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**Uncertainties in the Norwegian greenhouse gas
emission inventory**

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Preface

The uncertainty in the Norwegian greenhouse gas emission inventory has been investigated by a tier 2 analysis in 2011. A tier 2 analysis for the greenhouse gases was also performed in 2006, and the results from that analysis is given in Sandmo (2010). The uncertainty in the Norwegian emission inventory has also earlier been investigated systematically in three reports (Rypdal 1999; Rypdal and Zhang 2000; Rypdal and Zhang 2001). The first two of these three reports focused on the uncertainty in the greenhouse gas emissions, and the last report investigated the uncertainty in the emission estimates of long-range air pollutants.

The report has been prepared by Statistics Norway, with financial support by the Climate and Pollution Agency. The report has been written by Britta Hoem and Ketil Flugsrud in Statistics Norway's Division for environmental statistics, with contribution from Li-Chun Zhang in Division for statistical methods and standards. The report is available at: <http://www.ssb.no/english/subjects/01/>

Abstract

The national greenhouse gas (GHG) emission inventory is compiled from estimates based on emission factors and activity data and from direct measurements by plants. All these data and parameters will contribute to the overall inventory uncertainty. The uncertainties and probability distributions of the inventory input parameters have been assessed based on available data and expert judgements. Finally, the level and trend uncertainties of the national GHG emission inventory have been estimated using Monte Carlo simulation. The methods used in the analysis correspond to an IPCC tier 2 method, as described in the IPCC Good Practice Guidance (IPCC 2000) (IPCC 2000). Analyses have been made both excluding and including the sector LULUCF (land use, land-use change and forestry).

The uncertainty analysis performed in 2011 is an update of the uncertainty analyses performed for the greenhouse gas inventory in 2006 and 2000.

During the project we have been in contact with experts, and have collected information about uncertainty from them. Main focus has been on the source categories where changes have occurred since the last uncertainty analysis was performed in 2006. This includes new methodology for several source categories (for example for solvents and road traffic) as well as revised uncertainty estimates. For the installations included in the emission trading system, new information from the annual ETS reports about uncertainty in activity data and CO₂ emission factor (and N₂O emission factor for nitric acid production) has been used. This has improved the quality of the uncertainty estimates for the energy and manufacturing sectors.

The results show that the uncertainty level in the total calculated greenhouse gas emissions for 2009 is ± 4 per cent. When including the LULUCF sector, the total uncertainty is ± 17 per cent in 2009. The uncertainty estimate is lower now than previous analyses have shown. This is partly due to a considerable work made to improve the calculation methodology. It is also partly the uncertainty estimates themselves that have been improved.

The results also show that the increase in the total GHG emissions from 1990 to 2009 is 3 per cent, with an uncertainty in the trend of ± 3 percentage points. With the sector LULUCF included in the calculations there has been a decrease in the total emissions figures of -37 per cent, with a trend uncertainty of ± 7 percentage points.

Sammendrag

Det norske klimagassregnskapet er en sammenstilling av utslippsestimater beregnet med utgangspunkt i utslippsfaktorer og aktivitetsdata og direkte utslippsmålinger. Alle disse data og parametre bidrar til den totale usikkerheten i regnskapet. Usikkerheten og sannsynlighetsfordelingen for de forskjellige parametrene har blitt anslått ut fra tilgjengelige data og ekspertestimater. Til slutt er nivået og trenden for usikkerheten i det nasjonale klimaregnskapet blitt estimert ved hjelp av en Monte Carlo simulering. Metodene brukt i analysen tilsvarer en IPCC tier 2 metode, som beskrevet i IPCC Good Practice Guidance (IPCC 2000). Analyser har blitt gjort hvor LULUCF (land use, land-use change and forestry) -sektoren både er blitt inkludert og ekskludert.

Usikkerhetsanalysen utført i 2011 er en oppdatering av usikkerhetsanalysene av klimagassregnskapet gjennomført i 2006 og 2000.

I løpet av prosjektet har vi vært i kontakt med sakkyndige fagpersoner, og samlet informasjon om usikkerhet fra dem. Det har vært fokus på de kildekategorier hvor det er foretatt endringer siden den siste usikkerhetsanalysen ble gjennomført i 2006. Dette inkluderer ny metodikk for flere kildekategorier (for eksempel for løsemidler og veitrafikk), samt reviderte usikkerhetsestimater. For anlegg inkludert i kvotehandelssystemet er ny informasjon fra de årlige ETS-rapportene om usikkerhet i aktivitetsdata og CO₂-utslippsfaktor (og N₂O-utslippsfaktor fra salpetersyreproduksjon) blitt brukt. Dette har forbedret kvaliteten på usikkerhetsestimatene fra energi- og produksjonssektoren.

Resultatene viser at usikkerheten i nivå på de totale klimagassutslippene for år 2009 er ± 4 prosent. Når LULUCF-sektoren blir inkludert er den totale usikkerheten ± 17 prosent. Usikkerhetsestimatet er lavere nå enn hva tidligere analyser har vist. Dette er delvis på grunn av at et betydelig arbeid er blitt gjort for å forbedre beregningsmetodikken. Det er også delvis usikkerhetsestimatene i seg selv som er blitt forbedret.

Resultatene viser også at økningen i de totale klimagassutslippene er 3 prosent mellom 1990 og 2009, med en trendusikkerhet på ± 3 prosentpoeng. Med LULUCF-sektoren inkludert i beregningene har det vært en reduksjon i totale utslipp på -37 prosent, med en trendusikkerhet på ± 7 prosentpoeng.

Contents

Preface	3
Abstract	4
Sammendrag	5
1. Introduction	7
2. Overview of the methodology and emission data used	8
2.1. Statistical background for the analysis	8
2.2. Source category level of the analysis	9
2.3. Emission estimates	10
3. Terms and definitions	11
4. Uncertainties in input parameters	12
4.1. Update of uncertainty estimates	12
4.2. Means	13
4.3. Standard deviation and probability density	13
4.4. Dependencies between parameters	21
5. Results and discussion	23
5.1. Uncertainty in emission levels	23
5.2. Uncertainty in emission trends	25
5.3. Uncertainties by source category ("IPCC Table 6.1 and Table 6.2")	25
6. Further improvements	26
References	27
Appendix A: Source category level used in the analysis	29
Appendix B: Table 6.1 and Table 6.2	31
List of tables	51

1. Introduction

Uncertainty estimates are an essential element of a complete inventory of greenhouse gas emissions and removals. In the IPCC Good Practice Guidance (IPCC 2000) it is stated that all Annex I countries should derive uncertainty estimates for both the national level and the trend estimate, as well as for the component parts such as emission factors, activity data and other estimation parameters for each category. The uncertainty analysis is a means to help prioritise national efforts to reduce the uncertainty in the inventories, and guide decisions on methodological choices.

The national greenhouse gas (GHG) emission inventory is compiled from estimates based on emission factors and activity data and direct measurements by plants. All these data and parameters will contribute to the overall inventory uncertainty. The uncertainties and probability distributions of the inventory input parameters have been assessed based on available data and expert judgements. Finally, the level and trend uncertainties of the national GHG emission inventory have been estimated using Monte Carlo simulation. The methods used in the analysis correspond to an IPCC tier 2 method, as described in IPCC Good Practice Guidance (IPCC 2000). Analyses have been made both excluding and including the sector LULUCF (land use, land-use change and forestry).

2. Overview of the methodology and emission data used

2.1. Statistical background for the analysis

In the IPCC Good Practice Guidance (IPCC 2000) two different tiers for uncertainty analysis are described. The tier 1 method is performed by Norway every year for the UNFCCC reporting, as part of the key category analysis. The tier 2 method (based on the Monte Carlo approach) are more resource demanding and has been applied in the present analysis in 2011 and in previous analyses in 2006 and 2000.

The *IPCC tier 1 method* for combining uncertainties in inventory data is to use the error propagation method, which can be summarized by the two rules below:

Rule A: Where uncertain quantities are added, the standard deviation of the sum will be the square root of the sum of the squares of the standard deviations of the quantities that are added (this rule is *exact* for *uncorrelated* variables):

Equation 2.1:

$$U_{\text{total}} = \frac{\sqrt{(U_1 \cdot x_1)^2 + (U_2 \cdot x_2)^2 + \dots + (U_n \cdot x_n)^2}}{x_1 + x_2 + \dots + x_n}$$

Where:

U_{total} is the percentage uncertainty in the sum of the quantities (half the 95% confidence interval divided by the total (i.e. mean) and expressed as a percentage); x_i and U_i are the uncertain quantities and the percentage uncertainties associated with them, respectively.

In inventories, rule A is mainly used when adding source categories.

Rule B: Where uncertain quantities are *multiplied*, the same rule applies, except that the standard deviations must all be expressed as fractions of the appropriate mean values (this rule is *approximate* for *all* random variables).

Equation 2.2:

$$U_{\text{total}} = \sqrt{U_1^2 + U_2^2 + \dots + U_n^2}$$

In inventories, rule B is mainly used when calculating the total uncertainty of a source category from uncertainties in activity and emission factor.

The uncertainties by source categories are estimated using the error propagation equations, and simple combination of uncertainties by source category to estimate the overall uncertainty for one year and the uncertainty in the trend.

The error propagation method has limitations and cannot deal with correlations between datasets or across time. By using the *IPCC tier 2 method* an estimation of uncertainties by source category is made by using Monte Carlo analysis, followed by using Monte Carlo techniques to estimate overall uncertainty for one year and the uncertainty in the trend.

The principle of Monte Carlo analysis is to select random values of each parameter (in our case emission factor and activity data) from within their individual probability density functions, and to calculate the corresponding values (in our case emissions). This procedure is repeated many times, using a computer, and the

results of each calculation run build up the overall emission probability density function.

Monte Carlo analysis may be performed both at the source category level and for the inventory as a whole. As opposed to the tier 1 method, Monte Carlo analysis can deal with different probability density functions, varying degrees of source category correlations and more complex models.

A probability density function describes the range and relative likelihood of possible values. A confidence interval gives an estimated range of values which is likely to include an unknown population parameter, the estimated range being calculated from a given set of sample data. Quantitative uncertainty analysis is performed by estimating the 95 per cent confidence interval of the emission estimates for individual categories, for totals for each gas and for the total inventory.

The software used is internally produced by Statistics Norway, and the computer language "R" is used for the programming.

2.2. Source category level of the analysis

The uncertainty analysis is performed at the most detailed level of IPCC source categories (IPCC 2000). For some source categories an even more detailed specification is used, e.g. where different pollutants from a source sector have to be connected to different activity measures. One example is CH₄ and N₂O emissions from the source category 6B Waste water. The CH₄ emission estimates are based on the number of inhabitants in Norway, which is known with far less uncertainty than the nitrogen budgets used for calculating the N₂O emissions.

A more detailed specification is also made to be able to consider dependencies between only parts of source categories. For example the source category 4D1 Direct soil emissions is partly dependent on the animal numbers used in 4A Enteric fermentation and 4B Manure management, and partly dependent on other activity data.

Fuels have been grouped into five main categories; solid, gaseous, liquid, waste and bio energy. The allocation to groups has been made using international definitions based on the type of the original energy carrier, e.g. refinery gas and fuel gas is placed in "liquid" and CO gas is placed in "solid". This is a change from last analysis in 2006 when fuels were grouped by the physical phase when used. All gases were then classified as "gaseous", regardless of origin. This change affects the allocation of emissions on source categories with different uncertainty estimates.

In Appendix A, the source category level used in the study is listed.

For some source categories a separation into activity and emission factors is not possible due to lack of information. Examples are estimates reported by plants (in the cases when the plants have only reported emissions and not the activity data and emission factors used), and emissions that are aggregated from sources with diverse calculation methodologies (for example emissions from 2C5 Other metal production). These emission source categories have been assigned activity equal to 1, and the emission factor is set to be equal to the estimated emission. This is possible since the total uncertainty estimate is independent of scale for activity and emission factor¹.

¹ We may state the activity in any given unit, as long as the emission factor is stated in the corresponding unit. Examples: tonnes and kg/tonne, Gg and kg/Gg, or, as in this case, unit value and total emissions in kg.

Emissions from landfills, HFCs and some other sources have been transferred into the form of emission factor multiplied with activity rate, in spite of the fact that the estimates are based on more complex estimation models (e.g. taking time lag into account and using several activity data and emission factors).

There are two main sources of uncertainty in the calculated uncertainties:

- 1) Uncertainties in the input uncertainty data
- 2) Sampling uncertainty from the finite number of Monte Carlo simulations.

2.3. Emission estimates

In the analysis emission estimates for the different source categories (Appendix A) for the years 1990 and 2009 are taken from the Norwegian emission inventory. The Norwegian emission inventory is based on a general emission model and a series of more detailed satellite models, which cover specific emission sources and pollutants (e.g. road traffic) (Sandmo 2010). National emissions to air are mainly estimated from activity level statistics and emission factors (emission per unit activity). Emissions from large industrial plants are based on reports from the plants to the Climate and Pollution Agency (Klif).

Data from the 2011 submission to the UNFCCC were used in the analysis. All data except LULUCF were published by Statistics Norway 15.02.2011. The LULUCF data were supplied to the 2011 submission by the The Norwegian Forest and Landscape Institute.

3. Terms and definitions

μ (mean):	The expected value of a random variable, in this case the estimated emission figures in the greenhouse gas inventory
σ (standard deviation):	Shows how much variation or dispersion there is from the average (mean, or expected value). It is the positive square root of the variance of a random variable.
Probability density function:	An expression that gives the frequency of a value for a random variable as a function of that value; or, for continuous random variables, the frequency in an elemental range around that value.
Propagation of uncertainty:	The effect of variables' uncertainties (or errors) on the uncertainty of a function based on them. Or, the uncertainty of the model outputs induced by the uncertainties in its inputs. More information is given in section 2.1
Monte Carlo methods:	A class of computational algorithms that rely on repeated random sampling (or data generation) in order to obtain the solution of a mathematical problem. More information is given in section 2.1
Sensitivity:	Shows how the variation (uncertainty) in the output of a statistical model is attributed to different variations in the inputs of the model. In Appendix B, IPCC Table 6.1, the following sensitivities are defined: <ul style="list-style-type: none"> • Type A sensitivity shows the sensitivity of the trend in emissions to a systematic uncertainty in the emission estimate - i.e. one that is correlated between the base year and year t. • Type B sensitivity shows the sensitivity of the trend in emissions to a random uncertainty error in the emission estimate - i.e. one that is not correlated between the base year and year t.
Uncertainty:	<p>Percentage uncertainty is defined in the Good Practice Guidance (IPCC 2003) in terms of a confidence interval as</p> $\% \text{ uncertainty} = \frac{1}{2} (95\% \text{ Confidence Interval width}) / \mu \times 100$ <p>Under the assumption of (asymptotic) normal distribution, the 95% confidence interval is approximately 4 standard deviations.</p> <p>In the present report, uncertainty is defined as</p> $\% \text{ uncertainty} = 2\sigma / \mu \times 100$

4. Uncertainties in input parameters

This section presents the statistical model used in the analysis: Means, uncertainties and probability densities for all source categories, and dependencies between the parameters. Section 4.1 describes in more detail the changes since previous analyses.

4.1. Update of uncertainty estimates

The uncertainty analysis performed in 2011 is an update of the uncertainty analyses performed for the greenhouse gas inventory in 2006 and 2000. During the project we have been in contact with experts, and have collected information about uncertainty from them. Some other countries' choices of approaches and uncertainty estimates used in their uncertainty analyses have also been studied for information and comparison (Sweden, Denmark, Austria).

There has been a focus on the source categories where methodological changes have been made since the last uncertainty analysis was performed in 2006. For unchanged source categories, the judgement has been made that it is reasonable to assume that not much new information is available, and that no big changes are expected, in the uncertainty estimates after only five years. For the installations included in the emission trading system, new information from the reports about uncertainty in activity data and the CO₂ emission factors have been used. This has improved the quality of the uncertainty estimates for the energy and manufacturing sectors.

The main changes include:

- Where uncertainty estimates from IPCC Good Practice Guidance was used in the analysis in 2006 they have been compared with the corresponding estimates given in the 2006 IPCC Guidelines. A few times where emission factors used in the inventory are the same as in the 2006 IPCC Guidelines, the uncertainty estimates in the 2006 IPCC Guidelines has been taken into account while deciding which uncertainty estimate to use in the analysis (e.g by use of default factors for estimating CH₄ from enteric fermentation).
- All uncertainty estimates for the source categories where a new data source is used or methodological changes have been made since last analysis in 2006, has been reevaluated, for example for solvents and road traffic, where new models have been taken in use.
- The information about uncertainty estimates reported for the installations in the Norwegian Emission Trading System are used for estimating new uncertainty estimates for actual sectors. This is further discussed in the following section.

