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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 occured 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 CO_2 emission factor (and N_2O 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 CO_2-utslippsfaktor (og N_2O-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

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:

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

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:

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

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 CH_4 and N_2O emissions from the source category 6B Waste water. The CH_4 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 N_2O 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 "gasoeus", 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 factor[1].

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: • 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:	Percentace uncertainty is defined in the Good Practice Guidance (IPCC 2003) in terms of a confidence interval as $\%\ uncertainty = ½\ (95\%\ Confidence\ Interval\ width) / \mu \times 100$ Under the assumption of (asymptotic) normal distribution, the 95% confidence interval is approximately 4 standard deviations. In the present report, uncertainty is defined as $\%\ uncertainty = 2\sigma / \mu \times 100$

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 CO_2 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 CH_4 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 CO_2 emission factors (N_2O 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 CO_2 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 N_2O emissions from combustion. Truncated normal distribution was used for CH_4 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 CO_2 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 *pers. comm*[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 *pers. comm*[2]
1A2F	Coal/coke - other	0.8	Normal	Emission trading scheme (Klif 2011), Expert judgement industry, Norcem *pers. comm*[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 *pers. comm*[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 *pers. comm*[6]
2C2	Ferroalloys production	-	-	See emission factor
2C3	Aluminium production	3	Normal	Expert judgement industry, Norsk Hydro *pers. comm*[7]
2C4	SF_6 used in Al and Mg foundries	-	-	See emission factor
2C5	Mg production	0.25	Normal	Expert judgement industry, Norsk Hydro *pers. comm*[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_2O in anasthesia and as propellant – N_2O	-	-	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_2O	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 *pers. comm*[9]
6B	Waste water treatment - CH_4	1	Lognormal	Expert judgement, Statistics Norway
6B	Waste water treatment - N_2O pipeline and plant	25	Normal	Expert judgement, Statistics Norway (2006e)
6B	Waste water treatment - N_2O, 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_2O	Fac3	Beta	Expert judgement, Statistics Norway
1A1, 1A2, 1A4	Oil - general	N_2O	Fac3	Beta	Spread in data. Expert judgement. IPCC (1997), Rypdal and Zhang (2000)
1A1B	Coal/coke – petroleum refining	N_2O	Fac3	Beta	Spread in data. Expert judgement. IPCC (1997), Rypdal and Zhang (2000)
1A3A, 1A3C, 1A3D	Transport fuel	N_2O	Fac3	Beta	Spread in data. Expert judgement, Rypdal and Zhang (2000)
1A3B	Transport fuel	N_2O	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_2O	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 *pers. comm*[12]
2B5	Methanol and plastic production	CH_4	Fac2	Lognormal	Expert judgement, Statistics Norway
2B2	Nitric acid production	N_2O	6.0	Normal	Expert judgement industry, Yara *pers. comm*[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 *pers. comm*[13]
2C2	Ferroalloys production	CO_2	3	Normal	Expert judgement, SINTEF *pers. comm*[14]
2C3	Aluminium production	CO_2	10	Normal	International Aluminium Institute (IAI), Norsk Hydro *pers. comm*[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_2O	10	Normal	Expert judgement, Statistics Norway
2C3	Aluminium production	PFK	20	Normal	Expert judgement industry, Norsk Hydro *pers. comm*[15]
2C4	SF_6 used in Al and Mg foundries	SF_6	0.25	Normal	Expert judgement industry, Norsk Hydro *pers. comm*[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_2O in anasthesia and as propellant	N_2O	15	Normal	Expert judgement, Statistics Norway
A1, 4A3	Enteric fermentation - cattle and sheep	CH_4	25	Normal	Expert judgement, UMB *pers. comm*[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_2O	N_2O	Fac2	Lognormal	IPCC (1997)
4D1	Direct soil emission	N_2O	Fac5	Lognormal	IPCC (2000)
4D2	Animal production	N_2O	Fac2	Lognormal	IPCC (2000)
4D3	Indirect soil emission	N_2O	Fac3	Lognormal	IPCC (1997)
4F1	Agricultural residue burning	CH_4	Fac2	Lognormal	Expert judgement, Statistics Norway
4F1	Agricultural residue burning	N_2O	Fac3	Beta	Expert judgement, Statistics Norway
5A1	Forest Land remaining Forest Land, Fertilizer	N_2O	Fac5	Lognormal	NIJOS (2005)
5A1	Forest Land remaining Forest Land, Drainage	N_2O	Fac10	Lognormal	NIJOS (2005)
5A1	Forest Land remaining Forest Land, Wildfires	CH_4/ N_2O	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 Gjerald, 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_2O	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_2O	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 *pers. comm*[18]
6B	Waste water treatment - CH_4	CH_4	50	Lognormal	IPCC (2000) and expert judgement, Statistics Norway[b]
6B	Waste water treatment - N_2O, pipeline and plant	N_2O	70	Lognormal	Expert judgement, Rypdal and Zhang (2000)
6B	Waste water treatment - N_2O, not connected	N_2O	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_2O	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 Svardal, 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 N_2O from manure management, N_2O from manure spreading and N_2O 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 N_2O 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 CO_2 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 CO_2 is oxidised from methane (oil extraction, loading and coal mining)

