Norwegian Environment Agency

Greenhouse Gas Emissions 1990-2023

Annexes to NID 2025

Report

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Annexes to NID 2025

Annex 1: Key Categories

The key category assessment is made by Statistics Norway using the IPCC Approach 1 and the Approach 2 method, which includes uncertainty estimates. The assessment is updated annually and is made for the level and trend since 1990. Statistics Norway also considers the qualitative criteria for identification of key categories. In accordance with the IPCC good practice guidance for LULUCF (IPCC 2006) the analysis is made in two parts, one excluding LULUCF emissions and removals and another integrating LULUCF with the rest of the inventory.

Methodology used for identifying key categories:
The analysis has been made for the base year and the latest year using the approach 1 and approach 2 level and trend assessment according to the methods described in the 2006 IPCC guidelines and IPCC 2019 refinements.

The approach 1 method assesses the impacts of various source/sink categories on the level and the trend of the national emission inventory. In the approach 1 analysis key categories are the aggregated categories that together contribute up to either 95% of the level or 95% of the overall contribution to trend of all greenhouse gas emissions in Norway.

The approach 2 method also assesses the impacts on the level and the trend but information about the sources' uncertainties is also included in the analysis. Approach 2 key categories are those that add up to 90% of the contribution to level and trend in the national inventory.

The analysis is performed for all direct greenhouse gases, i.e. CO2, CH4, N2O, HFCs, PFCs and SF6, with all emissions converted to CO2-equivalents.

Results: The analyses have been performed for 1990 and 2023 GHG emission data. The main conclusion is that there are few differences in the result for 1990 compared with 2023.

For the Land use, Land-use Change and Forestry (LULUCF) sector, Table A1-2 shows the results of the key category analysis performed as described in IPCC (2006).

Table A1-1: Summary of identified emission key categories, identified by rank. Excluding LULUCF.

Category	Greenhouse Gas	2023 estimates ktons CO2 eq	Level and Trend assessment Rank (if Key Category)						Method
			Approach 1			Approach 2			
			L1 1990	L1 2023	T1	L2 1990	L2 2023	T2	
1A1-1A2-1A4. Stationary Fuel Combustion Biomass	CH_4	261.8	22	23	18	8	15	8	Tier 2
1A1-1A2-1A4. Stationary Fuel Combustion Gaseous Fuels	CO_2	10119	3	1	1	10	2	6	Tier 2
1A1-1A2-1A4. Stationary Fuel Combustion Liquid Fuels	CO_2	3513.8	2	3	3	13	16	11	Tier 2
1A1-1A2-1A4. Stationary Fuel Combustion Other Fuels	CO_2	1208.3	27	9	8	26	8	5	Tier 2
1A1-1A2-1A4. Stationary Fuel Combustion Solid Fuels	CO_2	368.3	16	20	15	28	.	.	Tier 2
1A3A. Civil Aviation	CO_2	1065.5	18	10	14	16	13	14	Tier 3
1A3B. Road Transportation	CO_2	7890.8	1	2	11	5	5	22	Tier 2
1A3B. Road Transportation	CH_4	14.4	.	.	.	.	.	24	Tier 2
1A3D. Navigation	CO_2	2741.5	12	4	6	9	1	7	Tier 2
1A3D. Navigation	CH_4	103.7	.	.	25	.	22	15	Tier 2
1A4. Other sectors - Mobile Fuel Combustion	CO_2	2497.2	9	6	10	6	3	9	Tier 2
1A5A. Stationary	CO_2	0.0	.	.	28	.	.	.	Tier 2
1A5B. Mobile	CO_2	231.3	23	24	19	.	.	.	Tier 2
1B1A. Coal Mining	CH_4	77.7	.	.	23	17	28	13	Tier 1
1B2A. Oil (incl. oil refineries, gasoline distribution)	CO_2	919.8	14	11	17	4	7	12	Tier 2

Category	Greenhouse Gas	2023 estimates ktons CO2 eq	Level and Trend assessment Rank (if Key Category)						Method
			Approach 1			Approach 2			
			L1 1990	L1 2023	T1	L2 1990	L2 2023	T2	
1B2A. Oil (incl. oil refineries, gasoline distribution)	CH_4	101.0	32	.	26	23	.	20	Tier 2
1B2C. Venting and Flaring	CO_2	669.0	11	16	7	1	4	1	Tier 3
1B2C. Venting and Flaring	CH_4	195.4	.	26	.	21	18	.	Tier 3
2A1. Cement Production	CO_2	594.2	20	17	.	.	.	.	Tier 3
2A2. Lime Production	CO_2	204.5	.	25	20	.	.	.	Tier 3
2B1. Ammonia Production	CO_2	727.4	15	14	.	.	29	.	Tier 2
2B10. Other	N_2O	134.5	.	.	27	.	.	.	
2B2. Nitric Acid Production	N_2O	54.5	10	.	4	20	.	10	Tier 3
2B5. Carbide Production	CO_2	0.3	24	.	13	.	.	17	Tier 2
2B6. Titanium dioxide production	CO_2	178.3	31	29	.	.	.	.	Tier 2
2B8. Petrochemical and carbon black production	CO_2	723.0	19	15	.	.	24	.	Tier 2
2C2. Ferroalloys production	CO_2	2549.6	5	5	.	25	23	.	Tier 2/3
2C3. Aluminium production	CO_2	1972.0	13	7	12	15	14	16	Tier 2/3
2C3. Aluminium production	PFC	93.9	4	.	2	3	.	2	Tier 2
2C4. Magnesium production	SF_6	.	7	.	.	.	.	.	Tier 2
2D1. Lubricant use	CO_2	41.4	.	.	22	.	.	.	Tier 2
2F. Product uses as substitutes for ODS	HFC	762.3	.	13	9	.	6	4	Tier 2
3A1. Cattle	CH_4	1788.0	8	8	16	7	9	21	Tier 2
3A2. Sheep	CH_4	463.5	21	19	.	19	21	.	Tier 2

Category	Greehouse Gas	2023 estimates ktons CO2 eq	Level and Trend assessment Rank (if Key Category)						Method
			Approach 1			Approach 2			
			L1 1990	L1 2023	T1	L2 1990	L2 2023	T2	
3A4. Other	CH_4	151.7	.	.	.	.	25	.	Tier 2
3B. Manure Management	N_2O	168.3	.	30	.	22	20	.	Tier 2
3B1. Cattle	CH_4	277.5	26	22	.	.	27	.	Tier 2
3D11. Synthetic Fertilizers	N_2O	567.7	17	18	21	14	19	23	Tier 1
3D12. Organic N fertilizer	N_2O	139.6	.	.	.	18	17	.	Tier 1
3D14. Crop Residue	N_2O	37.6	.	.	.	24	.	19	Tier 1
3D16. Cultivation of Histosols	N_2O	352.4	25	21	.	11	11	.	Tier 1
3D22. Nitrogen Leaching and Run-off	N_2O	183.3	29	27	.	12	12	18	Tier 1
3G. Liming	CO_2	132.5	28	.	24	.	.	.	Tier 1
5A1A. Managed Waste Disposal sites. Anaerobic	CH_4	850.3	6	12	5	2	10	3	Tier 2
5D1. Domestic Wastewater	CH_4	181.8	30	28	.	27	26	.	Tier 1

Table A1-2: Summary of identified LULUCF key categories, identified by rank.

Category	Greehouse Gas	2023 estimates ktons CO2 eq	Level and Trend assessment Rank (if Key Category)						Method
			Approach 1			Approach 2			
			L1 1990	L1 2023	T1	L2 1990	L2 2023	T2	
4(II)Crop. Cropland - drained organic soil	CH_4	104.6	.	.	.	40	41	.	Tier 1
4(II)Forest. Forest land - drained organic soils	N_2O	150.2	47	48	.	25	29	.	Tier 1
4.A.1. Forest remaining forest -	CO_2	-6464	7	4	2	4	2	1	Tier 3

Category	Greehouse Gas	2023 estimates ktons CO2 eq	Level and Trend assessment Rank (if Key Category)						Method
			Approach 1			Approach 2			
			L1 1990	L1 2023	T1	L2 1990	L2 2023	T2	
Litter + dead wood + Mineral soil									
4.A.1. Forest remaining forest - Living biomass	CO_2	-13457	1	1	6	1	1	6	Tier 3
4.A.1. Forest remaining forest, drained organic soils - Organic soil	CO_2	1210.7	17	12	.	13	17	.	Tier 1
4.A.2.a. Cropland to Forest - Litter	CO_2	-56.7	.	.	.	28	37	.	Tier 1
4.A.2.b.Ext. Extensive Grassland to Forest - Litter	CO_2	-309.0	.	31	21	39	5	5	Tier 1
4.A.2.b.Int. Intensive Grassland to Forest - Litter	CO_2	-26.9	46	.	32	16	.	12	Tier 1
4.A.2.b.Int. Intensive Grassland to Forest - Living biomass	CO_2	-54.7	.	.	47	.	.	30	Tier 1 / 3
4.A.2.c.Unm. Unmanaged Wetland to Forest - Litter	CO_2	-79.0	.	.	.	45	30	25	Tier 1
4.A.2.c.Unm. Unmanaged Wetland to Forest - Living biomass	CO_2	-9.9	.	.	.	.	.	39	Tier 3
4.A.2.d. Settlement to Forest - Litter	CO_2	-143.6	.	49	.	24	20	21	Tier 1
4.A.2.d. Settlement to Forest - Living biomass	CO_2	-55.1	.	.	48	.	46	24	Tier 1 / 3
4.B.1. Cropland remaining cropland - Organic soil	CO_2	1753.3	15	11	22	8	8	32	Tier 1
4.B.2.a. Forest to Cropland - DOM	CO_2	246.2	.	34	33	19	9	13	Tier 1 / 2

Category	Greehouse Gas	2023 estimates ktons CO2 eq	Level and Trend assessment Rank (if Key Category)						Method
			Approach 1			Approach 2			
			L1 1990	L1 2023	T1	L2 1990	L2 2023	T2	
4.B.2.a. Forest to Cropland - Living biomass	CO_2	92.6	.	.	.	.	42	42	Tier 1 / 3
4.B.2.a. Forest to Cropland - Mineral soil	CO_2	48.0	.	.	.	.	49	.	Tier 1
4.B.2.a. Forest to Cropland - Organic soil	CO_2	62.7	.	.	.	37	50	37	Tier 1
4.B.2.c. Unmanaged Wetland to Cropland - Organic soil	CO_2	18.3	.	.	41	27	.	18	Tier 1
4.C.1.Ext. Extensive Grassland remaining extensive grassland - Living biomass	CO_2	-353.2	.	28	20	.	51	35	Tier 3
4.C.1.Int. Intensive Grassland remaining intensive grassland - Living biomass	CO_2	-206.4	41	38	.	41	39	.	Tier 2 / 3
4.C.1.Int. Intensive Grassland remaining intensive grassland - Mineral soil	CO_2	21.8	.	.	.	.	.	38	Tier 1
4.C.1.Int. Intensive Grassland remaining intensive grassland - Organic soil	CO_2	70.1	.	.	.	44	.	.	Tier 1
4.C.2.a. Forest to Intensive Grassland - DOM	CO_2	331.6	.	30	19	.	4	4	Tier 1 / 2
4.C.2.a. Forest to Intensive Grassland - Living biomass	CO_2	78.2	.	.	.	.	35	22	Tier 1 / 3
4.D.1.a. Wetland Peat extraction -	CO_2	75.2	.	.	.	46	45	.	Tier 2

Category	Greehouse Gas	2023 estimates ktons CO2 eq	Level and Trend assessment Rank (if Key Category)						Method
			Approach 1			Approach 2			
			L1 1990	L1 2023	T1	L2 1990	L2 2023	T2	
on+off-site - Organic soil									
4.D.1.c.Man. Managed Wetlands remaining managed wetlands - Organic soil	CO_2	245.7	39	35	.	43	40	.	Tier 1
4.D.2.c.i. Forest to Managed Wetland - DOM	CO_2	27.9	.	.	.	.	53	.	Tier 1 / 2
4.D.2.c.i. Forest to Managed Wetland - Living biomass	CO_2	52.6	.	.	.	.	44	.	Tier 3
4.E.1. Settlements remaining settlements - Organic soil	CO_2	182.6	.	42	28	.	43	23	Tier 1
4.E.2.a. Forest to Settlement - DOM	CO_2	629.6	20	21	25	2	3	9	Tier 1 / 2
4.E.2.a. Forest to Settlement - Living biomass	CO_2	548.5	28	24	37	17	13	33	Tier 1 / 3
4.E.2.a. Forest to Settlement - Mineral soil	CO_2	94.0	.	.	.	23	28	36	Tier 1
4.E.2.a. Forest to Settlement - Organic soil	CO_2	95.5	.	.	.	42	52	.	Tier 1
4.E.2.b. Cropland to Settlement - Mineral soil	CO_2	-10.4	.	.	.	32	.	27	Tier 1
4.E.2.b. Cropland to Settlement - Organic soil	CO_2	240.4	.	36	.	.	21	.	Tier 1
4.E.2.c. Intensive Grassland to Settlement - Mineral soil	CO_2	18.1	.	.	.	.	.	46	Tier 1

Category	Greehouse Gas	2023 estimates ktons CO2 eq	Level and Trend assessment Rank (if Key Category)						Method
			Approach 1			Approach 2			
			L1 1990	L1 2023	T1	L2 1990	L2 2023	T2	
4.G-HWP. Harvested wood Products	CO_2	-434.8	19	26	14	7	24	11	Tier 1

Summaries for all analyses are presented as an attached Excel file and PDF, Annex I Analyses.xlsx. There are four sets of analyses, for approaches 1 and 2 with and without LULUCF. For each set, three analyses are presented: level 1990, level 2023, and trend. All tables are ranked by the assessment value for the 2023 level analysis.

References

IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan

IPCC (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Annex 2: Uncertainty Assessment

1. Summary

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 Approach 2 method, as described in IPCC (2006). Analyses have been made both excluding and including the sector LULUCF (land use, land-use change and forestry).

The report *Uncertainties in the Norwegian Greenhouse Gas Emission Inventory* (Rypdal, Kristin & Zhang, L-C. 2000) includes more detailed documentation of the analysis method used in all analyses. Major updates of the uncertainty data were performed in 2006 and 2011 (Flugsrud & Hoem 2011). In 2020-2021 a project was performed to update and improve the uncertainty analysis/parameters applied for the base year and the uncertainty estimates for the latest year. More detailed information can be found in the NIR 2022 Annex II section 5; “Evaluation of the work with Saturday paper”.

The results show that the uncertainty in the calculated greenhouse gas emissions for 2022 excluding LULUCF is ±3 per cent.

1.1 Level of the analysis

The uncertainty analysis is for most sources performed at the most detailed level of IPCC source categories (IPCC 2000). For some sources a more detailed separation is made, e.g., where different pollutants from a source sector must be connected to different activity measures, to be able to consider dependencies between only parts of the source groups. Energy carriers have been grouped into five main types: solid, gaseous, liquid, waste, and bio energy. The placement into 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".

Implementation of the 2006 IPCC guidelines (IPCC 2006) in the compilation of the inventory have affected the analysis through a higher level of detail in the source categories. Additional splitting of source categories, which has been done in previous analyses, is therefore now in most cases obsolete.

In Table A2-8, source category levels used in the study is listed.

For some emission sources, activity data and emission factors are not available. Examples are estimates based on measurements, emissions reported by plants (in the cases when the plants have only reported emissions and not activity data and emission factor used), and emissions that are aggregated from sources with diverse methods (for example emissions from 2C7 Other metal production). These emissions have been assigned activity equal to 1, and emission factor to be equal to the estimated value. This is possible since the total uncertainty estimate is independent of scale for activity and emission factor[1].

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

Table 6.2 from the IPCC good practice guidance is included in a separate attachment. This is a response to recommendations in previous ERT review reports. Column G is estimated as uncertainty for source category divided by total GHG emissions.

2. Uncertainties in input parameters

2.1 Emission estimates

In the analysis emission estimates for the different source categories for the base year and end year are taken from the Norwegian emission inventory.

The emission estimates used in the analysis comes from the national GHG emission inventory and is based on Norwegian measurements, literature data or statistical surveys. Some data are based on expert judgements.

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.

2.2 Standard deviation and probability density

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

1. Normal distribution
2. Lognormal distribution

For low uncertainties lognormal distributions approach the normal distributions. For large uncertainties the normal distribution may lead to negative values. To avoid this, the 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 that were in principle a difference between larger gains and losses that likely were normally distributed with lower uncertainties. These carbon balances might take both positive and negative values.

The uncertainties and densities given in the following sections are based on information for the end year. However, they were also used for 1990 and for the trend analysis. In reality, due to improved methods, the quality of the end year 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.

2.3 Activity data

The assessed standard deviations and corresponding probability densities are summarised in Table A2-1.

Table A2-1: Summary of standard deviation and probability density of activity data.

IPCC Source category	Pollutant source	Standard deviation (2σ). per cent[1]	Density shape	Source/ comment
1A1, 1A2	Coal/coke – general	5	Normal	Expert judgement industry, (Tokheim 2006)
1A1B	Coal/coke – petroleum refining	1.1	Normal	Emission trading scheme: Klif (2011), Spread in data: Rypdal, K. and Zhang, L.-C. (2000)
1A2A	Coal/coke - iron and steel	4.1	Normal	Emission trading scheme (Klif 2011), Expert judgement industry, (Tokheim 2006)
1A2G	Coal/coke - other	0.8	Normal	Emission trading scheme (Klif 2011), Expert judgement industry, (Tokheim 2006)

IPCC Source category	Pollutant source	Standard deviation (2σ). per cent[1]	Density shape	Source/ comment
1A4B	Coal/coke - residential	20	Normal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1A4C	Coal/coke - agriculture	30	Normal	Expert judgement, Statistics Norway
1A1, 1A2, 1A4	Wood	30	Lognormal	Expert judgement, Rypdal, K. and Zhang, L.-C. (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	IPCC 2006
1A1C	Gas - manufacture of solid fuels and other energy industries	0.2	Normal	Emission trading scheme (Klif 2011; NPD 2006)
1A2C	Gas - chemicals	1.7	Normal	Emission trading scheme (Klif 2011), Norwegian Petroleum Directorate, Statistics Norway (2000)
1A2D	Gas - pulp, paper, print	1.7	Normal	Emission trading scheme (Klif 2011), Norwegian Petroleum Directorate, Statistics Norway (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, K. and Zhang, L.-C. (2000)
1A1B	Oil - petroleum refining	1.1	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A1C	Oil – manufacture of solid fuels and other energy industries	1.8	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A2A	Oil - iron and steel	0.5	Normal	Emission trading scheme (Klif 2011),Rypdal, K. and Zhang, L.-C. (2000)
1A2C	Oil - chemicals	14.4	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A2D	Oil – pulp, paper, print	0.7	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A2G	Oil - other	2.6	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)

IPCC Source category	Pollutant source	Standard deviation (2σ). per cent[1]	Density shape	Source/ comment
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
1A1, 1A2	Waste – general	5	Normal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1A2E	Waste – Food processing beverages and tobacco	3		Expert judgement, Statistics Norway
1A2G	Waste - other manufacturing	3.2	Normal	Emission trading scheme (Klif 2011), Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1A4A	Waste - commercial/institutional	10	Lognormal	Expert judgement SSB 2024
1A3A, 1A3E	Transport fuel - civil aviation, motorized equipment and pipeline	20	Normal	Expert judgement, Rypdal, K. and Zhang, L.-C. (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, K. and Zhang, L.-C. (2000)
1B2A	Extraction of oil - transport, refining/storage	3	Normal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1B2A	Extraction of oil - distribution gasoline	5	Normal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1B2C	Venting	-	-	See emission factor
1B2C	Flaring	1.4	Normal	Emission trading scheme (Klif 2011), Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1B2C	Well testing	30	Normal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1C2	Injection and storage	5	Normal	Expert judgement, Norwegian Environmental Agency (2020)
2A1	Cement production	0.4	Normal	Emission trading scheme (Klif 2011)

IPCC Source category	Pollutant source	Standard deviation (2σ). per cent[1]	Density shape	Source/ comment
2A2	Lime production	0.4	Normal	Emission trading scheme (Klif 2011)
2A3	Glass production	14.1	Normal	Emission trading scheme (Klif 2011)
2A4	Other mineral production	0.1	Normal	Emission trading scheme (Klif 2011)
2B1	Ammonia production	3	Normal	Expert judgement industry, (Yara 2006)
2B2	Nitric acid production	-	-	See emission factor
2B5	Carbide production - SiC	3	Normal	Expert judgement industry (Gobain & Exolon 2006)
2B5	Carbide production - CaC	3	Normal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
2B6	Titanium dioxide production	3		Expert judgement, Statistics Norway
2B8	Methanol and plastic production	9.0	Normal	Emission trading scheme (Klif 2011)
2C1	Iron and steel production	1.2	Normal	Expert judgement industry, (Tinfos 2006)
2C2	Ferroalloys production	-	-	See emission factor
2C3	Aluminium production	3	Normal	Expert judgement industry, (Hydro 2006a)
2C4	Mg production	-	-	See emission factor
2C6	Zn production	5	Normal	Expert judgement, Statistics Norway
2C7	Ni production, anode production	10	Normal	Expert judgement, Statistics Norway
2D1	Lubricant use	0.9	-	Expert judgement, Statistics Norway.
2D2	Paraffin wax use	30	Normal	Expert judgement, Statistics Norway
2D3	Other		-	See emission factor
2E1	Electronics industry – By-product emissions	-	-	See emission factor
2F	Product uses as substitutes for ODS	10	Normal	Expert judgement, Statistics Norway 2022.See emission factor
2G1	Electrical equipment	10	Normal	Expert judgement, Statistics Norway 2022.
2G2	SF_6 and PFC from other product use	-	-	See emission factor
2G3	N_20 from product use	-	-	See emission factor
2H1	Pulp and paper	0.9	Normal	Emission trading scheme (Klif 2011)

IPCC Source category	Pollutant source	Standard deviation (2σ). per cent[1]	Density shape	Source/ comment
2H2	Food and beverage industry	10	Normal	Expert judgement, Statistics Norway
3A	Enteric fermentation	5	Normal	Expert judgement, (Norway 2006a)
3Ba	Manure management - CH_4	5	Normal	Expert judgement, (Norway 2006a)
3Bb	Manure management - N_2O	24	Normal	Expert judgement[2], (Norway 2006a; Norway 2006b; Norway 2006c)
3Da1	Inorganic N fertilizer	5	Normal	Rypdal (1999)
3Da2	Organic N fertilizer	19	Normal	Rypdal, K. and Zhang, L.-C. (2000)
3Da3	Urine and dung deposited by grazing animals	22	Lognormal	Expert judgement[4], Statistics Norway
3Da4	Crop residue	30	Lognormal	Grønlund et al. (2014)[3]
3Da6	Cultivation of organic soils	Fac2	Lognormal	Expert judgement, Statistics Norway
3Db1	Atmospheric deposition	30	Normal	Expert judgement, Statistics Norway
3Db2	Nitrogen leaching and run-off	70	Lognormal	Expert judgement, Statistics Norway
3F	Emissions from field burning of agricultural residues	10	Normal	Expert judgement, Statistics Norway
3G	Liming	5	Normal	IPCC (2006)
3H	Urea application	5	Normal	IPCC (2006)
4	Land use, land use change and forestry	-	-	Described in section LULUCF uncertainties2.5
5A	Solid waste disposal	20	Normal	Expert judgement, Statistics Norway
5B1	Composting	5	Normal	Expert judgement, Statistics Norway
5B2	Anaerobic digestion - Biogas	5	Normal	Expert judgement, Statistics Norway
5C	Waste incineration	10	Normal	Expert judgement, Statistics Norway 2024
5D1	Domestic wastewater	10	Normal	Expert judgement, Statistics Norway
5D2	Industrial wastewater	20	Normal	Expert judgement, Statistics Norway

[1] Strongly skewed distributions are characterised as fac3 etc, indicating that 2σ is a factor 3 below and above the mean.
[2] Population 5% (Norway 2006a), population swine 7% (SSB 2024) Nex 15% (Norway 2006b), distribution AWMS 10% (Norway 2006c), distribution pasture/ storage 15% (Norway 2006b)
[3] Grønlund et al. (2014) angir usikkerhet for eng til ± 50% og andre vekster ±25%.
[4] Population 5% (Norway 2006a), population swine 2024, Nex 15% (Norway 2006b)(Statistics Norway 2006b, distribution pasture/ storage 15% (Norway 2006b)

2.4 Emission factors

The assigned values and probability densities are shown in *Table A2-2*.

Table A2-2: Summary of standard deviation and probability density of emission factors.