The Norwegian Emission Trading System

Installations included in the Emission Trading System are obliged to report uncertainty estimates to the Climate and Pollution Agency each year. This information has been used in our uncertainty analysis. Reported data for 2009 have been used (Klif 2011). Uncertainty estimates for activity data and CO₂ emission factors (N₂O for nitric acid production) are used for the installations which are included in the inventory.

Error propagation rules (Eq. 2.1) have been used for calculating the combined uncertainty estimate for all the installations which belongs to the same source category and fuel type in the analysis (Appendix A). In cases where not all activities within the source category are included in the emission trading system, general uncertainty estimates have been used for the remaining activity in the source category, and the total uncertainty for the activity data and emission factor for the source category is calculated with the help of the error propagation rules (Eq. 2.1). For the installations where standard emission factors have been used, no uncertainty estimate is reported to the registry. In these cases the general uncertainty estimate for the emission factor for the actual source category is used.

By using the error propagation rules (Eq. 2.1) when calculating the combined uncertainty we assume that the data for the installations are uncorrelated. There are reasons to believe, though, that this gives an underestimation of the uncertainty in the cases when the same laboratory performs all the measurements throughout a year. We assume in our uncertainty estimations that it is only random measurement errors and no systematic errors, which gives a low uncertainty estimate for installations with many measure observations in one year, and for source categories which has a calculated combined uncertainty based on many different uncertainty estimates. This is for example the case for the uncertainty estimate for CO₂ from offshore gas combustion, where we have reported data from many oil fields, whose data we consider uncorrelated.

Another uncertainty which has not been taken into account is the one arising when we combine energy consumption figures from Statistics Norway's energy statistics with figures from the Norwegian Emission Trading System.

4.2. Means

The true values of the activity data and emission factors are unknown. The parameters that the estimations are based on are frequently called the "best estimate". It might be discussed whether these best estimates represent the mean or the median or something else. We have here assumed that the best estimate equals the mean, which in general is not the most probable value.

The best estimates are determined in the emission inventory development work and are based on Norwegian measurements, literature data or statistical surveys. Some data are based on expert judgements. See Sandmo (2010) for an introduction to the origin of the inventory data.

The emission factors are weighted averages for the source categories, calculated as total source category emission divided by source category activity. These data are not presented separately in this report. Emissions by source category are given in the tables in Appendix B.

4.3. Standard deviation and probability density

The probability densities used in this study have been divided into four types of model shapes:

1. Normal distribution
2. Truncated normal distribution
3. Lognormal distribution
4. Beta distribution

For low uncertainties, the distributions 2-4 above approach the normal distributions. For large uncertainties the normal distribution may lead to negative values. To avoid this, the distributions are when necessary truncated at 0, which means that there is a given probability of the value 0. The lognormal distribution and beta distribution are both asymmetrical distributions, giving a heavier tail of probabilities towards higher values. These two distributions are very similar in shape for low to medium size uncertainties. For higher uncertainties the beta distribution is more flat and the peak in the distribution is more close to the mean value. The beta distribution is, however, only defined for variables taking values between 0 and 1.

The densities were used in the following way: *Normal* or *lognormal* distributions were used for most of the categories. Normal distribution was used for uncertainties up to 30 percent, while lognormal distribution was used for higher uncertainties. Normal distribution was also used for carbon balances (LULUCF). These balances are in principle differences between larger gains and losses that likely were normally distributed with relatively low uncertainties. The balances might take both positive and negative values. *Beta* distribution and *truncated*

normal distribution were used only in a few special cases. Beta distribution was used for N₂O emissions from combustion. Truncated normal distribution was used for CH₄ emissions from stationary combustion of liquid fuels, and from flaring.

The uncertainties and densities given in the following sections are based on information for 2009. However, they were also used for 1990 and for the trend analysis. In reality, due to improved methods, the quality of the 2009 data inventory is higher than that of the 1990 data for several categories. Thus, the analysis may underestimate the uncertainty in 1990 emissions and in the trend. The CO₂ emissions are likely most affected by this problem.

The parameters for the probability density functions are themselves uncertain. This will contribute to uncertainty in the final estimates.

Standard deviation and probability density of activity data

The assessed standard deviations and corresponding probability densities are summarised in Table 4.1.

Table 4.1. Summary of standard deviation and probability density of activity data. 2009

IPCC Source category	Pollutant source	Standard deviation. per cent ^a	Density function	Source/ comment
1A1, 1A2	Coal/coke - general	5	Normal	Expert judgement industry, Norcem <i>pers. comm</i> ²
1A1B	Coal/coke – petroleum refining	1.1	Normal	Emission trading scheme (Klif 2011), Spread in data (Rypdal and Zhang 2000)
1A2A	Coal/coke - iron and steel	4.1	Normal	Emission trading scheme (Klif 2011), Expert judgement industry, Norcem <i>pers. comm</i> ²
1A2F	Coal/coke - other	0.8	Normal	Emission trading scheme (Klif 2011), Expert judgement industry, Norcem <i>pers. comm</i> ²
1A4B	Coal/coke - residential	20	Normal	Expert judgement, Rypdal and Zhang (2000)
1A4C	Coal/coke - agriculture	30	Normal	Expert judgement, Statistics Norway
1A1, 1A2, 1A4	Wood	30	Lognormal	Expert judgement, Rypdal and Zhang (2000)
1A1A	Gas – public electricity and heat production	0.8	Normal	Emission trading scheme (Klif 2011), Expert judgement, Statistics Norway
1A2	Gas - general	4	Normal	Norwegian Petroleum Directorate, Rypdal and Zhang (2000)
1A1C	Gas - manufacture of solid fuels and other energy industries	0.2	Normal	Emission trading scheme (Klif 2011), NPD <i>pers. comm</i> ³
1A2C	Gas - chemicals	1.7	Normal	Emission trading scheme (Klif 2011), Norwegian Petroleum Directorate, Rypdal and Zhang (2000)
1A2D	Gas - pulp, paper, print	1.7	Normal	Emission trading scheme (Klif 2011), Norwegian Petroleum Directorate, Rypdal and Zhang (2000)
1A4A	Gas - commercial/institutional	10	Normal	Expert judgement, Statistics Norway
1A4B, 1A4C	Gas - residential, agriculture/forestry/fishing	30	Normal	Expert judgement, Statistics Norway
1A1, 1A2	Oil - general	3	Normal	Spread in data, Rypdal and Zhang (2000)
1A1B	Oil - petroleum refining	1.1	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)

² Norcem (2006): Personal information, email from Lars André Tokheim, January 24 2006

³ NPD (2006): Personal information Norwegian Petroleum Directorate, email from Marta Melhus, January 26 2006

IPCC Source category	Pollutant source	Standard deviation. per cent ^a	Density function	Source/ comment
1A1C	Oil – manufacture of solid fuels and other energy industries	1.8	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A2A	Oil - iron and steel	0.5	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A2C	Oil - chemicals	14.4	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A2D	Oil – pulp, paper, print	0.7	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A2F	Oil - other	2.6	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A4A	Oil - commercial/institutional	20	Normal	Expert judgement, Statistics Norway
1A4B	Oil - residential	9.5	Normal	Emission trading scheme (Klif 2011), Expert judgement, Statistics Norway
1A4C	Oil - agriculture/forestry	10	Normal	Expert judgement, Statistics Norway
1A1A	Waste – general	5	Normal	Expert judgement, Rypdal and Zhang (2000)
1A2F	Waste - other manufacturing	3.2	Normal	Emission trading scheme (Klif 2011), Expert judgement, Rypdal and Zhang (2000)
1A4A	Waste - commercial/institutional	30	Lognormal	Expert judgement, Rypdal and Zhang (2000)
1A3A, 1A3E	Transport fuel - civil aviation, motorized equipment and pipeline	20	Normal	Expert judgement, Rypdal and Zhang (2000)
1A3B	Transport fuel - road	5	Normal	Expert judgement, Statistics Norway
1A3C	Transport fuel - railway	5	Normal	Expert judgement, Statistics Norway
1A3D	Transport fuel - navigation	20	Normal	Expert judgement, Statistics Norway
1A5A, 1A5B	Military fuel - stationary and mobile	5	Normal	Expert judgement, Statistics Norway
1B1A, 1B2B	Coal mining, extraction of natural gas	3	Normal	Expert judgement, Rypdal and Zhang (2000)
1B2A	Extraction of oil - transport, refining/storage	3	Normal	Expert judgement, Rypdal and Zhang (2000)
1B2A	Extraction of oil - distribution gasoline	5	Normal	Expert judgement, Rypdal and Zhang (2000)
1B2C	Venting	-	-	See emission factor
1B2C	Flaring	1.4	Normal	Emission trading scheme (Klif 2011), Expert judgement, Rypdal and Zhang (2000)
1B2C	Well testing	30	Normal	Expert judgement, Rypdal and Zhang (2000)
2A1	Cement production	0.4	Normal	Emission trading scheme (Klif 2011)
2A2	Lime production	0.4	Normal	Emission trading scheme (Klif 2011)
2A3	Limestone and dolomite use	14.1	Normal	Emission trading scheme (Klif 2011)
2A7	Other mineral production	0.1	Normal	Emission trading scheme (Klif 2011)
2B1	Ammonia production	3	Normal	Expert judgement industry, Yara pers. comm ⁴
2B2	Nitric acid production	-	-	See emission factor
2B4	Carbide production - SiC	3	Normal	Expert judgement industry, St. Gobain and Orkla Exolon pers. comm ⁵
2B4	Carbide production - CaC	3	Normal	Expert judgement, Rypdal and Zhang (2000)
2B5	Methanol and plastic production	9.0	Normal	Emission trading scheme (Klif 2011)

⁴ Yara (2006): Personal information, email from Tore Jensen, January 19 2006

⁵ St. Gobain and Orkla Exolon (2006): Personal information, email from Svein Haarsaker (Orkla Exolon), January 20 2006

IPCC Source category	Pollutant source	Standard deviation. per cent ^a	Density function	Source/ comment
2C1	Iron and steel production	1.23	Normal	Expert judgement industry, Tinfos <i>pers. comm</i> ⁶
2C2	Ferroalloys production	-	-	See emission factor
2C3	Aluminium production	3	Normal	Expert judgement industry, Norsk Hydro <i>pers. comm</i> ⁷
2C4	SF ₆ used in Al and Mg foundries	-	-	See emission factor
2C5	Mg production	0.25	Normal	Expert judgement industry, Norsk Hydro <i>pers. comm</i> ⁸
2C5	Ni production, anodes	10	Normal	Expert judgement, Statistics Norway
2D1	Pulp and paper	0.9	Normal	Emission trading scheme (Klif 2011)
2D2	Carbonic acid, bio protein	10	Normal	Expert judgement, Statistics Norway
2F	Consumption of halocarbons and SF ₆	-	-	See emission factor
3A, 3B, 3C, 3D	Solvent and other product use - CO ₂	-	-	See emission factor
3D	Use of N ₂ O in anaesthesia and as propellant - N ₂ O	-	-	See emission factor
4A	Enteric fermentation	5	Normal	Expert judgement, Statistics Norway, Division for agricultural statistics
4B1-9, 4B13	Manure management - CH ₄	5	Normal	Expert judgement, Statistics Norway, Division for agricultural statistics
4B11-12	Manure management - N ₂ O	24	Normal	Expert judgement ^b , Statistics Norway
4D1	Direct soil emission - fertilizer	5	Normal	(Rypdal 1999)
4D1	Direct soil emission - manure	20	Normal	Rypdal and Zhang (2000)
4D1	Direct soil emission - other	64	Lognormal	Expert judgement ^c , Statistics Norway and Rypdal and Zhang (2000)
4D1	Direct soil emission - organic soil	Fac2	Lognormal	Expert judgement, Statistics Norway
4D2	Animal production	22	Normal	Expert judgement ^d , Statistics Norway
4D3	Indirect soil emission - deposition	30	Lognormal	(Rypdal 1999)
4D3	Indirect soil emission - leakage	70	Lognormal	(Rypdal 1999)
4F1	Agricultural residue burning	10	Normal	Expert judgement, Statistics Norway
5A1	Forest Land remaining Forest Land, - general	-	-	See emission factor
5A1	Forest Land remaining Forest Land - wildfires	20	Normal	Expert judgement, Statistics Norway
5A2	Land converted to Forest Land	-	-	See emission factor
5B1	Cropland remaining Cropland - general	-	-	See emission factor
5B1	Cropland remaining Cropland - liming	5	Normal	Expert judgement, Statistics Norway
5B2	Land converted to Cropland	-	-	See emission factor
5C1	Grassland remaining Grassland	-	-	See emission factor
5C2	Cropland converted to Grassland	-	-	See emission factor
5D1	Wetlands remaining Wetlands	-	-	See emission factor
5D2	Land converted to Wetland	-	-	See emission factor
5E2	Land converted to Settlements	-	-	See emission factor
5F2	Land converted to Other land	-	-	See emission factor

⁶ Tinfos (2006): Personal information, email from Helga Gustavson, Tinfos Titan & Iron KS, January 26 2006

⁷ Norsk Hydro (2006): Personal information, email from Halvor Kvande, January 18 2006

⁸ Norsk Hydro (2006): Personal information, email from Vidar Ersnes, January 18 2006

IPCC Source category	Pollutant source	Standard deviation. per cent ^a	Density function	Source/ comment
5G	Other; Liming of lakes and rivers	5	Normal	Expert judgement, Statistics Norway
6A	Solid waste disposal	20	Normal	Expert judgement, Statistics Norway and SFT <i>pers. comm</i> ⁹
6B	Waste water treatment - CH ₄	1	Lognormal	Expert judgement, Statistics Norway
6B	Waste water treatment - N ₂ O pipeline and plant	25	Normal	Expert judgement, Statistics Norway (2006e)
6B	Waste water treatment - N ₂ O, not connected	30	Normal	Expert judgement, Statistics Norway (2011)
6C	Waste incineration	30	Normal	Expert judgement, Statistics Norway

^a Strongly skewed distributions are characterised as *fac3* etc, indicating that 2σ is a factor 3 below and above the mean.

^b Population 5%, Nex 15%, distribution AWMS 10%, distribution pasture/ storage 15%

^c N fixation 40% and crop residues 50% (Rypdal and Zhang 2000)

^d Population 5%, Nex 15%, distribution pasture/ storage 15%

Standard deviation and probability density of emission factors

The assigned values and probability densities are shown in Table 4.2.