- For all direct emissions of N_2O from agricultural soils, except for N_2O 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_2O	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_2O	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_2O	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_2O	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 CO_2 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 SF_6 emissions, which has increased from 2 to 56 per cent of the mean. However, the SF_6 emissions are strongly reduced because magnesium production was closed down. The figures for the emission of SF_6 from magnesium production was quite well known, but now a larger part of the SF_6 emissions comes from source categories with higher uncertainty. For N_2O there is also a considerable increase in the uncertainty between the years. One reason for the change can be found in that N_2O from the production of synthetic fertilizer with a quite low uncertainty contributes to a smaller part of the total N_2O 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 CO_2 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 N_2O 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 N_2O 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 CO_2 is increased, while the share of N_2O 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 ((μ2009-μ1990)*100/μ1990)	Uncertainty (2*σ*100/μ1990)
Total	**3**	**3**
CO_2	23	3
CH_4	-9	10
N_2O	-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 ((μ2009-μ1990)*100/μ1990)	Uncertainty (2*σ*100/μ1990)
Total	**-37**	**7**
CO_2	-33	10
CH_4	-9	10
N_2O	-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 CO_2 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 earlies 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 emis-sions	Year t emis-sions	Activity data uncer-tainty	Emis-sion factor uncer-tainty	Combined uncertainty	Combined uncer-tainty as % of total national emissions in year t	Type A sen-sitivity[1]	Type B sensitivity	Uncer-tainty in trend in national emis-sions intro-duced by emission factor uncer-tainty	Uncer-tainty in trend in national emis-sions intro-duced by activity data uncer-tainty	Uncer-tainty intro-duced into the trend in total national emissions
			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
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 prosessing, beverages, tobacco	CO_2	10	0	5	7	8.6	-	-0.000	-	-0.001	-	0.001
Gas combustion	Food prosessing, beverages, tobacco	CO_2	-	89	4	4	5.3	0.018	0.002	0.002	0.008	0.012	0.014
Oil combustion	Food prosessing, 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 emis-sions	Year t emis-sions	Activity data uncer-tainty	Emis-sion factor uncer-tainty	Combined uncertainty	Combined uncer-tainty as % of total national emissions in year t	Type A sen-sitivity[1]	Type B sensitivity	Uncer-tainty in trend in national emis-sions intro-duced by emission factor uncer-tainty	Uncer-tainty in trend in national emis-sions intro-duced by activity data uncer-tainty	Uncer-tainty intro-duced into the trend in total national emissions
			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
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 emis-sions	Year t emis-sions	Activity data uncer-tainty	Emis-sion factor uncer-tainty	Combined uncertainty	Combined uncer-tainty as % of total national emissions in year t	Type A sen-sitivity[1]	Type B sensitivity	Uncer-tainty in trend in national emis-sions intro-duced by emission factor uncer-tainty	Uncer-tainty in trend in national emis-sions intro-duced by activity data uncer-tainty	Uncer-tainty intro-duced into the trend in total national emissions
			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
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, Manufaqcture 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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IPCC Source category	Sub-category	Gas	Base year emis-sions	Year t emis-sions	Activity data uncer-tainty	Emis-sion factor uncer-tainty	Combined uncertainty	Combined uncer-tainty as % of total national emissions in year t	Type A sen-sitivity[1]	Type B sensitivity	Uncer-tainty in trend in national emis-sions intro-duced by emission factor uncer-tainty	Uncer-tainty in trend in national emis-sions intro-duced by activity data uncer-tainty	Uncer-tainty intro-duced into the trend in total national emissions
			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
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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			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
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 prosessing, beverages, tobacco	CH_4	0	0	5	72	72.2	-	-0.000	-	-0.000	-	0.000
Wood combustion	Food prosessing, 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 prosessing, beverages, tobacco	CH_4	-	0	4	72	72.1	0.001	0.000	0.000	0.000	0.000	0.000
Oil combustion	Food prosessing, 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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			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
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/f orestry/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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			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
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_2O	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_2O	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_2O	-	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_2O	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_2O	4	6	5	100	100.1	0.025	0.000	0.000	0.009	0.001	0.009
Coal/coke combustion	Petroleum refining	N_2O	0	0	1	100	100.0	0.002	0.000	0.000	0.001	0.000	0.001
Oil combustion	Petroleum refining	N_2O	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_2O	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_2O	1	2	2	100	100.0	0.007	0.000	0.000	0.004	0.000	0.004