IPCC Source category	Pollutant source	Gas	(2σ). per cent[1]	Density shape	Source/ comment
1A1, 1A2B, 1A2D, 1A2E, 1A4	Coal/coke - general	CO_2	7	Normal	Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A1B	Coal/coke – petroleum refining	CO_2	0.9	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A2A	Coal/coke – iron and steel	CO_2	16.0	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A2G	Coal/coke - other	CO_2	2.0	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (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, Statistics Norway (2000)
1A1C	Gas – Manufacture of solid fuels and other energy	CO_2	2.6	Normal	Emission trading scheme (Klif 2011), Norwegian Petroleum Directorate, Statistics Norway (2000)
1A2C	Gas - Chemicals	CO_2	1.6	Normal	Emission trading scheme (Klif 2011), Norwegian Petroleum Directorate, Statistics Norway (2000)
1A1, 1A2, 1A4	Oil - general	CO_2	3	Normal	Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A1B	Oil – petroleum refining	CO_2	0.9	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A2C	Oil - Chemicals	CO_2	1.1	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A2G	Oil - other	CO_2	2.8	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A4B	Oil - residential	CO_2	3.4	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)

IPCC Source category	Pollutant source	Gas	(2σ). per cent[1]	Density shape	Source/ comment
1A1, 1A4	Waste - general	CO_2	30	Normal	Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A2G	Waste - other	CO_2	25.2	Normal	Emission trading scheme (Klif 2011), Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A3A, 1A3B, 1A3C, 1A3D	Transport fuel	CO_2	3	Normal	Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A5A	Military fuel - stationary	CO_2	5	Normal	Expert judgement, Statistics Norway
1A5B	Military fuel - mobile	CO_2	10	Normal	Expert judgement, Statistics Norway
1A1, 1A2, 1A4	Coal/coke, wood, waste - general	CH_4	Fac2	Lognormal	Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A1B	Coal/coke – petroleum refining	CH_4	Fac2	Lognormal	Spread in data, Rypdal, K. and Zhang, L.-C. (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	Lognormal	Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
1A3A, 1A3C, 1A3D	Transport fuel	CH_4	25	normal	Spread in data. Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1A3B	Transport fuel	CH_4	45	Lognormal	Gustafsson (2005)
1A1, 1A2, 1A4, 1A5	Coal/coke, wood, gas, waste – general, military fuel – stationary	N_2O	Fac3	Lognormal	Expert judgement, Statistics Norway
1A5	military fuel – mobile	N_2O	Fac3	Lognormal	Expert judgement, Statistics Norway
1A1, 1A2, 1A4	Oil - general	N_2O	Fac3	Lognormal	Spread in data. Expert judgement. IPCC (1997), Rypdal, K. and Zhang, L.-C. (2000)
1A1B	Coal/coke – petroleum refining	N_2O	Fac3	Lognormal	Spread in data. Expert judgement. IPCC (1997), Rypdal, K. and Zhang, L.-C. (2000)
1A3A, 1A3C, 1A3D	Transport fuel	N_2O	25	Lognormal	Expert judgement, Rypdal, K. and Zhang, L.-C. (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

IPCC Source category	Pollutant source	Gas	(2σ). per cent[1]	Density shape	Source/ comment
1B2C	Venting	CO_2	Fac2	Lognormal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1B2C	Flaring	CO_2	4.5	Normal	Emission trading scheme (Klif 2011), Rypdal, K. and Zhang, L.-C. (2000)
1B2C	Well testing	CO_2	7	Normal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1B1A, 1B2B, 1B2C	Coal mining, extraction of natural gas, venting	CH_4	Fac2	Lognormal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1B2A	Extraction of oil - transport, refining/storage	CH_4	40	Lognormal	Expert judgement, Statistics Norway
1B2C	Flaring, well testing	CH_4	Fac2	Lognormal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1B2C	Flaring, well testing	N_2O	Fac3	Lognormal	Expert judgement, Rypdal, K. and Zhang, L.-C. (2000)
1C2	Injection and storage	CO_2	0	Normal	Expert judgement, Norwegian Environmental Agency (2020)
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	Glass production	CO_2	7	Normal	Expert judgement, Statistics Norway
2B1	Ammonia production	CO_2	7	Normal	Expert judgement industry, Yara (2006)
2B5	Carbide production	CO_2	10	Normal	Spread in data, Rypdal, K. and Zhang, L.-C. (2000)
2B6	Titanium dioxide production	CO_2	10	Normal	Expert judgement, Statistics Norway
2B8	Petrochemical and black carbon production	CO_2	0,74	Normal	Emission trading scheme (Klif 2011), Expert judgement, Statistics Norway
2B8	Petrochemical and black carbon production	CH_4	Fac2	Lognormal	Expert judgement, Statistics Norway
2B2	Nitric acid production	N_2O	7.0	Normal	Expert judgement industry, Yara (2006), Emission trading scheme (Klif 2011)
2C1	Iron and steel production	CO_2	1.3	Normal	Emission trading scheme (Klif 2011), Expert judgement industry, Tinfos (2006)
2C2	Ferroalloys production	CO_2	3	Normal	Expert judgement, SINTEF (2006)
2C3	Aluminium production	CO_2	10	Normal	International Aluminium Institute (IAI), Hydro (2006a)

IPCC Source category	Pollutant source	Gas	(2σ). per cent[1]	Density shape	Source/ comment
2C6	Zn production	CO_2	5	Normal	Expert judgement, Statistics Norway
2C7	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	PFC	20	Normal	Expert judgement industry, Hydro (2006a)
2C4	SF_6 used in Al and Mg foundries	SF_6	0.25	Normal	Expert judgement industry, Hydro (2006b)
2D1	Lubricant use	CO_2	20	Normal	IPCC (2006) and expert judgement, Statistics Norway
2D2	Paraffin wax use	CO_2	10	Normal	Expert judgement, Statistics Norway
2D3	Non-energy products - other	CO_2	10	Normal	Expert judgement, Statistics Norway
2D3	Non-energy products - other	N_2O	15	Normal	Expert judgement, Statistics Norway
2E1	Electronics industry – By-products emission	SF_6	60	Lognormal	Expert judgement, Statistics Norway
2F	Product uses as substitutes for ODS	HFC/PFC	50	Lognormal	Apply to HFK. Expert judgement, Statistics Norway
2G1	Electrical equipment	SF_6	60	Lognormal	Expert judgement, Statistics Norway
2G2	Other product use	SF_6	60	Lognormal	Expert judgement, Statistics Norway
2G3	Product use	N_2O	15	Normal	Expert judgement, Statistics Norway
2H1	Pulp and paper	CO_2	10	Normal	Expert judgement, Statistics Norway
2H2	Food and beverage industry	CO_2	10	Normal	Expert judgement, Statistics Norway
3A1	Enteric fermentation – cattle	CH_4	17	Normal	Expert judgement, NMBU (2006); NMBU (2020)
3A2	Enteric fermentation - sheep	CH_4	25	Normal	Expert judgement, NMBU (2006)
3A3	Enteric fermentation swine	CH_4	20	Normal	IPCC (2006)
3A4	Enteric fermentation - sother animal	CH_4	40	Normal	IPCC (2006) and expert judgement by Statistics Norway

IPCC Source category	Pollutant source	Gas	(2σ). per cent[1]	Density shape	Source/ comment
3Ba1, 3Ba3	Manure management – CH_4 – cattle and swine	CH_4	20	Normal	IPCC (2006)
3Ba2, 3Ba4	Manure management – CH_4 – sheep and other animal	CH_4	20	Normal	IPCC (2006)
3B	Manure management - N_2O	N_2O	Fac2	Lognormal	IPCC (2006)
3Da1	Direct soil emission inorganic fertilizer	N_2O	22	Normal	IPCC (2019)
3Da2-4	Direct soil emission	N_2O	Fac3	Lognormal	IPCC (2006)
3Da6	Direct soil emission – Cultivation of organic soils	N_2O	37	Lognormal	IPCC (2014)
3Db1	Atmospheric Deposition	N_2O	24	Normal	IPCC (2006)
3Db2	Nitrogen Leaching and Run-off	N_2O	Fac3	Lognormal	IPCC (2006)
3F1	Agricultural residue burning	CH_4	Fac2	Lognormal	Expert judgement, Statistics Norway
3F1	Agricultural residue burning	N_2O	Fac3	Lognormal	Expert judgement, Statistics Norway
3G	Liming	CO_2	10	Normal	Expert judgement, Statistics Norway
3H	Urea application	CO_2	10	Normal	Expert judgement, Statistics Norway
4	Land use, land use change and forestry	CO_2, N_2O and CH_4	-	-	Described in section 2.5
5A	Solid waste disposal	CH_4	30	Lognormal	SFT (2006b)
5B1	Composting – municipal solid waste	CH_4	Fac3	Lognormal	IPCC (2006)
5B1	Home composting	N_2O	Fac3	Lognormal	IPCC (2006)
5B2	Anaerobic digestion at biogas facilities	N_2O	Fac3	Lognormal	IPCC (2006)
5C	Waste incineration	CO_2	30	Normal	Expert judgement, Statistics Norway
5C	Waste incineration	CH_4	Fac2	Lognormal	Expert judgement, Statistics Norway

IPCC Source category	Pollutant source	Gas	(2σ). per cent[1]	Density shape	Source/ comment
5C	Waste incineration	N_2O	Fac3	Lognormal	Expert judgement, Statistics Norway
5D	Wastewater treatment and discharge	CH_4	30	Normal	IPCC (2006)
5D	Wastewater treatment and discharge	N_2O	50	Normal	IPCC (2006) Expert judgement, Statistics Norway 2022

[1] 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.
[2] BOD/ person 30%, Bo 30% (IPCC 2000) and MCF 25%. Dependencies between parameters

2.5 LULUCF uncertainties

Uncertainties of area estimates are based on a standard sampling methodology. Large areas, like forest land remaining forest land and extensive grasslands remaining grassland, have low area uncertainty due to a large number of NFI sampling plots. Small number of NFI sampling plots such as for land-use conversion categories, have relatively quite large area uncertainties. The absolute size of the uncertainty in those classes is nonetheless small.

The uncertainties of carbon stock change (CSC) estimates in tree living biomass in remaing and convertions to and from forest land, grasslands and wetlands were estimated as described in chapter 6.3.7. Estimated uncertainties are based on the sampling error. As for area estimates, the relative uncertainty estimates for CSC were quite large for small land-use categories, whereas their absolute size was comparably small (Table A2-3). For annual crop living biomass on cropland converted to lands and lands converted to croplands, the uncertainty was based on Tier 1 defaults. Similarly, for grass living biomass on grasslands converted to lands and lands converted to grasslands, uncertainties were also based on Tier 1 defaults. Uncertainty estimates for CSC estimates for the dead organic matter (DOM) pool for conver to and from forest land were based on expert judgement. Forest land remaining forest land CSC for DOM and mineral soil (combined), was derived from Monte Carlo simulations of modelling SOC with the Yasso07 model considering uncertainties for different parameters used for the litter production (input data) and the model (see section 6.4.1).

Table A2-3: Uncertainties of living biomass shown as total aggregated uncertainty (Utotal) based on the uncertainties of the C stock change (CSC) per hectare and the area estimates. 2 SE means two times the standard error.

Code	Land-use class	Area (%) – 2SE%	CSC (%)	U_{total} (%)	Density shape (U_{total})	Source/ comment
4A1	Forest land remaining forest land	2	33	32	Normal	NFI area + NFI living biomass
4A2	Cropland to forest land	52	90	104	Log normal	NFI area + NFI living biomass + IPCC (2019)
4A2	Extensive grassland to forest land	46	105	115	Log normal	NFI area + NFI living biomass + IPCC (2019)
4A2	Intensive grassland to forest land	71	96	119	Log normal	NFI area + NFI living biomass + IPCC (2019)
4A2	Settlements to forest land	41	137	143	Log normal	NFI area + NFI living biomass + IPCC (2019)
4A2	Unmanaged wetlands to forest land	63	84	105	Log normal	NFI area + NFI living biomass
4A2	Managed wetlands to forest land	102	121	158	Log normal	Sample variance and expert judgement, NIBIO
4B1	Cropland remaining cropland[a]	0	46	46	Normal	IPCC (2019)
4B2	Forest land to cropland	41	108	116	Log normal	NFI area + NFI living biomass + IPCC (2019)
4B2	Extensive grassland to cropland	149	75	167	Log normal	NFI area + IPCC (2019)
4B2	Intensive grassland to cropland	105	75	129	Log normal	NFI area + IPCC (2019)
4B2	Settlements to cropland	200	75	224	Log normal	NFI area + IPCC (2019)
4C1	Extensive grassland remaining extensive grassland	4	20	20	Normal	NFI area + NFI living biomass
4C1	Intensive grassland remaining intensive grassland	13	52	54	Normal	NFI area + NFI living biomass
4C2	Forest land to intensive grassland	31	159	162	Log normal	NFI area + NFI living biomass + IPCC (2019)
4C2	Cropland to intensive grassland	155	87	235	Log normal	NFI area + Expert judgement + NFI living biomass + IPCC (2019)

Code	Land-use class	Area (%) – 2SE%	CSC (%)	U_{total} (%)	Density shape (U_{total})	Source/ comment
4C2	Unmanaged wetlands to intensive grassland	121	149	192	Log normal	NFI area + NFI living biomass + IPCC (2019)
4D1	Unmanaged Wetlands remaining unmanaged wetlands	5	54	54	Normal	NFI area + NFI living biomass
4D1	Managed Wetlands remaining managed wetlands	37	82	90	Normal	NFI area + NFI living biomass
4D2	Forest land to managed wetlands	110	134	173	Log normal	NFI area + NFI living biomass
4E2	Cropland to settlements	40	74	84	Normal	NFI area + IPCC (2019)
4E2	Forest land to settlements	19	69	72	Normal	NFI area + NFI living biomass + IPCC (2019)
4E2	Extensive grassland to settlements	90	75	117	Log normal	NFI area + IPCC (2019)
4E2	Intensive grassland to settlements	67	68	95	Normal	NFI area + NFI living biomass + IPCC (2019)
4E2	Unmanaged wetlands to settlements	124	110	166	Log normal	NFI area + NFI living biomass + IPCC (2019)

[a] Area uncertainty of 0% is based on SSB data and pertains to orchards. The total area uncertainty for cropland remaining cropland is 7% based on NFI estimates

Table A2-4: Uncertainties of dead organic matter (DOM) shown as total aggregated uncertainty (U_{total}) based on the uncertainties of the C stock change (CSC) per hectare and the area estimates. 2 SE means two times the standard error.

Code	Land-use class	Area (%) – 2SE%	CSC (%)	U_{total} (%)	Density shape (U_{total})	Source/ comment
4A1	Forest land remaining forest land[a]	2	33	33	Normal	Sampling variance + Monte Carlo
4A2	Cropland to forest land	52	200	212	Log normal	NFI area + Expert judgement + IPCC (2019)
4A2	Extensive grassland to forest land	46	200	212	Log normal	NFI area + Expert judgement + IPCC (2019)
4A2	Intensive grassland to forest land	71	200	224	Log normal	NFI area + Expert judgement + IPCC (2019)

Code	Land-use class	Area (%) - 2SE%	CSC (%)	U_{total} (%)	Density shape (U_{total})	Source/ comment
4A2	Settlements to forest land	41	200	212	Log normal	NFI area + Expert judgement + IPCC (2019)
4A2	Unmanaged wetlands to forest land	63	200	212	Log normal	NFI area + Expert judgement + IPCC (2019)
4A2	Managed wetlands to forest land	102	200	235	Log normal	NFI area + Expert judgement + IPCC (2019)
4B2	Forest land to cropland	41	200	212	Log normal	NFI area + Expert judgement + IPCC (2019)
4C2	Forest land to intensive grassland	31	200	212	Log normal	NFI area + Expert judgement + IPCC (2019)
4D2	Forest land to managed wetlands	110	200	235	Log normal	NFI area + Expert judgement + IPCC (2019)
4E2	Forest land to settlements	19	200	201	Log normal	NFI area + Expert judgement + IPCC (2019)
[a] *Uncertainty in DOM is combined for litter, dead wood, and mineral soil because of the estimation method used (all three pools are modelled and not mutually independent); therefore, the same uncertainty is used as in Table A2-5*						

Uncertainties for mineral soil CSC factors on land-use conversion categories were found through the combination of error propagation (combining uncertainties as given in the IPCC 2019 Refinement) and expert judgement where necessary (Table A2-5). Uncertainties in the carbon loss from drained organic soils were calculated using the error ranges supplied in the IPCC 2013 Wetlands supplement for all drained organic soils on forest land, cropland, grassland, wetlands - land under peat extraction, and settlement subcategories. In addition, an expert judgement of 50% uncertainty for carbon loss from instant oxidation for lands converted to infrastructure settlements was used. For each land-use change category, error propagation was applied to the weighted fraction of emissions from each IPCC climate region. The calculations for settlements also considered subcategories (see chapter 6.8 on settlements subcategories). The uncertainty of the emission factors was then combined with the uncertainty of the area estimates determined by the sampling error. For two smaller classes (managed wetlands – peat extraction and orchards on croplands), the uncertainty of the area estimates is based on expert judgement as the NFI does not estimate their areas. The uncertainty in the soil type classification method, i.e., the inaccuracy of the soil maps, was ignored.

Table A2-5: Uncertainties of the mineral soil shown as total aggregated uncertainty (U_{total}) based on the uncertainties of the C stock change (CSC) and the area estimates. 2 SE means two times the standard error.

Code	Land-use class	Area (%) – 2SE%	CSC (%)	U_{total} (%)	Density shape (U_{total})	Source/ comment
4A1	Forest land remaining forest land [a]	2	33	33	Normal	Sampling variance + Monte Carlo
4A2	Cropland to forest land	55	151	161	Log normal	NFI area + expert judgement
4A2	Intensive grassland to forest land	71	608	450	Log normal	NFI area + expert judgement
4A2	Settlements to forest land	41	202	212	Log normal	NFI area + expert judgement
4B1	Cropland remaining cropland	7	50	50	Normal	NFI area + expert judgement
4B2	Forest land to cropland	44	151	157	Log normal	NFI area + expert judgement
4B2	Extensive grassland to cropland	149	200	300	Log normal	NFI area + expert judgement
4B2	Intensive grassland to cropland	122	200	235	Log normal	NFI area + expert judgement
4B2	Settlements to cropland	200	373	450	Log normal	NFI area + expert judgement
4C1	Intensive grassland remaining Intensive grassland	13	91	92	Normal	NFI area + IPCC(2006)
4C2	Forest land to intensive grassland	31	608	450	Log normal	NFI area + expert judgement
4C2	Settlement to Extensive Grassland	118	189	224	Log normal	NFI area + expert judgement
4C2	Cropland to Intensive grassland	200	200	300	Log normal	NFI area + expert judgement
4E2	Cropland to settlements	42	373	450	Log normal	NFI area + expert judgement
4E2	Forest land to settlements	19	202	212	Log normal	NFI area + expert judgement
4E2	Extensive grassland to Settlements	90	189	212	Log normal	NFI area + expert judgement
4E2	Intensive grassland to Settlements	67	189	201	Log normal	NFI area + expert judgement
4E2	Unmanaged wetlands to settlements	115	200	235	Log normal	NFI area + expert judgement

[a] Uncertainty for mineral soil in forest remaining forest is combined for litter, dead wood, and mineral soil (see Table A2-4).

Table A2-6: Uncertainties of the organic soil shown as total aggregated uncertainty (U_{total}) based on the uncertainties of the C stock change (CSC) and the area estimates. 2 SE means two times the standard error.

Code	Land-use class	Area (%) – 2SE%	CSC (%)	U_{total} (%)	Density shape (U_{total})	Source/ comment
4A1	Forest land remaining forest land	16	25	30	Normal	NFI area + IPCC (2014)
4A2	Cropland to forest land	141	25	143	Log normal	NFI area + IPCC (2014)
4A2	Unmanaged wetlands to forest land	77	25	81	Normal	NFI area + Borgen et al. (2014)
4A2	Managed wetlands to forest land	72	25	76	Normal	NFI area + IPCC (2014)
4B1	Cropland remaining cropland	24	18	30	Normal	NFI area + IPCC (2014)
4B2	Forest land to cropland	115	18	116	Log normal	NFI area + IPCC (2014)
4B2	Intensive grassland to cropland	200	18	201	Log normal	NFI area + IPCC (2014)
4B2	Managed wetlands to cropland	97	18	99	Normal	NFI area + IPCC (2014)
4B2	Unmanaged wetlands to cropland	161	18	162	Log normal	NFI area + IPCC (2014)
4C1	Intensive grassland remaining Intensive grassland	78	50	93	Normal	NFI area + IPCC (2014)
4C2	Cropland to intensive grassland	200	50	212	Log normal	NFI area + IPCC (2014)
4C2	Unmanaged wetlands to intensive grassland	121	50	131	Log normal	NFI area + IPCC (2014)
4D1	Managed wetlands - Peat extraction [a]	0	110	110	Log normal	Søgaard (2017)
4D1	Managed wetlands remaining managed wetlands (other drained wetlands)	37	25	45	Normal	NFI area + IPCC (2014)
4D2	Forest land to managed wetlands	200	25	212	Log normal	NFI area + IPCC (2014)
4E1	Settlement remaining settlement	54	22	58	Normal	NFI area + IPCC (2014)
4E2	Cropland to settlements	118	22	120	Log normal	NFI area + IPCC (2014)

Code	Land-use class	Area (%) – 2SE%	CSC (%)	U_{total} (%)	Density shape (U_{total})	Source/ comment
4E2	Forest land to settlements	70	22	73	Normal	NFI area + IPCC (2014)
4E2	Unmanaged wetlands to settlements	146	22	148	Log normal	NFI area + IPCC (2014)
[a] *The sub-category peat extraction includes on-site and off-site emissions; therefore, specific uncertainties for areas and CSC are not given.*						

For HWP, the reported uncertainty estimates for half-lives are ± 50%, according to IPCC (2006). In addition, there is 15% uncertainty related to the activity data – production and trade for countries with systematic census or surveys (IPCC 2006).

Default uncertainty estimates were also used for N_2O and CH_4 emissions from drained organic soils, for direct and indirect N_2O emissions, and biomass burning.

Table A2-7: Uncertainties of N_2O and CH_4 emissions for direct and indirect N_2O emissions and for drained organic soils shown as total uncertainty (U_{total}) based on the uncertainties of the emission factor (EF) and the activity data (AD). 2 SE means two times the standard error.

Code	Source	Land-use class	Gas	AD (%) - 2SE%	EF (%)	U_{total} (%)	Density shape (U_{total})	Source/ comment
4(I)	Direct N_2O from inorganic N inputs	Forest land	N_2O	20	200	201	Log normal	Expert judgement + SSB + IPCC(2019)
4(I)	Indirect N_2O - Atmospheric deposition	Forest land	N_2O	200	400	450	Log normal	IPCC (2019)
4(I)	Indirect N_2O - Leaching and runoff	Forest land	N_2O	167	223	300	Log normal	IPCC (2019)
4(I)	Direct N_2O from organic N inputs	Settlements	N_2O	20	200	201	Log normal	Expert judgement + SSB + IPCC(2019)
4(I)	Indirect N_2O - Atmospheric deposition	Settlements	N_2O	200	400	450	Log normal	IPCC (2019)
4(I)	Indirect N_2O - Leaching and runoff	Settlements	N_2O	200	400	450	Log normal	IPCC (2019)

Code	Source	Land-use class	Gas	AD (%) - 2SE%	EF (%)	U_{total} (%)	Density shape (U_{total})	Source/ comment
4(II)	Drained organic soils	Forest land	N_2O	16	119	120	Log normal	NFI area + IPCC (2014)
4(II)	Drained organic soils	Managed wetlands - Peat extraction	N_2O	100	113	151	Log normal	Søgaard (2017)
4(II)	Drained organic soils	Other managed wetlands	N_2O	36	119	124	Log normal	NFI area + IPCC (2014)
4(II)	Drained organic soils	Settlements	N_2O	40	31	51	Normal	NFI area + IPCC (2014)
4(II)	Drained organic soils	Cropland	CH_4	23	100	103	Log normal	NFI area + IPCC (2014)
4(II)	Drained organic soils	Forest land	CH_4	16	83	85	Normal	NFI area + IPCC (2014)
4(II)	Drained organic soils	Grassland	CH_4	64	65	91	Normal	NFI area + IPCC (2014)
4(II)	Drained organic soils	Managed wetlands - Peat extraction	CH_4	0	128	128	Log normal	Søgaard (2017)
4(II)	Drained organic soils	Other managed wetlands	CH_4	36	77	85	Normal	NFI area + IPCC (2014)
4(II)	Drained organic soils	Settlements	CH_4	40	43	59	Normal	NFI area + IPCC (2014)
4(III)	Direct N_2O	N mineralization/ immobilization	N_2O	100	200	224	Log normal	IPCC (2019)
4(III)	Indirect N_2O	N mineralization/ immobilization	N_2O	167	233	300	Log normal	IPCC (2019)
4(IV)	Biomass burning	Wildfires in forest	N_2O	0	70	70	Normal	Expert judgement + IPCC (2003)
4(IV)	Biomass burning	Wildfires in forest	CH_4	0	70	70	Normal	Expert judgement + IPCC (2003)

In the cases where the uncertainty of the activity data estimate was not derived from the NFI, and the uncertainty of the CSC was based on expert judgment, the total uncertainty was derived by combining the two uncertainties. The specific methods and assumptions are described further for each of the sinks/sources under the sections of the individual land-use categories in chapter 6.