Table 4.2. Summary of standard deviation and probability density of emission factors. 2009

IPCC Source category	Pollutant source	Gas	Standard deviation. per cent ^a	Density function	Source/ comment
1A1, 1A2B, 1A2D, 1A2E, 1A4	Coal/coke - general	CO ₂	7	Normal	Spread in data, Rypdal and Zhang (2000)
1A1B	Coal/coke – petroleum refining	CO ₂	0.9	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A2A	Coal/coke – iron and steel	CO ₂	16.0	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A2F	Coal/coke - other	CO ₂	2.0	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A2, 1A4	Gas - general	CO ₂	3.5	Normal	IPCC (2006), expert judgement, Statistics Norway
1A1A	Gas – public electricity and heat prod	CO ₂	0.6	Normal	Emission trading scheme (Klif 2011), Norwegian Petroleum Directorate, Rypdal and Zhang (2000)
1A1C	Gas – Manufacture of solid fuels and other energy	CO ₂	2.6	Normal	Emission trading scheme (Klif 2011), Norwegian Petroleum Directorate, Rypdal and Zhang (2000)
1A2C	Gas - Chemicals	CO ₂	1.6	Normal	Emission trading scheme (Klif 2011), Norwegian Petroleum Directorate, Rypdal and Zhang (2000)
1A1, 1A2, 1A4	Oil - general	CO ₂	3	Normal	Spread in data, Rypdal and Zhang (2000)
1A1B	Oil – petroleum refining	CO ₂	0.9	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A2C	Oil - Chemicals	CO ₂	1.1	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A2F	Oil - other	CO ₂	2.6	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A4B	Oil - residential	CO ₂	3.4	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)

⁹ SFT (2006): Personal information, email from Per Svardal, the Norwegian Pollution Control Authority, January 27 2006

IPCC Source category	Pollutant source	Gas	Standard deviation. per cent ^a	Density function	Source/ comment
1A1, 1A4	Waste - general	CO ₂	30	Normal	Spread in data, Rypdal and Zhang (2000)
1A2F	Waste - other	CO ₂	25.2	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal and Zhang (2000)
1A3A, 1A3B, 1A3C, 1A3D	Transport fuel	CO ₂	3	Normal	Spread in data, Rypdal and Zhang (2000)
1A5	Military fuel - stationary and mobile	CO ₂	5	Normal	Expert judgement, Statistics Norway
1A1, 1A2, 1A4	Coal/coke, wood, waste - general	CH ₄	Fac2	Lognormal	Spread in data, Rypdal and Zhang (2000)
1A1B	Coal/coke – petroleum refining	CH ₄	Fac2	Truncated N	Spread in data, Rypdal and Zhang (2000)
1A1, 1A2, 1A4, 1A5	Gas – general, military fuel – stationary and mobile	CH ₄	Fac2	Lognormal	Expert judgement, Statistics Norway
1A1, 1A2, 1A4	Oil - general	CH ₄	Fac2	Truncated N	Spread in data, Rypdal and Zhang (2000)
1A3A, 1A3C, 1A3D	Transport fuel	CH ₄	Fac2	Lognormal	Spread in data. Expert judgement, Rypdal and Zhang (2000)
1A3B	Transport fuel	CH ₄	45	Lognormal	(Gustafsson 2005)
1A1, 1A2, 1A4, 1A5	Coal/coke, wood, gas, waste – general, military fuel – stationary and mobile	N ₂ O	Fac3	Beta	Expert judgement, Statistics Norway
1A1, 1A2, 1A4	Oil - general	N ₂ O	Fac3	Beta	Spread in data. Expert judgement. IPCC (1997), Rypdal and Zhang (2000)
1A1B	Coal/coke – petroleum refining	N ₂ O	Fac3	Beta	Spread in data. Expert judgement. IPCC (1997), Rypdal and Zhang (2000)
1A3A, 1A3C, 1A3D	Transport fuel	N ₂ O	Fac3	Beta	Spread in data. Expert judgement, Rypdal and Zhang (2000)
1A3B	Transport fuel	N ₂ O	65	Lognormal	(Gustafsson 2005)
1B1A, 1B2B	Coal mining, extraction of natural gas	CO ₂	Fac2	Lognormal	Expert judgement, Statistics Norway
1B2A	Extraction of oil - transport, refining/storage, distribution gasoline	CO ₂	40	Lognormal	Expert judgement, Statistics Norway
1B2C	Venting	CO ₂	Fac2	Lognormal	Expert judgement, Rypdal and Zhang (2000)
1B2C	Flaring	CO ₂	4.5	Normal	Emission trading scheme (Klif 2011), Rypdal and Zhang (2000)
1B2C	Well testing	CO ₂	7	Normal	Expert judgement, Rypdal and Zhang (2000)
1B1A, 1B2B, 1B2C	Coal mining, extraction of natural gas, venting	CH ₄	Fac2	Lognormal	Expert judgement, Rypdal and Zhang (2000)
1B2A	Extraction of oil - transport, refining/storage	CH ₄	40	Lognormal	Expert judgement, Statistics Norway
1B2C	Flaring, well testing	CH ₄	Fac2	Truncated N	Expert judgement, Rypdal and Zhang (2000)
1B2C	Flaring, well testing	N ₂ O	Fac3	Beta	Expert judgement, Rypdal and Zhang (2000)
2A1	Cement production	CO ₂	0.6	Normal	Emission trading scheme (Klif 2011), IPCC (1997)
2A2	Lime production	CO ₂	0.5	Normal	Emission trading scheme (Klif 2011), Expert judgement, Statistics Norway
2A3, 2A7	Limestone and dolomite use, other mineral production	CO ₂	7	Normal	Expert judgement, Statistics Norway
2B1	Ammonia production	CO ₂	7	Normal	Expert judgement industry, Yara pers. comm ¹⁰
2B4	Carbide production - SiC	CO ₂	10	Normal	Expert judgement industry, St. Gobain and Orkla Exolon pers. comm ¹¹
2B4	Carbide production - CaC	CO ₂	10	Normal	Spread in data, Rypdal and Zhang (2000)
2B5	Methanol and plastic production	CO ₂	0.7	Normal	Emission trading scheme (Klif 2011), Expert judgement, Statistics Norway

¹⁰ Yara (2006): Personal information, email from Tore Jensen, January 19 2006

¹¹ St. Gobain and Orkla Exolon (2006): Personal information, email from Svein Haarsaker (Orkla Exolon), January 20 2006

IPCC Source category	Pollutant source	Gas	Standard deviation. per cent ^a	Density function	Source/ comment
2B4	Carbide production - SiC	CH ₄	10	Normal	SFT <i>pers. comm</i> ¹²
2B5	Methanol and plastic production	CH ₄	Fac2	Lognormal	Expert judgement, Statistics Norway
2B2	Nitric acid production	N ₂ O	6.0	Normal	Expert judgement industry, Yara <i>pers. comm</i> ¹⁰ , Emission trading scheme (Klif 2011)
2C1	Iron and steel production	CO ₂	1.3	Normal	Emission trading scheme (Klif 2011), Expert judgement industry, Tinfos <i>pers. comm</i> ¹³
2C2	Ferroalloys production	CO ₂	3	Normal	Expert judgement, SINTEF <i>pers. comm</i> ¹⁴
2C3	Aluminium production	CO ₂	10	Normal	International Aluminium Institute (IAI), Norsk Hydro <i>pers. comm</i> ¹⁵
2C5	Mg production, Ni production, anodes	CO ₂	10	Normal	Expert judgement, Statistics Norway
2C2	Ferroalloys production	CH ₄	Fac2	Lognormal	Expert judgement, Statistics Norway
2C2	Ferroalloys production	N ₂ O	10	Normal	Expert judgement, Statistics Norway
2C3	Aluminium production	PFK	20	Normal	Expert judgement industry, Norsk Hydro <i>pers. comm</i> ¹³
2C4	SF ₆ used in Al and Mg foundries	SF ₆	0.25	Normal	Expert judgement industry, Norsk Hydro <i>pers. comm</i> ¹⁶
2D1	Pulp and paper	CO ₂	10	Normal	Expert judgement, Statistics Norway
2D2	Carbonic acid, bio protein	CO ₂	10	Normal	Expert judgement, Statistics Norway
2F	Consumption of HFK and PFK	HFK/PFK	50	Lognormal	Apply to HFK. Expert judgement, Statistics Norway
2F	Consumption of SF ₆	SF ₆	60	Lognormal	Expert judgement, Statistics Norway
3A, 3B,3C, 3D	Solvent and other product use	CO ₂	10	Normal	Expert judgement, Statistics Norway
3D	Use of N ₂ O in anaesthesia and as propellant	N ₂ O	15	Normal	Expert judgement, Statistics Norway
A1, 4A3	Enteric fermentation - cattle and sheep	CH ₄	25	Normal	Expert judgement, UMB <i>pers. comm</i> ¹⁷
4A4-10	Enteric fermentation - other animal	CH ₄	40	Normal	IPCC (2006)
4B1-9, 4B13	Manure management	CH ₄	25	Normal	IPCC (1997)
4B11-12	Manure management - N ₂ O	N ₂ O	Fac2	Lognormal	IPCC (1997)
4D1	Direct soil emission	N ₂ O	Fac5	Lognormal	IPCC (2000)
4D2	Animal production	N ₂ O	Fac2	Lognormal	IPCC (2000)
4D3	Indirect soil emission	N ₂ O	Fac3	Lognormal	IPCC (1997)
4F1	Agricultural residue burning	CH ₄	Fac2	Lognormal	Expert judgement, Statistics Norway
4F1	Agricultural residue burning	N ₂ O	Fac3	Beta	Expert judgement, Statistics Norway
5A1	Forest Land remaining Forest Land, Fertilizer	N ₂ O	Fac5	Lognormal	NIJOS (2005)
5A1	Forest Land remaining Forest Land, Drainage	N ₂ O	Fac10	Lognormal	NIJOS (2005)
5A1	Forest Land remaining Forest Land, Wildfires	CH ₄ /N ₂ O	75	Lognormal	NIJOS (2005)
5A1	Forest Land remaining Forest Land, Forest inventory area, Living Biomass	CO ₂	15	Normal	NIJOS (2005)
5A1	Forest Land remaining Forest Land, Forest inventory area, Dead Biomass	CO ₂	50	Lognormal	NIJOS (2005)

¹² SFT (2006): Personal information, email from Eilev Gjerard, the Norwegian Pollution Control Authority, January 20 2006

¹³ Tinfos (2006): Personal information, email from Helga Gustavson, Tinfos Titan & Iron KS, January 26 2006

¹⁴ SINTEF (2006): Personal information, email from Bodil Monsen, February 3 2006

¹⁵ Norsk Hydro (2006): Personal information, email from Halvor Kvande, January 18 2006

¹⁶ Norsk Hydro (2006): Personal information, email from Vidar Ersnes, January 18 2006

¹⁷ UMB (2006): Personal information, email from Harald Volden, the Norwegian University of Life Sciences, January 27 2006

IPCC Source category	Pollutant source	Gas	Standard deviation. per cent ^a	Density function	Source/ comment
5A1	Forest Land remaining Forest Land, Forest inventory area, Soils, Mineral	CO ₂	25	Normal	NIJOS (2005)
5A1	Forest Land remaining Forest Land, Forest inventory area, Soils, Organic	CO ₂	Fac10	Lognormal	NIJOS (2005)
5A2	Land converted to Forest Land, Living biomass	CO ₂	25	Normal	Expert judgement, Statistics Norway
5A2	Land converted to Forest Land, Soils, Mineral	CO ₂	50	Lognormal	Expert judgement, Statistics Norway
5B1	Cropland remaining Cropland, Liming	CO ₂	10	Normal	NIJOS (2005)
5B1	Cropland remaining Cropland, Horticulture, Living biomass	CO ₂	25	Normal	NIJOS (2005)
5B1	Cropland remaining Cropland, Reduced tillage, Soils	CO ₂	Fac2	Lognormal	NIJOS (2005)
5B1	Cropland remaining Cropland, Erosion of new agriculture land, Soils				
5B1	Cropland remaining Cropland, Histosols, Soils	CO ₂	Fac3	Lognormal	NIJOS (2005)
5B2	Land converted to Cropland, Living biomass	CO ₂	25	Normal	NIJOS (2005)
5B2	Land converted to Cropland, Soils, Mineral	CO ₂	50	Lognormal	Expert judgement, Statistics Norway
5B2	Cropland, Disturbance	N ₂ O	Fac10	Lognormal	NIJOS (2005)
5C1	Grassland remaining Grassland, Other Grassland, Living biomass	CO ₂	50	Lognormal	Expert judgement, Statistics Norway
5C1	Grassland remaining Grassland, Histosols, Soils	CO ₂	Fac3	Lognormal	NIJOS (2005)
5C2	Cropland converted to Grassland, Horticulture, Living biomass	CO ₂	25	Normal	NIJOS (2005)
5D1	Wetlands remaining Wetlands, Living biomass	CO ₂	25	Normal	Expert judgement, Statistics Norway
5D1	Wetland remaining Wetland, Peat extraction, Soils	CO ₂	Fac3	Lognormal	NIJOS (2005)
5D2	Land converted to Wetland, Drainage	N ₂ O	Fac10	Lognormal	NIJOS (2005)
5E2	Land converted to Settlements, Living biomass	CO ₂	50	Lognormal	NIJOS (2005)
5E2	Land converted to Settlements, Soils	CO ₂	50	Lognormal	Expert judgement, Statistics Norway
5F2	Land converted to Other land, Living biomass	CO ₂	50	Lognormal	Expert judgement, Statistics Norway
5G	Other; Liming of lakes and rivers	CO ₂	10	Normal	NIJOS (2005)
6A	Solid waste disposal	CH ₄	30	Lognormal	SFT <i>pers. comm</i> ¹⁸
6B	Waste water treatment - CH ₄	CH ₄	50	Lognormal	IPCC (2000) and expert judgement, Statistics Norway ^b
6B	Waste water treatment - N ₂ O, pipeline and plant	N ₂ O	70	Lognormal	Expert judgement, Rypdal and Zhang (2000)
6B	Waste water treatment - N ₂ O, not connected	N ₂ O	Fac5	Lognormal	IPCC (2006) and expert judgement, Statistics Norway
6C	Waste incineration	CO ₂	30	Normal	Expert judgement, Statistics Norway
6C	Waste incineration	CH ₄	Fac2	Lognormal	Expert judgement, Statistics Norway
6C	Waste incineration	N ₂ O	Fac3	Lognormal	Expert judgement, Statistics Norway

^a Strongly skewed distributions are characterised as *fac2*, *fac3*, *fac5* and *fac10*, indicating that 2σ is respectively a factor 2, 3, 5 and 10 below and above the mean.

^b BOD/ person 30%, Bo 30% (IPCC 2000) and MCF 25%. Dependencies between parameters

¹⁸ SFT (2006): Personal information, email from Per Svoldal, the Norwegian Pollution Control Authority, January 27 2006

4.4. Dependencies between parameters

Some of the input parameters (emission factors and activity data) are for various reasons not independent, that means that their values are dependent (or correlated). The problem of dependencies may be solved by appropriate aggregation of the data or explicitly by modelling. In this work we have partly designed the dataset to reduce the problem with dependencies as well as introduced a number of dependence assumptions into the model. The determination of dependencies is sometimes a difficult task and requires some understanding of the data set and the assumptions it is based on.

Initial estimates with variable assumptions have shown that the assumptions on dependencies generally have little effect on the final conclusions on uncertainties. The assumptions of dependencies of data between years are, however, crucial for the determination of trend uncertainty (Rypdal and Zhang 2000).

Dependencies between activity data

The activity data are in principle independent. However, the same activity data may be used to estimate more than one source category (e.g. in the agriculture sector). Also the same activity data are used for estimating emissions of more than one pollutant (especially in the case of energy emissions).

The cases when activity data are assumed dependent in the statistical modelling are:

- The consumption of oil products in each sector. The sum of all oil products has a lower uncertainty than the consumption in each sector. In practice, this is treated by assuming that sectors are independent, and then by scaling all uncertainties so that total uncertainty equals a specified value
- Where the same activity data are used to estimate emissions of more than one pollutant
- The number of domestic animals. The same population data are used for estimation of a) methane from enteric fermentation, b) methane and nitrous oxide from manure management and c) nitrous oxide from agricultural soils
- For estimation of N₂O from manure management, N₂O from manure spreading and N₂O from animal production (pasture) a rough dependency estimation between source categories is made based on the contribution to the total source category emissions from the different animal types. The following dependency estimation has been used for the activity data:
 - 70 % of emissions dependent on cattle population
 - 30 % of emissions dependent on sheep population
- For estimation of N₂O from indirect soil emissions the following dependency estimation has been used for the activity data:
 - 23 % of emissions dependent on cattle population
 - 10 % of emissions dependent on sheep population
 - 67 % of emissions dependent on amount of synthetic fertilizer used

Dependencies between emission factors

Where emission factors have been assumed equal, we have treated them as dependent in the analysis.

The following assumptions have been made:

- The CO₂ emission factors for each fuel type are dependent
- The methane and nitrous oxide emission factors from combustion are dependent where they have been assumed equal in the emission inventory model
- In a few cases the emission factors of different pollutants are correlated. That is in cases when CO₂ is oxidised from methane (oil extraction, loading and coal mining)

- For all direct emissions of N₂O from agricultural soils, except for N₂O from cultivation of organic soil, the same emission factor is being used, and the source categories are dependent
- There is a dependency between the emission factor used for calculating emissions from cropland liming and other liming

There are also likely dependencies between other source categories in LULUCF, e.g. between the activity data in the source categories *5A1-3 Forest Land remaining Forest Land, Forest inventory area, Soils, Organic* and *5A-II Forest Land remaining Forest Land, Drainage*. However, we have no estimates for the uncertainty in activity data. Anyhow, the uncertainty in the emission factors is so large that even if the activity data is given an uncertainty it will have a minimal effect on the total uncertainty estimate for the source category.

Dependencies between data in the base year and the end year

The estimates made for 1990 and 2009 will to a large extent be based on the same data and assumptions.

Activity data

The activity data are determined independently in the two years and are in principle not dependent. Correlation could be considered in cases where activity data can not be updated annually or where updates are based on extrapolations or interpolations of data for another year.

This implies that we have assumed that errors in activity data are random, hence that systematic method errors are insignificant. It is, however, likely that there is a certain correlation between the activity data as they have been determined using the same methods.

Emission factors

Most of the emission factors are assumed unchanged from 1990 to 2009. Those that are not are all based on the same assumptions all years. This implies that all the emission factors are fully correlated between the two years.

This means that we have assumed that the emission factors assumed unchanged actually are unchanged from the base to end year. In reality it is expected that most emission factors are changing, but the degree of change is usually not known. Including this element in the analysis would increase the trend uncertainty.

As mentioned in section 2.2. *Level of the analysis*, for some emission source categories a separation into activity and emission factors is not possible due to lack of information. Emission source categories have then been assigned activity equal to 1, and the emission factor is set to be equal to the estimated emission. Using the current methodology, this gives rise to an error when the trend in emissions is studied. Since the emission factors in the base year and the last year are assumed fully correlated, the trend uncertainty for these source categories turn zero. This gives an underestimation of the uncertainty in the trend.

