonable, the latter appears to be a rare case. Therefore, applying output shares would result in an over-allocation of CH₄ emissions from *solid waste disposal* to the manufacturing industry, given the large output of this industry. Thus, emissions from *solid waste disposal* for CH₄ are allocated to waste management only (ISIC-E37-39).

15. The steps described above result in AEAs for industries and households on a territory basis. In order to benchmark them with official AEAs in line with SEEA, which are calculated according to the residence principle, the AEA bridging items are used to convert the official AEAs to a territory basis. More specifically, the bridging item *less national residents abroad* is subtracted and the bridging item *plus non-residents on the territory* is added to the reported AEAs. Since it is not immediately obvious how to best allocate the bridging items across industries, they are entirely added to and subtracted from the transportation and storage industry (ISIC-H).

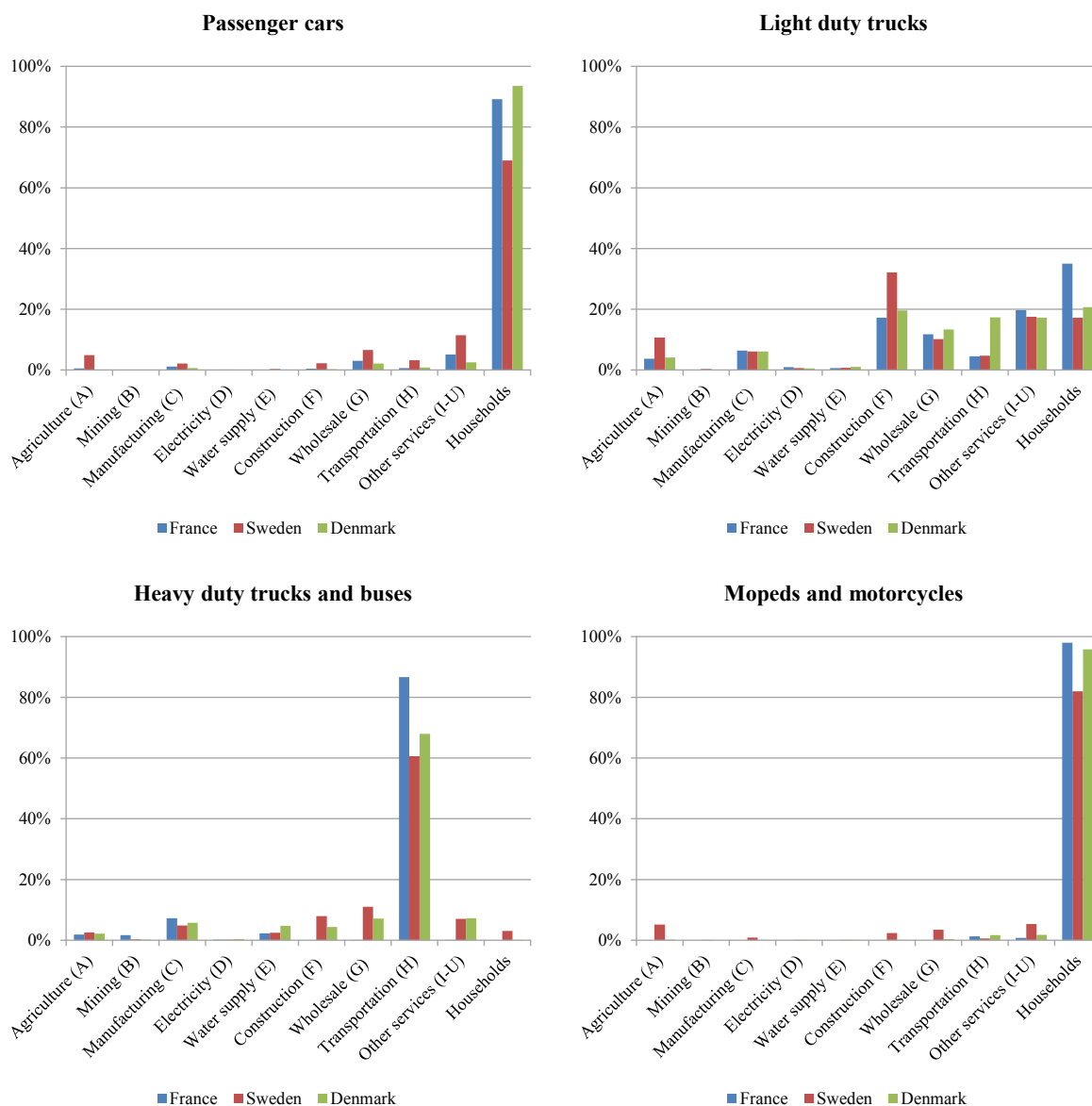
¹⁰ In theory, supply-and-use tables (SUTs) could be used to identify the secondary transport activities of industries, but they are only available for a limited number of countries. Moreover, SUTs do not allow identifying ancillary transport activities. Only transport satellite accounts could give a comprehensive overview of secondary and ancillary transport activities in all industries. Nevertheless, they are only available for very few countries and do not cover the transport activities of households.

¹¹ The UNFCCC inventories distinguish between road transport emissions from *passenger cars, light duty trucks, heavy duty trucks and buses, mopeds and motorcycles* and *other*. For the rare case that emissions are reported for the item *other*, those emissions are allocated in line with the information provided. Accordingly, Germany's *other* item ("CO₂ from lubricant co-incineration in 2-stroke road vehicles") is allocated to *mopeds and motorcycles*, the United Kingdom's *other* item ("Liquefied Petroleum Gases (LPG)") is allocated to *passenger cars* and Canada's *other* item ("Propane and Natural Gas Vehicles") is allocated to *passenger cars*.

¹² The heterogeneity of practices across Europe has led Eurostat to set up a Task Force on the allocation of road transport emissions to industries and households in 2016. The aim of the Task Force is to increase the quality and comparability of the allocation of road transport emissions across countries.

16. Furthermore, the OECD methodology excludes emissions related to Land Use, Land-Use Change and Forestry (LULUCF). This is consistent with the reported AEAs for European countries since [Eurostat’s manual on air emission accounts](#) explicitly states that “emissions from land use and land use change are excluded from the emission inventory totals as well as from AEA” (p. 60). It could be argued that the level of emissions related to LULUCF, and how they are allocated across industries and households, are key issues for some countries in the world (e.g. Brazil, Indonesia). The OECD methodology would need to be refined in the future in order to take this into account.

Figure 2: Allocation keys for road transport emissions in Denmark, France and Sweden



3. Results for CO₂, CH₄ and N₂O emissions

3.1. Validation of the OECD methodology: Estimated vs. official AEs

17. The OECD methodology outlined in the previous Section is applied to all Annex-I countries to the UNFCCC releasing both AEs and output data. This makes the comparison between “estimated AEs” and “official AEs” possible.

18. Average results for 18 countries¹³ between 2008 and 2014 are shown for CO₂ (Figure 3) CH₄ (Figure 5) and N₂O emissions (Figure 7). Note that comparing median emissions by industry in estimated and official accounts would give very similar results. A systematic assessment of dispersion using conventional measures illustrates the margins of error around averages or medians. Positive figures reflect over-allocations, whereas negative figures indicate under-allocations compared to the official AEs.