2.6 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, K. & Zhang, L.-C. 2000).

2.7 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) 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

2.8 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 sources 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 sources in LULUCF, but we have no estimates for the uncertainty in activity data, and 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.

2.9 Dependencies between data in base year and end year

The estimates made for the base year and end year will to a large extent be based on the same data and assumptions.

2.9.1 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 cannot 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.

2.9.2 Emission factors

Most of the emission factors are assumed unchanged from the base year to the end year. Those that are not all based on the same assumptions. 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.

2.10 The statistical modelling

Uncertainty analysis based on probabilistic analysis implies that uncertainties in model inputs are used to propagate uncertainties in model outputs. The result of the uncertainty estimation gives us the range and likelihood of various output values (Alison C. Cullen & Frey 1999).

Having generated a data set according to the specified parametric simultaneous distribution of the data described in Table A2-1 and Table A2-2, we may calculate any desired output defined as a function of the data. This gives us one simulated random realisation of this output, according to its marginal distribution derived from the underlying simultaneous distribution of the data. Independent repetition of the simulation gives an independent sample of the desired output according to its marginal distribution. The size of the sample is given by the number of repeated simulations and has nothing to do with the size of the original data set. Based on such an independent and identically distributed sample, we may use the sample mean as an estimate of the mean of the output; we may also use the sample standard deviation as an estimate of the standard deviation of the output.

2.11 Results of the Approach 2 Uncertainty analysis

Results for the uncertainties in the total emissions and trends for the GHG inventory, excluding and including the LULUCF sector are given in Chapter 1.6.

3. Source category level used in the analysis

Source category level used in the analysis is listed in Table A2-8.

Table A2-8: Source category level used in the analysis.

IPCC	Source Category	Pollutant source
1A1A_VT1	Public electricity and heat prod	Coal/coke combustion
1A1A_VT2	Public electricity and heat prod	Wood combustion
1A1A_VT3	Public electricity and heat prod	Gas combustion
1A1A_VT6	Public electricity and heat prod	Oil combustion
1A1A_VT7	Public electricity and heat prod	Waste combustion
1A1B_VT1	Petroleum refining	Coal/coke combustion
1A1B_VT6	Petroleum refining	Oil combustion
1A1C_VT3	Manufacture of solid fuels and other energy	Gas combustion
1A1C_VT6	Manufacture of solid fuels and other energy	Oil combustion
1A2A_VT1	Iron and steel	Coal/coke combustion
1A2A_VT2	Iron and steel	Wood combustion
1A2A_VT3	Iron and steel	Gas combustion
1A2A_VT6	Iron and steel	Oil combustion
1A2A_VT6	Iron and steel	Waste combustion
1A2B_VT1	Non-ferrous metal	Coal/coke combustion
1A2B_VT2	Non-ferrous metal	Wood combustion
1A2B_VT3	Non-ferrous metal	Gas combustion
1A2B_VT6	Non-ferrous metal	Oil combustion
1A2C_VT1	Chemicals	Coal/coke combustion
1A2C_VT2	Chemicals	Wood combustion
1A2C_VT3	Chemicals	Gas combustion
1A2C_VT6	Chemicals	Oil combustion
1A2C_VT7	Chemicals	Waste combustion
1A2D_VT1	Pulp, paper, print	Coal/coke combustion
1A2D_VT2	Pulp, paper, print	Wood combustion
1A2D_VT3	Pulp, paper, print	Gas combustion
1A2D_VT6	Pulp, paper, print	Oil combustion
1A2D_VT7	Pulp, paper, print	Waste combustion
1A2E_VT1	Food processing, beverages, tobacco	Coal/coke combustion
1A2E_VT2	Food processing, beverages, tobacco	Wood combustion
1A2E_VT3	Food processing, beverages, tobacco	Gas combustion
1A2E_VT6	Food processing, beverages, tobacco	Oil combustion
1A2E_VT7	Food processing, beverages, tobacco	Waste combustion
1A2G_VT1	Other manufacturing	Coal/coke combustion
1A2G_VT2	Other manufacturing	Wood combustion
1A2G_VT3	Other manufacturing	Gas combustion

IPCC	Source Category	Pollutant source
1A2G_VT6	Other manufacturing	Oil combustion
1A2G_VT7	Other manufacturing	Waste combustion
1A3A	Transport fuel - civil aviation	
1A3B	Transport fuel - road transportation	
1A3C	Transport fuel – railway	
1A3D	Transport fuel – navigation	
1A4A_VT2	Transport fuel - motorized equipment and pipeline	
1A4A_VT3	Commercial/institutional	Wood combustion
1A4A_VT6	Commercial/institutional	Gas combustion
1A4A_VT7	Commercial/institutional	Oil combustion
1A4B_VT1	Commercial/institutional	Waste combustion
1A4B_VT2	Residential	Coal/coke combustion
1A4B_VT3	Residential	Wood combustion
1A4B_VT6	Residential	Gas combustion
1A4C_VT1	Residential	Oil combustion
1A4C_VT2	Agriculture/forestry/fishing	Coal/coke combustion
1A4C_VT3	Agriculture/forestry/fishing	Wood combustion
1A4C_VT6	Agriculture/forestry/fishing	Gas combustion
1A5A	Agriculture/forestry/fishing	Oil combustion
1A5B	Military	Military fuel - stationary
1B1A	Military	Military fuel - mobile
1B2A_x	Coal mining, Extraction of natural gas	
1B2A_y	Extraction of oil – transport	
1B2A_z	Extraction of oil - refining/storage	
1B2B	Extraction of oil - distribution gasoline	
1B2C_x	Coal mining, Extraction of natural gas	
1B2C_y	Venting	
1B2C_z	Well testing	
1C2	Injection and storage	
2A1	Flaring	
2A2	Cement production	
2A3	Lime production	
2A4	Glass production	
2B1	Other mineral production	
2B2	Ammonia production	
2B5	Nitric acid production	
2B6	Silicone and calcium carbide production	
2B8	Titanium dioxide production	

IPCC	Source Category	Pollutant source
2B10	Petrochemical and black carbon production	
2C1	Iron and steel production	
2C2	Ferroalloys production	
2C3	Aluminium production	
2C4	Magnesium production	
2C6	Zinc production	
2C7	Ni production, anodes	
2D1	Lubricant use	
2D2	Paraffin wax use	
2D3	Other non-energy use of energy products	
2E1	Electronics industry – by-product emissions	
2F	Product uses as substitutes for ODS	
2G1	Electrical equipment	
2G2	SF_6 from other product use	
2G3	N_2O from product uses	
2H1	Pulp and paper	
2H2	Food and beverage industry	
3A1	Enteric fermentation – cattle	
3A2	Enteric fermentation – sheep	
3A3	Enteric fermentation – swine	
3A4	Enteric fermentation - other animal	
3B1	Manure management - CH_4 -cattle	
3B2	Manure management - CH_4 – sheep	
3B3	Manure management - CH_4- swine	
3B4	Manure management - CH_4 - other animal	
3B	Manure management - N_2O - solid storage	
3D11	Direct soil emission - Inorganic fertilizer	
3D12	Direct soil emission - Organic fertilizer	
3D13	Direct soil emission- Urine and dung by grazing animals	
3D14	Direct soil emission- Crop residue	
3D15	loss/gain soil organic matter	
3D21	Indirect soil emission- Deposition	
3D22	Indirect soil emission - leakage	
3F1	Field Burning of Agricultural Residue – cereals	
3G	Liming	
3H	Urea application	
4A1	Forest remaining forest - Litter + dead wood + Mineral soil	
4A1	Forest remaining forest - Living biomass	

IPCC	Source Category	Pollutant source
4A1	Forest remaining forest, drained organic soils - Organic soil	
4A2.a	Cropland to Forest – Dead wood	
4A2.a	Cropland to Forest – Litter	
4A2.a	Cropland to Forest - Living biomass	
4A2.a	Cropland to Forest - Mineral soil	
4A2.a	Cropland to Forest - Organic soil	
4A2.b.Ext	Extensive grassland to forest- Dead wood	
4A2.b.Ext	Extensive grassland to forest- Litter	
4A2.b.Ext	Extensive grassland to forest- Living biomass	
4A2.b.Int	Intensive grassland to forest- Dead wood	
4A2.b.Int	Intensive grassland to forest- Litter	
4A2.b.Int	Intensive grassland to forest- Living biomass	
4A2.b.Int	Intensive grassland to forest- mineral soil	
4A2.d	Settlement to Forest – Dead wood	
4A2.d	Settlement to Forest – Litter	
4A2.d	Settlement to Forest - Living biomass	
4A2.d	Settlement to Forest - Mineral soil	
4A2.c.Unm	Unmanaged Wetland to Forest – Dead wood	
4A2.c.Unm	Unmanaged Wetland to Forest – Litter	
4A2.c.Unm	Unmanaged Wetland to Forest - Living biomass	
4A2.c.Unm	Unmanaged Wetland to Forest - Organic soil	
4A2.c.Man	Managed Wetland to Forest – Dead wood	
4A2.c.Man	Managed Wetland to Forest - Litter	
4A2.c.Man	Managed Wetland to Forest - Living biomass	
4A2.c.Man	Managed Wetland to Forest - Organic soil	
4B1	Cropland remaining cropland - Living biomass	
4B1	Cropland remaining cropland - Mineral soil	
4B1	Cropland remaining cropland - Organic soil	
4B2.a	Forest to Cropland – Dead wood	
4B2.a	Forest to Cropland - Living biomass	
4B2.a	Forest to Cropland - Mineral soil	
4B2.a	Forest to Cropland - Organic soil	
4B2.b.Ext	Extensive Grassland to Cropland - Mineral soil	
4B2.b.Ext	Extensive Grassland to Cropland - Living biomass	
4B2.b.Int	Intensive Grassland to Cropland - Mineral soil	
4B2.b.Int	Intensive Grassland to Cropland - Living biomass	
4B2.b.Int	Intensive Grassland to Cropland - Organic soil	
4B2.d	Settlement to Cropland - Living biomass	

IPCC	Source Category	Pollutant source
4B2.d	Settlement to Cropland - Mineral soil	
4B2.c.Man	Managed Wetland to Cropland - Organic soil	
4B2.c.Unm	Unmanaged Wetland to Cropland - Organic soil	
4C1.Ext	Extensive Grassland remaining extensive grassland - Living biomass	
4C1.Int	Intensive Grassland remaining extensive grassland - Living biomass	
4C1.Int	Intensive Grassland remaining intensive grassland - Mineral soil	
4C1.Int	Intensive Grassland remaining intensive grassland – Organic soil	
4C2.a	Forest to intensive Grassland – Dead wood	
4C2.a	Forest to intensive Grassland - Living biomass	
4C2.a	Forest to intensive Grassland - Mineral soil	
4C2.b	Cropland to intensive Grassland-Living biomass	
4C2.b	Cropland to intensive Grassland- Mineral soil	
4C2.b	Cropland to intensive Grassland-Organic soil	
4C2.d	Settlement to intensive Grassland - Mineral soil	
4C2.c	Unmanaged Wetland to intensive Grassland - Living biomass	
4C2.c	Unmanaged Wetland to intensive Grassland - Organic soil	
4D1.a	Wetland Peat extraction - on+off-site - Organic soil	
4D1.c.Unm	Unmanaged Wetlands remaining unmanaged wetlands, - Living biomass	
4D1.c.Man	Managed Wetlands remaining managed wetlands, -Living biomass	
4D1.c.Man	Managed Wetlands remaining managed wetlands – organic soils	
4D2	Forest to managed Wetland – DOM	
4D2	Forest to managed Wetland - Living biomass	
4D2	Forest to managed Wetland - Organic soil	
4E1	Settlements remaining settlements - Organic soil	
4E2	Cropland to Settlement - Living biomass	
4E2	Cropland to Settlement - Mineral soil	
4E2	Cropland to Settlement – Organic soil	
4E2	Forest to Settlement – DOM	
4E2	Forest to Settlement - Living biomass	
4E2	Forest to Settlement - Mineral soil	
4E2	Forest to Settlement - Organic soil	
4E2.c.Ext	Extensive Grassland to Settlement - Living biomass	
4E2 c.Ext	Extensive Grassland to Settlement - Mineral soil	
4E2.c.Int	Intensive Grassland to Settlement - Living biomass	

IPCC	Source Category	Pollutant source
4E2.c.Int	Intensive Grassland to Settlement - Mineral soil	
4E2.d	Unmanaged Wetland to Settlement - Living biomass	
4E2.d	Unmanaged Wetland to Settlement - Mineral soil	
4E2.d	Unmanaged Wetland to Settlement - Organic soil	
4G	Harvested wood Products – HWP	
4(I)	Forest- Direct N_2O from inorganic N inputs - Inorganic N inputs	
4(I)	Settlement- Direct N_2O from organic N inputs - Organic N inputs	
4(I)	Forest Indirect N2O from inorganic N inputs-Atmospheric deposition	
4(I)	Forest Indirect N2O from inorganic N inputs-Leaching-runoff	
4(I)	Settlement Indirect N2O from organic N inputs- Atmospheric deposition	
4(I)	Settlement Indirect N2O from organic N inputs –Leaching and runoff	
4(II)	Cropland - drained organic soil - Organic soil CC + LC (CH4)	
4(II)	Forest land - drained organic soils (CH4)	
4(II)	Grassland - drained organic soils - Organic soil GG + LG (CH4)	
4(II)	Wetland Peat extraction - Organic soil (CH4)	
4(II)	Wetland - drained organic soils (CH4)	
4(II)	Settlement - drained organic soils (CH4)	
4(II)	Forest land - drained organic soils (N2O)	
4(II)	Wetland Peat extraction - Organic soil (N2O)	
4(II)	Wetland - drained organic soils (N2O)	
4(II)	Settlement - drained organic soils (N2O)	
4(III)	Direct N_2O from N mineralization/immobilization - Mineralization/immobilization	
4(III)	Indirect N_2O from N mineralization/immobilization	
4(IV)	Forest land – biomass burning (CH4)	
4(IV)	Forest land – biomass burning (N2O)	
5A	Solid waste disposal	
5B1	Composting – municipal solid waste	
5B2	Anaerobic digestion at biogas facilities	
5C	Waste incineration	
5D1	Domestic wastewater	
5D2	Industrial wastewater	

4. Approach 2 uncertainty reporting

The Approach 2 uncertainty reporting is attached as an Excel file, Annex 2 Table 6.2.xlsx.

5. References

Alison C. Cullen & Frey, H. C. (1999): *Probabilistic Techniques in Exposure Assessment. A Handbook for Dealing with Variability and Uncertainty in Models and Inputs*: Springer New York, NY. 336 pp

Bárcena, T. G., Dalsgaard, L., Strand, L. T., Mohr, C. W., Bjørkelo, K., Eriksen, R. & Søgaard, G. (2021): *A Tier 1 methodology for estimating changes in soil organic carbon after land use change on mineral soil*: NIBIO

Borgen, S. K. & Hylen, G. (2013): Emissions and methodologies for cropland and grassland used in the Norwegian national greenhouse gas inventory, Report 11/2013: Norwegian Forest and Landscape Institute (Norsk institutt for skog og landskap). 45 pp

Borgen, S. K., Dalsgaard, L. & Arnoldussen, A. (2014): CO2 emissions from Norwegian cropland soils: influence of IPCC tier level. In *Proceedings of the International conference on Soil carbon sequestration for climate, food security and ecosystem services, Reykjavik, Iceland, 27-29 May 2013*, pp. 101-108. Luxembourg: Publications Office of the European Union

Dalsgaard, L., Lange, H., Strand, L. T., Callesen, I., Borgen, S. K., Liski, J. & Astrup, R. (2016): Underestimation of boreal forest soil carbon stocks related to soil classification and drainage. *Canadian Journal of Forest Research*, 46 (12): 1413-1425

Dalsgaard, L., Kjønaas, O. J. & Lange, H. (2017): Forest soil carbon changes from measurements and models. Site-specific comparisons and implications for UNFCCC reporting. Ås: Norwegian Institute for Bioeconomy Research. 112 pp

EEA (2019): EMEP/EEA air pollutant emission inventory guidebook - 2019, https://www.eea.europa.eu/publications/emep-eea-guidebook-2019.

Flugsrud, K. & Hoem, B. (2011): Uncertainties in the Norwegian greenhouse gas emission inventory, Reports 35/2011: Statistics Norway (SSB-Statistisk sentralbyrå). 51 pp

Gobain, S. & Exolon, O. (2006). *E-mail from Svein Haarsaker (Orkla Exolon)* (January 20 2006).

Grønlund, A., Sturite, I., Riley, H., Fystro, G. & Lunnan, T. (2014): Nitrogen i restavlinger. 18 pp

Gustafsson, T. (2005): Improved structures for uncertainty analysis in the Swedish Greenhouse Gas Emission Inventory. *Commissioned report by the Swedish Environmental Protection Agency*, SMED Report No 69 2005: SMED-Swedish Methodology for Environmental Data

Holmengen, N. & Kittilsen, M. O. (2009): Estimating emissions of NMVOC from solvent and other product use. Revised model, Reports 2009/14: Statistics Norway (SSB-Statistisk sentralbyrå). 77 pp

Hydro, N. (2006a). *E-mail from Halvor Kvande* (January 18 2006).

Hydro, N. (2006b). *Email from Vidar Ersnes* (January 18 2006).

IPCC (1997): Greenhouse Gas Inventory. Reference Manual (Volume 3). *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*

IPCC (2000): Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories: Prepared by the National Greenhouse Gas Inventories Programme, J Penman, D Kruger, I Galbally, T Hiraishi, B Nyenzi, S Emmanul, L Buendia, R Hoppaus, T Martinsen, J Meijer, K Miwa and K Tanabe. Published for the IPCC by the Institute for Global Environmental Strategies, Japan

IPCC (2003): Good Practice Guidance for Land Use, Land-Use Change and Forestry: [Penman, J., M.Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe and F. Wagner (eds.)]. IPCC National Greenhouse Gas Inventories Programme. Institute for Global Environmental Strategies, Hayama, Kanagawa, Japan

IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan

IPCC (2014): 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. In Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. & Troxler, T. G. (eds) vol. wetlands supplement *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*

IPCC (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Karlengen, I. J., Svihus, B., Kjos, N. P. & Harstad, O. M. (2012): Husdyrgjødsel; oppdatering av mengder gjødsel og utskillelse av nitrogen, fosfor og kalium. Sluttrapport. (Manure; an update of amounts of manure and excretion of nitrogen, phosphorus and potassium. Final report). Ås: Departement of Animal and Aquacultural Sciences, Norwegian University of Life Sciences (Institutt for husdyr- og akvakulturvitenskap, NMBU-Norges miljø- og biovitenskapelige universitet)

Klif (2011): *Emission trading scheme*. In Agency, N. C. a. P. (ed.). http://www.klif.no/Tema/Klima-og-ozon/CO2-kvoter/Klimakvoter-for-2008/: Norwegian Climate and Pollution Agency

Kvingedal, E., Tornsjø, B., Holtskog, S., G., H. & Rypdal, K. (2000): Verification of the Norwegian Emission Inventory. Comparing emission intensity values with similar countries, TA-1736/00: Norwegian Pollution Control Authority (SFT-Statens forurensingstilsyn), Statistics Norway (SSB-Statistisk sentralbyrå)

Morken, J. & Hoem, B. (2011): Models for calculating methane emission from manure management in Norway, IMT-Rapport 43/2011: Norwegian University of Life Sciences (NMBU-Norges miljø- og biovitenskapelige universitet). 18 pp

NMBU. (2006). *Email from Harald Volden*: the Norwegian University of Life Sciences (January 27 2006).

NMBU. (2020). *Email from Egil Prestløkken: the Norwegian University of Life Sciences* (February 17 2020).

Norway, S. (2006a). *Email from Berit Bjørlo, Division for agricultural statistics,* : Statistics Norway, Division for agricultural statistics, (January 26 2006).

Norway, S. (2006b). *Personal communication with Henning Høie*: Statistics Norway, Division for environmental statistics, (February 2006).

Norway, S. (2006c). *Personal communication with Ole Rognstad*: Statistics Norway, Division for agricultural statistics, (February 2006).

NPD. (2006). *Mail from Marta Melhus*: Norwegian Petroleum Directorate.

Rypdal, K. (1999): Evaluation of uncertainty in the Norwegian emission inventory, SFT-report 99:01. TA-1609/99: Norwegian Pollution Control Authority (SFT-Statens forurensingstilsyn), Statistics Norway (SSB-Statistisk sentralbyrå). 58 pp

Rypdal, K. & Zhang, L.-C. (2000): Uncertainties in the Norwegian greenhouse gas emission inventory: Statistics Norway

Rypdal, K. & Zhang, L.-C. (2000): Uncertainties in the Norwegian greenhouse Gas Emission Inventory, Reports 2000/13: Statistics Norway (SSB-Statistisk sentralbyrå). 44 pp

Rypdal, K., Bloch, V. V. H., Flugsrud, K., Gobakken, T., Hoem, B., Tomter, S. & Aalde, H. (2005): Emissions and removals of greenhouse gases from land use, land-use change and forestry in Norway. *Commissioned report by Norwegian Pollution Control Authority (SFT-Statens Forurensningstilsyn) and Ministry of Agriculture and Food (Landbruks- og matdepartementet)*, NIJOS rapport 11/05: Center for International Climate and Environmental Research (CICERO-Senter for klimaforskning, Norwegian Institute of Land Inventory (NIJOS-Norsk institutt for jord- og skogkartlegging), Statistics Norway (SSB-Statistisk sentralbyrå). 105 pp

SFT (2006a): Documentation of methodology and results: QA/QC performed for Greenhouse Gas Emissions for Industrial plants included in the National Inventory. Oslo: Norwegian Pollution Control Authority (SFT-Statens forurensingstilsyn). 42 pp

SFT. (2006b). *Email from Per Svardal*: the Norwegian Pollution Control Authority (January 27 2006).

SINTEF. (2006). *Email from Bodil Monsen* (February 3 2006).

Søgaard, G., Økseter, R. and Borgen, S.K. (2017): Klimagassutslipp fra torvproduksjon i Norge. Metode, datagrunnlag og utslippfaktorer benyttet i klimagassregnskapet under FNs klimakonvensjon (UNFCCC) *NIBIO rapport 3(78)*. Ås, Norway: NIBIO

Tinfos. (2006). *Email from Helga Gustavson*: Tinfos Titan & Iron KS (January 26 2006).

Tokheim, L. A. (2006): Usikkerhet i utslippsfaktorer ifm. rapportering av CO2-utslipp, Report 9A-R06-002: Norcem Brevik

Yara. (2006). *E-mail from Tore Jensen* (January 19 2006).

Annex 3a: Reference Approach – Methods and detailed results

This annex contains technical information on the Reference approach for quality assurance of the energy combustion sector (1A) in the inventory.

The annex has two parts: First an overview of the methods used in preparing data for the reference approach, and second a more detailed presentation of the results of the analysis and the various causes of the RA/SA difference.

1. Methods in the reference approach

This section gives information on how the reference approach data are obtained from the energy balance. Most data are taken directly from the balance. However, modifications were required for some fuel types and balance posts:

<u>Supply data (Table1.A(b)):</u>
The energy supply data is collected from Statistics Norway's "Production and consumption of energy, energy balance and energy account". In some cases, the energy balance data were modified in order to fit into the reference approach framework:

- *NGL*: In the energy balance, NGL only contains production that is recorded as an unfractionated mix. Production which is recorded as fractionated products is included with LPG or ethane. In the RA there is no item for LPG/ethane production, and this production is included with NGL. (See NID section 3.6.2 on differences in NCVs and TJ/ktoe data between the published energy balance, as used here, and data reported to the IEA/Eurostat.)

- *Coal* (other bituminous coal): It was necessary to adjust for geographical differences, as the energy supply data does not include production of coal in the Russian settlement on Svalbard. This data is added to the RA figures for Other Bituminous coal in 1AB.