5. Results and discussion

5.1. Uncertainty in emission levels

The estimated uncertainties of the levels of total emissions and in each gas are shown in Table 5.1 and Table 5.2.

Table 5.1. Uncertainties in emission levels. Each gas and total GWP weighted emissions, excluding the LULUCF sector

	μ (mean)	Fraction of total emissions	Uncertainty 2σ (per cent of mean)
1990			
Total	50 mill. tonnes	1	5
CO ₂	35 mill. tonnes	0.70	3
CH ₄	4.7 mill. tonnes	0.09	17
N ₂ O	4.7 mill. tonnes	0.10	40
HFC	18 tonnes	0.00	50
PFC	3.4 mill. tonnes	0.07	21
SF ₆	2.2 mill. tonnes	0.04	2
2009			
Total	51 mill. tonnes	1	4
CO ₂	43 mill. tonnes	0.84	2
CH ₄	4.3 mill. tonnes	0.08	14
N ₂ O	3.0 mill. tonnes	0.06	58
HFC	708 ktonnes	0.01	48
PFC	379 ktonnes	0.01	20
SF ₆	64 ktonnes	0.00	56

Table 5.2. Uncertainties in emission levels. Each gas and total GWP weighted emissions, including the LULUCF sector

	μ (mean)	Fraction of total emissions	Uncertainty 2σ (per cent of mean)
1990			
Total	41 mill. tonnes	1	7
CO ₂	26 mill. tonnes	0.64	9
CH ₄	4.7 mill. tonnes	0.11	16
N ₂ O	4.7 mill. tonnes	0.12	38
HFC	18 tonnes	0.00	50
PFC	3.4 mill. tonnes	0.08	21
SF ₆	2.2 mill. tonnes	0.05	1
2009			
Total	26 mill. tonnes	1	17
CO ₂	17 mill. tonnes	0.67	23
CH ₄	4.3 mill. tonnes	0.16	14
N ₂ O	3.1 mill. tonnes	0.12	55
HFC	708 ktonnes	0.03	48
PFC	379 ktonnes	0.01	20
SF ₆	64 ktonnes	0.00	63

The total national emissions of GHG (LULUCF sector excluded) in 1990 are estimated with an uncertainty of 5 per cent of the mean. The main emission component CO₂ is known with an uncertainty of 3 per cent of the mean. The total uncertainty level was 4 per cent of the mean in 2009. There have been major changes in uncertainty level for the different emission components between the two years. The highest uncertainty change between 1990 and 2009 is in the uncertainty estimates for the SF₆ emissions, which has increased from 2 to 56 per cent of the mean. However, the SF₆ emissions are strongly reduced because magnesium production was closed down. The figures for the emission of SF₆ from magnesium production was quite well known, but now a larger part of the SF₆ emissions comes from source categories with higher uncertainty. For N₂O there is also a considerable increase in the uncertainty between the years. One reason for the change can be found in that N₂O from the production of synthetic fertilizer with a quite low uncertainty contributes to a smaller part of the total N₂O emissions in 2009 than in 1990. For the other gases there are only smaller changes in the uncertainty.

There is a big net uptake of CO₂ in Norwegian forests, and this reduces the mean value of the total national GHG emissions when the LULUCF sector is included. By including the LULUCF sector the results from the analysis show a total uncertainty of 7 per cent of the mean in 1990 and 17 per cent in 2009. This is due to the fact that the uncertainty in the LULUCF sector in general is higher than in most other sectors.

In the tier 2 uncertainty analysis carried out in the year 2006 (Sandmo 2010), the uncertainty for the total national emissions of GHG (LULUCF sector excluded) in 1990 was estimated to be 7 per cent of the mean. In the new analysis the uncertainty estimate is reduced with two percentage points. There are several reasons for the new lower estimate. One reason is that Statistics Norway and the Climate and Pollution Agency have increased the inventory quality by using improved methodologies for important source categories, as for example emissions from road traffic and from plants that participate in the Emission Trading System.

The main reason for the reduced uncertainty is however that Statistics Norway has collected new and lower uncertainty estimates for some activity data and emission factors that contributed substantially to the total uncertainty in the emission estimate. This means that much of the reduction in the total uncertainty of the inventory is not due to improved inventory methods, since the lower uncertainty partly is an effect of lower uncertainty estimates for some source categories which previously were overestimated. A source category with important reductions in uncertainty since the analysis in 2006 is the uncertainty in emissions of direct N₂O from other agricultural soil sources. This category includes emissions from crop residues, and the uncertainty reduction is mainly a result of lower crop production. Since the uncertainty estimates for agricultural soils are very dominating, changes in these source categories have large impact on the total uncertainty for the inventory.

In the 2006 analysis, the uncertainty in the N₂O estimate was estimated to 57 per cent of the mean. In this year's analysis the uncertainty estimate is reduced to 40 per cent of the mean. The other emission components show just minor changes in the uncertainty estimates for 1990 in the new analysis compared to the analysis from 2006.

For the last year in the two analyses (2004 in the 2006 analysis, 2009 in the present work), the reduction in total uncertainty from 6 to 4 per cent may simply reflect changes in the relative importance of the gases. The share of CO₂ is increased, while the share of N₂O is reduced.

In earlier analyses there has also been an error in the treatment of uncertainty for carbon sinks. This error has now been corrected, which has resulted in higher uncertainty estimates in the analyses including the LULUCF sector than in earlier analyses.

As mentioned earlier, another reason for the reduced uncertainty is that in the years between the two analyses important inventory improvement work has been carried through. New emission sources have also been included to make the greenhouse gas inventory for Norway more complete.

5.2. Uncertainty in emission trends

The estimated uncertainties of the trends of total emissions and each gas are shown in Table 5.3 and Table 5.4.

Table 5.3. Uncertainty of emission trends. 1990-2009, excluding the LULUCF sector

	Per cent change (($\mu_{2009}-\mu_{1990}$)*100/ μ_{1990})	Uncertainty ($2*\sigma*100/\mu_{1990}$)
Total	3	3
CO ₂	23	3
CH ₄	-9	10
N ₂ O	-36	11
HFC	-	-
PFC	-89	17
SF ₆	-97	0

Table 5.4. Uncertainty of emission trends. 1990-2009, including the LULUCF sector

	Per cent change (($\mu_{2009}-\mu_{1990}$)*100/ μ_{1990})	Uncertainty ($2*\sigma*100/\mu_{1990}$)
Total	-37	7
CO ₂	-33	10
CH ₄	-9	10
N ₂ O	-36	12
HFC	-	-
PFC	-89	19
SF ₆	-97	0

The result shows that the increase in the total GHG emissions from 1990 to 2009 is 3 per cent, with an uncertainty in the trend on ± 3 percentage points, when the LULUCF sector is not included. This means that the 2009 emissions are likely between 0 and 6 per cent above the 1990 emissions (a 95 percent confidence interval). Norway is by the ratification of the Kyoto Protocol obliged to limit the emissions of greenhouse gases in the period 2008-2012 to 1 per cent over the emissions in 1990 after trading with CO₂ quotas and the other Kyoto mechanisms is taken into account. It is important to keep in mind that the emission figures reported to the Kyoto Protocol has an uncertainty connected to the reported values.

With the sector LULUCF included in the calculations there has been a decrease in the total emissions figures on -37 per cent, with a trend uncertainty on ± 7 percentage points.

5.3. Uncertainties by source category (“IPCC Table 6.1 and Table 6.2”)

In the IPCC Good Practice Guidance (IPCC 2000) two reporting tables for the tier 1 and tier 2 uncertainty analyses are defined (named “IPCC Table 6.1” and “IPCC Table 6.2”). “IPCC Table 6.2” presents the results from the Monte Carlo analysis for single source categories, and not only for the total inventory and by emission component as has been presented in earlier analyses. “IPCC Table 6.1” gives the results for the tier 1 analysis by source category. The two tables are presented in Appendix B.

6. Further improvements

Areas for further improvements of the uncertainty analysis of the Norwegian greenhouse gas emission inventory:

- A conversion of the computer programme language used for the Monte Carlo analysis from "R" to "SAS", to enhance the userfriendliness.
- Take into account dependencies in the reported uncertainty estimates in the Emission Trading Registry in the analysis.
- Make a deeper analysis of the Norwegian uncertainty estimates for the different source categories and gases by comparing with other countries estimates and with "default" uncertainty estimates in the IPCC Guidelines.

Other areas for further improvements concerning uncertainty:

- An update of the uncertainty estimates for the long-range transboundary air pollutants. These gases were latest analysed in 2001 and need to be reviewed.

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Appendix A: Source category level used in the analysis

IPCC	Source Category	Pollutant source
1A1A	Public electricity and heat prod	General fuel combustion- Coal/coke
1A1A	Public electricity and heat prod	General fuel combustion- Wood
1A1A	Public electricity and heat prod	General fuel combustion- Gas
1A1A	Public electricity and heat prod	General fuel combustion- Oil
1A1A	Public electricity and heat prod	General fuel combustion- Waste
1A1B	Petroleum refining	General fuel combustion- Coal/coke
1A1B	Petroleum refining	General fuel combustion- Oil
1A1C	Manufacture of solid fuels and other energy	General fuel combustion- Gas
1A1C	Manufacture of solid fuels and other energy	General fuel combustion- Oil
1A2A	Iron and steel	General fuel combustion- Coal/coke
1A2A	Iron and steel	General fuel combustion- Wood
1A2A	Iron and steel	General fuel combustion- Gas
1A2A	Iron and steel	General fuel combustion- Oil
1A2B	Non-ferrous metal	General fuel combustion- Coal/coke
1A2B	Non-ferrous metal	General fuel combustion- Wood
1A2B	Non-ferrous metal	General fuel combustion- Gas
1A2B	Non-ferrous metal	General fuel combustion- Oil
1A2C	Chemicals	General fuel combustion- Coal/coke
1A2C	Chemicals	General fuel combustion- Wood
1A2C	Chemicals	General fuel combustion- Gas
1A2C	Chemicals	General fuel combustion- Oil
1A2D	Pulp, paper, print	General fuel combustion- Coal/coke
1A2D	Pulp, paper, print	General fuel combustion- Wood
1A2D	Pulp, paper, print	General fuel combustion- Gas
1A2D	Pulp, paper, print	General fuel combustion- Oil
1A2E	Food processing, beverages, tobacco	General fuel combustion- Coal/coke
1A2E	Food processing, beverages, tobacco	General fuel combustion- Wood
1A2E	Food processing, beverages, tobacco	General fuel combustion- Gas
1A2E	Food processing, beverages, tobacco	General fuel combustion- Oil
1A2F	Other	General fuel combustion- Coal/coke
1A2F	Other	General fuel combustion- Wood
1A2F	Other	General fuel combustion- Gas
1A2F	Other	General fuel combustion- Oil
1A2F	Other	Waste combustion- other manufacturing
1A3A	Transport fuel - civil aviation	
1A3B	Transport fuel - road transportation	
1A3C	Transport fuel - railway	
1A3D	Transport fuel - navigation	
1A3E	Transport fuel - motorized equipment and pipeline	
1A4A	Commercial/institutional	General fuel combustion- Coal/coke
1A4A	Commercial/institutional	General fuel combustion- Wood
1A4A	Commercial/institutional	Gas combustion- commercial/institutional
1A4A	Commercial/institutional	General fuel combustion- Oil
1A4A	Commercial/institutional	Waste combustion - commercial/institutional
1A4B	Residential	Coal/coke combustion- residential
1A4B	Residential	General fuel combustion- Wood
1A4B	Residential	Gas - residential
1A4B	Residential	General fuel combustion- Oil
1A4C	Agriculture/forestry/fishing	Coal/coke combustion- agriculture
1A4C	Agriculture/forestry/fishing	General fuel combustion- Wood
1A4C	Agriculture/forestry/fishing	Gas combustion - agriculture/forestry/fishing
1A4C	Agriculture/forestry/fishing	General fuel combustion- Oil
1A5A	Military	Military fuel - stationary
1A5B	Military	Military fuel - mobile
1B1A	Coal mining, Extraction of natural gas	
1B2A	Extraction of oil - transport	
1B2A	Extraction of oil - refining/storage	
1B2A	Extraction of oil - distribution gasoline	
1B2B	Coal mining, Extraction of natural gas	
1B2C	Venting	
1B2C	Well testing	
1B2C	Flaring	
2A1	Cement production	
2A2	Lime production	
2A3	Limestone and dolomite use	
2A7	Other mineral production	
2B1	Ammonia production	
2B2	Nitric acid production	
2B4	Silicium carbide production	
2B4	Calcium carbide production	
2B5	Methanol and plastic production	
2C1	Iron and steel production	

IPCC	Source Category	Pollutant source
2C2	Ferroalloys production	
2C3	Aluminium production	
2C4	SF6 used in Al and Mg foundries	
2C5	Mg production	
2C5	Ni production, anodes	
2D1	Pulp and paper	
2D2	Carbonic acid, bio protein	
2F	Consumption of halocarbons and SF6	
3A	Paint application	
3B	Degreasing and dry cleaning	
3C	Chemical products, Manufacture and processing	
3D	Other	
4A1	Enteric fermentation - cattle	
4A10	Enteric fermentation - other animal	
4A3	Enteric fermentation - sheep	
4A4	Enteric fermentation - goat	
4A6	Enteric fermentation - horse	
4A8	Enteric fermentation - swine	
4A9	Enteric fermentation - poultry	
4B1	Manure management - CH4 -cattle	
4B11	Manure management - N2O - Liquid storage	
4B12	Manure management - N2O - solid storage	
4B13	Manure management - CH4 - other animal	
4B3	Manure management - CH4 - sheep	
4B4	Manure management - CH4 -goat	
4B6	Manure management - CH4- horse	
4B8	Manure management - CH4- swine	
4B9	Manure management - CH4- poultry	
4D1	Direct soil emission - Fertilizer	
4D1	Direct soil emission - Manure	
4D1	Direct soil emission- Other	
4D1	Direct soil emission- Organic soil	
4D2	Animal production	
4D3	Indirect soil emission- Deposition	
4D3	Indirect soil emission - Leaching, other	
4F1	Burning of straw	
5A1	Forest Land remaining Forest Land, Fertilizer	
5A1	Forest Land remaining Forest Land, Drainage	
5A1	Forest Land remaining Forest Land, Wildfires	
5A1	Forest Land remaining Forest Land, Forest inventory area, Living Biomass	
5A1	Forest Land remaining Forest Land, Forest inventory area, Dead Biomass	
5A1	Forest Land remaining Forest Land, Forest inventory area, Soils, Mineral	
5A1	Forest Land remaining Forest Land, Forest inventory area, Soils, Organic	
5A2	Land converted to Forest Land, Living biomass	
5A2	Land converted to Forest Land, Soils, Mineral	
5B1	Cropland remaining Cropland, Liming	
5B1	Cropland remaining Cropland, Horticulture, Living biomass	
5B1	Cropland remaining Cropland, Reduced tillage, Soils	
5B1	Cropland remaining Cropland, Erosion of new agriculture land, Soils	
5B1	Cropland remaining Cropland, Histosols, Soils	
5B2	Land converted to Cropland, Living biomass	
5B2	Land converted to Cropland, Soils, Mineral	
5B2	Cropland, Disturbance	
5C1	Grassland remaining Grassland, Other Grassland, Living biomass	
5C1	Grassland remaining Grassland, Histosols, Soils	
5C2	Cropland converted to Grassland, Horticulture, Living biomass	
5D1	Wetlands remaining Wetlands, Living biomass	
5D1	Wetland remaining Wetland, Peat extraction, Soils	
5D2	Land converted to Wetland, Drainage	
5E2	Land converted to Settlements, Living biomass	
5E2	Land converted to Settlements, Soils	
5F2	Land converted to Other land, Living biomass	
5G	Other; Liming of lakes and rivers	
6A	Managed waste disposal on land	
6B	Waste water -CH4	
6B	Waste water - N2O pipeline	
6B	Waste water - N2O plant	
6B	Waste water - N2O not connected	
6C	Waste incineration	