19. It should be noted that total emissions in the official AEs on one hand, and the estimated AEs and UNFCCC inventories on the other hand, may slightly differ. This difference corresponds to the bridging item *other adjustments and statistical discrepancies*, which contributes to the balancing of official AEs and UNFCCC inventories.¹⁴ Since there is no obvious industry allocation for these adjustments and discrepancies, they could not be used to convert the benchmark official AEs to the territory principle. Fortunately, it is only for some countries that these *other adjustments and statistical discrepancies* are significant.

20. On average across countries and time, the OECD methodology produces very reliable estimates, even at a quite detailed industry level. The average misallocation of CO₂, CH₄ and N₂O emissions to any industry is less than 3.5% of overall emissions (Figure 4, Figure 6 and Figure 8). Another way of looking at the accuracy of the OECD estimates is to compute the share of misallocated emissions in a given country (Table 2).¹⁵ For CO₂ emissions, this share ranges between 4.0% in Latvia and 18.9% in Slovakia, with an average of 8.9% across countries. It should be noted that for some countries (Czech Republic, United Kingdom, Portugal and Slovenia), relatively large deviations could be explained by the size of the bridging item *other adjustments and statistical discrepancies*.

21. Dispersion around these average results generally lies within reasonable limits, in particular when potential outliers are excluded. To this end, 88% confidence intervals are considered, which is equivalent to taking out the upper and lower extreme value for each industry. Dispersion is important to keep in mind when evaluating the OECD methodology.

¹³ Austria, Belgium, Czech Republic, Germany, Denmark, Estonia, Finland, France, United Kingdom, Greece, Hungary, Italy, Latvia, the Netherlands, Slovakia, Slovenia, Portugal and Spain.

¹⁴ *Other adjustments and statistical discrepancies* only represent 2% of total CO₂ emissions on average across countries and over time, but can make up to 10% of total CO₂ emissions, 5% of total CH₄ emissions and 25% of total N₂O emissions in some countries.

¹⁵ The share of misallocated emissions in a country is computed as the sum of absolute errors in each industry, divided by twice the overall level of emissions in this country. Dividing by twice the total of emissions ensures that the share of misallocated emissions ranges between 0 and 100%.

Even though this methodology produces very reliable estimates on average, this does not exclude some heterogeneity due to country- or industry-specific circumstances.

Table 2. Share of misallocated emissions

(%, 2008-2014 average)

Country	CO ₂ emissions	CH ₄ emissions	N ₂ O emissions
AUT	8.8	1.8	3.5
BEL	5.3	0.5	1.9
CZE	9.5	5.4	14.8
DEU	10.1	6.3	2.0
DNK	6.4	1.6	0.9
EST	8.9	3.2	5.4
FIN	12.4	1.4	1.1
FRA	6.0	4.8	1.1
GBR	8.5	6.0	4.1
GRC	6.0	20.1	2.8
HUN	5.1	2.9	6.4
ITA	9.5	3.8	2.5
LVA	4.0	8.8	0.7
NLD	5.5	2.9	2.1
PRT	10.2	14.6	2.4
SVK	18.9	15.9	27.0
SVN	15.6	0.8	4.2
ESP	9.1	4.3	3.6
AVERAGE	8.9	5.6	4.1

Note: The share of misallocated emissions in a country is computed as the sum of absolute errors in each industry, divided by twice the overall amount of emissions in this country.

Figure 3: Estimated and official Air Emission Accounts for CO₂: Averages across country and time

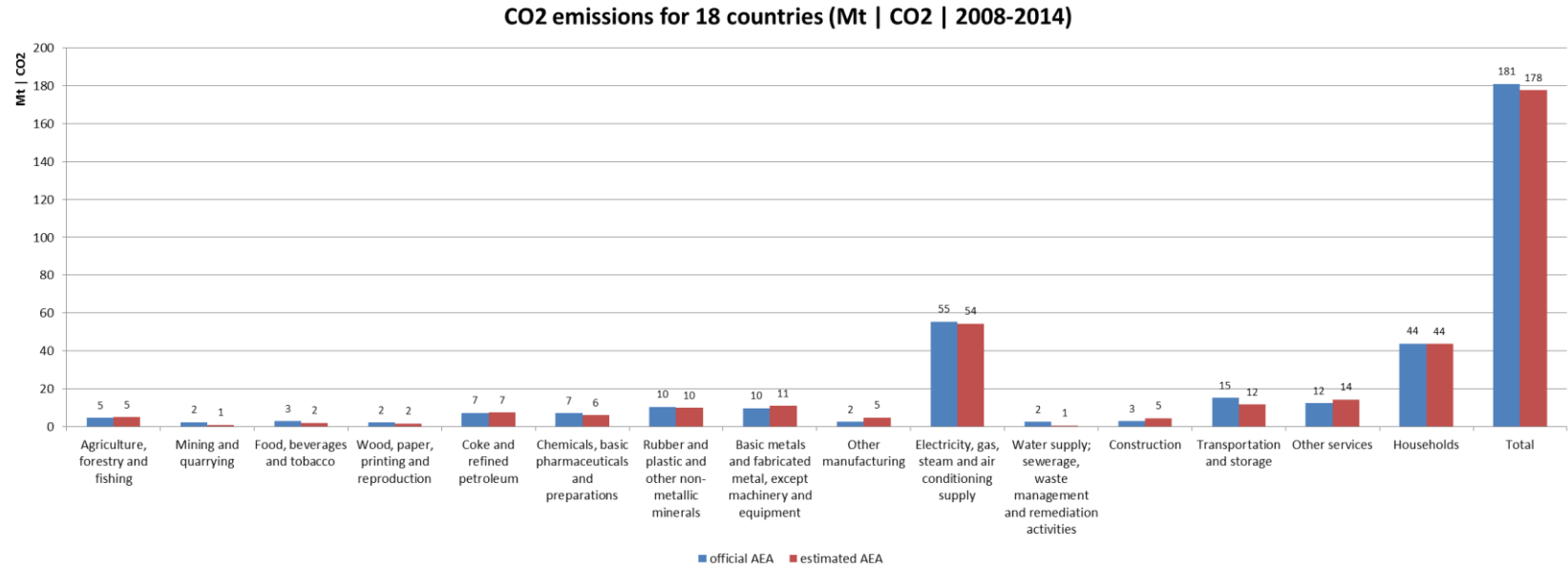
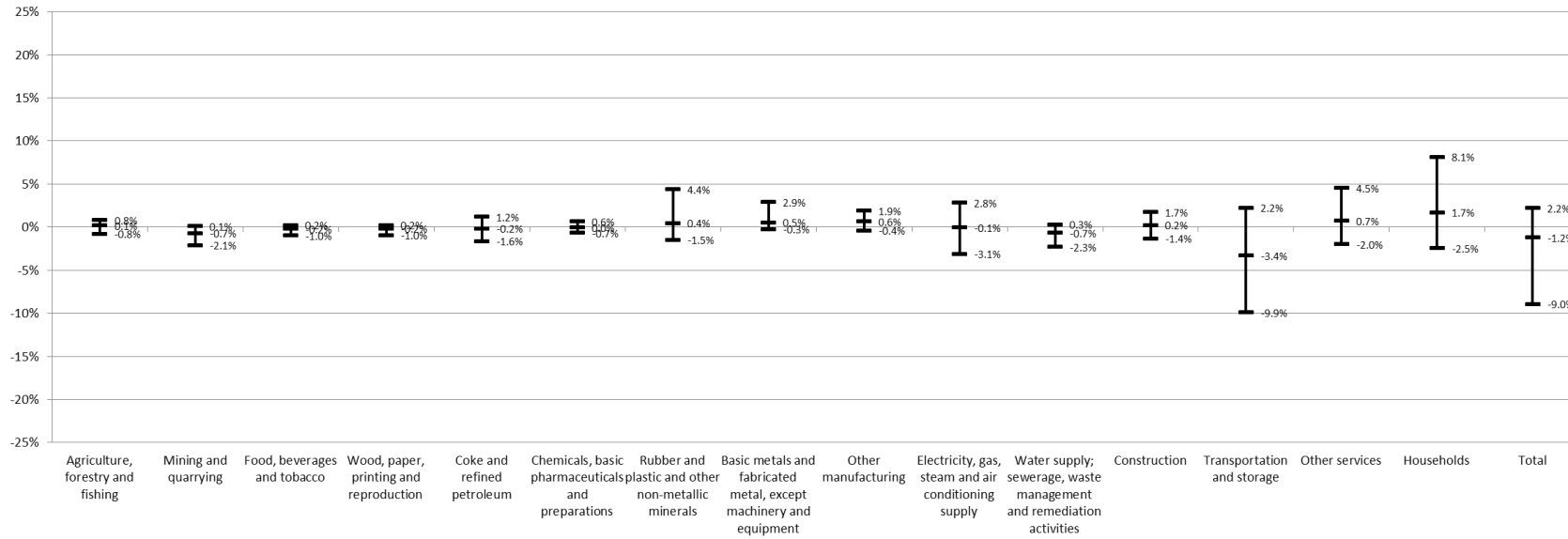