- It is necessary to manually adjust for some consumption of fossil fuel feedstock accounted for in the Industrial Process and Product Use chapter. This is added to feedstock, reductants and other non-energy use of fuels in 1AD, and applies for

Petroleum coke, Gas diesel oil, residual fuel oil, natural gas, LPG, Other bituminous coal and waste.

CRT table 1Ab presents fuel quantities in 1000 tonnes or million cubic meters. The fuel quantities are converted to TJ by appropriate Conversion factors (Table A3a-1). For most fuel types, the same conversion factors can be used throughout the time series, and for all supply side items (left hand column in the table). For other fuel types, the input data are on a lower aggregate level than in the CRT tables. In these cases, the conversion factor is calculated as a weighted average of the factors used in the energy balance. This applies to crude oil, natural gas dry, waste, solid biomass, and liquid biomass. For some fuel types, the conversion factors are different for the energy from production, imports, exports, stock change and bunkers. The Conversion factor given in table 1Ab is then an average weighted by the calculation of the Apparent Consumption.

Table A3a-1: Conversion Factors to Energy Units (Heat Equivalents) 2023.

Fuel Category	Fuel Type	All supply side items	Prod-uction	Im-ports	Ex-ports	Stock Change	Bun-kers	Apparent Con-sumption
Solid Fuels (TJ/kt)	Other Bituminous Coal	28.10						
	Coke Oven Gas	28.5						
Gas Fuels (TJ/106 m^3)	Natural Gas Dry		35.70	35.60	36.60	35.60	35.60	37.97
Liquid Fuels (TJ/kt)	Crude Oil		42.71	42.75	42.71	42.46		42.72
	Natural Gas Liquids	46.10						
	Gasoline	43.90						
	Jet Kerosene	43.10						
	Other Kerosene	43.10						
	Gas Diesel Oil	43.10						
	Residual Fuel Oil	40.60						
	LPG	46.10						
	Ethane	46.10						
	Naphtha	43.90						

Fuel Category	Fuel Type	All supply side items	Prod-uction	Im-ports	Ex-ports	Stock Change	Bun-kers	Apparent Con-sumption
	Bitumen	40.20						
	Lubricants	40.20						
	Petroleum Coke	35.00						
	Refinery Feedstocks	43.90						
Waste (TJ/kt)	Waste		15.75					15.75
Biomass	Solid biomass (TJ/kt)		16.70	20.65	17.41			16.92
	Liquid biomass (TJ/kt)		36.80	34.03	36.80			34.16
	Gas biomass (TJ/106 m^3)	50,40						

Once the apparent consumption is estimated, the remaining calculations are similar to the Sectoral Approach. Potential emissions were estimated using fuel-specific C coefficients. Emission factors used in the reference approach are the same as those used in the sectoral approach, multiplied by 12/44 to convert the emission factor for CO_2 to an emission factor for carbon. In those cases where the fuels are shown on a less aggregated level in the input data, the emission factors in the RA are as the NCVs implied emission factors per fuel type (weighted averages).

<u>Feedstock and non-energy use data (Table1.A(d)):</u>
The carbon in products from non-energy uses of fossil fuels that are excluded from the RA was then estimated and subtracted (see NID section 3.2.2). To obtain actual CO_2 emissions, net emissions were adjusted for any carbon that remained unoxidized as a result of incomplete combustion.

In general, these data are obtained from item 12 in the energy balance: "Consumption for non-energy purposes".

It was necessary to manually adjust for some consumption of fossil fuel feedstock accounted for in the Industrial Process and Product Use chapter.

2. Quantification of differences between RA and SA

This section is a detailed comparison of the fuel consumption in reference and sectoral approaches to the energy balance, which is the basis for both data sets. The comparison illustrates how the RA and SA are obtained from the energy balance, and how the different elements of the balance contribute to the differences between RA and SA. The comparison was made for the aggregate fuel groups and for all fossil fuels together. The comparison is summarized in Table 3-9.

The main result is that the difference between the energy consumption in RA and SA is primarily due to statistical differences in the energy balance. Another important, though smaller, contribution is differences between input and output in transformation. In addition, a number of other smaller differences were identified. The remaining difference between RA and SA after adjusting for these items is less than 1.2% of the SA energy consumption for all years, and generally below 0,5% from 2010 onwards.

The analysis is shown in energy terms. The RA/SA CO_2 differences are generally shifted in positive direction relative to the energy difference (see section 3.2.1).

2.1 Correspondence of RA and SA with the energy balance

The comparison of the Reference and Sectoral approaches is reported both in energy terms and in CO_2 terms in the CRT table 1AC. This section discusses the correspondence of the RA, the SA and the RA/SA difference to the energy balance. A basic premise is that the Sectoral approach is based on the consumption data in the energy balance (or the basic statistics that underlie the balance).

The reference approach is estimated as the total net supply *minus* energy corresponding to carbon excluded because it does not give CO_2 emissions that is recorded in the sectoral approach (CRT 1A). This means that the net supply may be broadly viewed as partitioned into three elements:

- Consumption for feedstocks and other non-energy use which is included in neither the reference nor the sectoral approaches
- The Reference approach, which includes
    - The Sectoral Approach
    - Items which are included in the net supply, but neither in the sectoral approach nor in the "energy excluded" part, and thus appear as the RA/SA difference. This applies in particular to the statistical difference, but also other energy balance items fall in this category. The part may have a negative sign.

The RA/SA difference also include other inconsistencies, in particular from different methods for delimiting feedstocks/non-energy use and from different (weighting of) conversion factors. See the the description of possible discrepancies in the IPCC guidelines (IPCC 2006), vol 2, ch. 6.8 for more details on possible discrepancies.

Figure A3a-1 illustrates the situation with data for Norway. The figure uses data for 2018 from the 2022 submission. Figures from 2018 are more illustrative than data from later years, due to larger RA-SA difference.

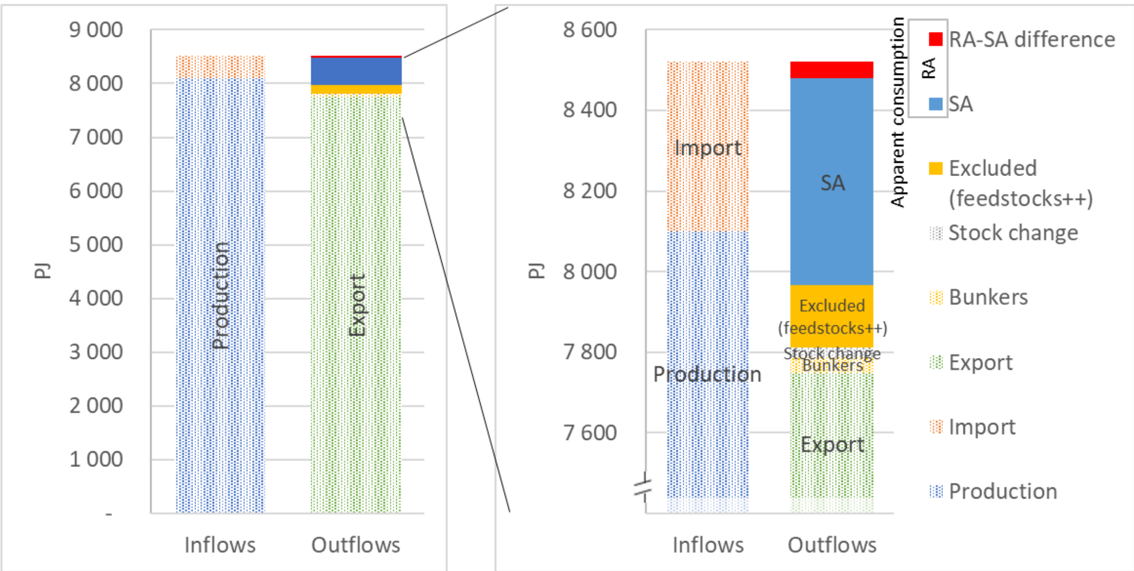

Figure A3a-1: Elements of the RA-SA analysis. Supply data in hatched colours, and the RA and SA in solid. Data for 2018.

The right-hand side of the figure is an enlarged view of the upper part of the left-hand side. The figure is basically a depiction of the supply part of the energy balance. Inflows and outflows are items that contribute with a positive and negative sign, respectively, to the net supply. The net supply corresponds to the solid colours and is partitioned into the SA energy consumption, energy excluded as feedstocks etc., and the RA-SA difference. The latter is not a part of the outflow as such but is a "balancing item" that is calculated as the remaining difference between the two columns.

The "apparent consumption" in the RA calculation will be approximately equal to the net supply in the energy balance. Small discrepancies due to different methods will appear as RA/SA difference, as detailed in sections 3.2.1

The partitioning of the net supply and the correspondence to items in the energy balance is shown in table Table A3a-1 below. The codes refer to the energy balance as published by Statistics Norway[2].

[2] Link to the energy balance: https://www.ssb.no/en/energi-og-industri/energi/statistikk/produksjon-og-forbruk-av-energi-energibalanse-og-energiregnskap.

Table A3a-1: Energy Balance and its allocation in the Reference and Sectoral Approaches.

Energy balance item	**How the energy balance net supply is partitioned**			**Corresponding info on other parts of the inventory (cf CRT Table1.A(d), right hand part)**
	Inventory: Sectoral approach (1A)	Reference approach: Excluded	RA/SA difference	Inventory: Sectors 1B, 2, etc.
Transformation items (7, 1.2)				
7. Transformation processes				
7.1-7.2 (blast furnaces and petroleum refineries): Transformation to other fossil fuels.			Part of "statistical differences in transformation", appears as RA/SA difference	
7-3-7.6 (power and heating plants):	Sectoral Approach: 1A1a			
1.2. Secondary energy production			Part of "statistical differences in transformation", appears as RA/SA difference	
8. Energy industries own use				
8.3. Petroleum refineries, petrol coke gas (cracker burn-off)		RA: excluded as part of "Fuel quantity for NEU" in Table1AD, reported as "other oil"		In the inventory, petrol coke gas (cracker burn-off) is in 1B2a4
8.3. Petroleum refineries, regular energy consumption	Regular energy consumption at refineries in 1A1b			
Other energy industries	Sectoral Approach: 1A1a-c			
9. Distribution losses For fossil fuels: Only flares in manufacturing and refineries		(Not excluded)	Appears as RA/SA difference	In the inventory, included in 2 Industrial processes, and in 1B2bc-flaring (refineries)
10 Final consumption (11+12)				
11. Non- energy consumption	Generally excluded from the SA.	RA: excluded as part of "Fuel quantity for NEU" in Table1AD,		In the inventory, included in 2 Industrial processes.

Energy balance item	How the energy balance net supply is partitioned			Corresponding info on other parts of the inventory (cf CRT Table1.A(d), right hand part)
	Exeptions: The sectoral approach includes emissions from non-energy use of gasoline, gas diesel oil, and residual oil (1A5a) and lubricants for two-stroke engines (1A5b)	adjusted for the amounts that correspond to the emissions reported in 1A5a and 1A5b.		
12. Final energy consumption	Sectoral Approach: 1A2-1A5.			
Exceptions: Coal and coke used as reducing agents with utilization of heat is accounted here in the energy balance, and not in item 12	Excluded from the SA.	RA: excluded as part of "Fuel quantity for NEU" in Table1AD		In the inventory, included in 2 Industrial processes.
13. Statistical differences (6+7-8-9-10)			Appears as RA/SA difference	

The table shows that the following items from the energy balance will remain as differences between the Reference and Sectoral approaches:

- Statistical differences in a wide sense. This includes:
    - Main statistical difference (item 13). Range: -25 to 219 PJ (Table A3a-1; excluding biofuels, electricity, and district heating).
    - Statistical differences within the transformation sector. This appears when the production of derived energy bearers (item 1.2) is different from the consumption in the transformation sectors (item 7). It includes transformation losses as well as statistical inconsistencies. Transformation to heat or power by combustion (items 7.3-7.5) is handled in the sectoral approach and is excluded from this comparison. Range: -33 to 10 PJ (table A3a-2).
- Distribution losses. For fossil fuels, this includes flaring in industry and refineries of natural gas and derived gases such as blast furnace gas, refinery gas, and fuel gas from ethylene cracking. Range: 2-5 PJ, not show in Table A3a-1.

In addition, the RA/SA difference will comprise inconsistencies that are known and quantifiable (see section 2.3 below), as well as remaining differences that may be due to minor differences in definitions and scope and to errors in the energy or emission inventories.

2.2 Analysis of the RA-SA difference

The analysis is summarized in Table A3a-2 below. The analysis in the CRT tables is shown in the left-hand part. The RA/SA difference is split into components in the right-hand part, showing the remaining difference when statistical and transformation differences and other quantified discrepancies are separated. The "other discrepancies" are detailed in the following tables.

Table A3a-2: Summary of RA/SA differences.

	Consumption data from CRT: Table 1AC			**Statistical difference and other discrepancies**				
Year	**RA: Apparent consumption (excluding non-energy use and feedstocks)**	**SA: Con-sumption**	**Difference RA-SA**	**Statistical difference (13)**	**Difference within transfor-mation (7.1 +f7.2+ 7.6 – 1.2)**	**Renewable fraction of waste**	**Remaining difference RA-SA**	**Remaining difference RA-SA in per cent of SA**
1990	341.6	358.0	-16.5	-21.2	2.5	1.2	3.4	0.9%
1995	412.1	407.5	4.6	7.1	-3.9	2.0	3.2	0.8%
2000	648.9	431.2	217.6	223.7	-8.8	2.4	5.0	1.2%

	Consumption data from CRT: Table 1AC			Statistical difference and other discrepancies				
Year	RA: Apparent consumption (excluding non-energy use and feedstocks)	SA: Con-sumption	Difference RA-SA	Statistical difference (13)	Difference within transfor-mation (7.1 +f7.2+ 7.6 – 1.2)	Renewable fraction of waste	Remaining difference RA-SA	Remaining difference RA-SA in per cent of SA
2005	621.0	478.5	142.5	143.2	-0.5	3.4	3.1	0.7%
2010	624.5	537.1	87.4	83.6	5.1	5.8	3.9	0.7%
2011	493.4	517.6	-24.2	-31.1	8.6	6.3	3.6	0.7%
2012	534.3	512.3	22.1	15.8	9.4	7.2	3.1	0.6%
2013	576.3	522.1	54.2	57.4	1.5	7.4	1.8	0.3%
2014	573.2	529.8	43.4	57.2	-9.1	7.5	1.7	0.3%
2015	573.4	531.6	41.8	58.9	-11.9	8.0	1.9	0.4%
2016	498.0	522.8	-24.9	-19.2	-0.5	8.0	2.0	0.4
2017	577.0	517.0	60.0	66.4	-1.1	7.9	1.7	0.3
2018	551.2	513.3	37.9	42.8	0.9	8.5	1.7	0.3
2019	489.0	499.5	-10.5	-8.3	3.7	8.4	1.6	0.3
2020	480.8	476.4	4.5	12.3	-2.1	8.2	1.7	0.4
2021	475.5	469.5	6.0	21.6	-9.4	8.5	1.3	0.3
2022	370.8	463.2	-92.4	-82.4	-3.9	8.5	1.4	0.3
2023	436.6	447.7	-11.1	4.6	-9.0	8.4	0.8	0.2

The main contribution to the RA-SA difference is by far the statistical differences in the energy balance. The remaining discrepancies are mainly due to differences between outflows and inflows in the transformation sector (losses in conversion, etc.). See figure Figure A3a-2.

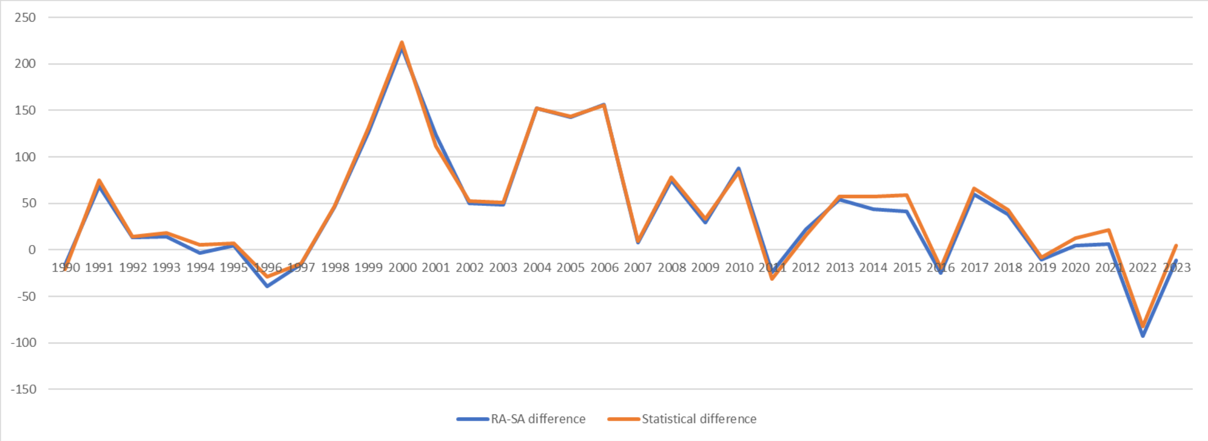

Figure A3a-2: RA-SA difference in PJ compared to statistical difference in the Norwegian energy balance.

Table A3a-3: Overview over the Reference and Sectoral approaches for energy. Natural gas. PJ.

	Consumption data from CRT: Table 1AC			Statistical difference and other discrepancies		
Year	**RA: Apparent con-sumption[1]**	**SA: Con-sumption**	**Difference RA-SA**	**Statistical difference**	**Remaining difference RA-SA**	**Remaining difference RA-SA in per cent of SA**
1990	68.2	89.9	-21.7	-21.7	0.0	0.0
1995	125.3	118.8	6.6	6.6	0.0	0.0
2000	166.0	141.3	24.6	23.1	1.5	1.1
2005	158.8	179.8	-21.0	-21.5	0.5	0.3
2010	243.7	219.3	24.4	23.7	0.7	0.3
2011	188.7	207.2	-18.4	-19	0.6	0.3
2012	210.6	203.9	6.7	5.9	0.8	0.4
2013	211.2	204.2	7.0	6.5	0.5	0.3
2014	214.0	214.7	-0.7	-1.1	0.4	0.2
2015	230.5	221.0	9.5	9.3	0.2	0.1
2016	216.6	218.2	-1.6	-2	0.4	0.2
2017	184.3	223.3	-39.0	-39.3	0.3	0.1
2018	208.2	210.4	-2.2	-2.6	0.4	0.2
2019	183.1	211.6	-28.5	-28.8	0.3	0.2
2020	166.5	201.1	-34.5	-34.9	0.4	0.2
2021	189.1	186.2	2.9	2.6	0.3	0.2

Year	Consumption data from CRT: Table 1AC			Statistical difference and other discrepancies		
	RA: Apparent con-sumption[1]	SA: Con-sumption	Difference RA-SA	Statistical difference	Remaining difference RA-SA	Remaining difference RA-SA in per cent of SA
2022	154.5	180.8	-26.3	-26.8	0.5	0.3
2023	173.5	175.4	-1.9	-2.3	0.4	0.2

[1] Excluding non-energy use and feedstocks

Table A3a-4: Overview over the Reference and Sectoral approaches for energy. Solid fuels. PJ.

Year	Consumption data from CRT: Table 1AC			Statistical difference and other discrepancies			
	RA: Apparent consump tion[1]	SA: Con-sumption	Difference RA-SA	Statistical difference	Difference within transfor-mation	Remaining difference RA-SA	Remaining difference RA-SA in per cent of SA
1990	7.9	7.5	0.4	0.1	0.1	0.2	2.5
1995	9.9	9.6	0.4	-0.2	0.2	0.4	3.8
2000	7.4	7.1	0.3	-0.4	0.1	0.6	7.9
2005	5.8	5.3	0.5	-0.1	0.1	0.5	8.6
2010	8.7	5.7	3.0	1.8	0.7	0.5	9.1
2011	11.3	5.5	5.8	4.3	1.0	0.6	10.4
2012	8.8	5.4	3.5	2.3	0.9	0.2	4.2
2013	6.4	5.0	1.4	0.4	0.9	0.0	0.8
2014	9.1	5.0	4.1	2.9	1.0	0.2	4.5
2015	8.3	4.7	3.6	2.5	0.9	0.1	2.4
2016	4.5	4.7	-0.2	-1.1	0.8	0.1	1.8
2017	7.7	5.3	2.4	1.2	1.0	0.2	3.9
2018	7.2	5.0	2.2	1	1.0	0.2	3.4
2019	6.5	4.7	1.9	0.9	0.9	0.1	1.6
2020	6.7	3.8	3.0	2.2	0.8	0.0	-0.2
2021	-2.6	3.9	-6.5	-7.5	0.9	0.1	2.9
2022	5.3	4.0	1.3	0.2	1.0	0.1	2.0
2023	4.8	3.3	1.4	0.5	0.9	0.0	0.8

1) Excluding non-energy use and feedstocks

Table A3a-5: Overview over the Reference and Sectoral approaches for energy. Waste. PJ.

	Consumption data from CRT: Table 1AC			Statistical difference and other discrepancies			
Year	RA: Apparent con-sumption[1]	SA: Con-sumption	Difference RA-SA	Statistical difference	Renew-able fraction of waste	Remaining difference RA-SA	Remaining difference RA-SA in per cent of SA
1990	3.1	3.9	-0.8	0.4	1.2	0.0	-0.6
1995	4.3	5.9	-1.6	0.4	2.0	0.0	-0.6
2000	5.2	7.2	-2.0	0.3	2.4	0.0	0.5
2005	6.7	9.9	-3.1	0.3	3.4	0.0	-0.3
2010	6.6	12.9	-6.3	0	5.8	-0.5	-3.8
2011	7.6	13.9	-6.3	0	6.3	0.0	0.1
2012	8.6	15.9	-7.3	0	7.2	-0.1	-0.7
2013	9.8	17.5	-7.7	0	7.4	-0.3	-1.7
2014	10.2	18.0	-7.8	0	7.5	-0.3	-1.9
2015	10.6	18.9	-8.3	0	8.0	-0.3	-1.6
2016	10.3	18.6	-8.3	0	8.0	-0.3	-1.6
2017	10.4	18.6	-8.2	0	7.9	-0.3	-1.6
2018	11.1	19.8	-8.8	0	8.5	-0.3	-1.3
2019	11.1	19.8	-8.7	0	8.4	-0.3	-1.5
2020	11.1	19.6	-8.5	0	8.2	-0.3	-1.5
2021	10.9	19.7	-8.8	0	8.5	-0.3	-1.7
2022	10.8	19.7	-8.9	0	8.5	-0.4	-1.9
2023	10.6	19.3	-8.7	0	8.4	-0.3	-1.7

1) Excluding non-energy use and feedstocks

Table A3a-6: Overview over the Reference and Sectoral approaches for energy. Liquid fuels. PJ.

	Consumption data from CRT: Table 1AC			Statistical difference and other discrepancies			
Year	RA: Apparent con-sumption[1]	SA: Con-sumption	Difference RA-SA	Statistical difference	Difference within trans-formation	Remaining difference RA-SA	Remaining difference RA-SA in per cent of SA
1990	262.3	256.6	5.7	0.0	2.5	3.2	1.2
1995	272.5	273.2	-0.7	0.3	-3.9	2.9	1.1
2000	470.3	275.5	194.8	200.7	-8.8	2.8	1.0
2005	449.7	283.6	166.2	164.5	-0.5	2.2	0.8
2010	365.5	299.2	66.3	58.1	5.1	3.2	1.1

	Consumption data from CRT: Table 1AC			Statistical difference and other discrepancies			
Year	RA: Apparent con-sumption[1]	SA: Con-sumption	Difference RA-SA	Statistical difference	Difference within trans-formation	Remaining difference RA-SA	Remaining difference RA-SA in per cent of SA
2011	285.7	291.1	-5.4	-16.4	8.6	2.5	0.8
2012	306.3	287.1	19.2	7.6	9.4	2.2	0.8
2013	348.9	295.4	53.5	50.5	1.5	1.5	0.5
2014	339.9	292.1	47.8	55.4	-9.1	1.4	0.5
2015	324.0	287.0	37.0	47.1	-11.9	1.8	0.6
2016	266.5	281.4	-14.8	-16.1	-0.5	1.7	0.6
2017	374.6	269.7	104.9	104.5	-1.1	1.5	0.6
2018	324.8	278.1	46.7	44.4	0.9	1.4	0.5
2019	288.3	263.4	24.9	19.6	3.7	1.5	0.6
2020	296.5	251.9	44.6	45.0	-2.1	1.7	0.7
2021	278.2	259.8	18.4	26.5	-9.4	1.2	0.5
2022	200.2	258.7	-58.5	-55.8	-3.9	1.2	0.5
2023	247.8	249.7	-1.9	6.4	-9.0	0.7	0.3

1) Excluding non-energy use and feedstocks

2.3 Other discrepancies

This section summarizes the RA/SA discrepancies beyond statistical and transformation differences, as quantified in the main fuel tables above, as well as other possible causes.