Appendix B: Table 6.1 and Table 6.2

Table 6.1. Tier 1 uncertainty calculation and reporting

A	B	C	D	E	F	G	H	I	J	K	L	M	
IPCC Source category	Sub-category	Gas	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity ¹	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the total national emissions
			Input data Gg CO ₂ equivalent	Input data Gg CO ₂ equivalent	Input data %	Input data %	$\sqrt{E^2 + F^2}$	$\frac{G \cdot D}{\Sigma D}$		$\frac{D}{\Sigma C}$	I • F	J • E • $\sqrt{2}$	$\sqrt{K^2 + L^2}$
			%	%	%	%	%	%	%	%	%	%	%
Total			41 203	25 964									
Coal/coke combustion	Public electricity and heat prod	CO ₂	205	112	5	7	8.6	0.037	-0.000	0.003	-0.003	0.019	0.019
Gas combustion	Public electricity and heat prod	CO ₂	-	1 119	1	1	1.0	0.045	0.027	0.027	0.018	0.032	0.036
Oil combustion	Public electricity and heat prod	CO ₂	14	110	3	3	4.2	0.018	0.002	0.003	0.007	0.011	0.013
Waste combustion	Public electricity and heat prod	CO ₂	97	429	5	30	30.4	0.503	0.009	0.010	0.268	0.074	0.278
Coal/coke combustion	Petroleum refining	CO ₂	161	247	1	1	1.4	0.014	0.004	0.006	0.003	0.009	0.010
Oil combustion	Petroleum refining	CO ₂	793	767	1	1	1.4	0.042	0.006	0.019	0.006	0.029	0.029
Gas combustion	Manufacture of solid fuels and other energy	CO ₂	5 185	10 541	0.19	3	2.6	1.052	0.176	0.256	0.456	0.070	0.461
Oil combustion	Manufacture of solid fuels and other energy	CO ₂	251	788	2	3	3.5	0.106	0.015	0.019	0.046	0.048	0.066
Coal/coke combustion	Iron and steel	CO ₂	60	12	4	16	16.5	0.008	-0.001	0.000	-0.010	0.002	0.010
Gas combustion	Iron and steel	CO ₂	-	3	4	4	5.3	0.001	0.000	0.000	0.000	0.000	0.000
Oil combustion	Iron and steel	CO ₂	45	59	0	3	3.0	0.007	0.001	0.001	0.002	0.001	0.002
Coal/coke combustion	Non-ferrous metal	CO ₂	0	0	5	7	8.6	-	-0.000	-	-0.000	-	0.000
Gas combustion	Non-ferrous metal	CO ₂	-	104	4	4	5.3	0.021	0.003	0.003	0.009	0.014	0.017
Oil combustion	Non-ferrous metal	CO ₂	268	83	3	3	4.2	0.014	-0.002	0.002	-0.006	0.009	0.011
Coal/coke combustion	Chemicals	CO ₂	133	110	5	7	8.6	0.037	0.001	0.003	0.004	0.019	0.019
Gas combustion	Chemicals	CO ₂	-	369	2	2	2.3	0.033	0.009	0.009	0.014	0.021	0.025
Oil combustion	Chemicals	CO ₂	1 064	837	14	1	14.4	0.465	0.004	0.020	0.004	0.413	0.413
Coal/coke combustion	Pulp, paper, print	CO ₂	16	0	5	7	8.6	-	-0.000	-	-0.002	-	0.002
Gas combustion	Pulp, paper, print	CO ₂	-	3	2	4	3.9	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Pulp, paper, print	CO ₂	210	336	1	3	3.1	0.040	0.005	0.008	0.015	0.008	0.017
Coal/coke combustion	Food processing, beverages, tobacco	CO ₂	10	0	5	7	8.6	-	-0.000	-	-0.001	-	0.001
Gas combustion	Food processing, beverages, tobacco	CO ₂	-	89	4	4	5.3	0.018	0.002	0.002	0.008	0.012	0.014
Oil combustion	Food processing, beverages, tobacco	CO ₂	456	237	3	3	4.2	0.039	-0.001	0.006	-0.004	0.024	0.025
Coal/coke combustion	Other manufacturing	CO ₂	396	335	1	2	2.2	0.028	0.002	0.008	0.004	0.009	0.010
Gas combustion	Other manufacturing	CO ₂	-	69	4	4	5.3	0.014	0.002	0.002	0.006	0.009	0.011
Oil combustion	Other manufacturing	CO ₂	1 135	815	3	3	3.8	0.120	0.002	0.020	0.007	0.073	0.074
Waste combustion	Other manufacturing	CO ₂	-	47	3	25	25.4	0.046	0.001	0.001	0.029	0.005	0.029
Transport fuel - civil aviation		CO ₂	679	1 071	20	3	20.2	0.834	0.016	0.026	0.047	0.735	0.736

A	B	C	D	E	F	G	H	I	J	K	L	M	
IPCC Source category	Sub-category	Gas	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity ¹	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Input data Gg CO ₂ equivalent	Input data Gg CO ₂ equivalent	Input data %	Input data %	$\sqrt{E^2 + F^2}$	$\frac{G \cdot D}{\Sigma D}$		$\frac{D}{\Sigma C}$	I • F	J • E • $\sqrt{2}$	$\sqrt{K^2 + L^2}$
							%	%	%	%	%	%	%
Transport fuel - road transportation		CO ₂	7 630	9 697	5	3	5.8	2.178	0.118	0.235	0.355	1.664	1.702
Transport fuel - railway		CO ₂	96	45	5	3	5.8	0.010	-0.000	0.001	-0.001	0.008	0.008
Transport fuel - navigation		CO ₂	1 696	2 001	20	3	20.2	1.558	0.023	0.049	0.068	1.373	1.375
Transport fuel - motorized equipment and pipeline		CO ₂	760	1 211	20	3	20.2	0.943	0.018	0.029	0.053	0.831	0.833
Coal/coke combustion	Commercial/institutional	CO ₂	-	5	20	7	21.2	0.004	0.000	0.000	0.001	0.004	0.004
Gas combustion	Commercial/institutional	CO ₂	-	50	10	4	10.6	0.021	0.001	0.001	0.004	0.017	0.018
Oil combustion	Commercial/institutional	CO ₂	812	734	20	3	20.2	0.571	0.005	0.018	0.016	0.504	0.504
Waste combustion	Commercial/institutional	CO ₂	3	0	30	30	42.4	-	-0.000	-	-0.001	-	0.001
Coal/coke combustion	Residential	CO ₂	24	2	20	7	21.2	0.001	-0.000	0.000	-0.002	0.001	0.003
Gas combustion	Residential	CO ₂	-	8	30	4	30.2	0.009	0.000	0.000	0.001	0.008	0.008
Oil combustion	Residential	CO ₂	1 318	454	9	3	10.1	0.176	-0.009	0.011	-0.031	0.148	0.151
Coal/coke combustion	Agriculture/forestry/fishing	CO ₂	12	0	30	7	30.8	-	-0.000	-	-0.001	-	0.001
Gas combustion	Agriculture/forestry/fishing	CO ₂	-	42	30	4	30.2	0.049	0.001	0.001	0.004	0.043	0.044
Oil combustion	Agriculture/forestry/fishing	CO ₂	1 975	1 883	10	3	10.4	0.757	0.015	0.046	0.046	0.646	0.648
Military fuel - stationary	Military	CO ₂	62	35	5	5	7.1	0.010	-0.000	0.001	-0.001	0.006	0.006
Military fuel - mobile	Military	CO ₂	394	228	5	5	7.1	0.062	-0.000	0.006	-0.002	0.039	0.039
Coal mining, Extraction of natural gas		CO ₂	7	5	3	72	72.1	0.013	-0.000	0.000	-0.000	0.000	0.000
Extraction of oil - transport		CO ₂	367	124	3	40	40.1	0.192	-0.003	0.003	-0.104	0.013	0.105
Extraction of oil - refining/storage		CO ₂	749	873	3	40	40.1	1.349	0.010	0.021	0.390	0.090	0.400
Extraction of oil - distribution gasoline		CO ₂	30	14	5	40	40.3	0.022	-0.000	0.000	-0.005	0.002	0.005
Coal mining, Extraction of natural gas		CO ₂	4	13	3	72	72.1	0.035	0.000	0.000	0.018	0.001	0.018
Venting		CO ₂	27	117	-	72	72.0	0.324	0.002	0.003	0.174	-	0.174
Well testing		CO ₂	80	20	30	7	30.8	0.024	-0.001	0.000	-0.005	0.021	0.021
Flaring		CO ₂	1 393	1 266	1	5	4.7	0.230	0.009	0.031	0.043	0.061	0.074
Cement production		CO ₂	634	842	0	1	0.7	0.023	0.011	0.020	0.006	0.013	0.014
Lime production		CO ₂	47	137	0	0	0.6	0.003	0.003	0.003	0.001	0.002	0.002
Limestone and dolomite use		CO ₂	24	31	14	7	15.8	0.019	0.000	0.001	0.003	0.015	0.015
Other mineral production		CO ₂	2	2	0	7	7.0	0.001	0.000	0.000	0.000	0.000	0.000
Ammonia production		CO ₂	500	335	3	7	7.6	0.098	0.000	0.008	0.003	0.034	0.035
Silicium carbide production		CO ₂	222	51	3	10	10.4	0.020	-0.002	0.001	-0.022	0.005	0.022

A	B	C	D	E	F	G	H	I	J	K	L	M	
IPCC Source category	Sub-category	Gas	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity ¹	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Input data Gg CO ₂ equivalent	Input data Gg CO ₂ equivalent	Input data %	Input data %	$\sqrt{E^2 + F^2}$	$\frac{G \cdot D}{\Sigma D}$		$\frac{D}{\Sigma C}$	I • F	J • E • $\sqrt{2}$	$\sqrt{K^2 + L^2}$
							%	%	%	%	%	%	%
Calcium carbide production		CO ₂	178	0	3	10	10.4	-	-0.003	-	-0.027	-	0.027
Methanol and plastic production		CO ₂	3	95	9	1	9.0	0.033	0.002	0.002	0.002	0.029	0.029
Iron and steel production		CO ₂	213	270	1	1	1.8	0.019	0.003	0.007	0.004	0.011	0.012
Ferroalloys production		CO ₂	2 554	1 446	-	3	3.0	0.167	-0.004	0.035	-0.012	-	0.012
Aluminium production		CO ₂	1 419	1 725	3	10	10.4	0.694	0.020	0.042	0.202	0.178	0.269
Mg production		CO ₂	128	0	0	10	10.0	-	-0.002	-	-0.020	-	0.020
Ni production, anodes		CO ₂	26	95	10	10	14.1	0.052	0.002	0.002	0.019	0.033	0.038
Pulp and paper		CO ₂	10	9	1	10	10.0	0.003	0.000	0.000	0.001	0.000	0.001
Carbonic acid, bio protein		CO ₂	67	172	10	10	14.1	0.094	0.003	0.004	0.031	0.059	0.067
Paint application		CO ₂	39	17	-	10	10.0	0.007	-0.000	0.000	-0.002	-	0.002
Degreasing and dry cleaning		CO ₂	-	1	-	10	10.0	0.000	0.000	0.000	0.000	-	0.000
Chemical products, Manufacture and processing		CO ₂	8	1	-	10	10.0	0.000	-0.000	0.000	-0.001	-	0.001
Other		CO ₂	100	96	-	10	10.0	0.037	0.001	0.002	0.008	-	0.008
Forest Land remaining Forest Land, Forest inventory area, Living Biomass		CO ₂	-6 413	-22 172	-	15	15.0	-12.809	-0.441	-0.538	-6.611	-	6.611
Forest Land remaining Forest Land, Forest inventory area, Dead Biomass		CO ₂	-2 042	-1 002	-	50	50.0	-1.929	0.007	-0.024	0.347	-	0.347
Forest Land remaining Forest Land, Forest inventory area, Soils, Mineral		CO ₂	-3 056	-4 584	-	25	25.0	-4.414	-0.065	-0.111	-1.614	-	1.614
Forest Land remaining Forest Land, Forest inventory area, Soils, Organic		CO ₂	136	144	-	280	280.0	1.552	0.001	0.003	0.396	-	0.396
Land converted to Forest Land, Living biomass		CO ₂	-5	-365	-	25	25.0	-0.352	-0.009	-0.009	-0.219	-	0.219
Land converted to Forest Land, Soils, Mineral		CO ₂	30	71	-	50	50.0	0.137	0.001	0.002	0.063	-	0.063
Cropland remaining Cropland, Liming		CO ₂	217	83	5	10	11.2	0.036	-0.001	0.002	-0.013	0.014	0.019
Cropland remaining Cropland, Horticulture, Living biomass		CO ₂	-24	-18	-	25	25.0	-0.018	-0.000	-0.000	-0.002	-	0.002

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			Input data Gg CO ₂ equivalent	Input data Gg CO ₂ equivalent	Input data %	Input data %	$\sqrt{E^2 + F^2}$	$\frac{G \cdot D}{\sum D}$		$\frac{D}{\sum C}$	I • F	J • E • $\sqrt{2}$	$\sqrt{K^2 + L^2}$
							%	%	%	%	%	%	%
Cropland remaining Cropland, Reduced tillage, Soils		CO ₂	-	-180	-	72	72.0	-0.499	-0.004	-0.004	-0.314	-	0.314
Cropland remaining Cropland, Erosion of new agriculture land, Soils		CO ₂	6	1	-	-	0.0	-	-0.000	0.000	-	-	-
Cropland remaining Cropland, Histosols, Soils		CO ₂	208	208	-	100	100.0	0.801	0.002	0.005	0.187	-	0.187
Land converted to Cropland, Living biomass		CO ₂	52	-2	-	25	25.0	-0.002	-0.001	-0.000	-0.021	-	0.021
Land converted to Cropland, Soils, Mineral		CO ₂	1	28	-	50	50.0	0.054	0.001	0.001	0.033	-	0.033
Grassland remaining Grassland, Other Grassland, Living biomass		CO ₂	126	0	-	50	50.0	-	-0.002	-	-0.096	-	0.096
Grassland remaining Grassland, Histosols, Soils		CO ₂	1 870	1 870	-	100	100.0	7.202	0.017	0.045	1.678	-	1.678
Wetland remaining Wetland, Peat extraction, Soils		CO ₂	3	3	-	100	100.0	0.013	0.000	0.000	0.003	-	0.003
Land converted to Settlements, Living biomass		CO ₂	271	299	-	50	50.0	0.577	0.003	0.007	0.156	-	0.156
Land converted to Settlements, Soils		CO ₂	39	259	-	50	50.0	0.500	0.006	0.006	0.285	-	0.285
Land converted to Other land, Living biomass		CO ₂	-	-4	-	50	50.0	-0.008	-0.000	-0.000	-0.005	-	0.005
Other; Liming of lakes and rivers		CO ₂	10	17	5	10	11.2	0.007	0.000	0.000	0.002	0.003	0.004
Waste incineration		CO ₂	0	0	30	30	42.4	-	-0.000	-	-0.000	-	0.000
Coal/coke combustion	Public electricity and heat prod	CH ₄	0	0	5	72	72.2	0.000	0.000	0.000	0.000	0.000	0.000
Wood combustion	Public electricity and heat prod	CH ₄	0	2	30	72	78.0	0.005	0.000	0.000	0.002	0.002	0.003
Gas combustion	Public electricity and heat prod	CH ₄	-	9	1	72	72.0	0.026	0.000	0.000	0.016	0.000	0.016
Oil combustion	Public electricity and heat prod	CH ₄	0	0	3	72	72.1	0.000	0.000	0.000	0.000	0.000	0.000
Waste combustion	Public electricity and heat prod	CH ₄	2	4	5	72	72.2	0.011	0.000	0.000	0.005	0.001	0.005
Oil combustion	Petroleum refining	CH ₄	5	1	1	72	72.0	0.002	-0.000	0.000	-0.004	0.000	0.004
Gas combustion	Manufacture of solid fuels and other energy	CH ₄	41	82	0	72	72.0	0.229	0.001	0.002	0.099	0.001	0.099