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			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
Coal/coke combustion	Iron and steel	N_2O	0	0	4	100	100.1	0.001	-0.000	0.000	-0.000	0.000	0.000
Wood combustion	Iron and steel	N_2O	0	0	30	100	104.4	0.000	0.000	0.000	0.000	0.000	0.000
Gas combustion	Iron and steel	N_2O	-	0	4	100	100.1	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Iron and steel	N_2O	0	0	0	100	100.0	0.000	-0.000	0.000	-0.000	0.000	0.000
Wood combustion	Non-ferrous metal	N_2O	-	0	30	100	104.4	0.001	0.000	0.000	0.001	0.000	0.001
Gas combustion	Non-ferrous metal	N_2O	-	0	4	100	100.1	0.001	0.000	0.000	0.001	0.000	0.001
Oil combustion	Non-ferrous metal	N_2O	1	0	3	100	100.0	0.001	-0.000	0.000	-0.001	0.000	0.001
Coal/coke combustion	Chemicals	N_2O	1	1	5	100	100.1	0.002	0.000	0.000	0.000	0.000	0.000
Wood combustion	Chemicals	N_2O	0	1	30	100	104.4	0.003	0.000	0.000	0.002	0.001	0.002
Gas combustion	Chemicals	N_2O	-	0	2	100	100.0	0.001	0.000	0.000	0.001	0.000	0.001
Oil combustion	Chemicals	N_2O	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_2O	0	0	5	100	100.1	-	-0.000	-	-0.000	-	0.000
Wood combustion	Pulp, paper, print	N_2O	27	20	30	100	104.4	0.079	0.000	0.000	0.006	0.020	0.021
Gas combustion	Pulp, paper, print	N_2O	-	0	2	100	100.0	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Pulp, paper, print	N_2O	1	1	1	100	100.0	0.004	0.000	0.000	0.001	0.000	0.001
Coal/coke combustion	Food prosessing, beverages, tobacco	N_2O	0	0	5	100	100.1	-	-0.000	-	-0.000	-	0.000
Wood combustion	Food prosessing, beverages, tobacco	N_2O	0	0	30	100	104.4	0.000	-0.000	0.000	-0.000	0.000	0.000
Gas combustion	Food prosessing, beverages, tobacco	N_2O	-	0	4	100	100.1	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Food prosessing, beverages, tobacco	N_2O	1	1	3	100	100.0	0.003	-0.000	0.000	-0.000	0.000	0.000
Coal/coke combustion	Other manufacturing	N_2O	0	0	1	100	100.0	0.001	0.000	0.000	0.001	0.000	0.001
Wood combustion	Other manufacturing	N_2O	6	4	30	100	104.4	0.017	0.000	0.000	0.001	0.004	0.005
Gas combustion	Other manufacturing	N_2O	-	0	4	100	100.1	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Other manufacturing	N_2O	3	2	3	100	100.0	0.008	0.000	0.000	0.001	0.000	0.001
Waste combustion	Other manufacturing	N_2O	-	1	3	100	100.1	0.004	0.000	0.000	0.003	0.000	0.003
Transport fuel - civil aviation		N_2O	7	11	20	100	102.0	0.041	0.000	0.000	0.015	0.007	0.017
Transport fuel - road transportation		N_2O	57	59	5	65	65.2	0.149	0.001	0.001	0.037	0.010	0.039
Transport fuel - railway		N_2O	11	5	5	100	100.1	0.020	-0.000	0.000	-0.004	0.001	0.005
Transport fuel - navigation		N_2O	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_2O	69	125	20	100	102.0	0.490	0.002	0.003	0.197	0.086	0.215
Coal/coke combustion	Commercial/ institutional	N_2O	-	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 emis-sions	Year t emis-sions	Activity data uncer-tainty	Emis-sion factor uncer-tainty	Combined uncertainty	Combined uncer-tainty as % of total national emissions in year t	Type A sen-sitivity[1]	Type B sensitivity	Uncer-tainty in trend in national emis-sions intro-duced by emission factor uncer-tainty	Uncer-tainty in trend in national emis-sions intro-duced by activity data uncer-tainty	Uncer-tainty intro-duced into the trend in total national emissions
			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
Wood combustion	Commercial/ institutional	N_2O	0	0	30	100	104.4	0.002	0.000	0.000	0.001	0.000	0.001
Gas combustion	Commercial/ institutional	N_2O	-	0	10	100	100.5	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Commercial/institut ional	N_2O	2	2	20	100	102.0	0.008	0.000	0.000	0.002	0.001	0.002
Waste combustion	Commercial/ institutional	N_2O	0	0	30	100	104.4	-	-0.000	-	-0.000	-	0.000
Coal/coke combustion	Residential	N_2O	0	0	20	100	102.0	0.000	-0.000	0.000	-0.000	0.000	0.000