Figure 4. Distribution of errors for CO₂ emissions

average deviation (%-share of the reported total) and 88% confidence interval | CO₂ for 18 countries for 2008-2014



Note: Across countries, the share of overall CO₂ emissions which are misallocated to the *agriculture, forestry and fishing* industry is 0.1% on average. In 88% of the cases, this share lies between -0.8% and +0.8%.

Figure 5: Estimated and official Air Emission Accounts for CH₄: Averages across country and time

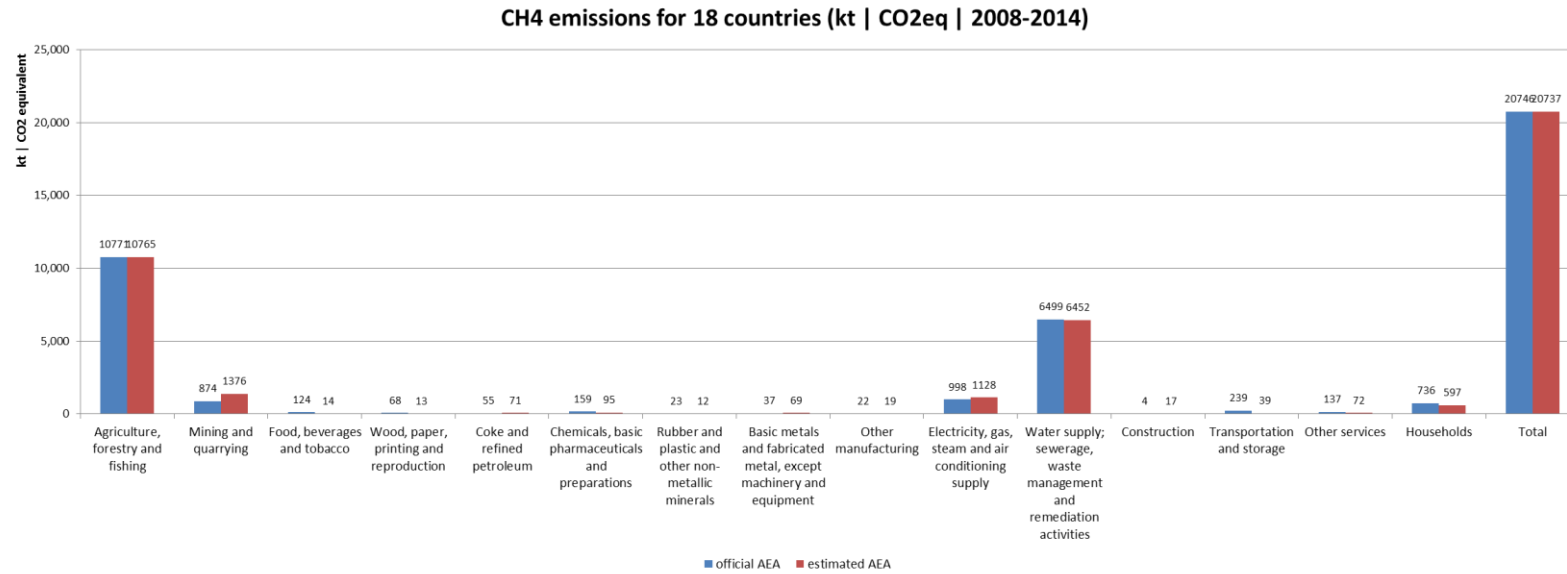
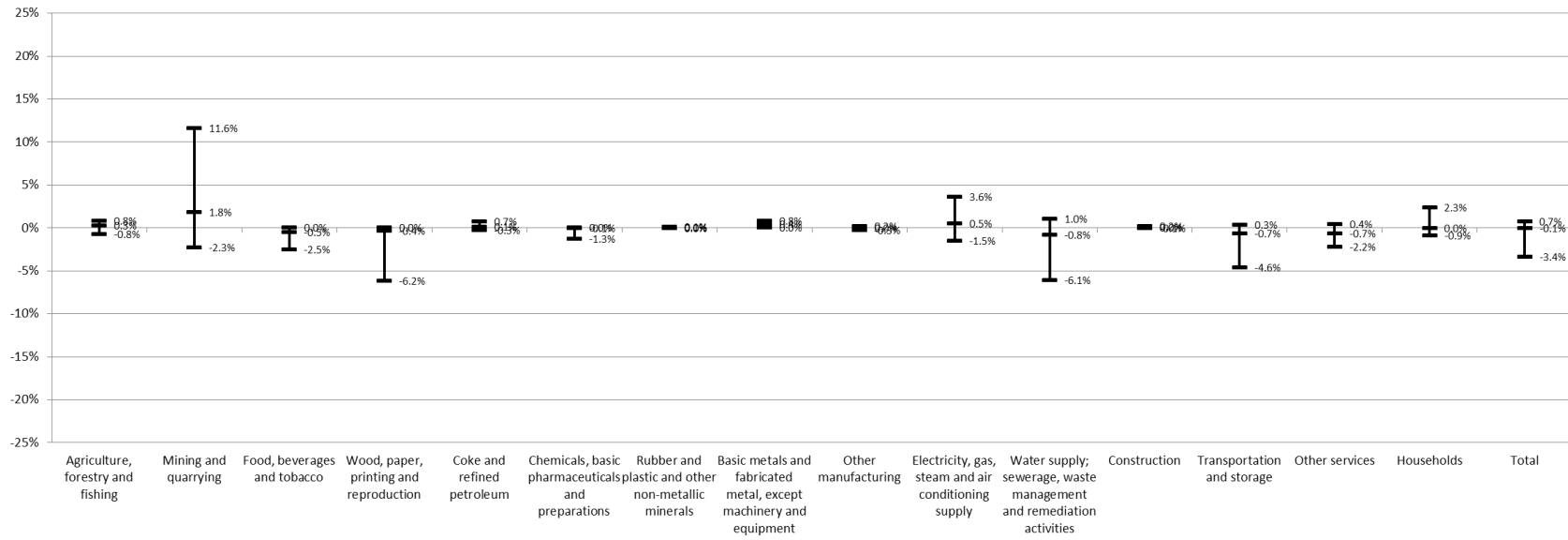


Figure 6. Distribution of errors for CH₄ emissions

average deviation (%-share of the reported total) and 88% confidence interval | CH₄ for 18 countries for 2008-2014



Note: Across countries, the share of overall CH₄ emissions which are misallocated to the *agriculture, forestry and fishing* industry is 0.3% on average. In 88% of the cases, this share lies between -0.8% and +0.8%.