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							%	%	%	%	%	%	%
Oil combustion	Manufacture of solid fuels and other energy	CH ₄	0	0	2	72	72.0	0.000	-0.000	0.000	-0.000	0.000	0.000
Coal/coke combustion	Iron and steel	CH ₄	0	0	4	72	72.1	0.000	-0.000	0.000	-0.000	0.000	0.000
Wood combustion	Iron and steel	CH ₄	0	0	30	72	78.0	0.000	0.000	0.000	0.000	0.000	0.000
Gas combustion	Iron and steel	CH ₄	-	0	4	72	72.1	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Iron and steel	CH ₄	0	0	0	72	72.0	0.000	0.000	0.000	0.000	0.000	0.000
Wood combustion	Non-ferrous metal	CH ₄	-	0	30	72	78.0	0.000	0.000	0.000	0.000	0.000	0.000
Gas combustion	Non-ferrous metal	CH ₄	-	0	4	72	72.1	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Non-ferrous metal	CH ₄	0	0	3	72	72.1	0.000	-0.000	0.000	-0.000	0.000	0.000
Coal/coke combustion	Chemicals	CH ₄	0	0	5	72	72.2	0.000	0.000	0.000	0.000	0.000	0.000
Wood combustion	Chemicals	CH ₄	0	0	30	72	78.0	0.001	0.000	0.000	0.000	0.000	0.000
Gas combustion	Chemicals	CH ₄	-	0	2	72	72.0	0.001	0.000	0.000	0.001	0.000	0.001
Oil combustion	Chemicals	CH ₄	1	1	14	72	73.4	0.004	0.000	0.000	0.001	0.001	0.001
Coal/coke combustion	Pulp, paper, print	CH ₄	0	0	5	72	72.2	-	-0.000	-	-0.000	-	0.000
Wood combustion	Pulp, paper, print	CH ₄	6	5	30	72	78.0	0.014	0.000	0.000	0.002	0.005	0.005
Gas combustion	Pulp, paper, print	CH ₄	-	0	2	72	72.0	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Pulp, paper, print	CH ₄	0	0	1	72	72.0	0.000	0.000	0.000	0.000	0.000	0.000
Coal/coke combustion	Food processing, beverages, tobacco	CH ₄	0	0	5	72	72.2	-	-0.000	-	-0.000	-	0.000
Wood combustion	Food processing, beverages, tobacco	CH ₄	0	0	30	72	78.0	0.000	-0.000	0.000	-0.000	0.000	0.000
Gas combustion	Food processing, beverages, tobacco	CH ₄	-	0	4	72	72.1	0.001	0.000	0.000	0.000	0.000	0.000
Oil combustion	Food processing, beverages, tobacco	CH ₄	0	0	3	72	72.1	0.000	-0.000	0.000	-0.000	0.000	0.000
Coal/coke combustion	Other manufacturing	CH ₄	0	0	1	72	72.0	0.000	0.000	0.000	0.000	0.000	0.000
Wood combustion	Other manufacturing	CH ₄	1	1	30	72	78.0	0.003	0.000	0.000	0.000	0.001	0.001
Gas combustion	Other manufacturing	CH ₄	-	0	4	72	72.1	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Other manufacturing	CH ₄	2	2	3	72	72.0	0.005	0.000	0.000	0.001	0.000	0.001
Waste combustion	Other manufacturing	CH ₄	-	1	3	72	72.1	0.001	0.000	0.000	0.001	0.000	0.001
Transport fuel - civil aviation		CH ₄	0	1	20	72	74.7	0.002	0.000	0.000	0.001	0.000	0.001
Transport fuel - road transportation		CH ₄	71	18	5	45	45.3	0.032	-0.001	0.000	-0.029	0.003	0.029
Transport fuel - railway		CH ₄	0	0	5	72	72.2	0.000	-0.000	0.000	-0.000	0.000	0.000
Transport fuel - navigation		CH ₄	4	52	20	72	74.7	0.149	0.001	0.001	0.086	0.036	0.093

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							%	%	%	%	%	%	%
Transport fuel - motorized equipment and pipeline		CH ₄	7	9	20	72	74.7	0.026	0.000	0.000	0.008	0.006	0.010
Coal/coke combustion	Commercial/institutional	CH ₄	-	0	20	72	74.7	0.000	0.000	0.000	0.000	0.000	0.000
Wood combustion	Commercial/institutional	CH ₄	0	0	30	72	78.0	0.001	0.000	0.000	0.000	0.000	0.000
Gas combustion	Commercial/institutional	CH ₄	-	0	10	72	72.7	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Commercial/institutional	CH ₄	2	2	20	72	74.7	0.006	0.000	0.000	0.001	0.001	0.002
Waste combustion	Commercial/institutional	CH ₄	0	0	30	72	78.0	-	-0.000	-	-0.000	-	0.000
Coal/coke combustion	Residential	CH ₄	2	0	20	72	74.7	0.000	-0.000	0.000	-0.002	0.000	0.002
Wood combustion	Residential	CH ₄	111	142	30	72	78.0	0.426	0.002	0.003	0.125	0.146	0.192
Gas combustion	Residential	CH ₄	-	0	30	72	78.0	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Residential	CH ₄	3	1	9	72	72.6	0.003	-0.000	0.000	-0.002	0.000	0.002
Coal/coke combustion	Agriculture/forestry/fishing	CH ₄	0	0	30	72	78.0	-	-0.000	-	-0.000	-	0.000
Wood combustion	Agriculture/forestry/fishing	CH ₄	-	0	30	72	78.0	0.000	0.000	0.000	0.000	0.000	0.000
Gas combustion	Agriculture/forestry/fishing	CH ₄	-	0	30	72	78.0	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Agriculture/forestry/fishing	CH ₄	4	3	10	72	72.7	0.009	0.000	0.000	0.001	0.001	0.002
Military fuel - stationary	Military	CH ₄	0	0	5	72	72.2	0.000	0.000	0.000	0.000	0.000	0.000
Military fuel - mobile	Military	CH ₄	0	0	5	72	72.2	0.001	0.000	0.000	0.000	0.000	0.000
Coal mining, Extraction of natural gas		CH ₄	56	35	3	72	72.1	0.098	-0.000	0.001	-0.001	0.004	0.004
Extraction of oil - transport		CH ₄	129	153	3	40	40.1	0.236	0.002	0.004	0.069	0.016	0.071
Extraction of oil - refining/storage		CH ₄	35	48	3	40	40.1	0.074	0.001	0.001	0.025	0.005	0.025
Coal mining, Extraction of natural gas		CH ₄	3	47	3	72	72.1	0.130	0.001	0.001	0.079	0.005	0.079
Venting		CH ₄	143	331	-	72	72.0	0.918	0.006	0.008	0.421	-	0.421
Well testing		CH ₄	0	0	30	72	78.0	0.000	-0.000	0.000	-0.000	0.000	0.000
Flaring		CH ₄	10	14	1	72	72.0	0.038	0.000	0.000	0.013	0.001	0.013
Silicium carbide production		CH ₄	7	2	3	10	10.4	0.001	-0.000	0.000	-0.001	0.000	0.001
Methanol and plastic production		CH ₄	2	3	9	72	72.6	0.008	0.000	0.000	0.003	0.001	0.003
Ferroalloys production		CH ₄	1	1	-	72	72.0	0.002	0.000	0.000	0.000	-	0.000
Enteric fermentation - cattle		CH ₄	1 420	1 268	5	25	25.5	1.245	0.009	0.031	0.226	0.218	0.314
Enteric fermentation - other animal		CH ₄	102	111	5	40	40.3	0.172	0.001	0.003	0.045	0.019	0.049
Enteric fermentation - sheep		CH ₄	431	461	5	25	25.5	0.453	0.005	0.011	0.115	0.079	0.140

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							%	%	%	%	%	%	%
Enteric fermentation - goat		CH ₄	9	7	5	40	40.3	0.010	0.000	0.000	0.001	0.001	0.002
Enteric fermentation - horse		CH ₄	12	25	5	40	40.3	0.039	0.000	0.001	0.017	0.004	0.017
Enteric fermentation - swine		CH ₄	17	22	5	40	40.3	0.034	0.000	0.001	0.011	0.004	0.012
Enteric fermentation - poultry		CH ₄	1	2	5	40	40.3	0.003	0.000	0.000	0.001	0.000	0.001
Manure management - CH ₄ - cattle		CH ₄	215	194	5	25	25.5	0.191	0.001	0.005	0.036	0.033	0.049
Manure management - CH ₄ - other animal		CH ₄	4	5	5	25	25.5	0.005	0.000	0.000	0.001	0.001	0.002
Manure management - CH ₄ - sheep		CH ₄	24	24	5	25	25.5	0.024	0.000	0.001	0.005	0.004	0.007
Manure management - CH ₄ - goat		CH ₄	2	1	5	25	25.5	0.001	0.000	0.000	0.000	0.000	0.000
Manure management - CH ₄ - horse		CH ₄	11	23	5	25	25.5	0.023	0.000	0.001	0.010	0.004	0.011
Manure management - CH ₄ - swine		CH ₄	23	29	5	25	25.5	0.029	0.000	0.001	0.009	0.005	0.010
Manure management - CH ₄ - poultry		CH ₄	19	37	5	25	25.5	0.037	0.001	0.001	0.015	0.006	0.017
Burning of straw		CH ₄	23	3	10	72	72.7	0.010	-0.000	0.000	-0.019	0.001	0.019
Forest Land remaining Forest Land, Wildfires		CH ₄	2	3	20	75	77.6	0.008	0.000	0.000	0.003	0.002	0.003
Managed waste disposal on land		CH ₄	1 682	1 065	20	30	36.1	1.479	0.000	0.026	0.004	0.731	0.731
Waste water - CH ₄		CH ₄	20	10	1	50	50.0	0.019	-0.000	0.000	-0.003	0.000	0.003
Waste incineration		CH ₄	0	0	30	72	78.0	0.000	0.000	0.000	0.000	0.000	0.000
Coal/coke combustion	Public electricity and heat prod	N ₂ O	1	1	5	100	100.1	0.002	-0.000	0.000	-0.000	0.000	0.000
Wood combustion	Public electricity and heat prod	N ₂ O	2	5	30	100	104.4	0.020	0.000	0.000	0.009	0.005	0.010
Gas combustion	Public electricity and heat prod	N ₂ O	-	3	1	100	100.0	0.011	0.000	0.000	0.007	0.000	0.007
Oil combustion	Public electricity and heat prod	N ₂ O	0	0	3	100	100.0	0.001	0.000	0.000	0.001	0.000	0.001
Waste combustion	Public electricity and heat prod	N ₂ O	4	6	5	100	100.1	0.025	0.000	0.000	0.009	0.001	0.009
Coal/coke combustion	Petroleum refining	N ₂ O	0	0	1	100	100.0	0.002	0.000	0.000	0.001	0.000	0.001
Oil combustion	Petroleum refining	N ₂ O	5	2	1	100	100.0	0.009	-0.000	0.000	-0.003	0.000	0.003
Gas combustion	Manufacture of solid fuels and other energy	N ₂ O	14	27	0	100	100.0	0.105	0.000	0.001	0.045	0.000	0.045
Oil combustion	Manufacture of solid fuels and other energy	N ₂ O	1	2	2	100	100.0	0.007	0.000	0.000	0.004	0.000	0.004

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							%	%	%	%	%	%	%
Coal/coke combustion	Iron and steel	N ₂ O	0	0	4	100	100.1	0.001	-0.000	0.000	-0.000	0.000	0.000
Wood combustion	Iron and steel	N ₂ O	0	0	30	100	104.4	0.000	0.000	0.000	0.000	0.000	0.000
Gas combustion	Iron and steel	N ₂ O	-	0	4	100	100.1	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Iron and steel	N ₂ O	0	0	0	100	100.0	0.000	-0.000	0.000	-0.000	0.000	0.000
Wood combustion	Non-ferrous metal	N ₂ O	-	0	30	100	104.4	0.001	0.000	0.000	0.001	0.000	0.001
Gas combustion	Non-ferrous metal	N ₂ O	-	0	4	100	100.1	0.001	0.000	0.000	0.001	0.000	0.001
Oil combustion	Non-ferrous metal	N ₂ O	1	0	3	100	100.0	0.001	-0.000	0.000	-0.001	0.000	0.001
Coal/coke combustion	Chemicals	N ₂ O	1	1	5	100	100.1	0.002	0.000	0.000	0.000	0.000	0.000
Wood combustion	Chemicals	N ₂ O	0	1	30	100	104.4	0.003	0.000	0.000	0.002	0.001	0.002
Gas combustion	Chemicals	N ₂ O	-	0	2	100	100.0	0.001	0.000	0.000	0.001	0.000	0.001
Oil combustion	Chemicals	N ₂ O	1	2	14	100	101.0	0.008	0.000	0.000	0.003	0.001	0.003
Coal/coke combustion	Pulp, paper, print	N ₂ O	0	0	5	100	100.1	-	-0.000	-	-0.000	-	0.000
Wood combustion	Pulp, paper, print	N ₂ O	27	20	30	100	104.4	0.079	0.000	0.000	0.006	0.020	0.021
Gas combustion	Pulp, paper, print	N ₂ O	-	0	2	100	100.0	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Pulp, paper, print	N ₂ O	1	1	1	100	100.0	0.004	0.000	0.000	0.001	0.000	0.001
Coal/coke combustion	Food processing, beverages, tobacco	N ₂ O	0	0	5	100	100.1	-	-0.000	-	-0.000	-	0.000
Wood combustion	Food processing, beverages, tobacco	N ₂ O	0	0	30	100	104.4	0.000	-0.000	0.000	-0.000	0.000	0.000
Gas combustion	Food processing, beverages, tobacco	N ₂ O	-	0	4	100	100.1	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Food processing, beverages, tobacco	N ₂ O	1	1	3	100	100.0	0.003	-0.000	0.000	-0.000	0.000	0.000
Coal/coke combustion	Other manufacturing	N ₂ O	0	0	1	100	100.0	0.001	0.000	0.000	0.001	0.000	0.001
Wood combustion	Other manufacturing	N ₂ O	6	4	30	100	104.4	0.017	0.000	0.000	0.001	0.004	0.005
Gas combustion	Other manufacturing	N ₂ O	-	0	4	100	100.1	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Other manufacturing	N ₂ O	3	2	3	100	100.0	0.008	0.000	0.000	0.001	0.000	0.001
Waste combustion	Other manufacturing	N ₂ O	-	1	3	100	100.1	0.004	0.000	0.000	0.003	0.000	0.003
Transport fuel - civil aviation		N ₂ O	7	11	20	100	102.0	0.041	0.000	0.000	0.015	0.007	0.017
Transport fuel - road transportation		N ₂ O	57	59	5	65	65.2	0.149	0.001	0.001	0.037	0.010	0.039
Transport fuel - railway		N ₂ O	11	5	5	100	100.1	0.020	-0.000	0.000	-0.004	0.001	0.005
Transport fuel - navigation		N ₂ O	11	14	20	100	102.0	0.057	0.000	0.000	0.018	0.010	0.021
Transport fuel - motorized equipment and pipeline		N ₂ O	69	125	20	100	102.0	0.490	0.002	0.003	0.197	0.086	0.215
Coal/coke combustion	Commercial/institutional	N ₂ O	-	0	20	100	102.0	0.000	0.000	0.000	0.000	0.000	0.000

A	B	C	D	E	F	G	H	I	J	K	L	M	
IPCC Source category	Sub-category	Gas	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity ¹	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Input data Gg CO ₂ equivalent	Input data Gg CO ₂ equivalent	Input data %	Input data %	$\sqrt{E^2 + F^2}$	$\frac{G \cdot D}{\Sigma D}$		$\frac{D}{\Sigma C}$	I • F	J • E • $\sqrt{2}$	$\sqrt{K^2 + L^2}$
							%	%	%	%	%	%	%
Wood combustion	Commercial/institutional	N ₂ O	0	0	30	100	104.4	0.002	0.000	0.000	0.001	0.000	0.001
Gas combustion	Commercial/institutional	N ₂ O	-	0	10	100	100.5	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Commercial/institutional	N ₂ O	2	2	20	100	102.0	0.008	0.000	0.000	0.002	0.001	0.002
Waste combustion	Commercial/institutional	N ₂ O	0	0	30	100	104.4	-	-0.000	-	-0.000	-	0.000
Coal/coke combustion	Residential	N ₂ O	0	0	20	100	102.0	0.000	-0.000	0.000	-0.000	0.000	0.000
Wood combustion	Residential	N ₂ O	10	13	30	100	104.4	0.051	0.000	0.000	0.016	0.013	0.021
Gas combustion	Residential	N ₂ O	-	0	30	100	104.4	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Residential	N ₂ O	4	1	9	100	100.4	0.005	-0.000	0.000	-0.003	0.000	0.003
Coal/coke combustion	Agriculture/forestry/fishing	N ₂ O	0	0	30	100	104.4	-	-0.000	-	-0.000	-	0.000
Wood combustion	Agriculture/forestry/fishing	N ₂ O	-	0	30	100	104.4	0.000	0.000	0.000	0.000	0.000	0.000
Gas combustion	Agriculture/forestry/fishing	N ₂ O	-	0	30	100	104.4	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Agriculture/forestry/fishing	N ₂ O	67	61	10	100	100.5	0.238	0.000	0.001	0.046	0.021	0.051
Military fuel - stationary	Military	N ₂ O	0	0	5	100	100.1	0.001	0.000	0.000	0.000	0.000	0.000
Military fuel - mobile	Military	N ₂ O	6	4	5	100	100.1	0.016	0.000	0.000	0.001	0.001	0.001
Well testing		N ₂ O	0	0	30	100	104.4	0.000	-0.000	0.000	-0.000	0.000	0.000
Flaring		N ₂ O	4	4	1	100	100.0	0.014	0.000	0.000	0.002	0.000	0.002
Nitric acid production		N ₂ O	2 074	460	-	6	6.0	0.106	-0.021	0.011	-0.123	-	0.123
Methanol and plastic production		N ₂ O	-	1	9	-	9.0	0.000	0.000	0.000	-	0.000	0.000
Ferroalloys production		N ₂ O	5	4	-	10	10.0	0.001	0.000	0.000	0.000	-	0.000
Other		N ₂ O	36	44	-	15	15.0	0.026	0.001	0.001	0.008	-	0.008
Manure management - N ₂ O - Liquid storage		N ₂ O	17	18	24	72	75.9	0.052	0.000	0.000	0.012	0.015	0.019
Manure management - N ₂ O - solid storage		N ₂ O	116	109	24	72	75.9	0.318	0.001	0.003	0.063	0.090	0.109
Direct soil emission - Fertilizer		N ₂ O	665	595	5	180	180.1	4.126	0.004	0.014	0.769	0.102	0.775
Direct soil emission - Manure		N ₂ O	240	232	20	180	181.1	1.616	0.002	0.006	0.350	0.159	0.385
Direct soil emission - Other		N ₂ O	160	138	64	180	191.0	1.017	0.001	0.003	0.164	0.304	0.345
Direct soil emission - Organic soil		N ₂ O	332	287	72	180	193.9	2.141	0.002	0.007	0.338	0.709	0.785
Animal production		N ₂ O	223	206	22	72	75.3	0.597	0.002	0.005	0.114	0.155	0.193
Indirect soil emission - Deposition		N ₂ O	71	82	30	100	104.4	0.329	0.001	0.002	0.090	0.084	0.123
Indirect soil emission - Leaching, other		N ₂ O	346	322	70	100	122.1	1.512	0.003	0.008	0.251	0.773	0.813