Wood combustion	Residential	N_2O	10	13	30	100	104.4	0.051	0.000	0.000	0.016	0.013	0.021
Gas combustion	Residential	N_2O	-	0	30	100	104.4	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Residential	N_2O	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_2O	0	0	30	100	104.4	-	-0.000	-	-0.000	-	0.000
Wood combustion	Agriculture/ forestry/fishing	N_2O	-	0	30	100	104.4	0.000	0.000	0.000	0.000	0.000	0.000
Gas combustion	Agriculture/ forestry/fishing	N_2O	-	0	30	100	104.4	0.000	0.000	0.000	0.000	0.000	0.000
Oil combustion	Agriculture/ forestry/fishing	N_2O	67	61	10	100	100.5	0.238	0.000	0.001	0.046	0.021	0.051
Military fuel - stationary	Military	N_2O	0	0	5	100	100.1	0.001	0.000	0.000	0.000	0.000	0.000
Military fuel - mobile	Military	N_2O	6	4	5	100	100.1	0.016	0.000	0.000	0.001	0.001	0.001
Well testing		N_2O	0	0	30	100	104.4	0.000	-0.000	0.000	-0.000	0.000	0.000
Flaring		N_2O	4	4	1	100	100.0	0.014	0.000	0.000	0.002	0.000	0.002
Nitric acid production		N_2O	2 074	460	-	6	6.0	0.106	-0.021	0.011	-0.123	-	0.123
Methanol and plastic production		N_2O	-	1	9	-	9.0	0.000	0.000	0.000	-	0.000	0.000
Ferroalloys production		N_2O	5	4	-	10	10.0	0.001	0.000	0.000	0.000	-	0.000
Other		N_2O	36	44	-	15	15.0	0.026	0.001	0.001	0.008	-	0.008
Manure management - N_2O - Liquid storage		N_2O	17	18	24	72	75.9	0.052	0.000	0.000	0.012	0.015	0.019
Manure management - N_2O - solid storage		N_2O	116	109	24	72	75.9	0.318	0.001	0.003	0.063	0.090	0.109
Direct soil emission - Fertilizer		N_2O	665	595	5	180	180.1	4.126	0.004	0.014	0.769	0.102	0.775
Direct soil emission - Manure		N_2O	240	232	20	180	181.1	1.616	0.002	0.006	0.350	0.159	0.385
Direct soil emission- Other		N_2O	160	138	64	180	191.0	1.017	0.001	0.003	0.164	0.304	0.345
Direct soil emission- Organic soil		N_2O	332	287	72	180	193.9	2.141	0.002	0.007	0.338	0.709	0.785
Animal production		N_2O	223	206	22	72	75.3	0.597	0.002	0.005	0.114	0.155	0.193
Indirect soil emission- Deposition		N_2O	71	82	30	100	104.4	0.329	0.001	0.002	0.090	0.084	0.123
Indirect soil emission - Leaching, other		N_2O	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 emis-sions	Year t emis-sions	Activity data uncer-tainty	Emis-sion factor uncer-tainty	Combined uncertainty	Combined uncer-tainty as % of total national emissions in year t	Type A sen-sitivity[1]	Type B sensitivity	Uncer-tainty in trend in national emis-sions intro-duced by emission factor uncer-tainty	Uncer-tainty in trend in national emis-sions intro-duced by activity data uncer-tainty	Uncer-tainty intro-duced into the trend in total national emissions
			Input data Gg CO_2 equiva-lent	Input data Gg CO_2 equiva-lent	Input data %	Input data %	$\sqrt{E^2+F^2}$ %	$\frac{G \bullet D}{\sum D}$ %	%	$\frac{D}{\sum C}$ %	$I \bullet F$ %	$J \bullet E \bullet \sqrt{2}$ %	$\sqrt{K^2+L^2}$ %
Burning of straw		N_2O	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_2O	1	1	-	180	180.0	0.004	-0.000	0.000	-0.001	-	0.001
Forest Land remaining Forest Land, Drainage		N_2O	11	12	-	280	280.0	0.129	0.000	0.000	0.033	-	0.033
Forest Land remaining Forest Land, Wildfires		N_2O	0	0	20	75	77.6	0.001	0.000	0.000	0.000	0.000	0.000
Cropland, Disturbance		N_2O	1	0	-	280	280.0	0.001	-0.000	0.000	-0.002	-	0.002
Land converted to Wetland, Drainage		N_2O	0	0	-	280	280.0	0.001	0.000	0.000	0.000	-	0.000
Waste water - N_2O plant		N_2O	-	37	25	70	74.3	0.107	0.001	0.001	0.063	0.032	0.071
Waste water - N_2O pipeline		N_2O	91	97	25	70	74.3	0.278	0.001	0.002	0.068	0.083	0.107
Waste water - N_2O not connected		N_2O	26	25	30	180	182.5	0.174	0.000	0.001	0.037	0.026	0.045
Waste incineration		N_2O	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 $\frac{0.01 \bullet D_x + \sum D_i - (0.01 \bullet C_x + \sum C_i)}{(0.01 \bullet C_x + \sum C_i)} \bullet 100 - \frac{\sum D_i - \sum C_i}{\sum C_i} \bullet 100$