Figure 7: Estimated and official Air Emission Accounts for N₂O: Averages across country and time

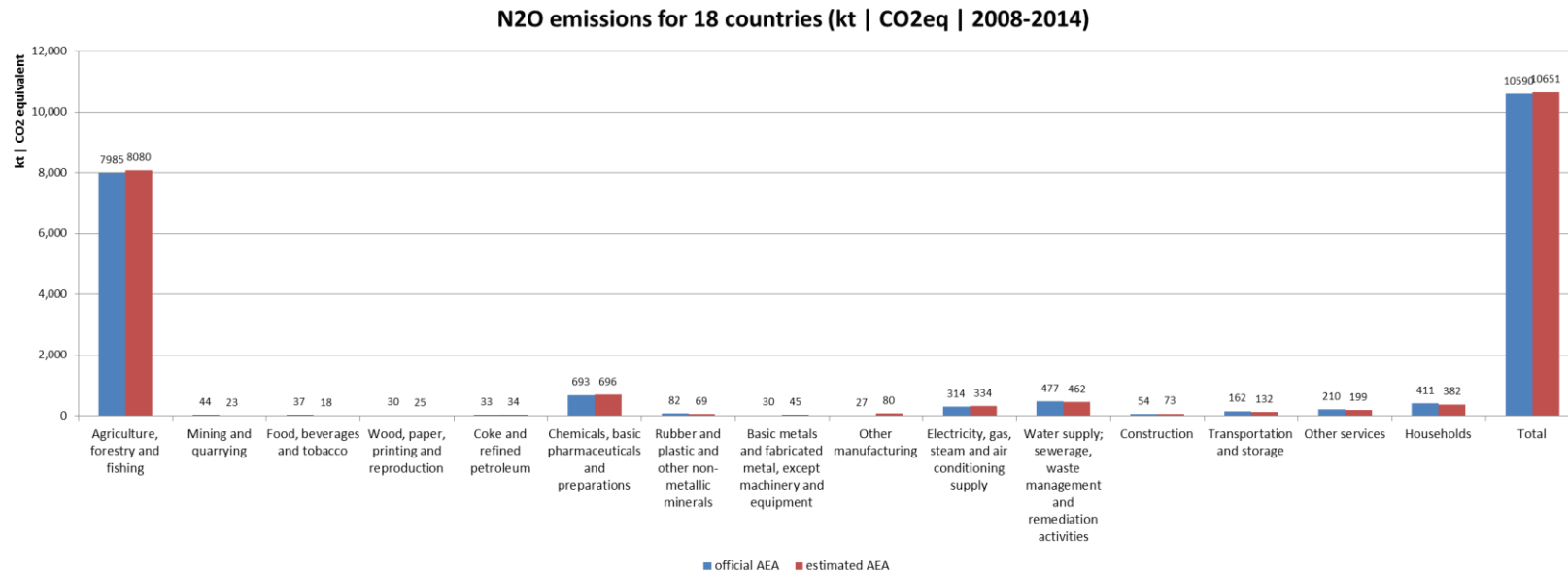
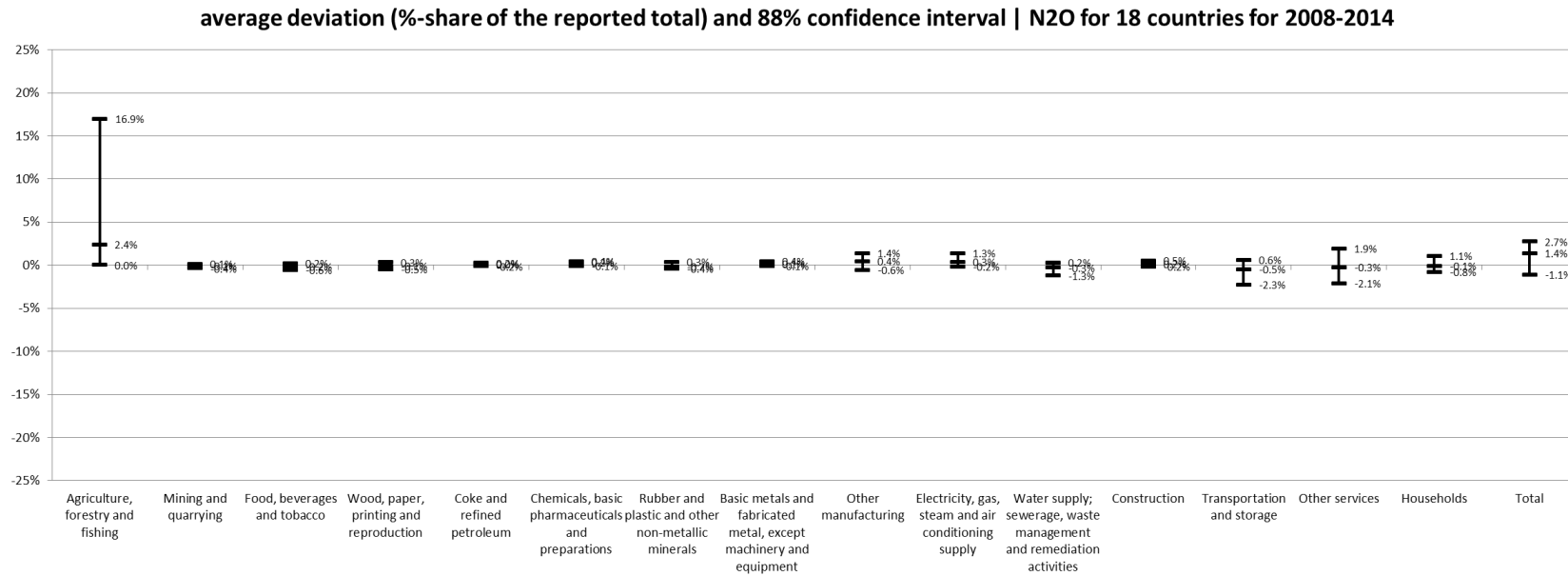


Figure 8. Distribution of errors for N₂O emissions



Note: Across countries, the share of overall N₂O emissions which are misallocated to the *agriculture, forestry and fishing* industry is 2.4% on average. In 88% of the cases, this share lies between 0.0% and +16.9%.

3.2. Accuracy of estimated AEAs for different industry groupings

22. When official AEAs are converted to the territory principle in order to use them as benchmarks, the relevant bridging items are conventionally imputed to the transportation and storage industry (ISIC–H). Nevertheless, part of the bridging items may be relevant for households as well. This could potentially explain some of the discrepancies between official and estimated AEAs. Indeed, Figure A A.2 in Annex A indicates that combining households (HH) and the transportation and storage industry (H) to form a combined industry (HH & H) slightly reduces the discrepancy between the two sets of accounts for CO₂ emissions. Nevertheless, this is not the case for the already well estimated CH₄ emissions (Figure A A.3 in Annex A) or N₂O emissions (Figure A A.4 in Annex A). It can be concluded that the assumption made to allocate bridging items does not significantly affect the comparison between estimated and official AEAs.