A	B	C	D	E	F	G	H	I	J	K	L	M	
IPCC Source category	Sub-category	Gas	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Type A sensitivity ¹	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	
			Input data Gg CO ₂ equivalent	Input data Gg CO ₂ equivalent	Input data %	Input data %	$\sqrt{E^2 + F^2}$	$\frac{G \cdot D}{\Sigma D}$	$\frac{D}{\Sigma C}$	I • F	J • E • $\sqrt{2}$	$\sqrt{K^2 + L^2}$	
							%	%	%	%	%	%	
Burning of straw		N ₂ O	9	1	10	100	100.5	0.005	-0.000	0.000	-0.010	0.000	0.010
Forest Land remaining Forest Land, Fertilizer		N ₂ O	1	1	-	180	180.0	0.004	-0.000	0.000	-0.001	-	0.001
Forest Land remaining Forest Land, Drainage		N ₂ O	11	12	-	280	280.0	0.129	0.000	0.000	0.033	-	0.033
Forest Land remaining Forest Land, Wildfires		N ₂ O	0	0	20	75	77.6	0.001	0.000	0.000	0.000	0.000	0.000
Cropland, Disturbance		N ₂ O	1	0	-	280	280.0	0.001	-0.000	0.000	-0.002	-	0.002
Land converted to Wetland, Drainage		N ₂ O	0	0	-	280	280.0	0.001	0.000	0.000	0.000	-	0.000
Waste water - N ₂ O plant		N ₂ O	-	37	25	70	74.3	0.107	0.001	0.001	0.063	0.032	0.071
Waste water - N ₂ O pipeline		N ₂ O	91	97	25	70	74.3	0.278	0.001	0.002	0.068	0.083	0.107
Waste water - N ₂ O not connected		N ₂ O	26	25	30	180	182.5	0.174	0.000	0.001	0.037	0.026	0.045
Waste incineration		N ₂ O	0	0	30	100	104.4	0.000	0.000	0.000	0.000	0.000	0.000
Consumption of halocarbons and SF ₆		HFK	0	708	-	50	50.0	1.363	0.017	0.017	0.859	-	0.859
Aluminium production		PFK	3 370	379	3	20	20.2	0.295	-0.042	0.009	-0.846	0.039	0.847
Consumption of halocarbons and SF ₆		PFK	-	0	-	50	50.0	0.000	0.000	0.000	0.000	-	0.000
SF ₆ used in Al and Mg foundries		SF ₆	2 144	0	-	0	0.3	-	-0.033	-	-0.008	-	0.008
Consumption of halocarbons and SF ₆		SF ₆	56	64	-	60	60.0	0.149	0.001	0.002	0.043	-	0.043

$$1 \frac{0.01 \cdot D_x + \sum D_i - (0.01 \cdot C_x + \sum C_i) \cdot 100 - \frac{\sum D_i - \sum C_i}{\sum C_i} \cdot 100}{(0.01 \cdot C_x + \sum C_i)}$$

Table 6.2. Tier 2 uncertainty reporting

IPCC Source category	Subcategory	Gas	Base year emissions Gg CO ₂ equivalent	Year t emissions Gg CO ₂ equivalent	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t %	% change in emissions between year t and base year %	Range of likely % change between year t and base year	
					% below (2.5 percentile)	% above (97.5 percentile)			Lower % (2.5 percentile)	Upper % (97.5 Percentile)
Total			41 203	25 964				-37		
Coal/coke combustion	Public electricity and heat prod	CO ₂	205	112	-9	8	0.037	-45	-49	-41
Gas combustion	Public electricity and heat prod	CO ₂	-	1 119	-1	1	0.046	...	-	-
Oil combustion	Public electricity and heat prod	CO ₂	14	110	-4	4	0.017	662	635	686
Waste combustion	Public electricity and heat prod	CO ₂	97	429	-28	29	0.499	344	314	378
Coal/coke combustion	Petroleum refining	CO ₂	161	247	-1	2	0.014	53	51	56
Oil combustion	Petroleum refining	CO ₂	793	767	-1	1	0.042	-3	-5	-2
Gas combustion	Manufacture of solid fuels and other energy	CO ₂	5 185	10 541	-2	3	1.052	103	103	104
Oil combustion	Manufacture of solid fuels and other energy	CO ₂	251	788	-3	3	0.101	213	207	220
Coal/coke combustion	Iron and steel	CO ₂	60	12	-17	17	0.008	-79	-81	-78
Gas combustion	Iron and steel	CO ₂	-	3	-5	5	0.001	...	-	-
Oil combustion	Iron and steel	CO ₂	45	59	-3	3	0.007	31	30	32
Coal/coke combustion	Non-ferrous metal	CO ₂	0	-	...	...	-	-100	-100	-100
Gas combustion	Non-ferrous metal	CO ₂	-	104	-5	6	0.022	...	-	-
Oil combustion	Non-ferrous metal	CO ₂	268	83	-4	4	0.013	-69	-70	-68
Coal/coke combustion	Chemicals	CO ₂	133	110	-8	8	0.036	-17	-23	-11
Gas combustion	Chemicals	CO ₂	-	369	-2	2	0.032	...	-	-
Oil combustion	Chemicals	CO ₂	1 064	837	-14	15	0.468	-21	-36	-4
Coal/coke combustion	Pulp, paper, print	CO ₂	16	-	...	...	-	-100	-100	-100
Gas combustion	Pulp, paper, print	CO ₂	-	3	-4	4	0.000	...	-	-
Oil combustion	Pulp, paper, print	CO ₂	210	336	-3	3	0.039	60	58	61
Coal/coke combustion	Food processing, beverages, tobacco	CO ₂	10	-	...	...	-	-100	-100	-100
Gas combustion	Food processing, beverages, tobacco	CO ₂	-	89	-5	5	0.018	...	-	-
Oil combustion	Food processing, beverages, tobacco	CO ₂	456	237	-4	4	0.036	-48	-50	-46
Coal/coke combustion	Other manufacturing	CO ₂	396	335	-2	2	0.029	-16	-16	-15
Gas combustion	Other manufacturing	CO ₂	-	69	-6	5	0.015	...	-	-
Oil combustion	Other manufacturing	CO ₂	1 135	815	-4	4	0.118	-28	-30	-26
Waste combustion	Other manufacturing	CO ₂	-	47	-25	25	0.047	...	-	-
Transport fuel - civil aviation		CO ₂	679	1 071	-16	17	0.700	58	25	104
Transport fuel - road transportation		CO ₂	7 630	9 697	-5	5	1.872	27	20	34
Transport fuel - railway		CO ₂	96	45	-5	5	0.009	-53	-56	-50
Transport fuel - navigation		CO ₂	1 696	2 001	-16	17	1.310	18	-7	50

IPCC Source category	Subcategory	Gas	Base year emissions Gg CO ₂ equivalent	Year t emissions Gg CO ₂ equivalent	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t %	% change in emissions between year t and base year %	Range of likely % change between year t and base year	
					% below (2.5 percentile)	% above (97.5 percentile)			Lower % (2.5 percentile)	Upper % (97.5 Percentile)
Transport fuel - motorized equipment and pipeline		CO ₂	760	1 211	-15	16	0.773	59	24	102
Coal/coke combustion	Commercial/institutional	CO ₂	-	5	-19	21	0.004	...	-	-
Gas combustion	Commercial/institutional	CO ₂	-	50	-10	10	0.020	...	-	-
Oil combustion	Commercial/institutional	CO ₂	812	734	-16	17	0.496	-10	-29	15
Waste combustion	Commercial/institutional	CO ₂	3	-	...	...	-	-100	-100	-100
Coal/coke combustion	Residential	CO ₂	24	2	-21	22	0.001	-93	-95	-91
Gas combustion	Residential	CO ₂	-	8	-27	30	0.009	...	-	-
Oil combustion	Residential	CO ₂	1 318	454	-8	9	0.150	-66	-69	-61
Coal/coke combustion	Agriculture/forestry/fishing	CO ₂	12	-	...	...	-	-100	-100	-100
Gas combustion	Agriculture/forestry/fishing	CO ₂	-	42	-31	29	0.050	...	-	-
Oil combustion	Agriculture/forestry/fishing	CO ₂	1 975	1 883	-8	9	0.646	-5	-15	7
Military fuel - stationary	Military	CO ₂	62	35	-7	7	0.010	-44	-48	-40
Military fuel - mobile	Military	CO ₂	394	228	-7	7	0.063	-42	-46	-38
Coal mining, Extraction of natural gas		CO ₂	7	5	-51	93	0.013	-38	-40	-35
Extraction of oil - transport		CO ₂	367	124	-34	50	0.199	-66	-68	-65
Extraction of oil - refining/storage		CO ₂	749	873	-32	44	1.343	17	12	22
Extraction of oil - distribution gasoline		CO ₂	30	14	-35	44	0.023	-52	-55	-50
Coal mining, Extraction of natural gas		CO ₂	4	13	-51	84	0.034	211	198	225
Venting		CO ₂	27	117	-52	86	0.319	332	332	332
Well testing		CO ₂	80	20	-31	30	0.024	-75	-84	-61
Flaring		CO ₂	1 393	1 266	-4	5	0.233	-9	-11	-7
Cement production		CO ₂	634	842	-1	1	0.024	33	32	34
Lime production		CO ₂	47	137	-1	1	0.003	194	192	195
Limestone and dolomite use		CO ₂	24	31	-15	15	0.019	30	6	57
Other mineral production		CO ₂	2	2	-7	7	0.001	-15	-15	-15
Ammonia production		CO ₂	500	335	-8	7	0.098	-33	-36	-30
Silicium carbide production		CO ₂	222	51	-10	10	0.021	-77	-78	-76
Calcium carbide production		CO ₂	178	-	...	...	-	-100	-100	-100
Methanol and plastic production		CO ₂	3	95	-8	9	0.033	3 516	3 080	3 968
Iron and steel production		CO ₂	213	270	-2	2	0.019	27	25	29
Ferroalloys production		CO ₂	2 554	1 446	-3	3	0.171	-43	-43	-43
Aluminium production		CO ₂	1 419	1 725	-10	11	0.718	22	17	27

IPCC Source category	Subcategory	Gas	Base year emissions Gg CO ₂ equivalent	Year t emissions Gg CO ₂ equivalent	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t %	% change in emissions between year t and base year %	Range of likely % change between year t and base year	
					% below (2.5 percentile)	% above (97.5 percentile)			Lower % (2.5 percentile)	Upper % (97.5 Percentile)
Mg production		CO ₂	128	-	...	...	-	-100	-100	-100
Ni production, anodes		CO ₂	26	95	-14	14	0.053	270	221	322
Pulp and paper		CO ₂	10	9	-10	9	0.003	-14	-15	-13
Carbonic acid, bio protein		CO ₂	67	172	-13	14	0.093	157	123	196
Paint application		CO ₂	39	17	-10	9	0.007	-56	-56	-56
Degreasing and dry cleaning		CO ₂	-	1	-10	10	0.000	...	-	-
Chemical products, Manufacture and processing		CO ₂	8	1	-10	10	0.000	-89	-89	-89
Other		CO ₂	100	96	-10	10	0.038	-4	-4	-4
Forest Land remaining Forest Land, Forest inventory area, Living Biomass		CO ₂	-6 413	-22 172	15	-13	12.691	246	246	246
Forest Land remaining Forest Land, Forest inventory area, Dead Biomass		CO ₂	-2 042	-1 002	49	-49	1.986	-51	-51	-51
Forest Land remaining Forest Land, Forest inventory area, Soils, Mineral		CO ₂	-3 056	-4 584	24	-25	4.510	50	50	50
Forest Land remaining Forest Land, Forest inventory area, Soils, Organic		CO ₂	136	144	-103	100	0.585	6	6	6
Land converted to Forest Land, Living biomass		CO ₂	-5	-365	26	-24	0.358	6 740	6 740	6 740
Land converted to Forest Land, Soils, Mineral		CO ₂	30	71	-50	51	0.139	136	136	136
Cropland remaining Cropland, Liming		CO ₂	217	83	-11	12	0.036	-62	-64	-59
Cropland remaining Cropland, Horticulture, Living biomass		CO ₂	-24	-18	24	-25	0.018	-23	-23	-23
Cropland remaining Cropland, Reduced tillage, Soils		CO ₂	-	-180	55	-57	0.398	...	-	-
Cropland remaining Cropland, Erosion of new agriculture land, Soils		CO ₂	6	1	0	0	-	-86	-86	-86

IPCC Source category	Subcategory	Gas	Base year emissions Gg CO ₂ equivalent	Year t emissions Gg CO ₂ equivalent	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t %	% change in emissions between year t and base year %	Range of likely % change between year t and base year	
					% below (2.5 percentile)	% above (97.5 percentile)			Lower % (2.5 percentile)	Upper % (97.5 Percentile)
Cropland remaining Cropland, Histosols, Soils		CO ₂	208	208	-81	80	0.659	-	-	-
Land converted to Cropland, Living biomass		CO ₂	52	-2	25	-24	0.002	-104	-104	-104
Land converted to Cropland, Soils, Mineral		CO ₂	1	28	-49	46	0.055	1 807	1 807	1 807
Grassland remaining Grassland, Other Grassland, Living biomass		CO ₂	126	-	...	...	-	-100	-100	-100
Grassland remaining Grassland, Histosols, Soils		CO ₂	1 870	1 870	-84	81	5.790	-	-	-
Wetland remaining Wetland, Peat extraction, Soils		CO ₂	3	3	-79	74	0.010	-	-	-
Land converted to Settlements, Living biomass		CO ₂	271	299	-49	46	0.556	11	11	11
Land converted to Settlements, Soils		CO ₂	39	259	-47	46	0.482	570	570	570
Land converted to Other land, Living biomass		CO ₂	-	-4	46	-50	0.008	...	-	-
Other; Liming of lakes and rivers		CO ₂	10	17	-10	12	0.007	64	54	77
Waste incineration		CO ₂	0	-	...	...	-	-100	-100	-100
Coal/coke combustion	Public electricity and heat prod	CH ₄	0	0	-55	89	0.000	-33	-37	-28
Wood combustion	Public electricity and heat prod	CH ₄	0	2	-56	101	0.005	244	131	415
Gas combustion	Public electricity and heat prod	CH ₄	-	9	-51	99	0.027	...	-	-
Oil combustion	Public electricity and heat prod	CH ₄	0	0	-61	56	0.000	742	712	768
Waste combustion	Public electricity and heat prod	CH ₄	2	4	-54	87	0.011	106	92	121
Oil combustion	Petroleum refining	CH ₄	5	1	-58	61	0.002	-86	-86	-86
Gas combustion	Manufacture of solid fuels and other e nergy	CH ₄	41	82	-53	82	0.223	101	100	101
Oil combustion	Manufacture of solid fuels and other energy	CH ₄	0	0	-61	56	0.000	-100	-100	-100
Coal/coke combustion	Iron and steel	CH ₄	0	0	-55	90	0.000	-53	-56	-51
Wood combustion	Iron and steel	CH ₄	0	0	-59	97	0.000	269	144	453
Gas combustion	Iron and steel	CH ₄	-	0	-54	84	0.000	...	-	-
Oil combustion	Iron and steel	CH ₄	0	0	-61	56	0.000	-22	-22	-21
Wood combustion	Non-ferrous metal	CH ₄	-	0	-55	108	0.000	...	-	-