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 prosessing, beverages, tobacco	CO_2	10	-	...	...	-	-100	-100	-100
Gas combustion	Food prosessing, beverages, tobacco	CO_2	-	89	-5	5	0.018	…	-	-
Oil combustion	Food prosessing, 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, Manufaqcture 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 illage, 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 prosessing, beverages, tobacco	CH_4	0	-	...	...	-	-100	-100	-100
Wood combustion	Food prosessing, beverages, tobacco	CH_4	0	0	-57	97	0.000	-96	-97	-93
Gas combustion	Food prosessing, beverages, tobacco	CH_4	-	0	-53	88	0.001	…	-	-
Oil combustion	Food prosessing, 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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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_2O	1	1	-74	105	0.002	-46	-50	-42
Wood combustion	Public electricity and heat prod	N_2O	2	5	-74	125	0.019	162	76	292
Gas combustion	Public electricity and heat prod	N_2O	-	3	-73	116	0.011	…	-	-
Oil combustion	Public electricity and heat prod	N_2O	0	0	-71	109	0.001	528	506	548
Waste combustion	Public electricity and heat prod	N_2O	4	6	-74	123	0.026	54	43	65
Coal/coke combustion	Petroleum refining	N_2O	0	0	-72	121	0.002	53	51	56
Oil combustion	Petroleum refining	N_2O	5	2	-73	121	0.009	-57	-57	-56
Gas combustion	Manufacture of solid fuels and other energy	N_2O	14	27	-74	121	0.107	101	101	102
Oil combustion	Manufacture of solid fuels and other energy	N_2O	1	2	-71	107	0.007	181	176	187
Coal/coke combustion	Iron and steel	N_2O	0	0	-72	116	0.001	-53	-56	-51
Wood combustion	Iron and steel	N_2O	0	0	-74	114	0.000	269	144	453
Gas combustion	Iron and steel	N_2O	-	0	-74	117	0.000	…	-	-
Oil combustion	Iron and steel	N_2O	0	0	-70	107	0.000	-57	-58	-57
Wood combustion	Non-ferrous metal	N_2O	-	0	-75	134	0.001	…	-	-
Gas combustion	Non-ferrous metal	N_2O	-	0	-69	128	0.001	…	-	-
Oil combustion	Non-ferrous metal	N_2O	1	0	-70	107	0.001	-71	-72	-69
Coal/coke combustion	Chemicals	N_2O	1	1	-72	115	0.002	-11	-17	-4
Wood combustion	Chemicals	N_2O	0	1	-74	124	0.003	295	166	519
Gas combustion	Chemicals	N_2O	-	0	-72	116	0.001	…	-	-
Oil combustion	Chemicals	N_2O	1	2	-71	125	0.008	64	33	100