The quantified differences all relate to the supply part of the reference approach (Table 1A.(b)).

- Waste: The handling of waste energy data is currently different in the RA and the SA. The RA follows the energy balance and gives only the non-renewable waste. In the SA, on the other hand, the fuel consumption data include renewable waste as well. Thus, the SA values for waste are higher, giving a negative contribution to the RA/SA difference.

The remaining differences when adjusting for these cases are in the order of 1-5 PJ, or below 1.2% of the sectoral approach.

There are many possible causes for the remaining differences. The reference approach is a rough approximation and is not expected to match the sectoral approach precisely. A number of sources for discrepancies are discussed in the IPCC guidelines (IPCC 2006), vol 2, ch. 6.8. Some case that merits mention here are:

- The NCV value for crude oil has a strong impact on the final difference, as the contribution from crude oil to the RA CO_2 emissions are actually larger than the total RA emissions. (Net export of secondary fuels balances the crude oil.) A reduction in the NCV value of 0.2%, from 42,7 to 42,6 TJ/kt, would give a reduction in the RA/SA difference in the order of 1 PJ.

3. References

IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan

Annex 3b Reference Approach – International comparison

This annex gives supporting data to NID section 3.2.1.2 on the comparison of energy supply data in the Reference Approach with corresponding data reported to Eurostat. Eurostat data in ktoe were downloaded from https://ec.europa.eu/eurostat/web/energy/database/additional-data#Energy%20balances .

As the compilation of the reporting to Eurostat was not completed in time for NID, this section is based on figures from the previous reporting. That is, the emission figures reported in 2024 are compared with corresponding figures from the Eurostat reporting. For these reasons, the following discussion will focus on data from 2022.

Table A3b-7 and Table A3b -8 expand NID table 3-10 to the detailed list of fuels. Table A3b-7 has the actual energy data, and Table A3b -8 shows the differences.

Table A3b-9 combines the columns for *apparent consumption* from Table A3b-7 and Table A3b -8 within a single framework and includes explanations for the differences.

Table A3b-10 and Table A3b-11 expand the data for *apparent consumption* from Table A3b-7 and Table A3b -8 to the complete time series.

Table A3b-7: Energy data in the CRT Reference Approach and data published by Eurostat. 2022. PJ.

	CRT Reference Approach, PJ						**Eurostat, PJ**					
Fuel	Prod.	Imp.	Exp.	Bunkers	Stock change	App. cons.	Prod.	Imp.	Exp.	Bunkers	Stock change	App. cons.
Crude oil	3 734 585	35	3 307	-	17	296	3 584	35	3 306	-	17	296
Orimulsion	-	-	-	-	-	-	-	-	-	-	-	-
Natural Gas Liquids	285	-	43	-	0	242	271	-	-	-	-	271
Gasoline	-	28	164	0	-1	-134	-	28	163	0	-1	-133
Jet kerosene	-	16	2	19	-0	-4	-	16	2	19	-0	-4
Other kerosene	-	0	0	-	-0	0	-	0	-	-	-0	0
Shale oil	-	-	-	-	-	-	-	-	-	-	-	-
Gas/diesel oil	-	164	101	12	-3	54	-	164	101	11	-3	55
Residual fuel oil	-	52	6	1	-0	45	-	52	6	1	-0	45
LPG	-	11	189	-	4	-181	-	11	189	-	4	-182
Ethane	-	34	10	-	0	25	-	34	10	-	0	24
naphta	-	6	76	-	0	-71	-	6	117	-	0	-111
Bitumen	-	14	0	-	-0	14	-	14	0	-	-	14
Lubricants	-	2	0	-	-	2	-	2	0	-	-	2
Petroleum coke	-	17	4	-	1	12	-	17	4	-	1	12

Refinery feedstocks	-	2	-	-	-	2	1	-	-	-	-	1
Other oil	-	-	-	-	-	-	-	0	0	-	-	0
Other liquid fossil	-	-	-	-	-	-	-	-	-	-	-	-
Liquid fossil totals	**3 870**	**382**	**3 901**	**31**	**17**	**302**	**3 856**	**380**	**3 898**	**31**	**17**	**291**
Anthracite	-	-	-	-	-	-	-	-	-	-	-	-
Coking coal	-	-	-	-	-	-	-	-	-	-	-	-
Other bituminous coal	4	23	2	-	1	24	3	23	2	-	1	23
Sub-bituminous coal	-	-	-	-	-	-	-	-	-	-	-	-
Lignite	-	-	-	-	-	-	-	-	-	-	-	-
Oil shale and tar sand	-	-	-	-	-	-	-	-	-	-	-	-
BKB and patent fuel	-	-	-	-	-	-	-	-	-	-	-	-
Coke oven/gas coke	-	11	0	-	0	11	-	11	0	-	0	11
Coal tar	-	-	-	-	-	-	-	-	-	-	-	-
Other solid fossil	-	-	-	-	-	-	-	-	-	-	-	-
Solid fossil totals	**4**	**34**	**2**	**-**	**1**	**34**	**3**	**34**	**2**	**-**	**1**	**34**
natural gas	4 572	2	4 405	-	-0	169	4 572	2	4 405	2	-0	167
Other gaseous fossil	-	-	-	-	-	-	-	-	-	-	-	-

Gaseous fossil totals	**4 572**	**2**	**4 405**	**-**	**-0**	**169**	**4 572**	**2**	**4 405**	**2**	**-0**	**167**
Waste	11	-	-	-	-	11	11	-	-	-	-	11
Other fossil fuels	-	-	-	-	-	-	-	-	-	-	-	-
Peat	-	-	-	-	-	-	-	-	-	-	-	-
Total	**8 457**	**418**	**8 309**	**31**	**18**	**517**	**8 442**	**417**	**8 306**	**32**	**18**	**503**

Table A3b -8: Differences between energy data in the CRT Reference Approach and data published by Eurostat. 2022. PJ.

	Difference, PJ						**Difference, per cent (base: Eurostat)**					
Fuel	Prod.	Imp.	Exp.	Bunkers	Stock change	App. cons.	Prod.	Imp.	Exp.	Bunkers	Stock change	App. cons.
Crude oil	1.4	0.0	1.3	-	0.0	0.1	0.0	0.0	0.0	.	0.0	0.0
Orimulsion	-	-	-	-	-	-	.	.	.	.	.	.
Natural Gas Liquids	14.2	-	42.6	-	0.1	-28.4	5.3	.	.	.	.	-10.5
Gasoline	-	-0.0	1.0	0.0	0.0	-1.0	.	-0.0	0.6	30.9	-1.8	0.8
Jet kerosene	-	-0.0	-0.0	0.0	-0.0	0.0	.	-0.0	-0.0	0.0	0.0	-0.0
Other kerosene	-	0.0	0.0	-	-0.0	-0.0	.	0.0	.	.	4.2	-0.0
Shale oil	-	-	-	-	-	-	.	.	.	.	.	.
Gas/diesel oil	-	-0.0	-0.0	0.7	0.0	-0.6	.	-0.0	-0.0	6.2	-0.0	-1.2
Residual fuel oil	-	-0.0	0.0	0.0	-0.0	-0.0	.	-0.0	0.0	0.0	0.0	-0.0

LPG	-	0.0	-0.5	-	-0.0	0.5	.	0.0	-0.3	.	-0.0	-0.3
Ethane	-	0.0	-0.4	-	0.0	0.4	.	0.0	-4.1	.	0.0	1.7
naphta	-	-0.0	-40.5	-	0.2	40.3	.	-0.0	-34.7	.	208.7	-36.4
Bitumen	-	0.0	0.0	-	-0.2	0.2	.	0.0	0.1	.	.	1.5
Lubricants	-	-0.0	0.0	-	-	-0.0	.	-0.0	0.1	.	.	-0.0
Petroleum coke	-	0.0	0.0	-	-0.0	-0.0	.	0.0	0.0	.	-0.0	-0.0
Refinery feedstocks	-1.3	1.5	-	-	-	0.2	-100.0	.	.	.	.	19.3
Other oil	-	-0.2	-0.1	-	-	-0.1	.	-100.0	-100.0	.	.	-100.0
Other liquid fossil	-	-	-	-	-	-	.	.	.	.	.	.
Liquid fossil totals	14.4	1.4	3.2	0.7	0.2	11.6	0.4	0.4	0.1	2.3	1.0	4.0
Anthracite	-	-	-	-	-	-	.	.	.	.	.	.
Coking coal	-	-	-	-	-	-	.	.	.	.	.	.
Other bituminous coal	0.5	-0.0	0.0	-	-0.0	0.5	16.3	-0.0	0.0	.	-0.0	2.3
Sub-bituminous coal	-	-	-	-	-	-	.	.	.	.	.	.
Lignite	-	-	-	-	-	-	.	.	.	.	.	.
Oil shale and tar sand	-	-	-	-	-	-	.	.	.	.	.	.
BKB and patent fuel	-	-	-	-	-	-	.	.	.	.	.	.
Coke oven/gas coke	-	0.0	0.0	-	-0.0	0.0	.	0.0	1.6	.	-0.0	0.0

Coal tar	-	-	-	-	-	-
Other solid fossil	-	-	-	-	-	-
Solid fossil totals	0.5	0.0	0.0	-	-0.0	0.5
Natural gas	0.0	0.0	-0.0	-1.6	-0.0	1.7
Other gaseous fossil	-	-	-	-	-	-
Gaseous fossil totals	0.0	0.0	-0.0	-1.6	-0.0	1.7
Waste	0.2	-	-	-	-	0.2
Other fossil fuels	-	-	-	-	-	-
Peat	-	-	-	-	-	-
Total	15.1	1.4	3.2	-0.9	0.1	14.1

.	.	.	.	.	.
.	.	.	.	.	.
16.3	0.0	0.0	.	-0.0	1.6
0.0	0.0	-0.0	-100.0	15.5	1.0
.	.	.	.	.	.
0.0	0.0	-0.0	-100.0	15.5	1.0
2.1	.	.	.	.	2.1
.	.	.	.	.	.
.	.	.	.	.	.
0.2	0.3	0.0	-2.9	0.7	2.8

Table A3b-9 combines the columns for *apparent consumption* from Table A3b-7 and Table A3b -8 within a single framework and includes explanations for the differences. The table excludes fuels that are either not produced/used in Norway or which are reported as "included elsewhere" (e.g., anthracite).

Table A3b-9: Comparison of apparent consumption in the CRT Reference Approach to data published by Eurostat. 2022. PJ.

Fuel	Apparent consumption reported in GHG inventory (TJ)	Apparent consumption in Eurostat reporting (TJ)	Absolute difference (TJ)	Relative difference%	Explanations for differences
Crude oil	296 401	296 285	116	0,0%	
Natural Gas Liquids	242 184	270 628	-28 444	-11,7%	Difference in NCV values for production. Different allocation of exports and naphtha, with differences also in NCV. Total difference for export of these fuels in ktonne terms close to 0.
Gasoline	-134 439	-133 432	-1 007	0,7%	Different allocation of export of gasoline, LPG and ethane. Total difference for these fuels close to 0
Jet kerosene	-3 799	-3 799	0	0,0%	
Gas/diesel oil	54 200	54 843	-643	-1,2%	Difference for bunkers
LPG	-181 129	-181 657	524	-0,3%	Different allocation of export, see note for gasoline
Ethane	24 717	24 301	416	1,7%	Different allocation of export, see note for gasoline
Naphtha	-70 530	-110 841	40 301	-57,2%	Different allocation of export, see note for NGL
Bitumen	13 724	13 526	198	1,4%	
Lubricants	1 908	1 908	0	0,0%	
Refinery feedstocks	1 532	1 284	242	16,2%	The CRT includes amounts of biofuels which are reported elsewhere in the reporting to Eurostat
Other oil	-	93	-93	..	Not reported in the CRT
Liquid fossil totals	302 299	290 669	11 630	3,8%	Net difference mainly due to - NCV differences for NGL production - NCV differences for NGL/naphtha export - CRT net supply of refinery feedstocks includes biofuels

Fuel	Apparent consumption reported in GHG inventory (TJ)	Apparent consumption in Eurostat reporting (TJ)	Absolute difference (TJ)	Relative difference%	Explanations for differences
Other bituminous coal	23 507	22 969	537	2,3%	Russian production of coal in Svalbard is included in CRT
Solid fossil totals	34 426	33 889	537	1,6%	
Natural gas	168 926	167 177	1 749	1,0%	CRT lacks option for natural gas bunkers
Gaseous fossil totals	168 926	167 177	1 749	1,0%	
Waste	11 234	11 005	228	2,0%	Different definitions
Total	516 885	502 741	14 144	2,8%	Over 2%

Table A3b-10 and Table A3b-11 expand the data for *apparent consumption* from Table A3b-7 and Table A3b -8 to the complete time series.

Note that the CRT and Eurostat data do not reflect the same levels of revisions and updates throughout the time series.

- The time series for 1990-2009 was revised in the national energy balance as reported in the reference approach but has not been resubmitted to IEA/Eurostat.
- Due to different updating and reporting cycles, changes may have been made to the CRT data that are not reflected in Eurostat data.

See NID section 3.2.1or more information.

Table A3b-10: Energy data in the CRT Reference Approach and data published by Eurostat. Apparent consumption by fuel group and year. PJ.

	CRT Reference Approach, PJ						Eurostat, PJ				
Year	Liquid	Solid	Gaseous	Other fossil	Total		Liquid	Solid	Gaseous	Other fossil	Total
1990	334.8	37.8	68.2	3.1	443.9		315.6	36.1	82.7	2.3	436.7
1991	389.8	34.5	87.0	3.0	514.3		337.2	32.8	80.9	2.9	453.8
1992	329.8	33.8	104.6	3.6	471.8		294.8	32.2	135.5	2.5	465.0
1993	341.5	37.3	111.3	3.8	493.8		313.1	35.6	154.7	2.8	506.3
1994	353.0	43.0	102.4	4.1	502.5		276.0	41.3	164.4	2.7	484.4
1995	362.1	44.5	125.3	4.3	536.4		293.9	42.9	144.9	2.4	484.2
1996	374.0	43.8	109.3	4.1	531.2		301.4	42.1	125.0	2.5	470.9
1997	363.0	44.8	154.2	4.8	566.7		308.1	43.1	164.2	2.4	517.8
1998	402.8	46.5	179.5	5.4	634.3		312.3	44.8	180.3	3.2	540.6
1999	489.0	45.3	174.7	4.8	713.8		331.1	44.5	199.1	3.3	578.0
2000	557.9	44.9	188.4	5.2	796.3		337.1	44.0	173.5	3.2	557.8
2001	419.9	40.4	274.1	5.3	739.7		328.8	39.5	258.0	3.5	629.7
2002	426.0	34.9	195.8	5.2	662.0		339.0	34.0	179.6	3.4	556.0
2003	415.1	33.9	238.6	6.5	694.1		414.0	33.0	217.3	4.7	669.0
2004	563.1	39.5	188.3	6.0	796.9		497.2	38.8	169.3	4.3	709.6
2005	548.4	33.1	184.4	6.7	772.6		511.4	32.5	170.5	4.6	719.0
2006	568.5	30.4	201.3	7.2	807.5		538.4	29.9	168.4	4.8	741.6
2007	398.5	34.3	226.9	7.1	666.7		408.4	33.7	203.8	4.9	650.7
2008	466.5	36.5	232.6	7.7	743.2		491.2	36.0	232.6	5.3	765.0
2009	429.8	23.9	226.6	7.4	687.7		516.3	23.5	226.6	5.4	771.9

2010	458.9	32.7	267.3	6.6	765.5		504.5	32.0	267.3	6.8	810.5
2011	381.3	36.1	214.0	7.6	638.9		404.9	35.4	211.8	7.8	660.0
2012	401.1	35.0	233.2	8.6	677.8		439.2	34.2	229.7	8.9	712.1
2013	442.5	33.1	235.4	10.0	720.9		496.3	32.5	235.3	10.1	774.2
2014	434.0	36.2	239.8	10.5	720.4		399.8	35.6	239.8	10.5	685.6
2015	423.9	34.9	259.1	10.8	728.8		242.0	34.4	259.5	10.9	546.7
2016	360.3	32.3	241.3	10.6	644.5		367.0	31.7	233.2	10.7	642.6
2017	461.5	36.0	211.7	10.6	719.9		435.5	35.5	208.6	10.6	690.2
2018	430.4	35.0	233.1	11.3	709.8		406.4	34.5	230.7	11.4	683.0
2019	390.4	34.1	210.9	11.4	646.7		368.6	33.5	208.6	11.1	621.8
2020	395.6	35.0	192.8	11.3	634.8		373.1	34.5	190.2	11.1	608.9
2021	380.7	35.7	179.5	11.1	607.0		359.8	35.2	210.0	10.9	615.9
2022	302.3	34.4	168.9	11.2	516.9		290.7	33.9	167.2	11.0	502.7

Table A3b-11: Energy data in the CRT Reference Approach and data published by Eurostat. Apparent consumption by fuel group and year. PJ.

	Difference, PJ						**Difference, per cent (base: Eurostat)**				
	Liquid	**Solid**	**Gaseous**	**Other fossil**	**Total**		**Liquid**	**Solid**	**Gaseous**	**Other fossil**	**Total**
1990	19.2	1.7	-14.5	0.8	7.2		6.1	4.7	-17.6	35.9	1.7
1991	52.6	1.6	6.2	0.1	60.6		15.6	5.0	7.6	4.6	13.3

1992	34.9	1.7	-30.9	1.1	6.8		11.9	5.2	-22.8	44.4	1.5
1993	28.3	1.7	-43.5	1.0	-12.5		9.1	4.7	-28.1	33.5	-2.5
1994	77.0	1.7	-62.0	1.5	18.1		27.9	4.1	-37.7	54.0	3.7
1995	68.2	1.7	-19.6	1.9	52.2		23.2	3.9	-13.5	77.1	10.8
1996	72.6	1.7	-15.6	1.6	60.3		24.1	4.0	-12.5	66.2	12.8
1997	54.9	1.7	-10.0	2.4	48.9		17.8	4.0	-6.1	98.1	9.5
1998	90.5	1.7	-0.7	2.2	93.6		29.0	3.7	-0.4	68.8	17.3
1999	157.9	0.8	-24.4	1.5	135.8		47.7	1.9	-12.3	45.4	23.5
2000	220.8	0.9	14.9	2.0	238.5		65.5	2.0	8.6	62.0	42.8
2001	91.1	0.8	16.2	1.8	110.0		27.7	2.1	6.3	51.9	17.5
2002	87.0	0.8	16.2	1.9	106.0		25.7	2.5	9.0	56.2	19.1
2003	1.1	0.9	21.3	1.9	25.1		0.3	2.7	9.8	39.8	3.8
2004	66.0	0.6	19.0	1.7	87.3		13.3	1.6	11.2	39.0	12.3
2005	37.0	0.6	13.9	2.1	53.6		7.2	1.9	8.2	45.6	7.5
2006	30.0	0.6	32.9	2.4	65.9		5.6	1.9	19.5	49.7	8.9
2007	-9.9	0.6	23.1	2.2	16.0		-2.4	1.8	11.3	45.0	2.5
2008	-24.7	0.5	0.0	2.4	-21.7		-5.0	1.4	0.0	45.3	-2.8
2009	-86.6	0.4	-0.0	2.0	-84.2		-16.8	1.6	-0.0	37.1	-10.9
2010	-45.6	0.7	0.0	-0.2	-45.0		-9.0	2.3	0.0	-3.6	-5.6
2011	-23.6	0.7	2.1	-0.3	-21.1		-5.8	1.9	1.0	-3.3	-3.2
2012	-38.1	0.8	3.4	-0.3	-34.2		-8.7	2.3	1.5	-3.6	-4.8
2013	-53.8	0.6	0.1	-0.2	-53.3		-10.8	1.9	0.0	-1.6	-6.9
2014	34.2	0.6	0.0	-0.0	34.8		8.6	1.6	0.0	-0.0	5.1
2015	182.0	0.6	-0.4	-0.0	182.1		75.2	1.6	-0.1	-0.4	33.3
2016	-6.7	0.6	8.0	-0.1	1.9		-1.8	1.8	3.4	-0.8	0.3

2017	26.0	0.6	3.2	0.0	29.7		6.0	1.6	1.5	0.2	4.3
2018	24.0	0.6	2.3	-0.1	26.8		5.9	1.6	1.0	-0.7	3.9
2019	21.8	0.5	2.4	0.3	25.0		5.9	1.6	1.1	2.3	4.0
2020	22.5	0.5	2.6	0.3	26.0		6.0	1.6	1.4	2.4	4.3
2021	20.8	0.5	-30.4	0.2	-8.9		5.8	1.5	-14.5	2.0	-1.4
2022	11.6	0.5	1.7	0.2	14.1		4.0	1.6	1.0	2.1	2.8

Annex 3c: Energy balance

The energy balance that forms the basis for the emissions from energy combustion (source category 1A), as well as for the reference approach, is available from Statistics Norway (Energy balance. Supply and consumption, by energy product. Statbank Norway, https://www.ssb.no/en/statbank/table/11561/.)

Annex 4: QA/QC plan and QA/QC procedures

1. Data quality objectives

Good practice defines the data quality objectives to be *transparency, completeness, consistency, comparability, and accuracy*. These objectives are used as a foundation of the QA/QC system implemented in Norway. In addition, we consider *timeliness* as part of the data quality objectives. Below we describe the objectives in more detail as they have been elaborated for the national system in Norway.

Transparency implies:

- Availability of sufficient documentation to enable estimates to be replicable from emission factors, activity data or plant emission measurement[3] for emission/removal data, irrespective of which institution or company made the estimates. This includes appropriate references to supplementary information (e.g., scientific literature)
- Availability of supplementary documentation (in English if practical) of models to enable a review, including a description of main assumptions and sources of data
- Availability of supplementary documentation (in English if practical) of data collection of key activity data
- Availability of sufficient documentation of methodological choices, including choice of measurement methods
- Explanation of reasons for not estimating an emission or removal occurring in Norway, for example an explanation of why an estimate is considered insignificant
- Documentation of QA/QC procedures

Completeness implies that:

- Estimates are made for all sources and sinks identified unless it can be documented that emissions/removals are insignificant

[6] This criterion can be difficult to fulfill in cases where complex models are used.

- Notation keys are used for all cells to be reported in the CRT
- Regular evaluation assessing potentially new sources and include these in the inventory

Consistency implies that:

- The same data sources and assumptions are used across gases, sectors and years of the inventory
- The same methodology has been used for all years of a time-series
- Data (activity data and measured data) have been collected using the same method for all years of the time-series
- Appropriate splicing techniques in accordance with the good practice guidance have been applied in cases of inconsistencies of time-series or changes in methodologies

Comparability implies that:

- Methodologies are consistent with the IPCC Guidelines and the good practice guidance
- Reporting guidelines are followed
- Emissions and removals are allocated to appropriate categories of the CRT as described in the IPCC Guidelines and good practice guidance

Accuracy implies that:

- Uncertainties are reduced by selecting higher tiers for key categories or increased sampling/frequency of surveyed data and emission measurements (taking costs into account)
- Data collected are checked to assess their reliability and possible over- or underestimates and identified biases are reduced
- Uncertainty estimates are collected or calculated and reported for all data
- Data are compared with independent information where possible

Timeliness implies that:

- Data are collected, processed, and reported in accordance with a timetable that allows reporting within the official deadline for submission to the UNFCCC

2. QA/QC responsibilities

All three institutions are responsible for implementing QC procedures to meet the data quality objectives of the data they collect. Each institution is also responsible for implementing QA procedures on method implementation and of data originally collected by another institution in addition to reviewing the QC performed on these data by the institution collecting the data.

The Norwegian Environment Agency, as the national entity, is responsible for the overall QA of the national system, including the UNFCCC reviews and any national reviews undertaken.

Statistics Norway and the Norwegian Institute of Bioeconomy Research are responsible for the QC of their respective data in the emission inventory. In addition, the Norwegian Environment Agency performs QC on the complete inventory, including the estimate of total emissions. The Norwegian Environment Agency may request Statistics Norway or the Norwegian Institute of Bioeconomy Research to revise the inventory if errors in the inventory are identified, or if any of the methodologies used are not as agreed by the cooperation meeting. In the event of a disagreement between the Norwegian Environment Agency and Statistics Norway on any numbers in the emission inventory, the Norwegian Environment Agency may change the estimates in the CRT. They will inform Statistics Norway about this decision and the reasons for it, and they will document in the NID why the data in the CRT are different from those of the national inventory compiled by Statistics Norway.