23. A combination of industries that can be looked at is *electricity, gas, steam and air conditioning supply* (ISIC–D) with *water supply, sewage, waste management and remediation activities* (ISIC–E). The rationale for testing this combination is that these industries used to be aggregated in the ISIC rev. 3 classification, thus making it potentially more difficult to split them in the AEAs following the ISIC rev. 4 classification. Nevertheless, Figure A A.5, Figure A A.6 and Figure A A.7 in Annex A show that aggregating industries ISIC–D and ISIC–E does not significantly affect the comparison between estimated and official AEAs.

3.3. Accuracy of estimated decoupling trends at the industry level

24. Another way to assess the reliability of the OECD methodology beyond emission levels is to compare decoupling trends computed from official and estimated AEAs. The most emitting industries are taken as examples to perform this comparison: the *manufacturing* industry (ISIC–C) is used for CO₂ emissions and the *agriculture* industry (ISIC–A) for CH₄ and N₂O emissions. Figure 9, Figure 10 and Figure 11 suggest that the OECD methodology leads to very reliable estimates of decoupling trends.

Figure 9: Decoupling analysis for CO₂ emissions in the manufacturing industry (GVA = gross value added at constant prices) - An increasing trend reflects decoupling

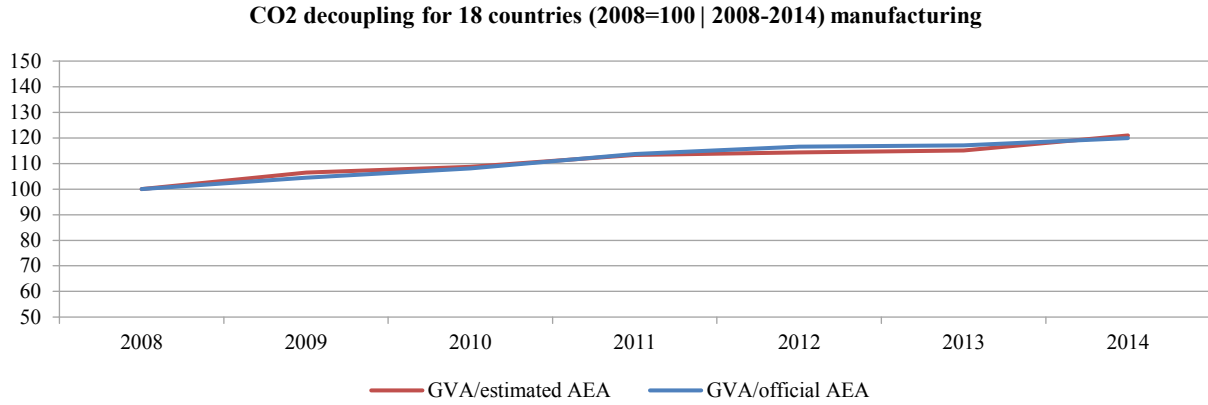


Figure 10: Decoupling analysis for CH₄ emissions in agriculture (GVA = gross value added at constant prices) - An increasing trend reflects decoupling

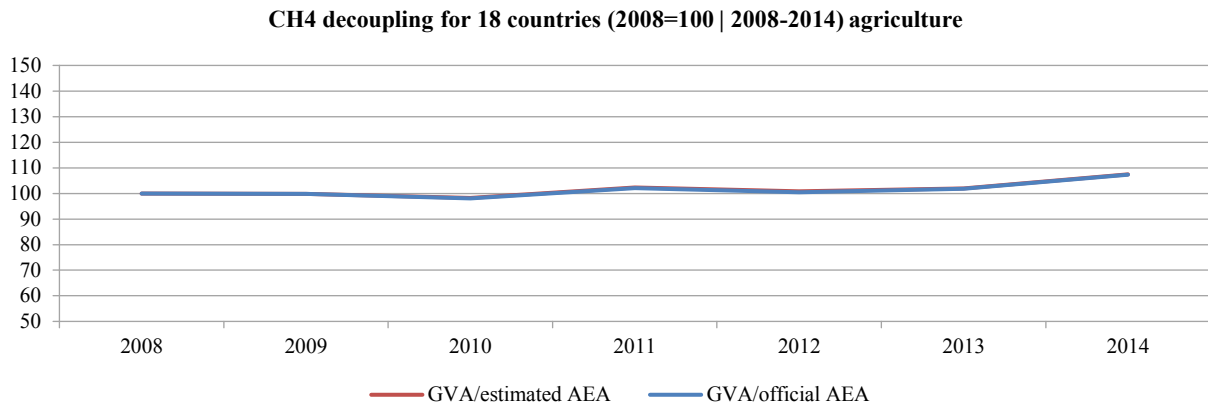
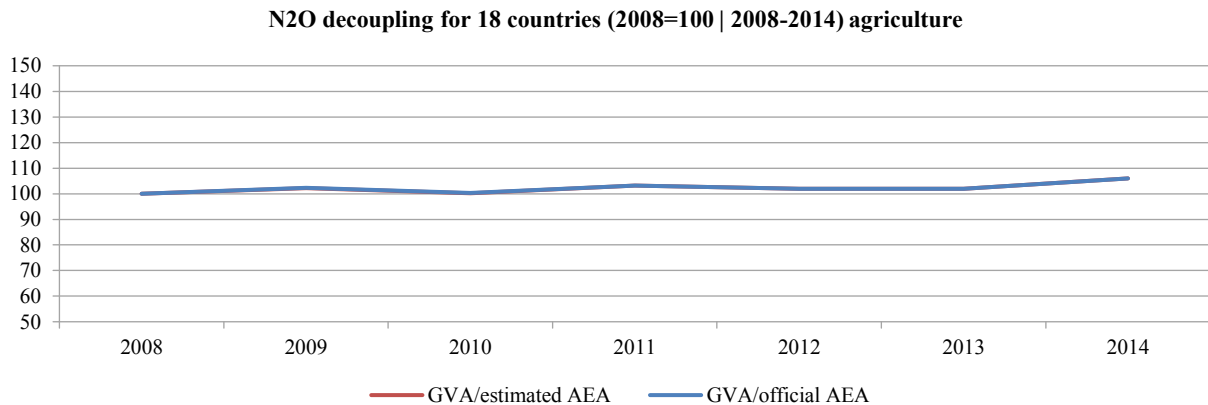


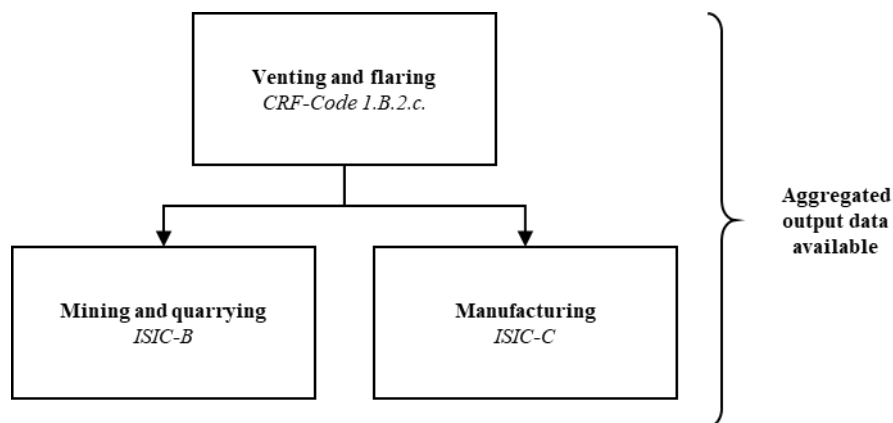
Figure 11: Decoupling analysis for N₂O emissions in agriculture (GVA = gross value added at constant prices) - An increasing trend reflects decoupling