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Coal/coke combustion	Pulp, paper, print	N_2O	0	-	...	...	-	-100	-100	-100
Wood combustion	Pulp, paper, print	N_2O	27	20	-75	132	0.078	-28	-52	13
Gas combustion	Pulp, paper, print	N_2O	-	0	-70	120	0.000	…	-	-
Oil combustion	Pulp, paper, print	N_2O	1	1	-70	107	0.004	56	55	57
Coal/coke combustion	Food prosessing, beverages, tobacco	N_2O	0	-	...	...	-	-100	-100	-100
Wood combustion	Food prosessing, beverages, tobacco	N_2O	0	0	-76	125	0.000	-96	-97	-93
Gas combustion	Food prosessing, beverages, tobacco	N_2O	-	0	-71	115	0.000	…	-	-
Oil combustion	Food prosessing, beverages, tobacco	N_2O	1	1	-71	106	0.003	-47	-49	-45
Coal/coke combustion	Other manufacturing	N_2O	0	0	-72	119	0.001	146	143	148
Wood combustion	Other manufacturing	N_2O	6	4	-75	123	0.017	-29	-52	9
Gas combustion	Other manufacturing	N_2O	-	0	-73	115	0.000	…	-	-
Oil combustion	Other manufacturing	N_2O	3	2	-71	108	0.008	-28	-30	-25
Waste combustion	Other manufacturing	N_2O	-	1	-71	118	0.004	…	-	-
Transport fuel - civil aviation		N_2O	7	11	-74	113	0.041	58	25	104
Transport fuel - road transportation		N_2O	57	59	-51	70	0.146	5	-2	10
Transport fuel - railway		N_2O	11	5	-84	99	0.020	-53	-56	-50
Transport fuel - navigation		N_2O	11	14	-73	129	0.058	30	3	65
Transport fuel - motorized equipment and pipeline		N_2O	69	125	-77	110	0.487	81	41	130
Coal/coke combustion	Commercial/ institutional	N_2O	-	0	-72	128	0.000	…	-	-
Wood combustion	Commercial/ institutional	N_2O	0	0	-74	136	0.002	4 429	2 890	6 832
Gas combustion	Commercial/ institutional	N_2O	-	0	-73	118	0.000	…	-	-
Oil combustion	Commercial/ institutional	N_2O	2	2	-72	113	0.008	-10	-29	15
Waste combustion	Commercial/ institutional	N_2O	0	-	...	...	-	-100	-100	-100
Coal/coke combustion	Residential	N_2O	0	0	-72	127	0.000	-94	-95	-91
Wood combustion	Residential	N_2O	10	13	-73	130	0.051	29	-11	92
Gas combustion	Residential	N_2O	-	0	-75	129	0.000	…	-	-
Oil combustion	Residential	N_2O	4	1	-71	110	0.005	-65	-69	-61
Coal/coke combustion	Agriculture/forestry/ fishing	N_2O	0	-	...	...	-	-100	-100	-100
Wood combustion	Agriculture/forestry/ fishing	N_2O	-	0	-74	118	0.000	…	-	-
Gas combustion	Agriculture/forestry/ fishing	N_2O	-	0	-72	120	0.000	…	-	-
Oil combustion	Agriculture/forestry/ fishing	N_2O	67	61	-71	112	0.231	-9	-19	2