3. QC procedures

The input data used in the Norwegian national inventory are classified as emission factors, model and other estimation parameters, activity data (statistical data) and emissions from industrial and large plants (point sources). The output is classified as estimated emissions and removals, CRT tables and NID information. QC procedures are established for each element of input data and output.

Chapter 6 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 1 (IPCC 2006) gives guidance on QC. QC is defined *as a system of routine technical activities, to measure and control the quality of the inventory as it is being developed*. The QC system is designed to:

i) Provide routine and consistent checks to ensure data integrity, correctness, and completeness

ii) Identify and address errors and omissions

iii) Document and archive inventory material and record all QC activities

The IPCC Guidelines distinguishes between *general* and *category-specific* QC procedures. The general procedures focus on the processing, handling, and documentation procedures that are common to all inventory source categories. The category specific QC procedures are directed at specific types of data used in the methods for individual categories and require knowledge of the category, the types of data available and the parameters associated with emissions.

3.1 General QC procedures

The general QC procedures are performed annually for all data collected and all estimated data. For all sectors except LULUCF, most of these checks are performed automatically through use of Statistics Norway's emission model. However, checks are also performed manually on some data, for example, emission data collected from plants and activity data, emission factors and other estimation parameters for key categories. Identified problems are normally corrected before the final submission or flagged for correction in the next submission. For the LULUCF sector, the QC measures are also described in chapter 6 of the NID.

Reported emissions, emission factors and activity data for the latest inventory year are routinely compared to those of the previous inventory year. For sectors other than LULUCF, changes larger than 50-185%, depending on gas and source, are automatically flagged for further manual QC. In addition, implied emissions factors (IEF) are calculated for emissions from stationary combustion and IPPU at point sources. The IEFs are subjected to the same comparison between the current and previous inventory year. The most thorough checks are made for the gases and categories with the largest contribution to total emissions. Result control routines include comparison of emission estimates at the level of reporting to the UNFCCC and LTRAP convention (NFR[4]).

The Norwegian emission inventory is produced in several steps. Statistics with preliminary emission estimates are published by Statistics Norway in June the year after the inventory year. These data are based on preliminary statistics and indicators and data that have been subjected to a less thorough quality control. The more final emission statistics, which forms the basis for the emission inventory reported to the UNFCCC (for all source categories except LULUCF) is published in November the year after the inventory year. At this stage, final statistics are available for almost all emission sources. Recalculations of the inventory are performed annually to ensure that methodological changes and refinements are implemented for the whole time series. This stepwise procedure is a part of the QA/QC procedure since all differences in data are recorded and verified.

General quality control procedures are performed for each of the steps above, but with different levels of detail and thoroughness as mentioned. The national emission model was revised in 2002 to facilitate the QC of the input data rather than the emission data only. Input data include emissions reported from large plants, activity data, emission factors and other estimation parameters.

The general checks for the three institutions are summarized in Table A4-1 to Table A4-3.

[4] Nomenclature for reporting of air pollution data to UNECE under the LRTAP convention.

Table A4-1: General annual QC checks for the Norwegian Environment Agency.

	Check	Responsible
Time-series and inventory version comparisons to detect problems with units, computational errors as well as other human errors.		
	Compare all emissions reported from industrial and other large plants to those of the previous inventory year and flag changes of more than 20% (10% for plants included in emission trading) for further QC.	NEA
Completeness checks		
	Identify large plants previously included in the inventory that no longer are included (and explain the reason for exclusion) and new plants included in the inventory (including an explanation of whether this plant is new) and communicate this information to SN.	NEA
Consistency checks		
	Checks for time-series consistency in cases where emissions from plants collected by the Norwegian Environment Agency only are available for parts of the time-series.	SN + NEA
	Checks for time-series consistency where activity data are only available on a non-annual or cyclical basis.	NIBIO (SN and NEA)
	IEF checks of input data: Checking derived emission factors for individual plants (reported emissions divided by energy consumption, production or other activity data), flagging plants whose IEFs deviate significantly from the default values for further investigation. The investigation of flagged observations is prioritized based on magnitude of emissions and deviation from default IEFs, focusing on correcting obvious errors.	SN, NEA
Recalculations		
	Check that appropriate recalculations are made, if needed, whenever methodologies or data sources have changed.	All
	Check that appropriate recalculations are made when preliminary data have been replaced with final data.	All (NIBIO in particular)
	Check that when recalculations are performed these are made consistently throughout the time-series.	All
	Check that where splicing techniques are needed, these are applied in accordance with good practice and are documented.	All
Documentation		
	Check documentation for completeness and need for general revisions	All
Acronyms: NEA: Norwegian Environment Agency, SN: Statistics Norway, NIBIO: The Norwegian Institute of Bioeconomy Research		

Table A4-2: General annual QC checks for Statistics Norway.

	Check	Responsible
Input data control		
	Identification and correction of input data with non-acceptable categories and values, double counting, inconsistencies, etc. Computerized flagging. Manual correction. Level of control: Data entry level. Accuracy.	Category experts
	Possible missing data for the most recent inventory year (n): Flagging of sources where input data exist for previous years, but not for the most recent inventory year. Computerized flagging. Manual correction. Level of control: Data entry level.	Category experts

	Check	Responsible
	Accuracy, consistency and completeness.	
	New sources for the most recent inventory year (n) or missing data previous years: Flagging of sources where there is input data for the most recent inventory year (n), but data is lacking for the precious years (n-1, n-2, n-3). Computerized flagging. Manual correction. Level of control: Data entry level. Accuracy, consistency and completeness.	Category experts
	Checking for extreme values in time series: Computerized control with flagging of input data where: The change from latest inventory year (n) and the previous year (n-1) is above or below certain limits. The value in latest inventory year (n) is above or below limits when compared with the average value for the three previous years (n-1, n-2 and n-3). The absolute change in value between latest inventory year (n) and the previous year (n-1) is larger than the third largest change in the whole time series. Limits of controls: Flagging when value outside X-Y% of reference value: CO_2, NO_x, NMVOC and CO: 70-135% CH_4, N_2O: 50-177% HFC, PFC, SF_6: 20-343% Computerized flagging. Manual correction. Level of control: Data entry level. Accuracy and consistency.	Category experts
Control of estimated emissions (results) – most recent inventory year		
	Identification and correction of input data with non-acceptable categories and values, double counting, inconsistencies, etc. Computerized flagging. Manual correction. Level of control: Estimated emissions. Accuracy.	Category experts
	Possible missing data for the most recent inventory year (n): Flagging of sources where emission data exist for previous years, but not for the most recent inventory year. Computerized flagging. Manual correction. Level of control: CRT-category times gas, and sources as published by Statistics Norway times gas. Accuracy, consistency and completeness.	Category experts
	Checking for extreme values in latest inventory year: Flagging of emission data where the change from previous inventory year (n-1) to the latest inventory year (n) is above or below certain limits: A change of more than 50% up or 33.33% down for a particular GHG and category A change of more than 0.1% compared with total emissions from all sources of that particular GHG Computerized flagging. Manual correction. Level of control: CRT category for each individual GHG. Accuracy and consistency.	Category experts
	Implied emissions factors for energy categories. Computerized flagging. Manual correction. Level of control: CRT category for each individual GHG. Accuracy and consistency.	
Control of estimated emissions (results) – recalculations		
	Checking of recalculations for whole time series: Flagging of emission data where values have changed more than certain limits compared with value in previous submitted inventory. A change of more than 0.001% for a particular GHG and category A change of more than X compared with total emissions from all sources of that particular GHG Computerized flagging. Manual correction. Level of control: CRT category for each individual GHG. Performed on whole time series except latest inventory year. Accuracy and consistency.	

	Check	Responsible
	Are all recalculations documented in NID?	Category experts
Control of recalculations		
	Check that appropriate recalculations are made, if needed, whenever methodologies or data sources have changed.	Category experts
	Check that appropriate recalculations are made when preliminary data have been replaced with final data.	Category experts
	Check that when recalculations are performed these are made consistently throughout the time-series.	Category experts
	Check that where splicing techniques are needed, these are applied in accordance with good practice and are documented.	Category experts

Table A4-3: General annual QC checks for the Norwegian Institute of Bioeconomy Research (NIBIO).

Check performer	Type of check
Checks for errors in time-series, units, computational and human errors	
All source-responsible	Evaluate emissions or removals from the whole time series for each category by: (1) comparing the current estimate to previous estimate(s) as appropriate, (2) re-checking and explaining to the extent possible the reason(s) behind trends or individual year estimates that significantly depart from the expected trend, and (3) checking the value of the implied emission (IEF) factors across the time series for outliers, or if IEFs are static, that the changes in emissions or removals are being captured.
LULUCF compiler and area expert(s)	Analyse area changes in land use and evaluate if trends and the range of annual changes seem reasonable.
Qualified NIBIO person	Cross check the areas of cultivated organic soils with Statistics Norway (SSB) to ensure consistency between the LULUCF and Agriculture Sectors.
LULUCF compiler	The area used for peat extraction is estimated by external data and it must be implemented manually in the area data derived from NFI. Correct reporting of managed and unmanaged wetlands in CRT tables is cross-checked.
Completeness checks	
LULUCF compiler	Check that all mandatory and chosen emission/removal sources are included.
LULUCF compiler	All LULUCF tables in CRT are inspected for missing annual values.
Recalculations	
LULUCF compiler & all source-responsible	Check of the consistency in the descriptions (NID): All recalculations made are described in the NID in chapter 10 Recalculations.
Documentation	

Check performer	Type of check
LULUCF compiler	Check that new methods are described in detail (in the NID or in publications referred to in the NID) and that the documentation is stored properly and can be made available upon request during review.
All source-responsible	Source/sink specific information is stored on a dedicated file server location for data storage. The servers are backed up daily. Only NIBIO participants in the GHG inventory system have access to add, edit and delete files. In addition, after submission deadline all data is in stored on a locked folder for archiving.

In the following, the procedures listed in table 6.1 in chapter 6 of the 2006 IPCC Guidelines (IPCC 2006) are described, as well as how these checks are performed for the Norwegian greenhouse gas emission inventory.

3.1.1 Check that assumptions and criteria for the selection of activity data, emissions factors, and other estimation parameters are documented

Thorough checks of emission factors and activity data and their documentation are performed for existing emission sources. When new sources appear (for example a new industrial plant) or existing sources for the first time are recognised as a source, the Norwegian Environment Agency delivers all relevant information to Statistics Norway. This information is then thoroughly checked by the inventory team at Statistics Norway. All changes in methodologies or data are documented and kept up to date.

3.1.2 Check for transcription errors in data input and references

Activity data are often statistical data. Official statistical data undergo a systematic revision process, which may be manual or computerised. The revision significantly reduces the number of errors in the statistics used as input to the inventory. Furthermore, all input data (reported emissions, emission factors and activity data) for the latest inventory year are routinely compared to those of the previous inventory year, using automated procedures. Large changes are automatically flagged for further, manual QC. In addition, implied emission factors (IEFs) are calculated for emissions from stationary combustion at point sources. The IEFs are subjected to the same comparison between the years t and t-1. The most thorough checks are made for the gases and categories with the largest contribution to total emissions.

3.1.3 Check that emissions and removals are calculated correctly

When possible, estimates based on different methodologies are compared. An important example is the metal production sector, where CO_2 estimates reported by the plants are compared with estimates based on the Good Practice methodology corrected for national circumstances. In this case, both production-based and reducing agent-based calculations are performed to verify the reported value. The Norwegian Environment Agency and Statistics Norway control and verify emission data reported to the Norwegian Environment Agency by industrial enterprises, registered in the database Forurensning. First, the Norwegian Environment

Agency checks the data received from these plants, and if errors are discovered, they may then ask the plants responsible to submit new data.

Subsequently, Statistics Norway makes, where possible, occasional comparable emission calculations based on activity data sampled in official statistics, and deviations are explained through contact with the plants.

3.1.4 Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used

All parameter values are compared with values used in previous years and with any preliminary figures available. Whenever large deviations are detected, the value of the parameter in question is first checked for typing errors or unit errors. Changes in emissions from large plants are compared with changes in activity level. If necessary, the primary data suppliers (e.g., the Norwegian Institute of Bioeconomy Research, The Norwegian Petroleum Directorate, Norwegian Public Roads Administration, various plants etc.) are contacted for explanations and possible corrections.

3.1.5 Check the integrity of database files

Checks of whether appropriate data processing steps and data relationships are correctly represented are made for each step of the process. Furthermore, it is verified that data fields are properly labelled, have correct design specifications and that adequate documentation of database and model structure and operation are archived.

3.1.6 Check for consistency in data between source categories

Activity data and other parameters that are common to several source categories should be evaluated for consistency. An example is recovery of landfill gas. A fraction of this gas is flared, and emissions are reported in the Waste source category. Another fraction is recovered for energy purposes, and this gas is an input to the energy balance with emissions reported in the Energy source category. Consistency checks ensure that the amount landfill gas subtracted from source category 5A (Managed waste disposal on land), equals the amount added to source category 1A (Energy combustion) and source category 5C (Waste incineration) (the amount of gas flared).

Consistency is also checked for activity data that is used in both the Agriculture and LULUCF sectors. This is the case for the area of organic soils on croplands and grasslands, which is used to estimate CO_2 emissions in the LULUCF sector (source categories 4.B and 4.C) and N_2O emissions in the agriculture sector (source category 3D16). Within agriculture (source categories 3A, 3B and 3D), the same activity data on animal numbers and characteristics is used as far as possible.

3.1.7 Check that the movement for inventory data among processing steps is correct

Statistics Norway has established automated procedures to check that inventory data fed into the model does not deviate too much from the estimates for earlier years, and that the calculations within the model are correctly made. Checks are also made that emissions data are correctly transcribed between different intermediate products. The model is constructed so that it gives error messages if factors are lacking, which makes it quite robust to miscalculations.

3.1.8 Check that uncertainties in emissions and removals are estimated and calculated correctly

An approach 2 uncertainty analysis for greenhouse gases is undertaken annually, see further information in section 1.6 and Annex 2.

3.1.9 Undertake review of internal documentation

For some sources, expert judgements dating some years back are used for activity data/emission factors. In most of the cases these judgements have not been reviewed since, and may not be properly documented, which may be a weakness of the inventory. The procedures have improved the last few years, and the requirements for internal documentation to support estimates are now quite strict; all expert judgements and assumptions made by the Statistics Norway staff should be documented. This should increase reproducibility of emissions and uncertainty estimates.

3.1.10 Check of changes due to recalculations

Emission time series are recalculated every year to ensure time series consistency. The recalculated emission data for a year are compared with the corresponding estimates from the year before. For example, CO_2 data calculated for 1990 in 2021 are compared with the 1990 CO_2 data calculated in 2020. The intention is to explain all major differences as far as possible. Changes may be due to revisions in energy data, new plants, correction of former errors and new emission methodologies.

3.1.11 Undertake completeness checks

Estimates are reported for all source categories and for all years to the best of our knowledge except for a few known data gaps, which are listed in section 1.7. There may, of course, exist sources of greenhouse gases which are not covered. However, emissions from potentially additional sources are likely to be very small or negligible. During the implementation of the 2006 IPCC Guidelines (IPCC 2006), a systematic evaluation of all potential new sources was performed.

3.1.12 Compare estimates to previous estimates

Internal checks of time series for all emission sources are performed every year when an emission calculation for a new year is implemented. It is examined whether any detected inconsistencies are due to data and/or methodology changes. For example, in 2017 Statistics Norway/the Norwegian Environment Agency calculated emission data for 2016 for the first time. These data were compared with the 2015 estimates for detection of any considerable deviations. There may be large deviations that are correct, caused for instance by the shutdown of large industrial plants or the launch of new ones.

3.1.13 QC of activity data

3.1.13.1 Statistics Norway

Documentation of the statistics and routines is available on web (www.ssb.no/en, for each statistic click at "about the index"). An example from the energy statistics is given below. As a part of the statistical production reported data are checked and the primary data providers are contacted for explanations/revisions if needed.

3.2 Category-specific QC

These checks are normally not performed on an annual basis but are performed regularly and in addition to the general QC checks, often in conjunction with improvement projects. The goal is to perform a category-specific QC, including an updated uncertainty analysis, within cycles of approximately 5 years for key categories and potential key categories, and at least every 10 years for other categories. An annual and long-term prioritization will be made annually by the Norwegian Environment Agency, Statistics Norway, and the Norwegian Institute of Bioeconomy Research, in collaboration with other relevant authorities, as a part of the improvement plan (with the Norwegian Environment Agency in charge) (see Section 3.6). For example, the review reports, QA/QC conclusions and need for improved emission data for emission reduction plans will be important for a final prioritization. QC findings are followed up by revising emission factors, activity data, other estimation parameters or the methodologies. The changes are approved in the autumn meetings between the Norwegian Environment Agency, Statistics Norway, and the Norwegian Institute of Bioeconomy Research.

3.2.1 Estimated emissions and removals

The QC checks on emission and removal estimates come in addition to those undertaken on the input data as described below.

The QC checks of estimates include:

- A comparison of the methodologies used to estimate emissions and removals with those recommended in the latest IPCC Guidelines
- A review of availability of data and resource requirements for selecting a higher tier
- A review of alternative methodologies
- A comparison of (higher tier) estimates with lower tiers when appropriate
- A comparison of estimates to those of inventories from countries with similar national circumstances using appropriate drivers
- An assessment of time-series consistency (for example, that the same method has been used for all years of the time-series) and use of splicing techniques (where relevant)
- A review and documentation of model assumptions

- A review and update of documentation, including archiving of supplementary documentation
- A check of whether the allocation to categories in the CRT is correct

QC checks for completeness include:

- A review of relevant emission sources not included in the inventory (the IPCC Guidelines, inventories from countries with similar national circumstances and literature)
- A review of methodologies and data availability for these potential sources
- A documentation of reasons for not including a source in the inventory

3.2.2 Emission data reported from industrial plants

Norway has a long experience of using GHG emissions from industrial point sources in the national GHG inventory. The Norwegian Environment Agency has been given the authority to manage and enforce the Pollution Control Act, the Product Control Act and the Greenhouse Gas Emission Trading Act. The Norwegian Environment Agency grants permits, establishes requirements, and sets emission limits, and carries out inspections to ensure compliance.

Plant emission data that are used in the EU emission trading system undergo annual QC checks through third party verification. The Norwegian Environment Agency also performs source-specific QC checks for other plants, with special emphasis on large point sources within key categories. Statistics Norway is responsible for reporting the results of the key category analysis to the Norwegian Environment Agency, while the Norwegian Environment Agency performs the assessment of the "key plants" within a category.

The QC checks include:

- An assessment and documentation of measurements and sampling
    - Measurement frequency
    - Sampling
    - Use of standards (e.g., ISO)
- An assessment and explanation of changes in emissions over time (e.g., changes in technology, production level or fuels) (annual check)
- An assessment of time-series consistency back to 1990 in cooperation with Statistics Norway[5] (if plant emission data are missing for some years and estimates are made using

[5] For plants included in the emission trading scheme historical data are derived in cooperation with the industry organization

aggregate activity data and emission factors). See (SFT 2006) for a major QA/QC exercise on the time series from 1990 to 2004 of greenhouse gas (GHG) emissions from the largest industrial plants in Norway.

- A comparison of plant emissions to production ratios with those of other plants, including explanations of differences
- A comparison of the production level and/or fuel consumption with independent statistics (in collaboration with Statistics Norway)
- An assessment of reported uncertainties (including statistical and non-statistical errors) to the extent this has been included in the reporting

The QC checks should be made in close cooperation with the plants. The inventory compilers in the Norwegian Environment Agency have easy access to data sources for each plant as all plants submit annual reports electronically as required by their regular permit, some are also covered by the EU emission trading system (EU ETS) and some were also covered by a voluntary agreement up to and including 2012.

The main documentation from the work is contained in Excel spread sheets. The emission reports from the plants are submitted in a standardized electronic format directly to the Norwegian Environment Agency by 1 March each year. The EU ETS reports are thoroughly checked by the agency by the Department of Climate, while the Department of Industry is in charge of checking the reports submitted due to regular permits. The agency has personnel with extensive technical competence in the relevant industry processes.

For the purpose of the inventory, additional QA is undertaken by the Section for Emission Inventories and Method before the data are sent to Statistics Norway. These QA checks include consideration of time-series consistency, inter-annual changes and more attention is now given to implied emission factors (IEF). When needed, further QC is undertaken in collaboration with the officer in the agency in charge for the specific plant and/or the plant. Time series are continuously recalculated if better data/information is gained.

The use of EU ETS data, data from regular reporting and data from the voluntary agreement does not represent a problem for the time series consistency. This is because the Norwegian GHG inventory for a long time (since the early 90ies) has included GHG emissions from industrial point sources (both emissions from processes and combustion). The new data sources provide data of better quality, and these are checked against the emissions reported under the regular permits.

3.2.2.1 Data from the EU ETS

The GHG inventory includes more reported data from the emissions trading system (ETS) from 2005 and onwards. In phase III of the ETS from 2013-2020 the scope of sectors covered was expanded, including aluminium production, ferroalloy production and intra-EU aviation. The scope of sectors was not expanded when phase IV started in 2021. Starting in 2013 all emission data from installations in the EU ETS are subject to verification from an accredited independent third party. This means that the Norwegian Environment Agency no longer verify the emissions but provide approval of the annual emissions verified by an independent third party. The decisions of approvals of the reports, applications for permits, the permits, the plans for measuring and reporting, the emission reports, allocation level reports, and approvals are all available to the public.

Industrial installations and aircraft operators covered by the EU ETS are required to have an approved monitoring plan, according to which they monitor and report their emissions during the year. In the case of industrial installations, the monitoring plan forms part of the approved permit that is also required. Installations and aircraft operators must monitor and report their annual emissions in accordance with two European Commission Regulations, the Monitoring and Reporting Regulation (MRR) and the Accreditation and Verification Regulation (AVR). The agency approves the monitoring plan, if we find it of high enough quality and consistent with the Monitoring and Reporting Regulation. The operators must then perform their measurements and calculations according to this plan, and report according to that. The data in the annual emissions report for a given year must be verified by an accredited verifier by 31 March of the following year. The agency then approves the verified data.

The agency has developed a web-based electronic reporting template based on the Commissions electronic templates for monitoring plans, annual emission reports. The activity-specific guidelines set out in the Monitoring and Reporting Regulation contain specific methodologies for determining the following variables: activity data (consisting of the two variables fuel/material flow and net calorific value), emission factors, composition data, oxidation and conversion factors. These different approaches are referred to as tiers. The increasing numbering of tiers from one upwards reflects increasing levels of accuracy, with the highest numbered tier as the preferred tier.

The operator may apply different approved tier levels to the different variables' fuel/material flow, net calorific value, emission factors, composition data, oxidation or conversion factors used within a single calculation. The choice of tiers shall be subject to approval by the competent authority (in Norway, The Norwegian Environment Agency). Equivalent tiers are referred to with the same tier number and a specific alphabetic character (e.g., Tier 2a and 2b). For those activities where alternative calculation methods are provided within these guidelines an operator may only change from one method to the other if he can demonstrate to the satisfaction of the competent authority that such change will lead to a more accurate monitoring and reporting of the emissions of the relevant activity.

The highest tier approach shall be used by all operators to determine all variables for all source streams for all category B or C installations. Only if it is shown to the satisfaction of the competent authority that the highest tier approach is technically not feasible or will lead to unreasonably high costs, may a next lower tier be used for that variable within a monitoring methodology.

Norway has transposed the Monitoring and Reporting Regulation into national law.
All documentation like applications for permits, the permits, the plans for measuring and reporting, the emission reports and approvals are all available to the public.

Data for some important sectors have been reviewed as part of the reviews performed at the Norwegian Environment Agency. However, the EU ETS has introduced a new reporting channel with its own, more specific, energy data. This has made it apparent that for some facilities, the reported emissions do not correspond fully to the energy data reported to Statistics Norway. This is one of the reasons that Statistics Norway has introduced a new check in the current inventory cycle. The total emissions from a facility will be compared to emissions calculated from data reported to the energy statistics together with default emission factors. If deviations are found, the comparison will be made at the level of fuel types. The tolerances for allowed differences are to be decided, as we do not know yet the magnitude of the potential deviations.

The differences between the energy data in the EU ETS and Statistics Norway that has been identified typically refers to emissions from fuel streams in chemical industries and gas processing units that are derived from raw materials. These often have deviating, plant specific emission factors and energy contents, and in some cases, they are reported as raw materials used in the energy statistics.

3.2.2.2 The Forurensning database

The Forurensning database includes the data and information reported by the plants under their regular permit and data as reported under the EU ETS. The database eases the work of the inventory compilers at the agency as a lot of data is easily available. Specific queries can be tailored for withdrawal of data from the database.