3.4. Accuracy of estimated AEs when less detailed information on output is available

25. While all 42 Annex-I countries to the UNFCCC report GHG inventories in a consistent way, not all of them provide output data with the same level of detail. Therefore, the OECD methodology is also tested with less detailed output data.¹⁶ The allocation method is adjusted accordingly. While the general principles of the method are unchanged, the level at which the allocation takes place needs to be aligned with the less detailed output data. Using the same example as shown in Figure 1, the more aggregated output data leads to allocating emissions recorded in the inventory item *venting and flaring* to two ISIC industries (Figure 12). The allocation key remains the output share of the two industries involved in the split.

Figure 12: Mapping between the classification used in the UNFCCC inventories and the ISIC rev. 4 classification - Example



26. As shown in Table 3, when allocations of air emissions to industries are compared at the 1-digit industry level, results remain very reliable. Table 1 shows for which countries only aggregated output data are available. Results for these countries are provided in Annexes C and D.

27. In Annex C, the OECD methodology is also tested for Canada where official AEs are only available for GHGs as a whole (i.e. for the sum of CO₂, CH₄ and N₂O emissions in CO₂ equivalents).

¹⁶ Whereas output data at a 2-digit industry level was used for the estimation of AEs in previous Sections, output data at a 1-digit level is now used.

Table 3: Average percentage deviations from the total between using the more aggregated and more disaggregated output data for 18 countries between 2008 and 2014

ISIC rev. 4 industry code	CO ₂ emissions	CH ₄ emissions	N ₂ O emissions
A	0.0	0.0	0.0
B	-0.3	-2.4	-0.1
C	1.4	2.5	0.3
D	-0.6	0.0	-0.1
E	0.1	0.0	0.0
F	-0.4	0.0	-0.1
G	-0.1	0.0	0.0
H	0.2	0.0	0.0
I-U	-0.3	0.0	0.0
HH	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0

4. Conclusion

28. The methodology described in this paper allows estimating reliable AEAs for CO₂, CH₄ and N₂O emissions. Decoupling trends are also accurately reflected in the estimated accounts. Of course, the accuracy of the results may depend on the specific countries, industries and emissions which are considered, as well as more generally on the quality of the emission data in the UNFCCC inventories and on the output data in the national accounts. Nevertheless, the official AEAs, which are used as benchmarks, may also contain measurement errors, so that average results across country and time provide a very good basis to validate the OECD methodology.

29. This methodology can be applied to all Annex-I countries to the UNFCCC for CO₂, CH₄ and N₂O emissions, with a level of detail depending on the availability of output data. Concretely, current data availability allows to estimate AEAs for CO₂, CH₄ and N₂O emissions for Iceland, Japan, Kazakhstan, New Zealand, Ukraine, the United States and the Russian Federation. For the first six countries, the availability of output data allows to break down air emissions into eight industries, and for the Russian Federation into 14 industries. Additionally, the existing AEAs for Canada, which are only available for GHGs as a whole, can be complemented with individual estimates for CO₂, CH₄ and N₂O emissions.

30. It is important to note that the quality of these estimated AEAs is strongly dependent on the quality of the underlying energy statistics and balances which are used to compile UNFCCC inventories. For this reason, improving the quality of energy statistics and balances should remain a priority in countries.

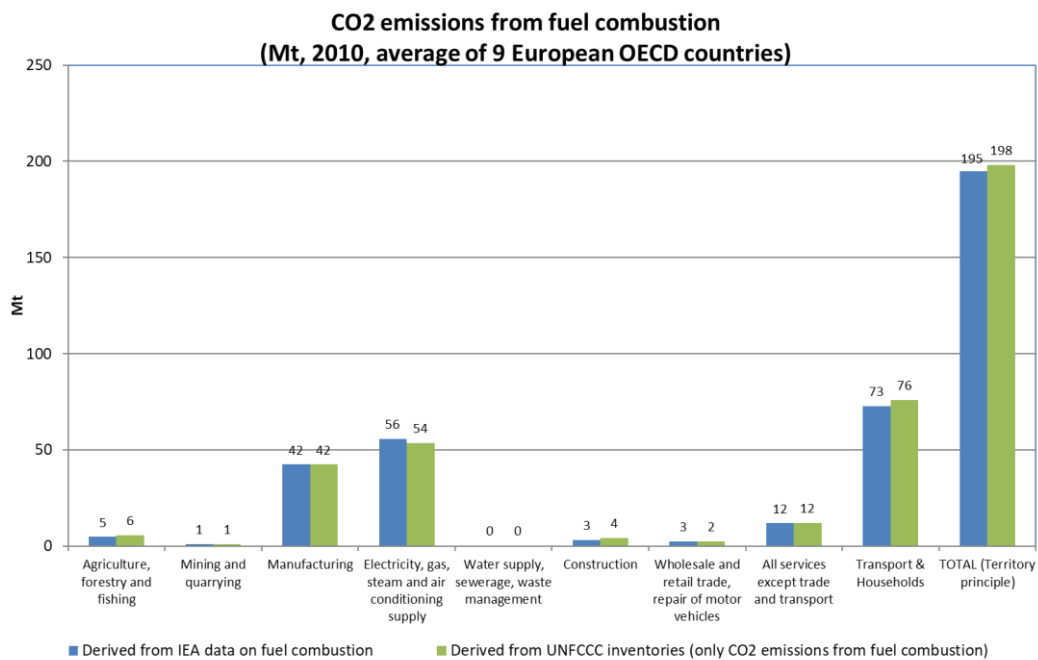
31. Future work should focus on the estimation of AEAs for non-Annex-I countries, the estimation and allocation of LULUCF emissions, and the residence-territory adjustment. More generally, future data availability may also allow improving the present estimates, in particular when it comes to the allocation of road transport emissions.

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Annex A. Comparison of official and estimated AEAs for different industry groupings

Figure A A.1. Comparing air emission accounts using IEA data and UNFCCC inventories for CO₂ emissions from fuel combustion



Note: The nine European OECD countries are Austria, Belgium, Czech Republic, Denmark, France, Hungary, Italy, the Netherlands and United Kingdom.