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Military fuel - stationary	Military	N_2O	0	0	-73	114	0.001	21	13	30
Military fuel - mobile	Military	N_2O	6	4	-76	104	0.015	-31	-36	-27
Well testing		N_2O	0	0	-74	136	0.000	-75	-84	-61
Flaring		N_2O	4	4	-75	112	0.013	-15	-16	-13
Nitric acid production		N_2O	2 074	460	-6	6	0.108	-78	-78	-78
Methanol and plastic production		N_2O	-	1	-9	9	0.000	…	-	-
Ferroalloys production		N_2O	5	4	-10	10	0.001	-28	-28	-28
Other		N_2O	36	44	-15	15	0.026	25	25	25
Manure management - N_2O - Liquid storage		N_2O	17	18	-53	80	0.047	1	-5	6
Manure management - N_2O - solid storage		N_2O	116	109	-52	84	0.290	-6	-11	-1
Direct soil emission - Fertilizer		N_2O	665	595	-82	220	3.633	-11	-16	-4
Direct soil emission - Manure		N_2O	240	232	-82	219	1.417	-4	-9	1
Direct soil emission- Other		N_2O	160	138	-84	245	0.944	-13	-63	109
Direct soil emission- Organic soil		N_2O	332	287	-86	228	1.961	-14	-68	120
Animal production		N_2O	223	206	-54	84	0.569	-8	-13	-3
Indirect soil emission- Deposition		N_2O	71	82	-70	142	0.345	15	10	21
Indirect soil emission - Leaching, other		N_2O	346	322	-69	170	1.496	-7	-11	-3
Burning of straw		N_2O	9	1	-70	112	0.005	-85	-87	-83
Forest Land remaining Forest Land, Fertilizer		N_2O	1	1	-83	219	0.004	-58	-58	-58
Forest Land remaining Forest Land, Drainage		N_2O	11	12	-87	317	0.111	6	6	6
Forest Land remaining Forest Land, Wildfires		N_2O	0	0	-55	95	0.001	42	8	92
Cropland, Disturbance		N_2O	1	0	-90	328	0.001	-86	-86	-86
Land converted to Wetland, Drainage		N_2O	0	0	-89	309	0.001	-	-	-
Waste water - N_2O plant		N_2O	-	37	-55	88	0.109	…	-	-
Waste water - N_2O pipeline		N_2O	91	97	-56	95	0.302	7	-24	51

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Waste water - N_2O not connected		N_2O	26	25	-80	209	0.157	-5	-38	50
Waste incineration		N_2O	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

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