3.2.2.3 The Norwegian Pollutant Release and Transfer Register (PRTR)

In addition to posting data and information from the EU ETS on the agency's web page, other data is also made publicly available. Data from the plants as reported under their regular permit can be accessed through the Norwegian Pollutant Release and Transfer Register (PRTR). The Norwegian PRTR website provides information about discharges to air and water, waste transfers, production volumes and energy use for most of the emission sources in Norway. The website includes both point sources and diffuse emissions.

Offshore oil and gas extraction
The operators of oil and gas fields at the Norwegian Continental Shelf report their emissions to NEA on annual basis (according to requirements in the "HSE-regulations"). The HSE-regulations can be downloaded from the websites of the Petroleum Safety Agency: PDFs of regulations (ptil.no). The reporting is mandatory and regulated by the Norwegian Pollution Control Act and associated official guidelines (M-107) issued by NEA.

Operators are required to quality assure information on activity and emissions prior to reporting to the Norwegian Environment Agency (as stated in the Management Regulation 34c).

The annual reports from the operators are revised by the NEA. This includes for instance crosschecking of reported CO_2 emission data against ETS-reports and crosschecking of reported fugitive emissions (methane and NMVOC) against data reported by the operators. Annual emissions from loading of crude oil onto shuttle tankers on the Norwegian continental shelf are reported by the VOC Industrial cooperation. The VOC Industrial cooperation reports are available in Norwegian.

The NEA also evaluate historical trends by looking at excel-plots and figures generated from the reporting database. Results which deviate from previous reports are then easily identified and followed up against the operator. This might lead to corrections in figures in the database.

In the auditing of the reported emissions, the NEA focuses on e.g., field specific methods, sources with high emission on the specific field and leakages.

Statistics Norway gathers activity data used in the calculation from the Norwegian Offshore Directorate. The figures are quality controlled by comparing them with the figures reported in the field operators annually report to the Norwegian Environment Agency and the Norwegian Offshore Directorate and time series are checked.

3.2.2.4 Inspections

The agency has a separate Inspection and Environmental Data Department, which includes two sections for product and industrial control. This department is working independently from the department evaluating emissions permits. They inspect and monitor industrial sites/plants, including underlying documentation for the emission estimates. The Department is part of the NEA and its tasks are described in the National System and it is hence considered a part of the inventory system.

The department has extensive competence and experience in performing audits and inspections. They also have technical expertise in industrial processes and offshore oil and gas production. There is exchange of knowledge and experience between the experts on the ETS and this department. The department has regular training courses for the inspectors, where the regulations they shall audit after is an important element. Particular controls are directed to the plants included in the emission trading system to check that the monitoring plan is in line with how the operator monitors and reports the emissions. The plants are to be controlled based on the risk of erroneous reporting of emissions.

In their applications for permits, the plants describe their internal Quality Control Systems. It is a requirement in the permits that they apply and operate this system. This is one of the areas that the Inspection and Environmental Data Department carefully controls when they carry out inspections and audits at the facilities.

3.2.3 Emission factors & other estimation parameters

The category specific QC is performed by the Norwegian Environment Agency, Statistics Norway, the Norwegian Institute of Bioeconomy Research and/or another institution with expertise in the category subject to review. It can address a single category or several related categories (e.g., road transportation and agriculture) and will include an assessment of the emissions factors currently in use and conclude on the need for revisions.

This QC will include the following elements:

- A comparison of the emission factor with those
  - recommended in the IPCC Guidelines
  - identified through a literature search (peer reviewed literature and other reports)
  - identified by national source-experts (e.g., industry organizations and researchers)
  - that can be derived from emission data reported from the plants
- An assessment of the representativeness of the emission factors used for national circumstances (particularly when they are based on default emission factors and international research)
- A quantification of the uncertainty (addressing statistical and non-statistical errors)
- An assessment of the content of documentation, including technical documentation
- An assessment of the availability (archiving) of documentation, including technical documentation
- An assessment of changes in emission factors over time due to changes in technology and/or management

3.2.4 Activity data

The category specific QC is performed by the Norwegian Environment Agency, Statistics Norway and The Norwegian Institute of Bioeconomy Research for the data collected by each institution. Some activity data are originally collected by another institution. In these situations, the Norwegian Environment Agency, Statistics Norway, or the Norwegian Institute of Bioeconomy Research (as appropriate) are responsible for assessing the QC applied on these data and perform their own additional QC on aggregate data.

The activity data QC will include the following elements:

- An evaluation and documentation of the QC routines applied at the survey level (at the point of interview/field work and the data checking/processing level)

- An evaluation of the techniques used to obtain annual data (if applicable)
- An assessment of sampling and representativeness, including an evaluation of possible bias for application of the data in inventories (for LULUCF area data and for statistical survey data)
- An assessment of the classification of land areas and assumptions needed to apply data from the national forest inventory (NFI)
- A review and assessment of alternative data sources
- A comparison with independent data sources (if possible)
- A quantification of uncertainties (including statistical and non-statistical errors)

3.2.4.1 The National Forest Inventory

Survey level

The Norwegian Institute of Bioeconomy Research is responsible for the Norwegian National Forest Inventory (NFI). The NFI has long traditions and the attributes assessed or measured in the field are subject to frequent revisions, while at the same time an attempt is made to preserve the long time series of key attributes. The main objectives of the NFI are to provide updated forest information to national forest administrations, to be able to report adequately to international forest resources assessments and to provide data for special studies.

Prior to every field season, all field workers are gathered for one week of briefing on the inventory work. New attributes or altered definitions of attributes will especially be emphasized. The course includes practical training and exercises, under which the assessments and measurements made by each of the fieldworkers will be compared and discussed in plenary.

During the field season, each field worker will usually be visited by a supervisor from the head office. The supervisor will join the field worker on some sample plots in the field, giving an opportunity to discuss possible problems and misunderstandings with regard to classifications and measurements. Normally an assessment check will also be performed, i.e. a subset of the sample plots will be measured a second time by an independent control team. Normally the proportion of plots selected for checking constitutes about 5% of the plots. The results from the assessment check will not be used to replace or adjust the original data, but only to assess data quality, detect misunderstandings and incorrect working techniques. Thus, it may lead to improvement of field instructions and training.

Data is being entered directly into a handheld data logger during the inventory work. A number of consistency checks has been built into the data logger, e.g. to ensure that the correct attributes will be assessed under the current area class. Data from the previous inventory cycle will be stored in the data logger and a warning will appear if the data are not in accordance with what has been assessed before. That also includes single tree data where current diameter and tree height will be checked against the one measured 5 years earlier, in order to detect an unlikely increment rate or any confusion with identifying trees. Every week the data are transferred to the head office via e-mail. Further testing for correspondence between different attributes will also be carried out and detected errors or inconsistencies will be returned to the field crew for clarification. Transitions between land use categories are checked for consistency.

Data processing

After calculation of volume and annual increment of each sampled tree, the estimates are aggregated to geographical regions and the whole country. One sample plot in the 3x3 km grid represents an area close to 900 ha. After having made the appropriate summaries, the results are compared with corresponding data from the last inventory and the entire time series of data.

3.2.5 Documentation

For each category, a review and update of the documentation is performed if needed. The requirements for documentation will be highest for key categories. The QC should include:

- An assessment of whether the documentation is sufficient to understand the data, methods, and assumptions behind an estimate of emissions or removals
- A recording of changes that have been made as a response to the QC checks
- A description of consequences for the time-series of changes in data or methods
- Writing and archiving of additional technical documentation as needed (in English if practical or in Norwegian) to enable the replicability of estimates for a reviewer, in some cases running the calculation scripts is necessary to reproduce numbers due to high complexity particularly for LULUCF.

3.2.6 Common Reporting Tables (CRT)

After the implementation of reporting with the ETF GHG inventory reporting tool, Statistics Norway and the Norwegian Institute of Bioeconomy Research transfer emission data using both Excel and JSON imports. Separate datasets for activity data and notation keys have been developed.

Statistics Norway and the Norwegian Environment Agency are responsible for additional checks on an annual basis:

- Check of total emissions against those of the emission model
- Check of sectoral totals against those of the emission model
- Check of notable changes from previous submissions for individual categories
- Check of correct use of notation keys
- Check of exported CRT JSON data and manually updated CRT Excel tables to ensure that they are in accordance with the results of the emission model

The Norwegian Institute of Bioeconomy Research is responsible for checking all LULUCF entries with data from its database. Exported CRT tables are checked to ensure that they are in accordance with the LULUCF database.

The Norwegian Environment Agency is responsible for a final check of the CRT for completeness and for checking that Statistics Norway and The Norwegian Institute of Bioeconomy Research have completed the QC checks they are responsible for. The Norwegian Environment Agency is responsible for making the final approval of the CRT tables.

3.2.7 National Inventory Report (NID)

The Norwegian Environment Agency is responsible for the annual QC of the NID. This includes checking that:

- Emissions and removals (including the key category analysis) in tables and text are consistent with those reported in the CRT
- Trends in emissions and removals are explained
- All methodological changes since the previous NID are explained
- All recalculations are explained and the effect on time-series consistency reported
- The textual description reflects methodologies used and are sufficient to understand estimation procedures
- Responses to the review report are reflected
- Priorities for improvements are described in accordance with decisions
- All other information is correct (including QA/QC plan, uncertainties and completeness)

3.2.8 Timeliness

The Norwegian Environment Agency, Statistics Norway and the Norwegian Institute of Bioeconomy Research have agreed on a timetable to enable the Norwegian Environment Agency to report to the EU and UNFCCC by March 15 (see chapter 1.5). It is the responsibility of the Norwegian Environment Agency, Statistics Norway, and the Norwegian Institute of Bioeconomy Research to make this timetable known in their respective institutions to ensure that the internal deadlines for data collection and processing in each institution as far as possible follow the emission inventory production cycle.

3.2.9 QC documentation

The members of the inventory team working with individual sectors or part of a sector go through their submissions included quality controls with the relevant coordinator/inventory compiler.

Statistics Norway and the Norwegian Environment Agency have carried out several studies on specific emission sources, e.g., emissions from road, sea, and air transport, emissions from landfills as well as emissions of HFCs and SF_6. These projects are repeated in regular intervals when new information is available. During the studies, emission factors have been assessed and amended to represent the best estimates for national circumstances, and a rationale for the choice of emission factor is provided. The emission factors are often compared with factors from literature. Furthermore, activity data have been closely examined and quality controlled, as have the uncertainty estimates.

The QC procedures for the different emission sources are described in the QA/QC-chapters of the relevant source categories. The source category-specific analyses have primarily been performed for key categories on a case-by-case basis, which is described as good practice.

3.2.10 Verification studies

In general, the final inventory data provided by Statistics Norway and the Norwegian Institute of Bioeconomy Research are checked and verified by Norwegian Environment Agency. Some verification studies, which have been performed previously, are briefly described in the following.

Emission estimates for a source are often compared with estimates performed with a different methodology. In particular, Norway has conducted a study on verification of the Norwegian emission inventory (Kvingedal et al. 2000). The main goals of that work were to investigate the possibility of using statistical data as indicators for comparing emission estimates between countries on a general basis, and to test the method on the Norwegian national emission estimates. In the report, Norwegian emission data were compared with national data for Canada, Sweden, and New Zealand. It was concluded that no large errors in the Norwegian emission inventory were detected. The process of verification did, however, reveal several smaller reporting errors; emissions that had been reported in other categories than they should have been. These errors were corrected. We acknowledge that this method of verification only considers consistency and completeness compared with what other countries report. It is not a verification of the scientific value of the inventory data themselves.

In 2002, a project funded by the Nordic Council of Ministers compared emissions of greenhouse gases from the agricultural sector in the national emission inventories with the emissions derived from the IPCC default methodology and the IPCC default factors.

In 2006, as part of the improvements for the Initial report under the Kyoto Protocol, the Norwegian Environment Agency performed a major QA/QC exercise on the time series from 1990 to 2004 of greenhouse gas (GHG) emissions from the largest industrial plants in Norway. A first time series of emission data as well as activity data was established for each plant based on existing data sources. It was then possible to identify lack of emission data and activity data for any year or time series and possible errors in the reported data.

Possible errors were typically identified if there were discrepancies between reported activity data (consumption of raw materials, production volumes etc.) and emissions, or if there were large variations in the existing time series of emissions. The emission data were supplemented and/or corrected, if possible, by supply of new data from the company, supplementary data from

Norwegian Environment Agency paper archives, verification of reported emission data by new calculations based on reported activity data and calculation of missing emissions (if sufficient activity data were present). A final time series of greenhouse gas emissions from 1990 to 2004 were established and the main documentation from this work is contained in Excel spread sheets and in a documentation report (SFT 2006).

From 2005 and especially from 2008, Norway's use of plant specific data has been strengthened by the availability of data from the EU ETS. The Norwegian Environment Agency conducted the verification of the annual reports up until the inventory year 2012. Since then, verification has been performed by an accredited third party. As a data source, the EU ETS provides better quality data, and these data are checked against the emissions reported under the regular permits and the reports submitted as part of the voluntary agreement.

In 2009, a new model for calculating the emissions of NMVOC from the use of solvents and other product uses was developed. The emission factors were evaluated and revised through a cooperation project between the Nordic countries. The results from the new model were compared against the similar results in Sweden and the United Kingdom; see Holmengen and Kittilsen (2009) for more details.

In 2011, the Norwegian University of Life Sciences (NMBU) published a comparison of the methodologies used for calculating 2o emissions from manure management in Sweden, Finland, Denmark and Norway (Morken & Hoem 2011).

In a project in 2012 at the Norwegian University of Life Sciences (NMBU) that updated the Norwegian nitrogen excretion factors and the values for manure excreted for different animal species, comparisons were made with the corresponding factors used in Sweden, Denmark and Finland and with IPCC default factors as a verification of the Norwegian factors (Karlengen et al. 2012). Comparisons were also made of the emission factors used for calculating enteric methane. In 2015, the equations for calculating emissions from enteric fermentation were evaluated and updated.

In 2015, IEFs for many of the IPPU source categories have been compared with what other Annex I countries have reported using a tool developed by the UNFCCC.

In 2019, a technical committee on agricultural greenhouse gas emission ("Teknisk beregningsutvalg for klimagassutslipp i jordbruk") on behalf of the Ministry of Agriculture and Food, published its final report. This document pointed out possible ways to improve the emission inventory to better reflect mitigation measures and where enhanced knowledge is needed.

The Norwegian Government and the agricultural organisations have in 2019 entered a letter of intent about reducing greenhouse gas emissions and increase the carbon sink from agriculture with 5 million tonnes CO_2 equivalents for the period 2021-2030. As part of the follow-up of this deal will the recommendations from the Technical committee on agricultural greenhouse gas emission be followed up on a yearly basis, and other possible improvements will be pointed out which can contribute to the knowledge base for improvements of activity data or emission factors in the national emission inventory.

3.3 QA procedures

According to the 2006 IPCC Guidelines (IPCC 2006), "Good practice for QA procedures includes reviews and audits to assess the quality of the inventory, to determine the conformity of the procedures taken and to identify areas where improvements could be made". QA involves reviewers that have not been involved in preparing the inventory. They should be independent from the institutions involved in the national system, or not closely involved in the inventory compilation. We distinguish between QA of input data and of the entire inventory.

3.3.1 Statistical data and emissions reported from plants

3.3.1.1 Emissions reported from plants

Emission data reported from the plants to the Norwegian Environment Agency are entered into the database Forurensning and the information is forwarded to an officer in charge. The officer in charge will check the following:

- That the data in Forurensning are registered as reported from the plants and appropriate corrections are made
- The methodology that was used for estimating emissions
- Emission in comparison to the emission level reported for the previous year. Emissions are displayed graphically. In the case of large deviations, the plant is contacted to provide an explanation.
- Emission relative to the production level. In the case of large variations in this ratio the plant is contacted to provide an explanation.
- The emissions seen in relation to other factors, for example changes in production technologies, control technologies or fuels

The Section for Emission Inventories and Analysis in the Norwegian Environment Agency are performing additional checks of data before they are sent Statistics Norway, including assessment of time-series consistency and consistency of data reported from plants using comparable technologies.

Also, the Department of Inspection and Environmental Data in the Norwegian Environment Agency, includes two units responsible for chemicals and product control, and industrial and offshore control. These sections work independently from the units responsible for the evaluating of emissions permits. They inspect and monitor industrial sites, including underlying documentation for the emission estimates.

There are two types of controls, one is a *frequency-based control,* and the other is a *specific campaign control*. The frequency-based control is as shown in Table A4-4.

Table A4-4: Independent control frequency of industrial plants.

Control class[1]	Inspection	Audit	Self-reporting
1	Every four years	Every four years	Annually
2	Every six years	Every six years	Annually
3	Every 3-4 years	-	Annually
4	If needed	-	If needed

[1]Industrial sites are divided into four control classes. Those that have the largest potential to generate pollution are included in class 1. Those that are included in class 4 have a relatively limited potential to generate pollution. The potential to generate pollution is determined by the hazard of their emissions and discharges, the quality/sensitivity of the recipient and the use of hazardous chemicals.

An inspection is a one-day on-site control, while an audit may take 3-5 days. The focus of a control/revision may vary. The administrative department in charge of evaluating emission permits can suggest topics for focus of the controls. Control campaigns take place after a consideration of experiences and results of previous campaigns. Typically, such campaigns will be used to check reported emissions.

The Norwegian Environment Agency has several possibilities for sanctions and other enforcement instruments to ensure compliance at industrial sites. They include the requirement to provide information to the authorities, coercive fines, withdrawal of the permit, and reporting violations to the prosecuting authorities.

Particular controls are directed to the plants included in the emission trading system to check that reported emissions are in compliance with the emission trading regulation (Annex 3). The reported emissions are subject to a third-party verification, performed by institutions formally approved for such verification. In addition, the Norwegian Environment Agency conduct audits at about 5-10 EU ETS installations each year. These audits evaluate the installations emissions monitoring systems and procedures and are carried out in addition to the third-party verification.

For the purpose of the inventory, additional QA is undertaken by the Section for Emission Inventories and analysis in the Norwegian Environment Agency before the data are sent to Statistics Norway. These QA checks include consideration of time-series consistency and a comparison of emissions per unit produced.

3.3.1.2 Statistical data

All data collected by institutions not included in the national system undergo a QA performed by the Norwegian Environment Agency or Statistics Norway or the Norwegian Institute of Bioeconomy Research as appropriate. Furthermore, when possible, the inventory teams perform a QA of data collected in their institutions in addition to the QC performed by the units responsible for the data collection. For example, Statistics Norway, compares energy use reported from the plants to Statistics Norway (used in the energy balance) with energy use reported by the same plants to the Norwegian Environment Agency within the EU ETS system or reports submitted due to the regular permits.

For some sources, activity data used in one sector are examined by experts from another sector. For example, during the production of the emission inventory, there is a data exchange between the LULUCF and the agricultural sectors. Thus, there is a two-way QA of data for these sectors.

At Statistics Norway, the statistics that form the basis for the emission inventory is produced in conjunction with the NAMEA statistics (emissions distributed on economic activities). This alternative aggregation of emissions gives a different perspective and will thus in some cases show the need for improvement. The statistics are evaluated, combined with information from the national accounts, and published by experts at Statistics Norway not involved in the production of the emission inventory. The emission statistics are also used by the research department at Statistics Norway.

3.3.1.3 Methodologies

In some cases, experts from other institutions carry out emission estimates themselves, and discrepancies with the emission inventory lead to scrutiny of both the inventory and the external emission calculations. One such example is within agriculture.

3.3.2 LULUCF-specific QA

Two external quality-assurance actions were undertaken in 2012. First, elicitation by the Norwegian Institute for Forest and Landscape (now NIBIO) of a qualified researcher was performed to evaluate and improve the methodologies applied for emission estimates from cropland and grassland. This work resulted in substantial method revisions for most source categories due to the lack of methods evaluation since their development was documented by (Rypdal et al. 2005). Moreover, detailed documentation and justification of the new methods are provided in the report Emissions and methodologies for cropland and grassland used in the Norwegian national greenhouse gas inventory (Borgen & Hylen 2013). The second external QA was a smaller task performed on the final emission estimates for mineral soil on grassland remaining grassland, which was elicited from an expert at Colorado State University. This task provided a review of the emission calculations (the new Tier 1 method application) and the method and activity data documentation. The methods were developed in accordance with the IPCC 2006 Guidelines and implemented in the National GHG inventory in 2013.

Work was done to QA the Yasso07 model estimates for mineral soil on forest land (Tier 3 forest land remaining forest land methodology for dead wood, litter, and mineral soil) in 2014 – 2015. In this project, modelled and measured soil C stocks were compared on two field sites over time. Results from these sites and the overall estimation methodology for the relevant pools on forest land were discussed at two seminars with three contracted external experts from Finland, Denmark, and Norway (Dalsgaard et al. 2017). In addition, Yasso07 (current methodology) and field estimates of soil C stocks were compared (Dalsgaard et al. 2016).

Further verification steps are ongoing. From 2023 to 2025, the Gjenferd project has provided field measurements of soil organic carbon (SOC) stock change for six sites in Norway to verify the Tier 3 methodology. Two manuscripts are currently being prepared for submission to peer-reviewed journals. In 2023, the National Soil Monitoring Program began, where soil samples are collected annually from a subsample of NFI plots classified as forest land. This process will continue for 10 years, followed by a remeasurement of the same plots 10 years later. The goal is to achieve full national coverage of SOC stock change measurements by 2042, providing data for the Tier 3 model-based estimates, currently using Yasso07.

With the implementation of the IPCC 2006 Guidelines, an external QA was elicited on the HWP calculations. The QA was performed by an expert from the Swedish University of Agricultural Sciences before the NIR 2015 submission.

An external QA was performed on the updated Tier 1 methodology to estimate changes in soil organic carbon after land-use change on mineral soils (Bárcena et al. 2021) in 2020 – 2021 by a LULUCF expert from the Stockholm Environment Institute (Estonia). A soil expert at the Norwegian University of Life Sciences was involved in developing the methodology. The methodology was implemented in NIR 2021.

External QA was carried out in 2021 for determining the settlement subdivisions methodology.

3.3.3 The entire inventory

3.3.3.1 UNFCCC review

The annual review of the inventory and NID under the UNFCCC is considered to be part of the QA. This review is performed by a team of experts (sector experts and generalists) from other Parties. Their tasks include examining the data and methods used by Norway along with the documentation and concluding whether they are in accordance with current guidelines. The review results in a review report which indicates specific areas where the inventory is in need of improvement.

3.3.3.2 EU initial quality checks and comprehensive reviews

The European Environment Agency (EEA) supports the European Commission with the compilation of the EU GHG inventory and the implementation of the initial quality checks (QA/QC) of the GHG inventories of Member States. Norway's GHG inventory is not part of the EU GHG inventory but has since 2023 been included in EEAs quality checks. Norway's GHG inventory also underwent a comprehensive review by the EEA in 2020 and will undergo comprehensive reviews in 2025, 2027 and 2032.

3.3.3.3 Expert peer review

The inventory and its documentation are published annually, and industry associations, relevant research institutions, directorates and environmental organizations may review and suggest improvements to the inventory. Any results of this review will be used by the cooperating institutions to improve the inventory.

It is a priority for the Norwegian LULUCF reporting team to invite external experts as consultants for QA purposes when new estimation methods are developed. The resulting QA reports are referred to and listed in the NID in the appropriate context.

3.3.3.4 Audits

The Norwegian Environment Agency, Statistics Norway and the Norwegian Institute of Bioeconomy Research are audited by the Auditor General of Norway. In addition to financial audits, the auditor general also performs performance audits, which consist of a systematic analysis of the economy and an evaluation of the efficiency and effectiveness of the government administration on the basis of the decisions and intentions of the Norwegian parliament. The Office of the Auditor General uses performance audits to shed light on specific areas within the government administration where there is a risk of noncompliance and/or deficiencies in relation to the resolutions and intentions of the Norwegian parliament. An audit of the national system may be initiated as a part of this.

The usefulness of having a private company conduct an independent audit of the implementation of the national system will be considered at a later stage.

3.3.3.5 QA through usage of data

QA is performed by experts as part of the usage of the emission inventory. One such activity is the evaluation of policy in mitigation analyses where emission figures are used at a very detailed level, which may reveal shortages in e.g. the level of detail of the inventory. Mitigation analyses are performed by experts in the Norwegian Environment Agency and other institutions, and there is a close collaboration with the emission inventory team. Thus, information regarding lack of accuracy or transparency easily reaches the inventory team, and possibilities for improvements are considered. A similar usage of the inventory is found in the production of future projections of emissions and removals in scenario analyses.