Figure A A.2. Comparing different levels of aggregation for transportation and storage (H), households (HH) and combining both (HH & H) for CO₂ emissions

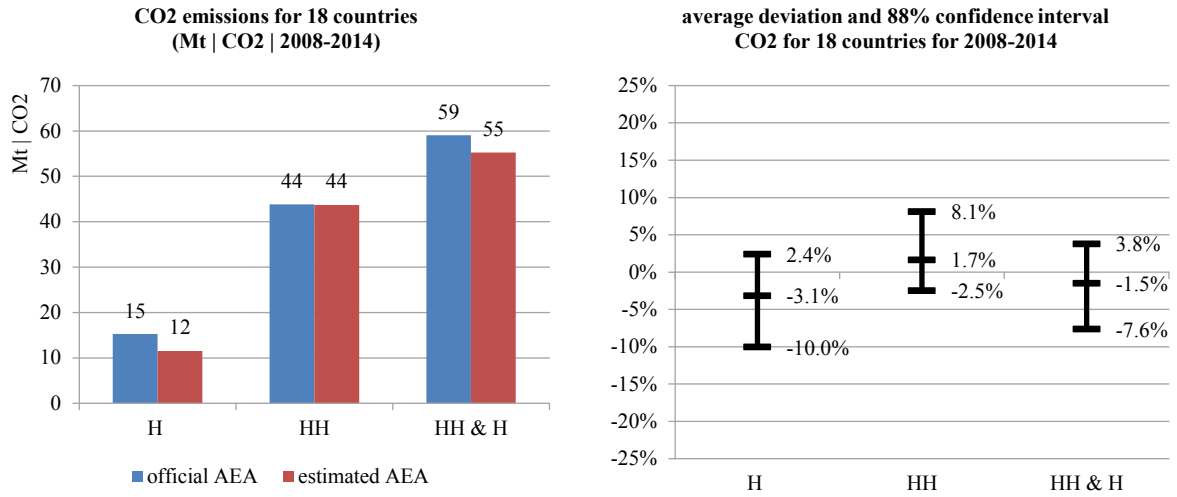


Figure A A.3. Comparing different levels of aggregation for transportation and storage (H), households (HH) and combining both (HH & H) for CH₄ emissions

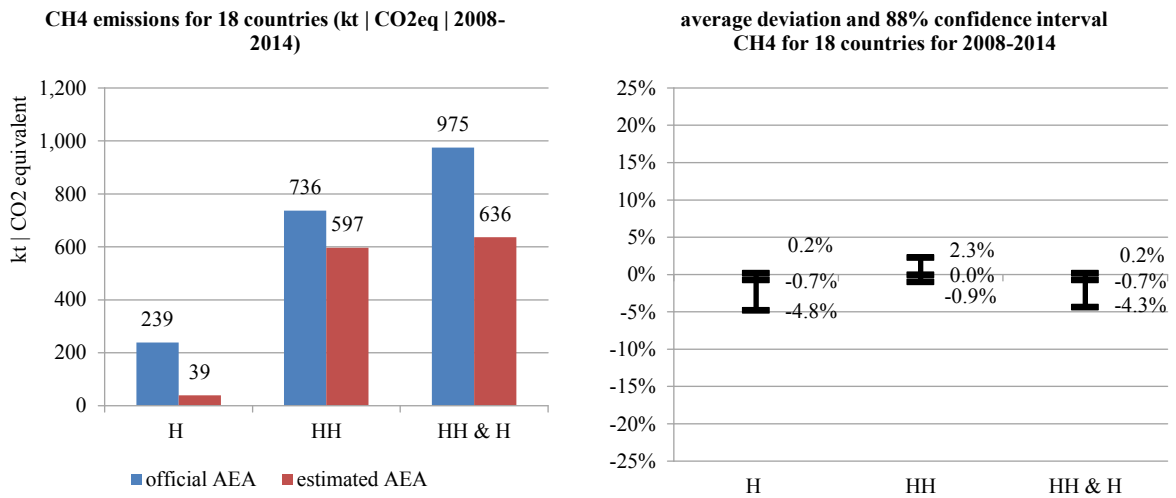


Figure A A.4. Comparing different levels of aggregation for transportation and storage (H), households (HH) and combining both (HH & H) for N₂O emissions

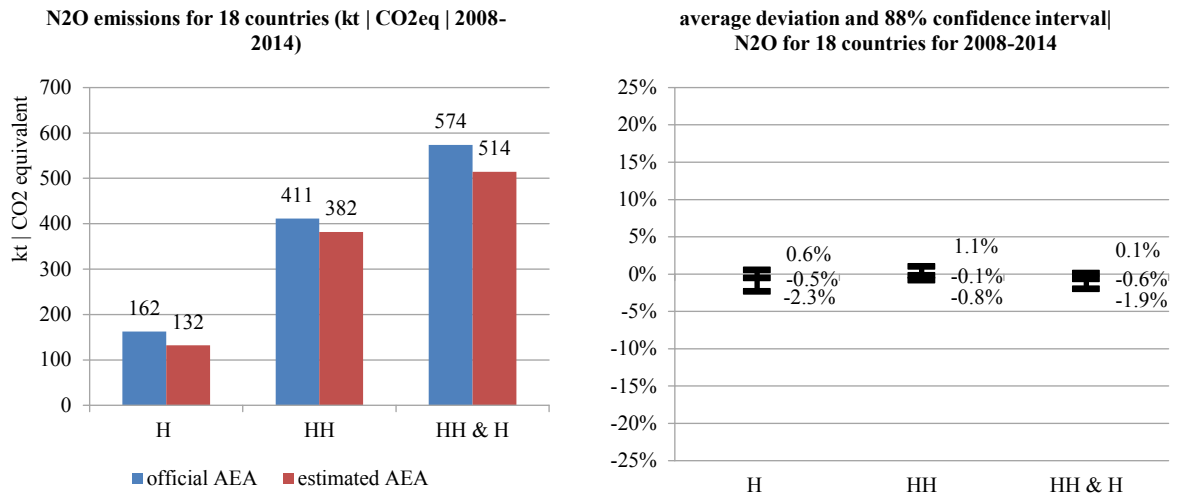


Figure A A.5 Comparing different levels of aggregation for electricity and gas (D) and water supply and waste management (E) for CO₂ emissions

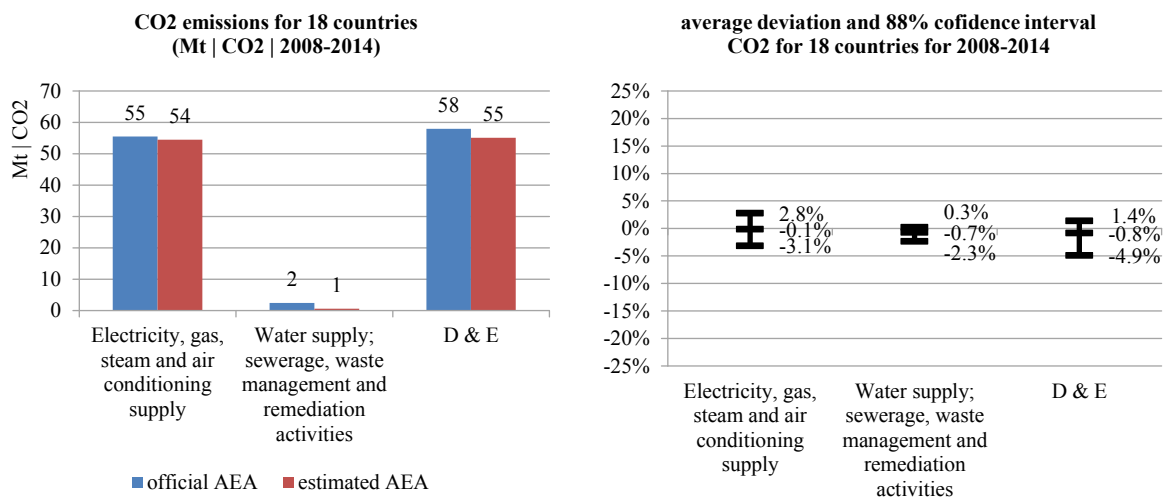


Figure A A.6. Comparing different levels of aggregation for electricity and gas (D) and water supply and waste management (E) for CH₄ emissions.