IPCC Source category	Subcategory	Gas	Base year emissions Gg CO ₂ equivalent	Year t emissions Gg CO ₂ equivalent	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t %	% change in emissions between year t and base year %	Range of likely % change between year t and base year	
					% below (2.5 percentile)	% above (97.5 percentile)			Lower % (2.5 percentile)	Upper % (97.5 Percentile)
Gas combustion	Non-ferrous metal	CH ₄	-	0	-52	92	0.000	...	-	-
Oil combustion	Non-ferrous metal	CH ₄	0	0	-62	57	0.000	-39	-41	-37
Coal/coke combustion	Chemicals	CH ₄	0	0	-55	90	0.000	-11	-17	-4
Wood combustion	Chemicals	CH ₄	0	0	-58	98	0.001	295	166	519
Gas combustion	Chemicals	CH ₄	-	0	-52	94	0.001	...	-	-
Oil combustion	Chemicals	CH ₄	1	1	-60	66	0.003	-6	-23	15
Coal/coke combustion	Pulp, paper, print	CH ₄	0	-	...	...	-	-100	-100	-100
Wood combustion	Pulp, paper, print	CH ₄	6	5	-57	99	0.015	-17	-45	30
Gas combustion	Pulp, paper, print	CH ₄	-	0	-53	77	0.000	...	-	-
Oil combustion	Pulp, paper, print	CH ₄	0	0	-61	56	0.000	107	105	108
Coal/coke combustion	Food processing, beverages, tobacco	CH ₄	0	-	...	...	-	-100	-100	-100
Wood combustion	Food processing, beverages, tobacco	CH ₄	0	0	-57	97	0.000	-96	-97	-93
Gas combustion	Food processing, beverages, tobacco	CH ₄	-	0	-53	88	0.001	...	-	-
Oil combustion	Food processing, beverages, tobacco	CH ₄	0	0	-62	56	0.000	-41	-43	-39
Coal/coke combustion	Other manufacturing	CH ₄	0	0	-54	90	0.001	22	21	23
Wood combustion	Other manufacturing	CH ₄	1	1	-57	93	0.003	-29	-52	9
Gas combustion	Other manufacturing	CH ₄	-	0	-53	88	0.000	...	-	-
Oil combustion	Other manufacturing	CH ₄	2	2	-61	55	0.004	-5	-8	-2
Waste combustion	Other manufacturing	CH ₄	-	1	-53	86	0.001	...	-	-
Transport fuel - civil aviation		CH ₄	0	1	-53	90	0.002	86	47	140
Transport fuel - road transportation		CH ₄	71	18	-35	49	0.031	-75	-76	-73
Transport fuel - railway		CH ₄	0	0	-54	85	0.000	-53	-56	-50
Transport fuel - navigation		CH ₄	4	52	-54	90	0.145	1 061	816	1 374
Transport fuel - motorized equipment and pipeline		CH ₄	7	9	-53	87	0.027	33	4	70
Coal/coke combustion	Commercial/institutional	CH ₄	-	0	-52	84	0.000	...	-	-
Wood combustion	Commercial/institutional	CH ₄	0	0	-56	93	0.001	9 944	6 531	15 274
Gas combustion	Commercial/institutional	CH ₄	-	0	-51	87	0.000	...	-	-
Oil combustion	Commercial/institutional	CH ₄	2	2	-58	68	0.005	-11	-30	13
Waste combustion	Commercial/institutional	CH ₄	0	-	...	...	-	-100	-100	-100
Coal/coke combustion	Residential	CH ₄	2	0	-55	83	0.000	-94	-95	-91
Wood combustion	Residential	CH ₄	111	142	-54	104	0.446	27	-12	90
Gas combustion	Residential	CH ₄	-	0	-55	98	0.000	...	-	-

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					% below (2.5 percentile)	% above (97.5 percentile)			Lower % (2.5 percentile)	Upper % (97.5 Percentile)
Oil combustion	Residential	CH ₄	3	1	-58	65	0.003	-66	-70	-61
Coal/coke combustion	Agriculture/forestry/fishing	CH ₄	0	-	...	...	-	-100	-100	-100
Wood combustion	Agriculture/forestry/fishing	CH ₄	-	0	-58	105	0.000	...	-	-
Gas combustion	Agriculture/forestry/fishing	CH ₄	-	0	-53	96	0.000	...	-	-
Oil combustion	Agriculture/forestry/fishing	CH ₄	4	3	-57	64	0.008	-16	-25	-5
Military fuel - stationary	Military	CH ₄	0	0	-52	95	0.000	-29	-34	-24
Military fuel - mobile	Military	CH ₄	0	0	-50	88	0.001	-36	-41	-32
Coal mining, Extraction of natural gas		CH ₄	56	35	-51	93	0.098	-38	-40	-35
Extraction of oil - transport		CH ₄	129	153	-34	50	0.246	18	14	23
Extraction of oil - refining/storage		CH ₄	35	48	-33	41	0.072	36	31	42
Coal mining, Extraction of natural gas		CH ₄	3	47	-50	85	0.124	1 753	1 680	1 837
Venting		CH ₄	143	331	-52	86	0.904	131	131	131
Well testing		CH ₄	0	0	-60	68	0.000	-75	-84	-61
Flaring		CH ₄	10	14	-60	53	0.031	40	37	43
Silicium carbide production		CH ₄	7	2	-11	10	0.001	-77	-78	-76
Methanol and plastic production		CH ₄	2	3	-53	83	0.008	74	53	96
Ferroalloys production		CH ₄	1	1	-51	85	0.002	-23	-23	-23
Enteric fermentation - cattle		CH ₄	1 420	1 268	-23	24	1.194	-11	-16	-4
Enteric fermentation - other animal		CH ₄	102	111	-40	40	0.171	9	2	17
Enteric fermentation - sheep		CH ₄	431	461	-24	24	0.458	7	-0	14
Enteric fermentation - goat		CH ₄	9	7	-39	40	0.011	-24	-29	-19
Enteric fermentation - horse		CH ₄	12	25	-40	38	0.039	109	97	124
Enteric fermentation - swine		CH ₄	17	22	-38	40	0.035	32	23	42
Enteric fermentation - poultry		CH ₄	1	2	-40	37	0.003	49	39	59
Manure management - CH ₄ -cattle		CH ₄	215	194	-25	25	0.187	-10	-15	-3
Manure management - CH ₄ - other animal		CH ₄	4	5	-24	25	0.005	19	11	28
Manure management - CH ₄ - sheep		CH ₄	24	24	-23	25	0.024	0	-6	7

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Manure management - CH ₄ -goat		CH ₄	2	1	-24	26	0.001	-31	-35	-26
Manure management - CH ₄ - horse		CH ₄	11	23	-25	26	0.023	109	97	124
Manure management - CH ₄ - swine		CH ₄	23	29	-26	23	0.028	30	21	39
Manure management - CH ₄ - poultry		CH ₄	19	37	-26	25	0.036	97	83	110
Burning of straw		CH ₄	23	3	-54	87	0.010	-85	-87	-83
Forest Land remaining Forest Land, Wildfires		CH ₄	2	3	-54	100	0.008	42	8	92
Managed waste disposal on land		CH ₄	1 682	1 065	-31	38	1.457	-37	-52	-17
Waste water - CH ₄		CH ₄	20	10	-39	57	0.018	-50	-50	-49
Waste incineration		CH ₄	0	0	-55	93	0.000	522	304	869
Coal/coke combustion	Public electricity and heat prod	N ₂ O	1	1	-74	105	0.002	-46	-50	-42
Wood combustion	Public electricity and heat prod	N ₂ O	2	5	-74	125	0.019	162	76	292
Gas combustion	Public electricity and heat prod	N ₂ O	-	3	-73	116	0.011	...	-	-
Oil combustion	Public electricity and heat prod	N ₂ O	0	0	-71	109	0.001	528	506	548
Waste combustion	Public electricity and heat prod	N ₂ O	4	6	-74	123	0.026	54	43	65
Coal/coke combustion	Petroleum refining	N ₂ O	0	0	-72	121	0.002	53	51	56
Oil combustion	Petroleum refining	N ₂ O	5	2	-73	121	0.009	-57	-57	-56
Gas combustion	Manufacture of solid fuels and other energy	N ₂ O	14	27	-74	121	0.107	101	101	102
Oil combustion	Manufacture of solid fuels and other energy	N ₂ O	1	2	-71	107	0.007	181	176	187
Coal/coke combustion	Iron and steel	N ₂ O	0	0	-72	116	0.001	-53	-56	-51
Wood combustion	Iron and steel	N ₂ O	0	0	-74	114	0.000	269	144	453
Gas combustion	Iron and steel	N ₂ O	-	0	-74	117	0.000	...	-	-
Oil combustion	Iron and steel	N ₂ O	0	0	-70	107	0.000	-57	-58	-57
Wood combustion	Non-ferrous metal	N ₂ O	-	0	-75	134	0.001	...	-	-
Gas combustion	Non-ferrous metal	N ₂ O	-	0	-69	128	0.001	...	-	-
Oil combustion	Non-ferrous metal	N ₂ O	1	0	-70	107	0.001	-71	-72	-69
Coal/coke combustion	Chemicals	N ₂ O	1	1	-72	115	0.002	-11	-17	-4
Wood combustion	Chemicals	N ₂ O	0	1	-74	124	0.003	295	166	519
Gas combustion	Chemicals	N ₂ O	-	0	-72	116	0.001	...	-	-
Oil combustion	Chemicals	N ₂ O	1	2	-71	125	0.008	64	33	100

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Coal/coke combustion	Pulp, paper, print	N ₂ O	0	-	-	-100	-100	-100
Wood combustion	Pulp, paper, print	N ₂ O	27	20	-75	132	0.078	-28	-52	13
Gas combustion	Pulp, paper, print	N ₂ O	-	0	-70	120	0.000	...	-	-
Oil combustion	Pulp, paper, print	N ₂ O	1	1	-70	107	0.004	56	55	57
Coal/coke combustion	Food processing, beverages, tobacco	N ₂ O	0	-	...	...	-	-100	-100	-100
Wood combustion	Food processing, beverages, tobacco	N ₂ O	0	0	-76	125	0.000	-96	-97	-93
Gas combustion	Food processing, beverages, tobacco	N ₂ O	-	0	-71	115	0.000	...	-	-
Oil combustion	Food processing, beverages, tobacco	N ₂ O	1	1	-71	106	0.003	-47	-49	-45
Coal/coke combustion	Other manufacturing	N ₂ O	0	0	-72	119	0.001	146	143	148
Wood combustion	Other manufacturing	N ₂ O	6	4	-75	123	0.017	-29	-52	9
Gas combustion	Other manufacturing	N ₂ O	-	0	-73	115	0.000	...	-	-
Oil combustion	Other manufacturing	N ₂ O	3	2	-71	108	0.008	-28	-30	-25
Waste combustion	Other manufacturing	N ₂ O	-	1	-71	118	0.004	...	-	-
Transport fuel - civil aviation		N ₂ O	7	11	-74	113	0.041	58	25	104
Transport fuel - road transportation		N ₂ O	57	59	-51	70	0.146	5	-2	10
Transport fuel - railway		N ₂ O	11	5	-84	99	0.020	-53	-56	-50
Transport fuel - navigation		N ₂ O	11	14	-73	129	0.058	30	3	65
Transport fuel - motorized equipment and pipeline		N ₂ O	69	125	-77	110	0.487	81	41	130
Coal/coke combustion	Commercial/institutional	N ₂ O	-	0	-72	128	0.000	...	-	-
Wood combustion	Commercial/institutional	N ₂ O	0	0	-74	136	0.002	4 429	2 890	6 832
Gas combustion	Commercial/institutional	N ₂ O	-	0	-73	118	0.000	...	-	-
Oil combustion	Commercial/institutional	N ₂ O	2	2	-72	113	0.008	-10	-29	15
Waste combustion	Commercial/institutional	N ₂ O	0	-	...	...	-	-100	-100	-100
Coal/coke combustion	Residential	N ₂ O	0	0	-72	127	0.000	-94	-95	-91
Wood combustion	Residential	N ₂ O	10	13	-73	130	0.051	29	-11	92
Gas combustion	Residential	N ₂ O	-	0	-75	129	0.000	...	-	-
Oil combustion	Residential	N ₂ O	4	1	-71	110	0.005	-65	-69	-61
Coal/coke combustion	Agriculture/forestry/fishing	N ₂ O	0	-	...	...	-	-100	-100	-100
Wood combustion	Agriculture/forestry/fishing	N ₂ O	-	0	-74	118	0.000	...	-	-
Gas combustion	Agriculture/forestry/fishing	N ₂ O	-	0	-72	120	0.000	...	-	-
Oil combustion	Agriculture/forestry/fishing	N ₂ O	67	61	-71	112	0.231	-9	-19	2

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					% below (2.5 percentile)	% above (97.5 percentile)			Lower % (2.5 percentile)	Upper % (97.5 Percentile)
Military fuel - stationary	Military	N ₂ O	0	0	-73	114	0.001	21	13	30
Military fuel - mobile	Military	N ₂ O	6	4	-76	104	0.015	-31	-36	-27
Well testing		N ₂ O	0	0	-74	136	0.000	-75	-84	-61
Flaring		N ₂ O	4	4	-75	112	0.013	-15	-16	-13
Nitric acid production		N ₂ O	2 074	460	-6	6	0.108	-78	-78	-78
Methanol and plastic production		N ₂ O	-	1	-9	9	0.000	...	-	-
Ferroalloys production		N ₂ O	5	4	-10	10	0.001	-28	-28	-28
Other		N ₂ O	36	44	-15	15	0.026	25	25	25
Manure management - N ₂ O - Liquid storage		N ₂ O	17	18	-53	80	0.047	1	-5	6
Manure management - N ₂ O - solid storage		N ₂ O	116	109	-52	84	0.290	-6	-11	-1
Direct soil emission - Fertilizer		N ₂ O	665	595	-82	220	3.633	-11	-16	-4
Direct soil emission - Manure		N ₂ O	240	232	-82	219	1.417	-4	-9	1
Direct soil emission- Other		N ₂ O	160	138	-84	245	0.944	-13	-63	109
Direct soil emission- Organic soil		N ₂ O	332	287	-86	228	1.961	-14	-68	120
Animal production		N ₂ O	223	206	-54	84	0.569	-8	-13	-3
Indirect soil emission- Deposition		N ₂ O	71	82	-70	142	0.345	15	10	21
Indirect soil emission - Leaching, other		N ₂ O	346	322	-69	170	1.496	-7	-11	-3
Burning of straw		N ₂ O	9	1	-70	112	0.005	-85	-87	-83
Forest Land remaining Forest Land, Fertilizer		N ₂ O	1	1	-83	219	0.004	-58	-58	-58
Forest Land remaining Forest Land, Drainage		N ₂ O	11	12	-87	317	0.111	6	6	6
Forest Land remaining Forest Land, Wildfires		N ₂ O	0	0	-55	95	0.001	42	8	92
Cropland, Disturbance		N ₂ O	1	0	-90	328	0.001	-86	-86	-86
Land converted to Wetland, Drainage		N ₂ O	0	0	-89	309	0.001	-	-	-
Waste water - N ₂ O plant		N ₂ O	-	37	-55	88	0.109	...	-	-
Waste water - N ₂ O pipeline		N ₂ O	91	97	-56	95	0.302	7	-24	51

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Waste water - N ₂ O not connected		N ₂ O	26	25	-80	209	0.157	-5	-38	50
Waste incineration		N ₂ O	0	0	-72	139	0.000	2	-34	59
Consumption of halocarbons and SF ₆		HFK	0	708	-40	56	1.358	3 861 171	3 861 171	3 861 171
Aluminium production		PFK	3 370	379	-20	19	0.291	-89	-89	-88
Consumption of halocarbons and SF ₆		PFK	-	0	-39	55	0.000	...	-	-
SF ₆ used in Al and Mg foundries		SF ₆	2 144	-	-	-100	-100	-100
Consumption of halocarbons and SF ₆		SF ₆	56	64	-47	70	0.148	15	15	15

List of tables

4.1. Summary of standard deviation and probability density of activity data. 2009.....	14
4.2. Summary of standard deviation and probability density of emission factors. 2009.....	17
5.1. Uncertainties in emission levels. Each gas and total GWP weighted emissions, excluding the LULUCF sector.....	23
5.2. Uncertainties in emission levels. Each gas and total GWP weighted emissions, including the LULUCF sector.....	23
5.3. Uncertainty of emission trends. 1990-2009, excluding the LULUCF sector.....	25
5.4. Uncertainty of emission trends. 1990-2009, including the LULUCF sector.....	25
6.1. Tier 1 uncertainty calculation and reporting.....	31
6.2. Tier 2 uncertainty reporting.....	41