3.3.3.6 International collaboration

Contact with other countries gives important input and QA to the Norwegian Emission Inventory. Norway has since 2013 participated in Nordic meetings, where specific issues in the inventories are raised, and the approaches in different countries have been discussed. These collaborative meetings were first started in the LULUCF sector and other sectors joined later. This gives important new perspectives that is being considered in the Norwegian emission inventory team. Norway also participates in the EU's working group 1 meetings and related workshops etc relevant to the GHG inventory.

3.3.4 Implementation of QA/QC procedures

The institutions of the national system have implemented the QA/QC plans by establishing internal procedures. These procedures assign internal responsibilities for the QA/QC checks. The QA/QC procedures are under continuous development, and inventory compilers in all institutions of the national system are informed about the data quality objectives of the national system, as well as any priority areas related to the development of the QA/QC procedures.

4. Plan for improving the data

The emission estimation methodologies are being improved continuously. Statistics Norway and the Norwegian Environment Agency have carried out several studies on specific emission sources. Often, such projects are connected to an evaluation of emission reduction measures. An important consequence of Statistics Norway's work is increased environmental relevance of the statistical system. As far as possible, data collection relevant to the emission inventories is integrated into other surveys and statistics.

The inventory may, for some source categories, need to be further developed before it can fulfill the data quality objectives. The three institutions collectively produce plans for improving the data. The plans are based on the key category analysis, the UNFCCC review, QA/QC activities, new information and other needs, for example, needs for better data for the development of emission reduction strategies (mitigation analyses) and regional statistics.

The cooperating institutions produce a plan for improvements of the inventory. This plan may also point out needs that cannot be handled through ordinary inventory projects, because more in-depth research projects are required.

5. References

Bárcena, T. G., Dalsgaard, L., Strand, L. T., Mohr, C. W., Bjørkelo, K., Eriksen, R. & Søgaard, G. (2021): *A Tier 1 methodology for estimating changes in soil organic carbon after land use change on mineral soil*: NIBIO

Borgen, S. K. & Hylen, G. (2013): Emissions and methodologies for cropland and grassland used in the Norwegian national greenhouse gas inventory, Report 11/2013: Norwegian Forest and Landscape Institute (Norsk institutt for skog og landskap). 45 pp

Dalsgaard, L., Lange, H., Strand, L. T., Callesen, I., Borgen, S. K., Liski, J. & Astrup, R. (2016): Underestimation of boreal forest soil carbon stocks related to soil classification and drainage. *Canadian Journal of Forest Research*, 46 (12): 1413-1425

Dalsgaard, L., Kjønaas, O. J. & Lange, H. (2017): Forest soil carbon changes from measurements and models. Site-specific comparisons and implications for UNFCCC reporting. Ås: Norwegian Institute for Bioeconomy Research. 112 pp

Holmengen, N. & Kittilsen, M. O. (2009): Estimating emissions of NMVOC from solvent and other product use. Revised model, Reports 2009/14: Statistics Norway (SSB-Statistisk sentralbyrå). 77 pp

IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan

Karlengen, I. J., Svihus, B., Kjos, N. P. & Harstad, O. M. (2012): Husdyrgjødsel; oppdatering av mengder gjødsel og utskillelse av nitrogen, fosfor og kalium. Sluttrapport. (Manure; an update of amounts of manure and excretion of nitrogen, phosphorus and potassium. Final report). Ås: Departement of Animal and Aquacultural Sciences, Norwegian University of Life Sciences (Institutt for husdyr- og akvakulturvitenskap, NMBU-Norges miljø- og biovitenskapelige universitet)

Kvingedal, E., Tornsjø, B., Holtskog, S., G., H. & Rypdal, K. (2000): Verification of the Norwegian Emission Inventory. Comparing emission intensity values with similar countries, TA-1736/00: Norwegian Pollution Control Authority (SFT-Statens forurensingstilsyn), Statistics Norway (SSB-Statistisk sentralbyrå)

Morken, J. & Hoem, B. (2011): Models for calculating methane emission from manure management in Norway, IMT-Rapport 43/2011: Norwegian University of Life Sciences (NMBU-Norges miljø- og biovitenskapelige universitet). 18 pp

Rypdal, K., Bloch, V. V. H., Flugsrud, K., Gobakken, T., Hoem, B., Tomter, S. & Aalde, H. (2005): Emissions and removals of greenhouse gases from land use, land-use change and forestry in Norway. *Commissioned report by Norwegian Pollution Control Authority (SFT-Statens Forurensningstilsyn) and Ministry of Agriculture and Food (Landbruks- og matdepartementet)*, NIJOS rapport 11/05: Center for International Climate and Environmental Research (CICERO-Senter for klimaforskning, Norwegian Institute of Land Inventory (NIJOS-Norsk institutt for jord- og skogkartlegging), Statistics Norway (SSB-Statistisk sentralbyrå). 105 pp

SFT (2006): Documentation of methodology and results: QA/QC performed for Greenhouse Gas Emissions for Industrial plants included in the National Inventory. Oslo: Norwegian Pollution Control Authority (SFT-Statens forurensingstilsyn). 42 pp

Annex 5: Agriculture

1. Livestock characterisation

1.1 Animal population data

Table A5-1 and Table A5-2 gives the animal population data used in the Norwegian emission estimations, presented at a detailed level.

Table A5-1: Animal population data used in the estimations. Animal numbers. 1990, 1995, 2000, 2005, 2010, 2014-2023.

	1990	1995	2000	2005	2010	2014	2015	2016
Mature dairy cattle	325 896	310 346	284 880	255 663	232 294	222 553	222 276	220 461
Beef cow (other mature cattle)	8 193	20 334	42 324	54 841	67 110	73 894	77 408	84 372
Replacement heifer	143 904	138 359	129 500	118 090	111 122	109 813	111 391	113 462
Heifers for slaughter<1 year	4 134	3 232	6 267	3 745	2 966	3 117	2 176	1 820
Bulls for slaughter<1 year	13 847	10 825	23 295	14 868	11 685	15 518	11 984	10 633
Heifers for slaughter>1 year	24 878	24 477	32 443	29 098	27 000	34 421	32 757	32 662

Bulls for slaughter>1 year	171 871	169 104	175 101	160 711	148 883	138 048	136 877	139 121
Sheep <1 year (adj. for lifetime)	622 862	683 599	643 141	685 466	659 895	676 867	706 468	757 659
Sheep >1 year	714 384	783 922	766 098	717 098	691 450	683 479	716 252	729 014
Piglets	131 096	139 572	152 387	167 393	190 235	185 346	175 256	177 265
Young pigs for breeding	3 318	5 756	8 976	9 691	10 829	11 670	10 053	11 384
Sows	62 271	62 861	62 936	64 309	69 843	67 753	63 150	63 657
Boars	2 046	1 727	1 453	1 299	1 096	953	1 058	796
Fattening pigs	1 059 589	1 153 285	1 280 884	1 404 856	1 565 736	1 587 993	1 537 703	1 591 311
Deer	0	0	2 280	4 173	7 249	7 714	7 469	7 838
Dairy goats	64 041	58 630	50 578	44 374	35 706	31 461	33 627	34 660
Other goats	19 759	20 082	19 131	18 163	20 793	21 750	21 891	22 198
Horses	31 430	38 013	51 156	61 784	76 752	78 635	78 303	77 350
Laying hens	2 895 663	3 556 841	3 228 812	3 343 410	3 945 607	4 320 632	4 359 188	4 336 730
Chickens reared for laying	3 459 064	2 984 493	2 184 479	3 066 358	2 777 268	2 686 575	2 738 693	2 614 453
Broilers	15 864 401	23 318 120	35 757 612	43 612 212	61 245 745	73 974 651	63 406 519	65 898 097
Turkeys for slaughter	528 240	776 428	673 282	953 112	1 141 867	1 245 554	1 260 617	1 179 466
Ducks and geese for slaughter	18 551	27 267	81 365	69 368	153 831	302 757	298 089	291 989
Turkeys, ducks and geese reared for laying	15 506	29 930	20 292	45 378	36 901	20 662	23 811	19 530
Reindeer	242 443	212 333	172 407	234 608	254 384	232 905	211 974	211 666

Mink	56 411	44 199	68 526	98 247	107 980	174 613	161 394	143 156
Foxes	104 126	122 146	86 160	76 756	49 213	49 143	40 734	31 828
	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	
Mature dairy cattle	215 849	211 730	199 417	195 076	196 934	189 099	183 022	
Beef cow (other mature cattle)	88 332	92 304	94 001	99 748	106 082	109 517	108 693	
Replacement heifer	114 771	114 249	111 134	111 819	112 613	107 606	103 561	
Heifers for slaughter<1 year	2 326	3 037	2 981	2 475	2 531	3 402	4 024	
Bulls for slaughter<1 year	9 800	13 481	11 480	9 467	8 952	9 996	11 906	
Heifers for slaughter>1 year	21 845	27 156	24 169	27 178	29 415	26 224	40 218	
Bulls for slaughter>1 year	159 825	168 203	155 043	148 833	148 347	157 573	152 019	
Sheep <1 year (adj. for lifetime)	746 214	732 206	671 779	660 826	668 023	656 644	623 422	
Sheep >1 year	730 666	676 937	634 028	644 880	621 374	639 278	627 292	
Piglets	170 140	172 919	163 636	157 108	156 336	148 864	146870	
Young pigs for breeding	10 779	11 428	11 363	10 440	9 596	9 182	9 508	
Sows	60 919	62 517	57 831	54 654	53 419	52 187	50 995	
Boars	799	1 344	889	874	884	852	893	
Fattening pigs	1 589 084	1 642 094	1 568 614	1 513 595	1 505 436	1 491 456	1 491 386	
Deer	7 086	7 970	8 072	8 347	8 302	7 949	7 805	
Dairy goats	34 126	34 583	35 019	33 960	34 443	34 167	33352	
Other goats	21 112	23 413	24 017	25 236	26 305	26 895	27826	

Horses	76 511	80 470	80 919	81 877	83 566	85 456	88307	
Laying hens	4 365 344	4 308 640	4 627 642	4 585 350	4 666 613	4 667 401	4585739	
Chickens reared for laying	2 631 703	2 143 725	1 880 977	1 507 652	1 448 201	3 670 383	3257694	
Broilers	63 516 948	62 738 774	68 409 911	67 262 533	72 350 290	72 328 966	72 028 454	
Turkeys for slaughter	1 037 274	825 264	822 691	892 615	922 121	896 361	913 650	
Ducks and geese for slaughter	278 423	274 298	282 672	286 611	243 838	349 219	374 727	
Turkeys, ducks and geese reared for laying	20 601	12 336	16 945	14 730	12 180	17 770	17 273	
Reindeer	213 913	213 012	215 144	213 753	212 866	217 809	215 481	
Mink	107 039	136 993	82 540	44 198	7 500	6376	NO	
Foxes	21 124	27 554	24 918	18 056	1 626	758	NO	

Table A5-2: Animal population data used in the estimations. Animal places. 1990, 1995, 2000, 2005, 2010, 2014-2023.

	1990	1995	2000	2005	2010	2014	2015	2016	2017
Replacement heifer	311 279	299 284	280 121	255 862	239 839	246 165	240 419	243 924	247 715
Heifers for slaughter<1 year	2224	1886	3159	2452	1999	2125	1495	1193	1595
Bulls for slaughter<1 year	7 416	6 258	11 424	9 246	7 299	9 729	7 514	6 667	6 231
Heifers for slaughter>1 year	44 796	45 216	60 353	55 167	51 411	65 498	63 318	63 169	41 906
Bulls for slaughter>1 year	282 528	277 979	273 925	253 923	223 573	199 249	198 814	211 218	244 399
Fattening pigs (animal places)	376 643	355 147	319 293	350 665	415 686	405 176	403 399	401 455	392 141
Chickens reared for laying (animal places)	1 729 532	1 424 417	997 262	1 341 532	1 166 453	1 119 406	1 141 122	1 089 355	1 096 543
Broilers (animal places)	3 172 880	4 352 716	6 257 582	7 183 188	9 527 116	11 380 716	9 754 849	10 138 169	9 771 838
Turkeys for slaughter (animal places)	176 080	269 504	243 775	360 637	452 438	498 222	504 247	471 786	414 910
Ducks and geese for slaughter (animal places)	4 638	6 434	18 177	14 714	31 062	60 551	59 618	58 398	55 685
Turkeys, ducks and geese reared for laying (animal places)	15 506	29 930	20 292	45 378	36 901	20 662	23 811	19 530	20 601
	2018	**2019**	**2020**	**2021**	**2022**	**2023**			
Replacement heifer	245 636	240 049	245 069	247 748	230 862	225 246			
Heifers for slaughter<1 year	2027	2071	1 721	1 767	2 401	2 717			
Bulls for slaughter<1 year	7 965	7 414	6 169	5 809	6 489	7 399			
Heifers for slaughter>1 year	50 329	45 159	51 046	55 006	41 857	63 790			
Bulls for slaughter>1 year	252 164	231 431	222 899	223 390	238 866	232 099			
Fattening pigs (animal places)	389 589	366 489	360 089	365 452	360 225	346 963			
Chickens reared for laying (animal places)	893 219	783 740	628 188	603 417	1 529 326	1 357 373			

Broilers (animal places)	9 652 119	10 524 602	10 348 082	11 130 814	11 127 533	11 081 301			
Turkeys for slaughter (animal places)	330 106	329 076	357 046	368 848	358 544	365 460			
Ducks and geese for slaughter (animal places)	54 860	56 534	57 322	48 768	69 544	74 945			
Turkeys, ducks and geese reared for laying (animal places)	12 336	16 945	14 730	12 180	17 770	17 273			

2. Methane emissions from enteric fermentation in Norway's cattle and sheep population

2.1 GE and Y_m

Values for gross energy intake (GE) and CH_4 conversion rate (Y_m) used in the tier 2 CH_4 emissions from enteric fermentation from cattle and sheep are given in Table A5- 3.

Table A5- 3: Average gross energy intake (GE) and CH4 conversion rate (Ym). 1990, 1995, 2000, 2005, 2010, 2014-2023.

		1990	1995	2000	2005	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Mature Dairy Cattle	Average GE (MJ/head/day)	261.3	263.2	260.4	270.5	288.9	306.5	308.4	307.8	307.6	316.3	318.3	319.2	319.7	315.6	313.4
	Ym (%)	6.9	69	6.9	6.8	6.6	6.5	6.5	6.5	6.5	6.5	6.4	6.4	6.4	6.4	6.4
Mature Non-Dairy Cattle	Average GE (MJ/head/day)	194.0	194.0	194.0	194.0	194.0	194.0	194.0	194.0	194.0	194	194	194	194	194	194
	Ym (%)	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Heifer for replacement	Average GE (MJ/head/day)	122.3	125.2	125.0	131.2	137.3	135.2	138.6	139.0	138.8	139.7	140.6	142.1	143.4	141.5	140.3
	Ym (%)	6.6	6.7	6.7	6.8	6.9	6.9	6.9	6.9	6.9	6.9	6.9	7.0	7.0	6.9	6.9
Heifer slaughtered before 12 months	Average GE (MJ/head/day)	53.4	63.7	65.5	82.3	81.1	93.9	96.5	97.1	91.0	79.3	97.4	97.1	99.7	98.9	91.4
	Ym (%)	5.9	5.9	5.8	5.9	5.9	5.9	5.9	5.8	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Heifer slaughtered after 12 months	Average GE (MJ/head/day)	76.2	78.9	78.7	81.7	82.8	91.1	93.4	94.7	92.5	89.9	90.2	85.7	87.8	103.5	102.4
	Ym (%)	7.2	7.2	7.2	7.2	7.2	7.1	7.0	7.0	7.0	7.0	7.0	7.1	7.1	6.6	6.6

		1990	1995	2000	2005	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Bulls slaughtered before 12 months	Average GE (MJ/head/day)	74.3	89.7	84.6	109.1	109.3	118.0	118.8	119.9	118.7	125.8	123.5	124.2	124.5	125.2	113.8
	Ym (%)	5.8	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.6	5.7	5.7	5.7	5.7	5.7
Bulls slaughtered after 12 months	Average GE (MJ/head/day)	109.5	116.9	118.8	127.5	133.8	137.1	139.5	138.1	136.2	135.6	138.1	139.6	140.8	139.7	137.9
	Ym (%)	6.5	6.4	6.3	6.2	6.0	5.9	5.9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6,0
Sheep	Average GE (MJ/head/day)	32.7	32.5	32.4	32.6	32.8	32.9	33.3	32.8	32.1	31.6	32.4	32.3	32.5	33.6	32.8
	Ym (%)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6

3. Nitrogen excretion tables and background information for N and VS for cattle

3.1 Nitrogen excretion tables

Table A5-4: Nitrogen excretion. 1990, 1995, 2000, 2005, 2010, 2014-2023. Total N. N excretion per animal, kg.

	1990	1995	2000	2005	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Dairy cattle	107.6	96.2	100.9	113.2	124.0	126.6	129.0	129.9	128.6	128.3	133.0	134.1	134.7	133.0	131.5
Suckling cows	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0
Replacement heifers	66.9	66.0	67.9	77.2	85.1	86.5	86.6	86.7	86.8	87.5	89.0	92.1	93.9	89.3	89.3
Heifers for slaughter	58.5	61.2	55.8	64.3	66.1	65.4	69.1	68.1	68.1	61.8	64.5	66.4	65.7	65.6	63.2
Bull for slaughter	53.8	54.7	52.6	65.5	68.1	66.8	69.9	72.7	72.2	69.0	71.4	73.3	75.0	74.5	73.4
Sows	15.4	17.5	19.7	21.8	24.0	24.0	23.9	23.7	23.6	23.5	23.3	23.2	23.1	22.9	22.9
Boars	12.3	14.0	15.7	17.5	19.2	19.2	19.1	19.0	18.9	18.8	18.7	18.6	18.4	18.3	18.3
Piglets	3.2	3.2	3.2	3.2	3.2	3.0	3.0	2.9	2.9	2.8	2.8	2.8	2.7	2.7	2.7
Fattening pigs	4.0	3.8	3.6	3.4	3.2	3.0	2.9	2.8	2.7	2.6	2.5	2.5	2.4	2.3	2.3
Young pigs for breeding	7.6	8.1	8.6	9.1	9.6	11.1	11.6	12.1	12.6	13.1	13.6	14.1	14.6	15.0	15
Laying hens	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Chickens reared for laying	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Broilers	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turkeys for slaughter	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Ducks and geese for slaughter	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

	1990	1995	2000	2005	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Turkeys, ducks and geese reared for laying	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Horses	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Dairy goats	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
Other goats	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Sheep over 1 year old	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
Sheep under 1 year old	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Mink	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Foxes	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Deer	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Reindeer	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4

Table A5-5: Nitrogen excretion. 1990, 1995, 2000, 2005, 2010, 2014-2023. Ammonium N.

	1990	1995	2000	2005	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Dairy cattle	60.4	48.8	54.3	63.7	71.2	72.3	73.5	73.9	73.3	73.3	75.4	76.1	76.5	75.8	74.8
Suckling cows	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6	52.6
Replacement heifers	40.2	38.3	40.2	47.1	52.8	53.8	53.8	53.8	53.9	54.4	55.4	57.5	58.7	55.6	55.6
Heifers for slaughter	27.1	28.3	31.0	38.0	40.8	47.9	51.8	53	50.1	43.7	44.9	41.7	42.9	39.2	37.7
Bull for slaughter	31.6	30.1	29.6	39.0	41.2	40.3	42.3	44.1	43.9	41.8	43.3	44.6	45.7	45.4	44.7
Sows	10.6	11.7	12.8	13.9	15.0	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3
Boars	8.5	9.2	10.2	11.1	12.0	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
Piglets	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.8

	1990	1995	2000	2005	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Fattening pigs	2.8	2.6	2.5	2.3	2.2	2.0	1.9	1-9	1.8	1.7	1.7	1.6	1.6	1.5	1.5
Young pigs for breeding	5.3	5.6	5.8	6.1	6.4	7.4	7.8	8.1	8.4	8.7	9.1	9.4	9.7	10.0	10.0
Laying hens	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Chickens reared for laying	0.06	0.05	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Broilers	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Turkeys for slaughter	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ducks and geese for slaughter	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Turkeys, ducks and geese reared for laying	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Horses	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Dairy goats	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1
Other goats	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Sheep over 1 year old	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Sheep under 1 year old	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Mink	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Foxes	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Deer	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Reindeer	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4

3.2 Activity data tables for calculation of N and VS for mature dairy cows and young cattle

Table A5-6: Activity data used for calculation of N and VS for mature dairy cow and young cattle. 1990, 1995, 2000, 2005, 2010, 2014-2023.

Year	Mature dairy cows				Heifer for replacement				Bulls for slaughter			
	Milk yield (kg ECM per cow per year)	Weight (kg)	Protein content in the roughage g/kg dry matter	calculated protein content. g/kg dry matter	Weight by first calving (kg)	Feeding period. months	Protein content in the roughage g/kg dry matter	Protein content in concentrates. g/kg dry matter	Slaughter weight	Slaughter age. Months	Protein content in the roughage g/kg dry matter	Protein content in concentrates. g/kg dry matter
1990	6 320	508	150	184	435	26.0	140	184	255	18.8	140	184
1995	6 326	525	150	149	449	26.0	140	149	276	18.9	140	149
2000	6 156	524	150	167	448	26.0	140	167	269	16.7	140	167
2005	6 723	562	150	184	481	26.0	140	184	296	17.7	140	184
2010	7 373	597	150	195	511	25.9	140	195	302	16.9	140	195
2014	7 711	596	150	195	510	26.9	140	195	302	15.9	140	195
2015	7 958	605	150	195	518	25.9	140	195	310	16.2	140	195
2016	8 062	606	150	195	519	25.8	140	195	317	16.8	140	195
2017	7 902	606	150	195	519	25.9	140	195	313	17.3	140	195
2018	7 840	610	150	195	523	25.8	140	195	306	16.4	140	195
2019	8 395	617	150	195	528	25.9	140	195	313	16.7	140	195
2020	8 463	630.	150	195	539.8	26.3	140	195	318	17.0	140	195
2021	8 489	639	150	195	547.2	26.4	140	195	322	17.1	140	195
2022	8 299	621	150	195	531.4	25.7	140	195	321	17.1	140	195
2023	8 208	617	150	195	528.7	26.1	140	195	318	17	140	195

4. $Frac_{GASF}$

Table A5-7 presents weighting of loss factors based on basis data for N-loss factor, N-share and amount for the different synthetic fertilizers. The NH_3 emission factors (g NH_3/kg N applied) for the different types of fertilizers is updated in the 2025 submission with EEA 2023 factors.

Table A5-7: Weighting of loss factors based on basis data for N-loss factor, N-share and amount for the different synthetic fertilizers. 2023.

Fertilizer type	Amount of fertilizer (tonnes)	Amount of Nitrogen (tonnes)	Loss (g NH_3/kg N applied)
Ammonium nitrate	0	0	24
Ammonium nitrate m/S	80 110	21 574	24
Potassium sulphate	769	0	0
Potassium sulphate m/Mg	1600	0	0
Potassium chloride	59	0	0
Kalkamonsalpeter	2 168	585	24
Calcium nitrate	6 943	1 076	24
Calcium nitrate m/B	2 958	458	24
NK-fertilizer 22-12	3 560	782	24
NP fertilizer 12-23	1 335	158	84
NPK-fertilizer 8-5-19	507	41	24
NPK-fertilizer 12-4-18	15 327	1 809	24
NPK-fertilizer 15-7-12	91	14	24

Fertilizer type	Amount of fertilizer (tonnes)	Amount of Nitrogen (tonnes)	Loss (g NH_3/kg N applied)
NPK-fertilizer 18-3-15	21 085	3 711	24
NPK-fertilizer 20-4-11	2 756	540	24
NPK-fertilizer 22-2-12	21 135	4 565	24
NPK-fertilizer 22-3-10	82 855	17 899	24
NPK-fertilizer 24-4-6	5	1	84
NPK-fertilizer 25-2-6	92 119	22 661	24
NPK-fertilizer 27-3-5	1 582	427	84
NPK-fertilizer 27-2-4	33 360	9 007	84
PK-fertilizer 0-11-21	463	0	0
P-fertilizer 0-20-0	155	0	0
Urea	383	164	195
Other fertilizer with N content	911	150	24
Other fertilizer	0	0	0 1

Annex 6: Common reporting format (CRT) tables

The common reporting format (CRT) tables for 1990-2023 are available through EIONETs central data repository (https://cdr.eionet.europa.eu/no/un/UNFCCC/) and at the UNFCCC web site.

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The Norwegian Environment Agency is a government agency under the Ministry of Climate and Environment.

We work for a clean and diverse environment. Our primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature and prevent pollution.

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