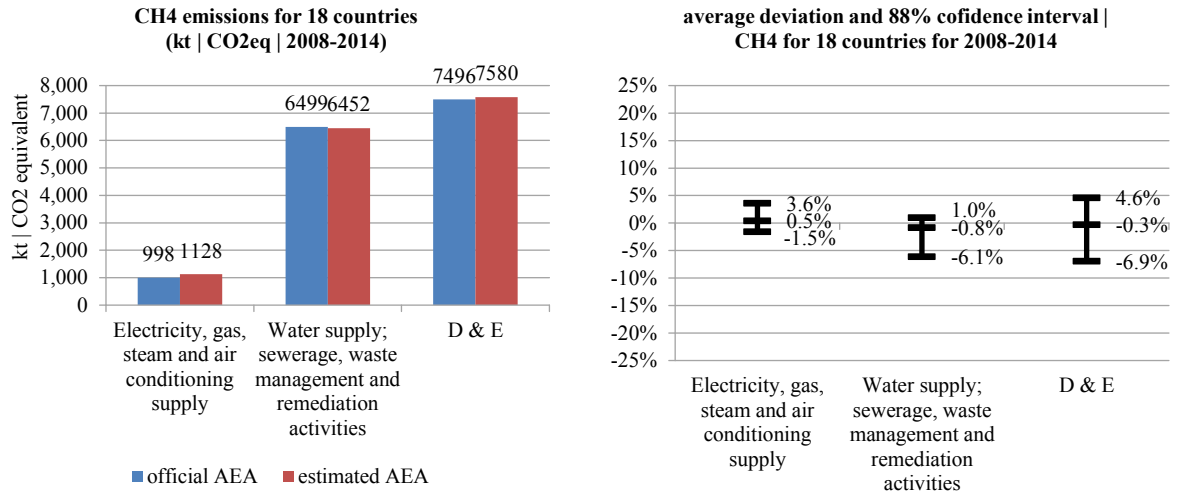
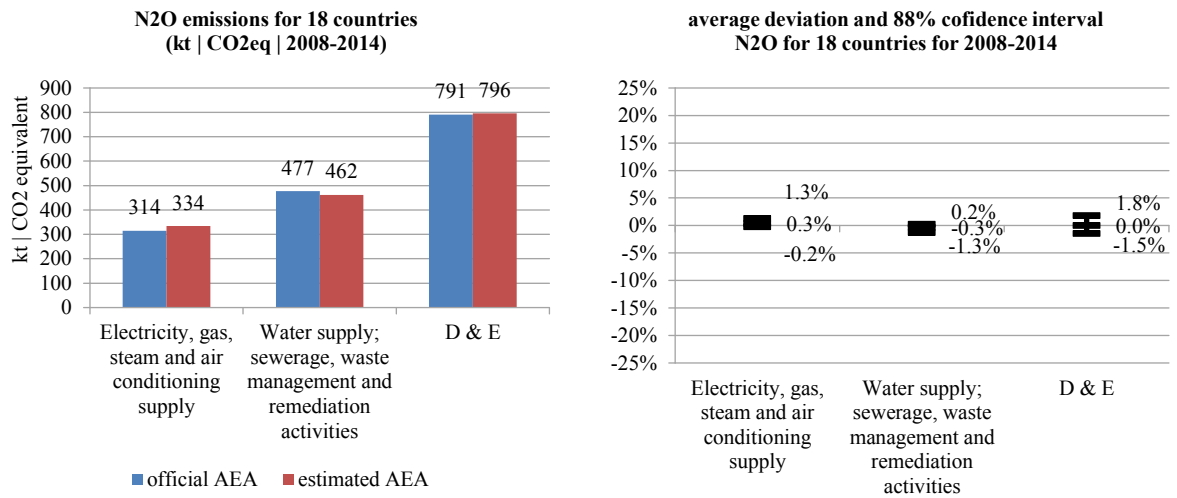


Figure A A.7. Comparing different levels of aggregation for electricity and gas (D) and water supply and waste management (E) for N₂O emissions



Annex B. Comparison of official and estimated AEAs for countries releasing detailed output data

Annex B shows the results of using the OECD methodology in combination with more disaggregated output data for 18 countries (Austria, Belgium, Czech Republic, Germany, Denmark, Estonia, Finland, France, United Kingdom, Greece, Hungary, Italy, Latvia, the Netherlands, Slovakia, Slovenia, Portugal and Spain) and three types of emissions (CO₂, CH₄ and N₂O), on average across time (2008-2014).

Annex B-E can be accessed online

<http://www.oecd.org/sdd/towards-global-seea-air-emission-accounts-annex.pdf>

Annex C. Comparison of official and estimated AEAs for countries releasing aggregated output data

Annex C shows the results of using the OECD methodology in combination with more aggregated output data for six countries (Switzerland, Ireland, Luxembourg, Norway, Sweden and Poland) and three types of emissions (CO₂, CH₄ and N₂O), on average across time (2008-2014). Additionally, results for Canada are shown for emissions of greenhouse gases as a whole (CO₂, CH₄ and N₂O combined), on average across time (2009-2012).

Annex B-E can be accessed online

<http://www.oecd.org/sdd/towards-global-seea-air-emission-accounts-annex.pdf>

Annex D. Estimated AEAs for Japan

Annex D describes and presents the estimated air emission accounts for CO₂, CH₄ and N₂O emissions for Japan. Japan is a slightly specific case because its output data for electricity, gas, steam and air conditioning supply (ISIC–D) include output for water supply; sewage, waste management and remediation activities (ISIC–E). Therefore, these two industries are also aggregated in the OECD estimated air emission accounts. Any inventory which is supposed to be allocated to industry ISIC–D and/or industry ISIC–E gets allocated to industry ISIC–D and ISIC–E, based on the output share of industry ISIC–D and ISIC–E.¹⁷

Annex B-E can be accessed online

<http://www.oecd.org/sdd/towards-global-seea-air-emission-accounts-annex.pdf>

¹⁷ The following eight inventories are concerned: fuel combustion for commercial/institutional sectors; solid waste disposal; composting; anaerobic digestion at biogas facilities; waste incineration; open burning of waste; domestic wastewater treatment and discharge; other wastewater treatment and discharge.

Annex E. Estimated AEAs for Iceland, Kazakhstan, New Zealand, the Russian Federation, Ukraine and the United States

Annex E describes and presents the estimated air emission accounts for CO₂, CH₄ and N₂O emissions for Iceland, Kazakhstan, New Zealand, the Russian Federation, Ukraine and the United States.

The estimates for three types of emissions (CO₂, CH₄ and N₂O) and on average across time (2008-2014) are based on using the OECD methodology in combination with more aggregated output data for Iceland, Kazakhstan, New Zealand, Ukraine and the United States.

For Kazakhstan, output data are only available for 2010-2013 and therefore the estimates are only reported for this timespan.

For the Russian Federation, more detailed output data are used. The Russian Federation only recently compiled output data applying the ISIC rev. 4 classification. The stability of output shares across time and industries (based on ISIC rev. 3) was analysed, concluding that the shares are very stable during the 2005-2016 period. Thus, for the time being, the 2016 output shares are used as allocation keys for all years for which air emission accounts are estimated (2008-2014).

Annex B-E can be accessed online

<http://www.oecd.org/sdd/towards-global-seea-air-emission-accounts-annex.pdf>